

Aquarium Plants



Christel Kasselmann

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Preface

Dedicated to my parents in gratitude

Today, aquarium plants enjoy a surprising degree of popularity. On the one hand, the numerous new imports and cultivars have, over the last couple of years, expanded the range of plants available; on the other hand, the varied choice of technical and growth-enhancing accessories have increased the desire for beautifully arranged aquariums. A significant number of aquarium plants serve not only decorative purposes, but hobbyists have placed a special emphasis on the maintenance and propagation of species which are rare or threatened by the destruction of their native habitats. One expression of this trend is the special associations and clubs formed by plant enthusiasts, in both Germany and abroad. In Germany, the *VDA Working Group on Aquatic Plants (Arbeitskreis Wasserpflanzen im VDA)* is an important contributor to the dissemination of information about aquarium plants through their publication *Aqua-Planta*. To many aquarists the cultivation of aquatic and marsh plants also serves the purpose for research in biological and ecological contexts, which is why the maintenance of aquarium plants can also be seen as being part of the protection of species, nature and the environment in general.

In this book I want to try to offer a wide-ranging scope of information. The general section will cover the native habitats of aquatic and marsh plants in detail, a topic which has previously been neglected by other publications. Ecological data obtained on location

are discussed in the context of contradictory assertions made by other authors, and will also provide clues regarding the optimum conditions for cultivation. The book's segment on plants delivers a comprehensive and complete overview of those species, cultivars and growth forms which are currently in culture. Along with familiar plants, species that are rare and difficult to maintain are included as well, this being an important aspect for those plant enthusiasts who tend to specialize in certain areas.

The plant descriptions, catalogued in alphabetical order for easy reference, contain all essential characteristics which are necessary to enable a definite plant identification and avoid any confusion. Furthermore, detailed information is provided about successful plant cultivation and propagation. I wish to emphasize at this point that, with very few exceptions, all species listed have been kept in home aquariums or have been researched in their natural environment. Data on the plants' ecology—listed for every plant catalogued—provides important information on the requirements of individual species. Much of this data is based on my own studies of biotopes, which were conducted in the course of 25 trips to tropical regions and countries. Important references for further reading conclude some of the individual plant descriptions and should, along with the comprehensive bibliography at the end of the book, refer interested hobbyists to more detailed publica-

tions. Also an extensive glossary of terms explains specialist terminology.

The importance of ecological factors for the growth of aquatic and marsh plants in their native habitats, as well as within the aquarium, forms the core of this book. Over the last 15 years, my main interest has been in the research of the natural environment of aquarium plants in order to expand the limited knowledge about their ecological needs, as well as to study their respective status within the natural community of living beings, thereby obtaining a sound basis for optimum cultivation. Studies in biotopes have so far only been completed for a comparatively small number of aquatic and marsh plants, and information on the ecology of individual species is very limited, even in specialist botanical literature. The efforts undertaken by travelling aquarists to collect and publish such data are considered especially valuable because they provide the plant enthusiast with a first indication on species-specific cultivation. Previous publications covering the ecology of aquarium plants have been primarily concerned with research on *Cryptocoryne* and *Aponogeton* habitats. Each one of these descriptions can only be evaluated as a "snapshot" of conditions prevailing at that particular time; nevertheless they permit a basic insight into the ecology and sociology of those plants. Even though the chemical composition of the water in native habitats is always subject to certain fluctuations, the fundamental underlying condition of the waterways will remain surprisingly stable over the entire year. Biotope studies are necessary and instrumental for our awareness and understanding of plant life in the aquarium, and its requirements. It was, therefore, my aim to include in this book all the informative ecological data available so far in the most comprehensive way possible. Also just as important are detailed observations made in aquariums, which will contribute in equal

importance to the expansion of knowledge about aquatic plant ecology.

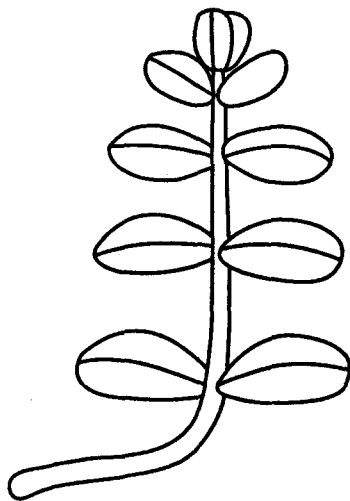
This book is aimed especially at those aquarists and hobby botanists who enjoy and are interested in aquarium plants. In compiling the manuscript it has not always been easy to find a linguistic basis and level of information which meet the needs of both beginners and those aquarists with a prior knowledge of botany. The book's concept, and also the broad range of illustrations, enable a multifaceted use. The color atlas can assist the lay person with the identification of plants, and also with cultivation and maintenance, because the text offers a wide spectrum of information on selection, cultivation and propagation of aquarium plants. Specialized and more interested plant enthusiasts will find extensive information on the differentiation between species, as well as detailed bibliographical references in the individual plant listings, thereby enabling a closer focus on certain aspects. Furthermore, the book is also relevant to the scientific researcher due to its—probably unique—catalogue of ecological data and valuable information provided in it. Finally, many rare plants are portrayed in photographs for the first time.

During the preparation of this book, which took many years, I was extensively supported by several good friends. A special thank you goes to Mr. Josef Bogner (Botanical Gardens, Munich, Germany), whom I consulted with on many botanical and biological aspects. During a friendship lasting nearly 20 years, marked by a readiness to help, extensive discussion and a never ending application to the topic, he provided countless ideas and suggestions for my own plant research. Thanks also to Mr. Harry W.E. van Bruggen (Heemskerk, Netherlands) for the friendly cooperation over many years, as well as the careful scrutiny of and critical comments on my manuscript. Valuable ideas and support through information provided about the *Cryptocoryne*

genus was also received from Mr. Jan Bastmeijer (Emmen, Netherlands), Hans Ehrenberg (Berlin, Germany), Prof. Dr. Niels Jacobsen (Copenhagen, Denmark), as well as my unforgotten, late friend, Friedrich Möhlmann. My special thanks also go to Mr. Julius Hoechstetter (Trostberg, Germany) and Mr. Hartmut Loose (Botanical Gardens, Berlin, Germany) for their stimulating contributions and their supply of plant material. I was also supported over many years with the supply of live plants by the aquatic plant nurseries Den-

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Christel Kasselmann
Berlin, summer of 1999



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Aquatic and Marsh Plants in Their Natural Habitats

Compared to previous times, today there exists an ever increasing interest in the natural habitats of aquatic plants. The science covering the interrelationships of organisms and their surrounding environment is called ecology. The function of ecology is to analyze and comprehend all operative, active factors and their respective functions and tasks within natural biotopes and living environments.

Although the native habitats of local aquatic and marsh plants have previously often been the subject of research and have

been studied exhaustively, our knowledge of the association (sociology) as well as the natural living environment of tropical aquatic and marsh plants is surprisingly fragmentary. Detailed ecological data on habitats of each and every aquarium plant, based, for instance, on the analysis of water, substrate, flow speed of the water current, as well as light conditions, is also extremely rare or completely unavailable. Furthermore, the little data listed in aquaristic literature often contains entirely misleading interpretations and generalizations which, in turn, convey a

***Sagittaria guayanensis* is a genuine aquatic plant not cultivated in aquariums (native habitat in Mexico).**





Inflorescence of *Eichhornia azurea* in its natural habitat in Venezuela.

totally false picture of the ecology of tropical aquatic and marsh plants. Even the mere purpose of biotope studies is occasionally put into question and criticized as being irrelevant, the reason being that conclusions supposedly cannot be drawn from such studies which would be applicable to aquarium plant cultivation, and that, on the other hand, plants are, in any case, adaptable in their behavior. Such points of view are, of course, absolutely nonsensical and cause damage to aquaristics that are oriented towards the future and that stipulate the research of living organisms maintained in aquariums as the most important objective.

An in-depth study with the living environment of tropical aquatic and marsh plants will quickly show that their specific ecology is exceptionally multifaceted and their overall context of interrelationships is very complex. It also has to be remembered that only a small number of existing marsh and aquatic plants have previously been cultivated within an aquarium; the overwhelming majority have not been kept at all, or if so, only briefly. It also seems obvious that the causes for failures in cultivation are mostly found in the ignorance of the plants' basic requirements. It was never the objective of biotope research to carbon-copy the habitats, but only the desire to expand the level of knowledge about the way of life and the requirements of different plant species, with the specific aim of avoiding mistakes in cultivation. In order to comprehend their ecology, both general as well as specific descriptions of ecological systems which permit a differentiating consideration of the requirements of every individual species are extremely important. A lot can be learned from the research conducted in natural biotopes, and every analysis constitutes an important building block in the detailed knowledge of the living requirements of each and every plant. The objective must be to assemble all these building blocks to form a complete mosaic!

Environmental Factors

TEMPERATURE

Temperature not only has a decisive influence on plant metabolism but also on many other biological processes, for example, flower formation, fruit ripening, germination, etc. Plant photosynthesis is highly dependent on the surrounding temperature because every individual plant requires a specific temperature range for its growth. The lower limit of this temperature range constitutes the minimum; the upper limit constitutes the maximum conditions in which the plant can maintain its growth. Below or above these cardinal points, the plant will cease to grow. Within the minimum-maximum range, growth speed will not increase in a linear way with a rise in temperature but will instead drop off again after having reached a certain peak which is specific and unique for every plant species. This temperature point or value at which the plant displays its maximum growth intensity constitutes the optimum temperature.

It can be concluded from these observations on general growth behavior that aquatic and marsh plants will not prosper optimally in their native habitats over the entire spectrum of seasons. Accordingly, research data obtained from habitats has to be evaluated within this context. Some species react to extreme temperatures with a change in appearance, for example, through the formation of smaller leaves or shorter internodes.

Plants originating from warmer areas make heavier demands on temperature requirements, compared to those from areas displaying distinct seasonal variations. Studies of terrestrial plants have shown that the optimum temperature of tropical or subtropical plants ranges between 30–40 °C, and between 15–30 °C for all other species (Larcher 1984). It was also found that plants in their natural environment have adapted to a temperature change between night and day.

For successful cultivation of aquatic and marsh plants, it is essential to find both the tolerance limits as well as the optimum temperature for every individual species. A series of carefully planned and executed experiments is necessary to establish precise and optimal growth curves or projections, which have, until now, not been determined for aquarium plants. Important hints regarding growth limitations and approximate optimum temperature values for individual species can also come from everyday data and experience extracted from the daily practice of cultivation in hothouses and aquariums, as well as research conducted within natural living environments. Whereas some species (e.g., *Valisneria*) display a big temperature tolerance range, others display very moderate growth limits (refer also to Appendix 1).

The following account illustrates the complex effects that the temperature factor has on the behavior of aquatic and marsh plants within an area displaying a distinct seasonality:

In July 1993 the author studied numerous habitats of aquatic and marsh plants in north-eastern Argentina. This region has a distinct seasonal climate. The month of July is in the midst of the cold time of year. Median temperatures for the city of Corrientes measure 15.7 °C, with 47 mm of rainfall recorded. Both values constitute almost the minimum over the entire year and monthly average readings say little about the absolute temperature levels which can be considerably higher or lower. During the 2-week stay in July, nightly temperatures hovered around the frost limit. During this period daytime air temperatures reached a maximum of only 15 °C over an entire week. Daytime water temperatures measured 6 to 15 °C. The effects of these extremely low water and air temperatures on the plants was clearly visible everywhere. Large contingents of floating plants, including *Eichhornia azurea* and *Pistia stratiotes*, displayed frozen and dried foliage. Oxygen

deficiency was evident in many waterways, caused by the large amount of dead foliage; this, in turn, led to massive fish mortality (refer to p. 56 for more information on oxygen content). It could also be observed that the low water temperatures often had no negative influence on plant growth under water. Unusually strong submersed specimens of *Eichhornia azurea*, thick contingents of *Cabomba caroliniana* var. *caroliniana* and var. *flavida*, *Egeria najas*, *Myriophyllum aquaticum* and *Hydrocleys nymphoides* could be found everywhere. Some of the aquatic and marsh plants flowered lushly during the short-days within this cold period, the low temperatures in several cases being an important triggering factor for flower formation (for example, *Echinodorus uruguayensis*).

LIGHT

Because it is an essential provider of energy for photosynthesis, light is important for many growth and developmental processes of plants. Furthermore, it has an important influence on the morphology and anatomy of plants, as well as on photoperiodic occurrences.

Measuring light intensity in natural habitats of tropical and subtropical aquatic and marsh plants is extremely important for the expansion of knowledge about the requirements of the different aquarium plants, and also to be able to sustain optimum maintenance conditions in line with their requirements. In order to better understand questions and problems relating to this, several basic aspects of the general importance of light as an environmental factor will be explored in more detail. The intensity and duration of light radiation within nature is not as continuous as it is in the aquarium; it not only changes in the course of a day but also over the whole year in accordance with geographic latitude.

Light radiation is reduced to a larger degree within water than is the case within air.



Detailed close-up of a Dutch aquarium.

Long-wave heat rays entering water are already absorbed in the top few millimeters, the bulk of infrared radiation being absorbed in the first couple of centimeters. Even in a depth of about 1 m, only half of the radiation will still be present. The range that can be utilized by aquatic plants for photosynthetic purposes lies between 380 and 780 nm and will be selectively absorbed with increasing depth, whereby red light will be absorbed first in clear water, followed by the yellow and green spectral range, and finally blue light, which thus manages to reach larger depths of water.

Furthermore, light absorption as well as the color spectrum are persistently influenced by coloring and clouding matter (humic substances, plankton, algae, floating matter resulting from wash off) contained in the water. In a yellow- or brown-colored waterway, for example, there will not only be strong light

absorption because of humic matter, but the coloring of the water will simultaneously cause a modification of the spectral composition, which means that the yellow spectral range, and not the blue light, will penetrate deepest into the water.

Due to reflection on the water surface, the radiation supply in waterways depends to a large extent on the angle of incidence. With the sun high in the sky, reflection will be negligible so that light can enter the water almost unbroken. When the sun is low in the sky, reflection will increase to such a degree that a large amount of light is unable to penetrate the water. This intense reflection on the water surface during a low-positioned sun has the effect that the day will be shorter for plants existing under water and below a specific depth, compared to other species living on land.

Generally, with regard to the overall bal-

Habitat of *Vallisneria americana* var. *americana* in Papua New Guinea. The plant displays a high temperature tolerance.

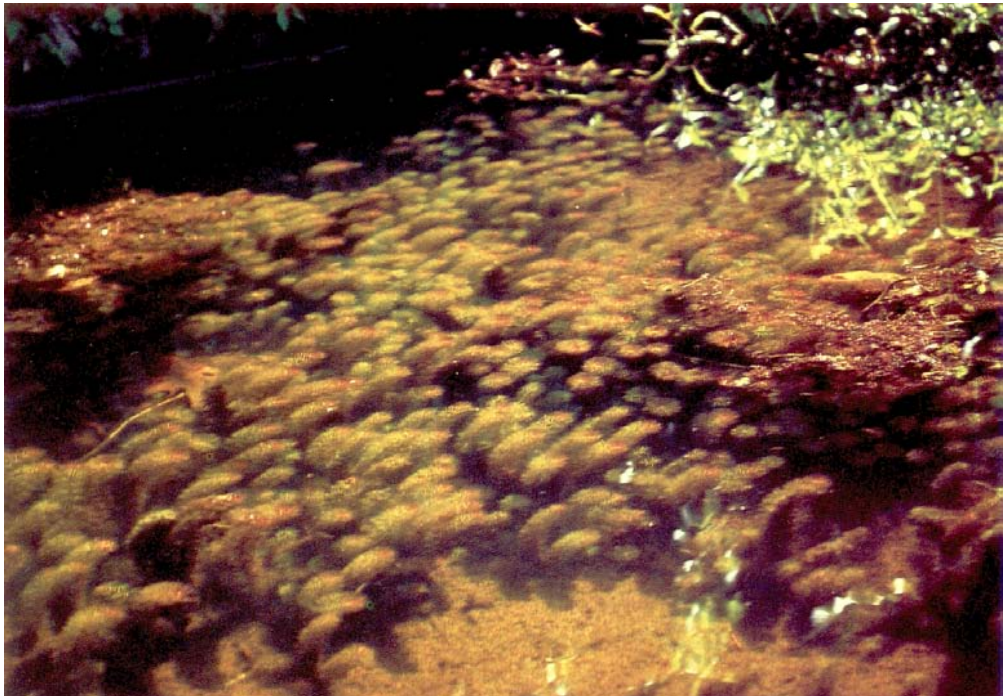


ance of radiation, the light climate in the tropics does not differ much from areas in medium latitudes. There are, however, fundamental differences. For one, the sun will rise and set much quicker in the tropics. Also, radiation intensity will be generally higher in the tropics and can reach readings over 150 klx during clear midday skies, whereas values in our areas will be only about 100–120 klx. Furthermore, the length of day in equatorial regions will vary only slightly over an entire year and will more or less measure a constant 12-hour period.

Light intensity is greatly influenced by the degree of clouding. Light intensity for species growing in water will additionally decrease through the reflection on the water surface already mentioned, as well as possibly through the shading effect of floating plants. Comparably few higher plants are able to reach depths of 3–10 m in clear fresh-

water. Beyond that, only limited societies of algae will exist in depths of 30 m. For those species growing in great depths, quantity and quality of light will change considerably. Most aquarium plants are found in their natural habitats either outside the waterways in the form of marsh plants, or within a depth range of up to 30 cm, and will only occasionally be found in deeper water during peak water. Furthermore, a large range of aquarium plants will populate unshaded and semi-sunny areas within their natural biotopes, and do not prefer shaded locations as is occasionally falsely indicated in aquaristic literature. Even though less light for photosynthesis is available to plants existing in water—compared to their terrestrial counterparts—due to light being absorbed by reflection on the water surface as well as a greater depth, levels of light intensity at the natural locations of aquarium plants are nevertheless generally

This biotope of *Limnophila indica* features crystal clear water.



considerably higher than in the aquarium (see also the recorded readings at the end of this chapter).

It is interesting to note in this context that the plants' photosynthetic production cannot be randomly increased through an increase in light intensity, but that (in line with the optimum temperature curves) a species-related optimum light curve can be established for every plant species through experimental research. During rising light intensity, this curve will show an increase in assimilatory activity only up to a specific range (optimum); thereafter it will not increase any further or will even decrease, which is possibly caused by a reciprocal relationship with other limiting factors of influence, for instance, temperature or CO₂ supply.

Corresponding to their differing capacities to utilize strong or weak light, one distinguishes between strong light or sun plants, and weak light or shade plants. Shade plants have the advantage of being able to better

utilize low-light intensity compared to sun plants; they reach their highest assimilation during conditions of weak-light intensity. For this reason shade plants can still populate relatively dark locations in a forest and will prosper best under conditions of weak light. A typical feature is large wide leaf blades, as found, for example, in certain wide-leaved *Cryptocoryne* species and also *Barclaya motleyi*. Shade plants will die off under certain conditions if they are subjected to too high light radiation. Sun plants, in contrast, require intensive radiation and, compared to shade plants, will make better use of the latter through a superior photosynthetic performance. They require more light and will die off if they receive an insufficient amount of light.

Optimum light curves as well as assimilation curves for aquarium plants have so far been compiled for only a few individual plants, resulting in a limited definite classification of species into shade or sun plants.

***Bacopa caroliniana* under intense sunlight at a locality in Mexico.**



Photosynthesis curves of *Anubias barteri* var. *nana* and *Bacopa caroliniana* were established at the University of Marburg, resulting in the classification of *A. barteri* var. *nana* as a typical shade plant and *B. caroliniana* as a sun plant (Sauer 1989).

Within these two major groups very different reaction formations occur, which are either genetically predetermined or modifiable through environmental conditions. Gessner (1955) conducted research on the assimilation performance of several aquatic plants and found that populations of *Aponogeton madagascariensis* and *Elodea canadensis* both belong to the category of shade plants, but, nevertheless, react differently from one another. During intensive lighting of 110 klx over a period of several hours, and under a constant temperature, *Elodea canadensis* displayed a constant rate of assimilation. In contrast, a drop in the assimilation performance was noticeable with *Aponogeton madagascariensis* after only an hour into the same experiment.

Most aquarium plants will probably be classified as sun plants if subjected to similar studies, with only very few species, for instance several *Cryptocoryne* and *Anubias* species, ending up in the category of shade plants. However, as long as there is no scientific data available on aquarium plants that enables a clear-cut classification into either sun or shade plants and their reaction formations, these assumptions will remain subjective and hypothetical. Experience in cultivation as well as research at native locations already teach us today that most aquarium plants will prosper better under conditions of intense lighting compared to less light. Damage to plants caused by too much light in the aquarium can thus hardly be expected to occur in the majority of cultivated species. In contrast, the danger of assimilation being downgraded through insufficient light intensity to such an extent that the point of compensation—at which CO₂ absorption (photo-

synthesis) and CO₂ release (respiration) are at the same level—is consistently undercut and far greater, resulting in the plant dying off eventually.

On the other hand, it must not be overlooked that plants, within certain limitations, have the capacity to adapt to different light intensities and light qualities within their natural habitats. Plants living in greater depths, for example, will generally display reduced respiration, compared to their counterparts living on the water surface. Furthermore, higher aquatic plants will react to different light conditions through the formation of differing anatomical and morphological features.

Aquarists are well aware of the behavior of *Salvinia*: if its shoots are cultivated under intensive lighting they will produce strong boot- and bag-shaped leaves, whereas the leaves of the shade form are much smaller and lie flat on the water. Gessner (1955) also reports on the formation of shade and sun forms in several species. For example, the shade form of *Lagarosiphon major* will display more limited branching compared to the sun form, a phenomenon also visible in other higher aquatic plants. *Lobelia dortmanna* reacts to decreasing light intensity with increasingly longer leaf blades. Lack of light suppressed the formation of utricles in *Utricularia intermedia*. Many fast-growing plants react to a lack of light with characteristic changes (etiolation), which, for example, become visible in the form of long internodes and petioles and often as smaller blades.

With the kind support of Mr. Karlheinz Sauer as well as the Osram company, the author had the opportunity to conduct lux readings using the measuring device Optronic, at natural habitats in Madagascar and Ecuador (see Table 1).

The results of light intensity tests show that aquatic and marsh plants, which grow in totally sunny locations above the water or in shallow depths, are subjected in the course of

Table 1: Light intensity readings.

Location	Date	Time	Cloud cover	Lux values
Madagascar				
Berenty	26/12/86	08:30	cloudless	114,000
		09:00	cloudless	121,000
Fort Dauphin	27/12/86	08:00	cloudless	64,000
		14:00	cloudless	114,700
		14:30	cloudy	67,000
		15:00	heavy clouds, sun hardly visible, shortly prior to rainfall	25,200
		16:45	Strong clouds, sun invisible, rainy	4,890
Fort Dauphin (surrounding region)	28/12/86	07:20	clear, very little clouds	51,700
		08:00	slightly cloudy	67,100
		09:40	cloudless	104,100
		10:30	cloudless	116,400
		13:30	cloudless	108,000
			shaded by trees	8,460 up to 25,000
	29/12/86	06:15	cloudless	20,000
		12:00	cloudless	127,800
		12:30	cloudless	128,500
		12:35	cloudy	67,000
		15:00	cloudless	95,200
		18:15	heavy, dark clouds	1,885
		18:40	slightly cloudy, sun visible	330
		18:45	as above	260
		18:50	light clouds, sunset	120
		18:55	as above	30
		19:05	as above	5
	30/12/86	05:30	cloudless	4,890
		07:30	cloudless	56,300
		07:45	cloudless	60,600
		08:45	cloudless	87,400
		11:00	cloudless	122,300
		11:30	cloudless	125,200
		11:50	cloudless	128,600
		12:00	cloudless	139,300
		12:30	slight clouds	127,000
		12:55	cloudless	130,200
		14:00	slight clouds	102,800
		14:05	cloudless	119,900
		14:25	cloudless	105,700

Table 1: Light intensity readings *continued*.

Location	Date	Time	Cloud cover	Lux values
Andasibé	31/12/86	12:00	cloudless	139,300
	10/01/87	09:00	very slight clouds	74,800
		09:05	slightly more clouds	53,400
		09:45	heavy clouds	24,000
		11:30	small, white clouds, sun unobscured	137,500
		11:35	sun behind clouds	80,000
		15:00	uniform, heavy clouds	1,350
Near Beforona altitude 900m	03/01/87	10:00	sun clearly visible, small white clouds	70,000
		10:10	sun clearly visible, almost cloudless	146,000
Ecuador				
Coca	07/02/90	08:35	all readings	58,300
		08:50	very light clouds,	63,700
		09:00	sun always unobscured	68,400
		09:30	by clouds	80,000
		10:00		91,200
		10:35		104,100
		10:50		106,000
		11:00		113,300
		11:35		127,500
		12:00	heavier clouds	77,300
		12:07	slightly cloudy	126,800
		13:30	slightly cloudy	119,200
		14:15	heavy clouds	33,600
		15:30	slightly cloudy	90,500
	08/02/90	07:30	white and black clouds	16,310
		08:10	white and black clouds	19,800
		12:45	cloudless	156,400
		13:00	sun obscured by dark clouds	34,600
		14:00	cloudless	127,700
		14:30	cloudless	108,600
		15:00	cloudless	90,100
		15:30	sun obscured by clouds	19,600
		15:30	under trees, cloudy	8,000 up to 13,000
		16:00	cloudless	62,200
		16:50	small white clouds	32,400
		17:30	small white clouds	13,070
		18:00	small white clouds	2,420
		18:30	sunset	280
		09/02/90	08:00	heavy rain

Table 1: Light intensity readings *continued*.

Location	Date	Time	Cloud cover	Lux values
Quito	10/12/90	06:00	dawn	—
altitude 3000		06:40	sunrise	1,433
m directly on		06:42	cloudless	2,070
the equator		06:45	cloudless	4,000
		06:50	cloudless	5,390
		06:55	cloudless	8,550
		07:00	cloudless	11,520
		07:15	cloudless	18,800
		07:30	cloudless	26,700
		07:45	cloudless	29,800
		08:00	cloudless	41,000
		08:15	cloudless	49,500
		08:30	cloudless	58,000

the day to a very strong—in comparison to aquariums—and highly varying radiation which is dependent on both the degree of clouding and time of day. Average readings will be considerably lower in half-shaded locations but will still lie well above values recorded in aquariums (refer also to data on lighting intensity on p. 49). Highly shaded biotopes, however, will display only a re-

duced lighting intensity of maximal 3000 lx on the water surface, even under cloudless skies, which will be reduced even further with increasing depth. Horst (1986), for example, in a highly shaded streamlet filled with *Cryptocoryne* in southern Thailand, recorded 1500 lx on the water surface during a bright sunny day at around 15:00 h, and further readings of 600 lx in a depth of 20 cm

Many *Eriocaulon* species—one of which is seen here in its habitat in Malawi—are purely aquatic plants, the cultivation of which in aquariums has so far been unsuccessful.



and only 120 lx in 40 cm. In a *Cryptocoryne cordata* biotope (*C. siamensis*-type) readings of 50 lx in complete shade and 40,000 lx in full bright sunlight were recorded in locations only a few hundred meters apart.

THE SUBSTRATE AS A SOURCE OF NUTRIENTS

Only a few of the cultivated aquarium plants constitute genuine aquatic plants in which nutrient absorption occurs both through the root system as well as through the entire surface area. The majority of aquarium plants are marsh plants which, in contrast to genuine aquatic plants, will in most cases develop a strong root system and extract most of their nutrients required for growth from the substrate. In doing so, not all plants behave the same; the absorbed amount of nutrients and its composition are, in fact, specific to the individual species and highly dependent on the substrate. A chemical analysis of the

plant's dry matter, conducted in a laboratory, can show the content and distribution of individual nutritional elements within the plant. The analysis will provide information about the occurrence of plants in specific substrates (indicator plants) and also serve to determine fertilization requirements. If plants are cultivated in the laboratory with nutrient solutions, the composition of which are known, and subsequently analyzed with the aid of the dry matter analysis to determine their content of individual nutrient elements, conclusions can be drawn about the nutrient requirements of plants which, in turn, will enable focused fertilization in cases of deficiency symptoms.

The structure of the soil is essentially determined by the size of the grains. This, in turn, defines the pore volume which plays an important role in the aeration and water circulation within the soil. Coarse-grained soils will let air, water and roots penetrate it more easily than fine-grained soils. Sand, clay, loam (mixture of sand and clay), lime and

Iron precipitation on *Blyxa aubertii* in a biotope in Sri Lanka.



humus soils, among others, can be distinguished. Pure clay soils are rich in nutrients and extremely fine-grained, thus permitting hardly any air or water exchange.

Loam soils (clay and sand parts at 20–50% each) with a high humus portion are the most suitable for plant growth. A large pore volume guarantees good aeration which in turn is also supported by living organisms existing within the soil, for example, dog periwinkles in aquariums.

Laterite-containing soils (red soils) and pure laterite soils are typical for tropical areas. They are identifiable by their red coloring and hardening, to which the term laterite (later [lat.] = brick) refers. They are extremely poor in nutrient content and in most cases rich in iron and/or aluminum. Nevertheless, they usually contain sufficient nutrients for aquatic plants because, due to the rapid mineralization of the dead plant matter as well as the generally low conductivity of the water, the released nutrients can immediately be reabsorbed by the plants.

The acid or alkaline reaction of the soil (pH-value) has a big influence on the water's constitution and the nutrient supply of the plants. Most soils within the tropics have a pH-value within the acid to neutral range; lime soils with alkaline reaction are found only in areas with low precipitation (around 1000 mm). Different plants have varying demands on the pH-value of both soil and water. Most tropical and subtropical aquatic plants grow in acid to neutral soils. There are, however, species, e.g., *Vallisneria* as well as several *Potamogeton* species, which prefer both a calcium-rich base and water with a pH-value within the alkaline range. Typical aquatic living environments with high pH-values are, for example, the great African lakes, Lake Malawi and Lake Tanganyika. Several of the lime-preferring species, however, display a large tolerance range so that their cultivation in the aquarium remains satisfactory even in a weak acid or neutral envi-

ronment. Lime-avoiding species, in contrast, which prosper in very acid conditions in their natural habitats, react in a less adaptive manner. It was impossible, for example, to keep several *Cryptocoryne* species originating from Borneo in an aquarium without an appropriate acid environment.

Even though the substrate is of great importance as a source of nutrients, it has so far been largely neglected as an ecological factor within aquaristics. This is especially evident in the fact that, on the one hand, soil analyses of natural locations have hardly been conducted, resulting in only a very limited knowledge of it. On the other hand, daily aquaristic practice utilizes liquid fertilizers as a useful aid in the event of nutrient deficiency. They are added to the water, whereas special soil fertilizers are almost entirely absent from the retail market. By adding liquid fertilizers, however, an unwanted and difficult to control algae development is aided. The use of soil fertilizer, on the other hand, enables a focused fertilization of only those plants that display inhibited or bad growth.

For this reason the manufacturers of fertilizer products are called upon to supplement their liquid preparations with a soil fertilizer, for instance, in the form of small capsules, which, similar to preparations developed for the fertilization of potted plants, enables a targeted and effective fertilization of individual plants.

WATER

Water constitutes an important ecological factor for the life of aquatic and marsh plants. Water movement, currents, hardness, pH-value and nutrient composition especially influence the growth of plants and are very important.

Aquatic and marsh plants can be found in both stagnant and flowing waterways. The different character of these living environments is defined essentially by water move-

ment as well as the currents to which the plants are subjected. The strength of the current, in turn, influences the soil quality.

The majority of aquarium plants exist in stagnant or weak current biotopes. A smaller number are found in fast-flowing waters, with only very few species being able to adapt to strong and ripping currents.

Water movement is of great importance for several physiological metabolic processes. It enables processes of exchange and accelerates the supply of nutrients as well as the removal of waste products.

Assimilation in different plants (*Ceratophyllum demersum*, *Myriophyllum spicatum*, *Elodea canadensis* and *Potamogeton perfoliatus*, among others) in both stagnant and flowing water was compared in a range of scientific studies (Gessner 1955). A distinctly slower growth could be observed in stagnant water, compared to moving water. This is

due to the fact that in stagnant water a surrounding zone low in carbonic acid will form around the plant due to the plant's respiration and assimilation, leading to a slow-down in growth. The positive effect of water movement is found in its destruction of this zone, thereby aiding diffusion processes. The water movement only has to be strong enough to prevent the formation of such a zone low in carbonic acid around the plant. A further increase in water movement does not necessarily lead to an increase in the assimilation performance, but quite to the contrary, can again lead to an impediment to growth. Research on the strength of water movement and current conditions in the natural habitats of our aquarium plants is, therefore, extremely important and has to be considered and assessed individually for each separate species.

Although many aquatic plants exist in stag-

Living environment of *Jasarum steyermarkii* in the Gran Sabana in Venezuela. This rare aquatic plant is not being cultured in the aquarium.



nant waters within their native environment, there is nevertheless a slight water movement present, caused mainly by wind, which should not be underestimated in its effect. Switching off the filter in an aquarium, as is occasionally recommended, does in no way correspond to natural conditions but will instead lead to an impediment to the assimilation process due to the stagnating water and thus result in a worse growth performance of the plants.

In contrast to biotopes with stagnant water, the presence of aquatic plants in moving waterways is predominantly influenced by the speed of the current. The latter itself is subject to large variations, even within one and the same river section. For example, the current flow above the riverbed is considerably lower than within free-flowing water or on the water surface. Aquatic plants which prefer currents are often adapted to the ripping water movement to such a degree that they cannot exist without them anymore.

Some aquatic plants, for example, species from the Podostemaceae and Hydrostachyaceae families, which exist exclusively in rapids and waterfalls, have adapted in such an extreme way to the fast-flowing and ripping water of their environments that their cultivation in an aquarium is entirely impossible for this very reason alone. These plants display a variety of adaptations to such strong currents and the rocky soil riverbeds which even enable them to display generative reproduction within these rapids.

The native habitats of our aquarium plants are furthermore characterized by a specific water condition which, within certain limits, is subject to daily and annual variations. Most tropical and subtropical waters which accommodate aquatic plants display very salt-deficient, soft water with a pH-value within a weak acid to neutral range (around pH 6.0–7.0) due to their mineral-deficient substrate. Occasionally pH-value readings between 5.5 and 6.0 can be recorded. In such waters, though, the species count is already somewhat reduced. Only few aquatic plants are

specially adapted to live in such an acid environment, an example of which is the black water of the Rio Negro in Brazil.

Waterways that contain medium to hard water with a more or less high alkaline pH-value are relatively rare in tropical and subtropical regions. Examples for such habitats are Lake Tanganyika and Lake Malawi in Africa, as well as several rivers and lakes in Mexico. In these environments, characterized by unusual water pH-values, the number of aquatic plant species is also noticeably more limited. This finding is based not only on water analyses in natural biotopes conducted by the author, but also corresponds to tests done by other authors. The results, however, are in distinct contrast to the many studies completed on native, genuine submersed aquatic plants (see Gessner 1959), the presence of which is almost exclusively limited to alkaline waters.

Essential for optimum plant growth in their natural habitats is a complete and constant nutrient supply within the water. Head springs often transport nutrient-rich water into the streams and thereby visibly promote plant growth.

The water analyses listed in Table 3 convey an idea of the chemical characteristics as well as the nutrient conditions in several tropical waterways, which are characterized by plant populations with varied species and individual plants. The studies done by Horst (1986) are recommended for additional reference.

BLACK WATER, CLEAR WATER, WHITE WATER

Numerous scientific studies conducted in the 1950s, mainly in the Amazon river system (Sioli 1950, Braun 1952, Gessner 1959, Sioli and Klinge 1961, among others), led to a rough classification into three types of water, based on physical (coloring and clouding) and chemical differences between a number of rivers. Based on their typical features black, clear and white water can be distin-

guished, with many intermediate forms existing, of course, resulting in not every waterway being able to be categorized within this model.

Typical white water rivers display loamy-yellow, turbid water and, in contrast to clear and black water rivers, contain a large amount of inorganic floating matter which deposits on the riverbanks and forms an especially fertile soil. Examples of white water rivers are the Rio Solimões, in the upper Amazon, as well as rivers mentioned on pp. 36 and 42, namely the Yanayacu in Peru and the Sepik in Papua New Guinea.

Clear water rivers, on the other hand, are poor in sediments and contain very clear, yellow green to dark olive green water with high visibility. White sandy beaches often form on the riverbanks. One such river described in detail is the Rio Guaporé in Brazil's southwest (see p. 29).

The third group is made up of black water

rivers which are characterized by clear, transparent but dark brown-colored water. The typical deep brown color is a result of the regular flooding of the surrounding forests which leads to the inflow of humic matter. As a result black water is exceptionally acid and very poor in dissolved minerals. Due to its interesting fish fauna the Rio Negro (Brazil) is the most widely known black water river in aquaristics.

The main reasons for the formation of different types of waterways are the composition of the riverbed as well as climatic and geographic conditions.

Because of the large differences between these three categories of waterways with regard to their physical, chemical and biological constitution, the character of the water flora differs accordingly in the respective types.

Genuine black water rivers provide extremely inhospitable living conditions for

Utricularia foliosa and *Azolla caroliniana* exist in the black water of the Rio Nanay (Peru).

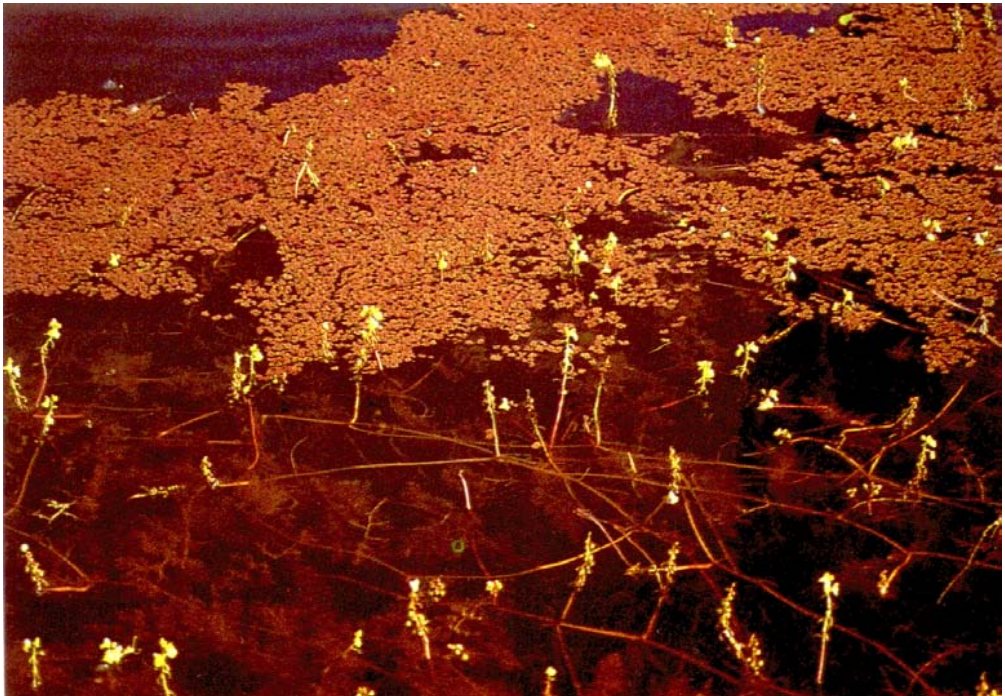


Table 2: Water values of selected black water, clear water, and white water biotopes.

		Biotope		
		Black water Rio Negro (Brazil)	Black water Rio Copal (Peru)	Clear water Rio Tapajoz (Brazil)
Date		—	June 1983	—
Water temperature	in °C	26–29.5	27.5	—
pH-value		3.7–4.3	6.0	4.6–6.65
Conductivity (at 20 °C)	in $\mu\text{S}/\text{cm}$	6–9	17	10–16
Carbonate hardness (KH)	in °dH	<0.1	0	0.15–0.4
Total hardness (GH)	in °dH	<0.1	0.12	0.13–0.82
Calcium hardness	in °dH	0.26	0.07	0.21
Magnesium hardness	in °dH	traces	0.05	0.03
Carbon dioxide (CO_2)	in mg/L	high	~1	0.71–3.5
Oxygen (O_2)	in %	—	—	86–117 (27 °C)
Sodium (Na)	in mg/L	0.75	1.9	1.26
Potassium (K)	in mg/L	0.35	1.1	0.50
Iron ($\text{Fe}^{2+/3+}$)	in mg/L	<0.24	—	0–0.3
Ammonium (NH_4^+)	in mg/L	—	—	0.07–0.18
Chloride (Cl^-)	in mg/L	1.20	<7	0.05–1.60
Sulfate (SO_4^{2-})	in mg/L	4.81	n.d.	0–2
Nitrate (NO_3^-)	in mg/L	—	1.6	0–0.08
Nitrite (NO_2^-)	in mg/L	—	<0.1	—
Phosphate (PO_4^{3-})	in mg/L	<0.157	—	0
Zinc (Zn)	in $\mu\text{g}/\text{L}$	—	5	—
Cadmium (Cd)	in $\mu\text{g}/\text{L}$	—	n.d.	—
Lead (Pb)	in $\mu\text{g}/\text{L}$	—	n.d.	—
Copper (Cu)	in $\mu\text{g}/\text{L}$	—	7	—
Humic acids		high	high	traces

n.d. = not detectable

plant growth. Apart from their strong coloration, they are defined by the very acid water of many Amazonian rivers with pH-values of 3.7 to 4.3 as well as the low content of hydrogen carbonates, leading to the plants' exclusive dependency on free carbon dioxide for their nutrition. These characteristics constitute important limiting factors and prevent growth of most aquatic plants within black water. Only a select few and highly specialized species have managed to adapt to this unusual living environment and are, in turn, unable to adapt to a change to different conditions.

Black water rivers are not only found in the Amazon region and in Guyana, but also in many other countries. The limited range of pH-values for this type of waterway as laid down by earlier authors in conjunction with studies in the Amazon river system, has to be expanded up to a pH range of about 5, based on further studies conducted in other black water rivers. Nevertheless it is a common feature of all black water rivers that they are always extremely poor as to plant populations. Typical aquatic plants in the black water of the Rio Negro are, for example, *Cabomba aquatica*, *Utricularia foliosa*, *Azolla*

Table 2: Water values of selected black water, clear water, and white water biotopes *continued*.

		Biotope		
		Clear water Rio Chinipo (Peru)	White water Amazon, Rio Solimões (Brazil)	White water Rio Ucayali (Peru)
Date		June 1983	—	June 1983
Water temperature	in °C	26	27–28	25
pH-value		7.2	6.5–7.5	7.1
Conductivity (at 20 °C)	in $\mu\text{S}/\text{cm}$	142	10–127	154
Carbonate hardness (KH)	in °dH	4.7	0.6–1.8	3.9
Total hardness (GH)	in °dH	4.9	0.64–1.27	2.9
Calcium hardness	in °dH	3.6	1.08–1.2	2.9
Magnesium hardness	in °dH	1.3	0.03–0.14	0
Carbon dioxide (CO ₂)	in mg/L	10	3.95	10
Oxygen (O ₂)	in %	—	<91	—
Sodium (Na)	in mg/L	3.9	2.60–3.35	9.0
Potassium (K)	in mg/L	0.5	0.90–1.10	1.8
Iron (Fe ^{2+/3+})	in mg/L	—	0.22	—
Ammonium (NH ₄ ⁺)	in mg/L	—	traces	—
Chloride (Cl ⁻)	in mg/L	<5	0–3.40	<5
Sulfate (SO ₄ ²⁻)	in mg/L	n.d.	0–4.94	n.d.
Nitrate (NO ₃ ⁻)	in mg/L	0.8	0.16–0.28	0.8
Nitrite (NO ₂ ⁻)	in mg/L	—	—	—
Phosphate (PO ₄ ³⁻)	in mg/L	<0.7	<0.145	0.7
Zinc (Zn)	in $\mu\text{g}/\text{L}$	11	—	7
Cadmium (Cd)	in $\mu\text{g}/\text{L}$	n.d.	—	n.d.
Lead (Pb)	in $\mu\text{g}/\text{L}$	n.d.	—	n.d.
Copper (Cu)	in $\mu\text{g}/\text{L}$	27	—	13
Humic acids		traces	0	0

n.d. = not detectable

caroliniana and several species of the Podostemaceae family. In the black water biotopes of Guyana, with pH-values between 3.9 and 4.2, one occasionally finds *Mayaca fluviatilis* and *Tonina fluviatilis*. But the living environments of several *Cryptocoryne* species in Asia, too, constitute typical black waters. An example, described in detail, is the channel system of Tasek Bera on the Malaysian Peninsula with *Cryptocoryne purpurea* (p. 212).

Clear water rivers, too, display an acid environment, pH-values between 4.6 and 6.6 as well as the transparency of the water pro-

viding a more advantageous light climate, thereby enabling many plants to adapt to such conditions. Clear water rivers are also characterized by an extreme deficiency in minerals and are accordingly poor in nutrients. But, as the water analysis of the Rio Guaporé, for example, shows, there nevertheless exists a comprehensive and consistent nutrient supply which enables multifaceted plant growth in these waters. Possibly the most limiting factor for aquatic plant populations is the considerably changing water level as it fluctuates with the seasons.



The clear water of the Rio Guaporé (Brazil) provides an optimum living environment for many plants.

Typical white water rivers are also very soft waters which, in contrast to black water, display a distinctly higher content of dissolved minerals which is reflected accordingly in higher conductivity. Also, white water has a pH-value within the weak acid to slightly alkaline range between 6.6 and 7.2. The richness in nutrients in this type of water essentially permits the survival of many species. Strong turbidity, reduced light penetration as well as varying seasonal water levels are, however, important growth limiting factors. Submersed plants are mostly absent from white waters and the vegetation is limited to the growth of floating plants, for example, *Azolla* and *Ceratopteris* species, *Eichhornia crassipes*, *Phyllanthus fluitans*, *Pistia stratiotes* and others.

The different water analyses of several Brazilian and Paraguayan rivers listed in Table 2 illustrate the differences between black water, clear water and white water as outlined above

(Brazilian rivers according to Gessner 1959, Sioli and Klinge 1961 as well as data from the author, with the water samples of the Peruvian rivers having been collected by W. Staechk).

Seasonal Influences, Vegetation Rhythm, and Types of Waterways

Tropical and subtropical aquatic and marsh plants have conquered very different living environments in the course of evolution. Their natural biotopes are boggy flood areas, puddles, ponds, lakes, more or less fast-flowing streams and rivers as well as man-made living environments, such as rice paddies, pools and storage lakes. These ecosystems are subjected to the seasonality typical for the tropics, namely rain-intensive and rain-deficient seasons and associated variations in water levels,



Growth of floating plants in the white water of the Rio Yanayacu (Peru).

as well as seasonally changing light and climate conditions.

Waterways can be classified as constantly water-carrying (permanent) and periodically dry (temporary) biotopes. These in turn can have either stagnant or flowing water. Within these types of waters there are intermediate stages if the amount of rainfall or the length of the dry period changes decisively due to climatic change. A generally periodically drying waterway can thus carry water during the dry season due to extreme climatic conditions. Alternatively, a usually permanent biotope can dry out during prolonged periods of drought. Generally, though, biotopes can quite clearly be categorized into the above types of waterways. Even though plants are adaptable within limitations and are able to react in a flexible manner to changes in their environment, irreparable damage to these living communities, which have evolved over millennia, will occur in the event of major

climatic change, and many species will be unable to survive in their present locations.

Populating a specific waterway is possible by only those plants which are able to adapt to the prevailing ecological realities. Temporary waters, for example, were permanently populated by only those species which had the capacity to survive dry periods with the aid of bulbs, tubers or drought-resistant seeds. The occurrence of individual plants in temporary waters is thus determined by the duration of the dry period which is, in turn, defined by the geological and climatic conditions of the regions. The length of the dry period is, therefore, partly responsible for the distribution of different species. Simultaneously, conclusions on life cycles can be drawn from the occurrence of plants in certain areas. The presence of certain species in temporary waters, however, does not exclude the possibility that they may also be found in permanent waters.

The giant pond lily (*Victoria amazonica*) inhabits the tranquil bays of the Amazon.





Temporary biotope on Mafia Island (Tanzania) with dense plant growth during the wet season. The same biotope during the dry season, completely dried out.



In contrast to plants in temporary biotopes, species in permanent waters (mostly rivers, lakes or very large swamp areas) lead a different existence. The difference between high and low water, which is dependent on the seasonal alternation of dry and wet periods, is essentially responsible for the populating of such waterways. Only a few aquatic and marsh plants are able to adapt to an increased water level of more than 1.5 m during the wet season and the corresponding reduction in light, and to survive for several months in a greater depth. Furthermore, there is the strong current often prevalent in permanent waters in which only a few aquatic plants (for example, Podostemaceen) can survive. For this very reason this ecological niche was conquered by only a few species.

Permanent waters usually display plant growth in only the shallow bank area or on the water surface. It is mostly absent in greater depth. Accordingly, only very few aquatic or marsh plants anchored to the soil bed are found in rivers with great variations in water levels measuring several meters, but only species which float on or below the water surface and which prefer calm enclaves. An exception is *Victoria amazonica* which can take root even in turbid white water of calm tributaries of the Amazon, in 8–10 m of depth.

Climate Rhythms

Light and temperature variations which, on the one hand, occur during the course of the day and, on the other hand, are dependent on the periodic seasonal change, have an essential influence on the conditions under which tropical and subtropical aquatic and marsh plants prosper. In the tropics the length of both day and night vary only a little in the course of a year, so that there generally occurs a daytime warming-up phase as well as a cooling-down period during the night, lasting 12 hours each. The consistently moist equa-

torial zone is characterized by high precipitation, more or less evenly distributed over the year, as well as balanced temperatures, average annual temperature readings ranging between 25 and 27 °C, with those recorded during the coldest month not falling below 18 °C on average. Therefore—in contrast to subtropical or temperate zones—there are no distinct seasons, the plants' growth instead being essentially influenced by the daily temperature variations between day and night (daytime climate).

With increasing latitude, the ratio between length of day and length of night over a year will shift increasingly. Accordingly, depending on these seasonal variations, the temperature, too, changes, so that one finds clearly defined seasons in subtropical regions to which the vegetation has adapted. The cold season, with its short days, generally constitutes the time of year with the least light availability.

Not only the length of day and night, but also the difference between day and night temperatures, influences growth processes (see vegetation rhythms), flowering behavior and germination. For example, it is known from the cultivation of some *Echinodorus* species that they display genetically determined photoperiodical behavior and form inflorescences only at a specific length of day, thereby clearly indicating an adaptation to the geographical distribution (see also introduction to the genus *Echinodorus* on p. 229).

Plants from subtropical regions are especially in a position to endure extreme temperature variations. For example, in subtropical areas of the Southern Hemisphere (South Brazil to North Argentina), areas populated by numerous aquarium plants, night temperatures can occasionally drop to the frost levels during winter. On the other hand, air temperatures can reach values above 35 °C during the day. These extreme temperature differences in native locations, however, do not in any way always have a positive impact on plant

growth. Studies of terrestrial plants (Larcher 1984) have shown that for species from temperate zones, differences between day and night temperatures of 5–10 °C, in the case of tropical plants of about 3 °C, have an optimum effect on growth. These research results can certainly allow limited conclusions on the growth behavior of tropical and subtropical aquatic and marsh plants. The author is not familiar, however, with any comparative studies of individual species. A consistent difference in temperature between day and night corresponds to a natural rhythm. It is necessary to differentiate, though, between those species which populate small and stagnant waters, and which are consequently subjected to larger daily fluctuations in temperature in accordance with their geographic distribution, and those species which are found in expansive, stagnant or flowing waters. Within the latter, daily temperature variations in the tropics are only small; temperatures in waters outside the equatorial zone, however, can be subject to considerable variations over the seasons.

Some aquarium plants which are subject to the periodic change of wet and dry seasons in their natural habitats are identified in scientific literature as being annual. In contrast to perennial species, the life-span of these annual plants is limited. In most cases, though, this short life-span is imposed upon the plants categorized as annual by their disadvantageous environmental conditions (summer and winter, wet and dry seasons) within their natural locations. As is often found during cultivation, this annual characteristic is rarely genetically predetermined.

Of the numerous aquarium plants, only very few are really annual or rather have a short life-span: among these are *Hydrothrix gardneri*, *Blyxa aubertii*, races of *Echinodorus major* which die off after the flowering stage in emersed cultivation, as well as the individually less known and less kept *Eriocaulon* species. Several other aquarium

plants, however, *Barclaya longifolia* and *Aponogeton* species among others, display a regular change between rest and vegetation periods.

Adaptation Characteristics of Aquatic and Marsh Plants

Typical for many tropical and subtropical marsh plants living in temporary waters or in flood areas of stagnant or flowing waters, are their symptoms of adaptation to the periodic change of rain-intensive and rain-deficient seasons. During the dry season, the plants grow more or less on the edges of waterways, either completely emersed or in only a few centimeters of water. In case of the waterway drying up, this can also lead to the plant completely dying off after some time. During high-water levels, plants lead a partial or entire existence under water. Plants found in such locations are obviously in a position to adapt to an emersed and submersed existence over the course of annual seasons. They display a changing life cycle and have to have blossomed and borne fruit within a certain period of time, i.e., from the start of the rainy season up to their possible withering stage at the end of the dry period, in order to ensure their reproduction.

At the onset of the wet season many aquatic and marsh plants will initially form typical juvenile forms. From the vegetation organs which have remained in the soil from the dry period (rhizome, tuber, bulb), some mostly delicate juvenile leaves will emerge which are often narrow, strap-shaped, soft and pellucid. In the course of plants developing from seeds, these typical juvenile leaves will also form, following the formation of one or two cotyledons. Only with increasing age and progressing plant growth will those submersed and floating leaves develop which are

typical for every individual species. These leaves, through their anatomical structure which is characterized by more or less absent stomata, thin outer epidermis as well as wide air ducts, display a special adaptive quality to water as a medium. The aquatic leaves are thus able to absorb oxygen, carbon dioxide and nutrients directly from the water. The leaves will shrivel rapidly and wither in dry air due to the lack of support tissue and transpiration protection. If the water level begins to slowly drop again, amphibious growing plants will change over to their emersed stage, i.e., they will cease to form submersed leaves but will increasingly form air leaves above the water surface and will then proceed to mature to their full size. These leaves growing above the water surface will assume a totally different appearance in many species compared to their submersed state (heterophylly = having different leaves). Whereas the underwater leaves are often delicate, thin,

transparent and ribbon-like or dissected in order to achieve a larger surface, entire, hard, leathery and often hairy leaf blades are typical features of air leaves. The formation of differently structured leaves in different mediums can be observed especially well in *Hygrophila difformis*, as well as *Limnophila* and *Myriophyllum* species. During sinking water levels during dry periods, flower and seed formation will commence. If the locations are beginning to dry out, the plants will develop an increasingly squat appearance until the foliage will often entirely dry up in line with the reduced moisture within the soil. Whereas in some species only the survival organ will survive in the dry soil, other species will die off entirely, and only their seeds will remain in a state of suspense until the onset of the next wet season, when advantageous environmental conditions will initiate germination. Once they reach the water surface, many genuine aquatic plants will form floating leaves

Hygrophila corymbosa with submersed and emersed shoots in a river on Sulawesi.



which lie flat on the surface and which also display typical features of adaptation in their anatomical structure. They are especially rich in intercellulars which aid photosynthesis. At the same time, the floating leaves of some plants, for example, water lilies, display countless hydropotes ("water drinkers," gland-like cells of the epidermis) on the leaf's underside which assist in the absorption of water and mineral nutrients. Such hydropotes can also be found on the leaves of many aquatic plants.

Using their roots and rhizomes, some aquatic plants, such as *Nymphaea* and *Nuphar* species, are in a position to grow in badly aerated and oxygen-deficient soils. As a form of morphological adaptation to this environment, they have formed a system of cavities through which oxygen from the floating leaves can be transported to those plant segments existing within the soil. These cavities are so large that it is possible to actually blow air through the petiole of a water lily.

In especially thick soils, roots growing above the surface, bulbous roots on shoots, and, as an extreme adaptation to this environment, pneumatophores can be found occasionally on plants in tropical waters. The presence of such pneumatophores in several *Ludwigia* species is well-known. Pneumatophores generally develop in a very oxygen-deficient environment and can be distinguished from normal roots by their white, spongy and bloated tissue, incorporating large intercellular cavities (aerenchyma) which serve aeration and air storage purposes. These pneumatophores grow vertically into the air, probably absorb oxygen from the atmosphere and transport it to the submersed shoots via the aerating tissue.

Floating plants, too, display adaptive morphological and anatomical features. In the *Salvinia* species, for example, the two floating leaves are equipped with numerous intercellular spaces, whereas the submersed leaf hanging in the water is divided into many

Flowering *Nymphaea lotus* in temporary waters in Senegal.



filiform pubescent lobes and has adopted the functions of the absent roots. The bloated, spongy petioles, which display a comprehensive aerating tissue and thus enable the plants to float on the surface, are conspicuous in *Ceratopteris pteridoides*, *Eichhornia crassipes* and *Trapa natans*. The underside of the leaf in *Limnobium* is conspicuously bloated and thickened, which also enhances the floatability of the plant.

Specifically worth mentioning is the often distinct moisture protection found in floating plants. This protection serves to keep the transpiring upper leaf sections above the water surface dry from rain or dew. The fact that it is impossible to moisten the leaf of *Nelumbo nucifera*, which is covered with papilla, is well-known. But in the *Salvinia* species, too, the floating leaves are effectively protected from moisture by papilla arranged in rows and on which hairs are located. At the

same time, the boat-shaped floating leaves enable a quick run-off of rainwater. Moisture protection in other species (e.g., *Pistia stratiotes*) is achieved through a strong pubescence. The bulging in floating leaves in some aquatic plants (e.g., *Phyllanthus fluitans*) is also notable. It also has the purpose of ensuring a rapid flow-off of rainwater from the surface.

The occurrence of strap-shaped and especially smooth, undulate or bullate leaves, for example, in some *Aponogeton*, *Cryptocoryne* and *Vallisneria* species, is a conspicuous feature in some aquatic plants. Such leaf shapes and structures can be explained both as measures of adaptation as well as protection, since the leaves, due to their shape or surface structure, offer the least possible resistance to any water current. Narrow or ribbon-like leaves are especially formed by those species that exist in flowing waterways. They are also

***Ceratopteris pteridoides* forms spongy, thickened petioles which increase the plant's floatability (photographed on the Rio Yanayacu, Peru).**



typical of rheophytes, plants that are found between high and low water zones and are often subjected to short-time flooding. Their leaves are firm, leathery or coarse, and have at least a length to width ratio of 4:1.

Other features of adaptation to the surrounding environment can be observed in several other aquatic plants originating from Lake Malawi and Lake Tanganyika. These two East African lakes are well-known to aquarists because of their rich content of fish fauna. In the transitional zone between gravel and sand, and within the reed zone, there exist some aquatic plants which have created living conditions for themselves with the help of special adaptive features geared to the special living environment within these waters. *Valisneria spiralis* var. *denseserrulata*, for example, features conspicuously short and very hard leaves through which the plants can better resist any wave movement. *Ceratophyllum demersum* and *Myriophyllum spicatum*, too, display a variation in appearance totally different from other habitats by having short internodes as well as hard leaf and stem structures, which can also be interpreted as a protective and adaptive measure against wave movement. Furthermore, the shoots in *C. demersum* are of such compact growth that they do not move freely in the water as is common in other populations, but, due to their greater density, will drop to the bottom where they are subjected to a lesser wave movement compared to that found on the water surface.

The giant water lily, *Victoria amazonica*, too, has developed an optimum adaptive and protective characteristic to the natural living environment. The plant produces imposing floating leaves up to 2.5 m in diameter, on the surface of which the necessary stoma, which are important for respiration and assimilation, can be found. These floating leaves feature a strongly ribbed leaf venation as well as an up to 10-cm high curved margin, thereby setting a strong resistance against the water's wave movement and preventing the leaf's destruction.

Other features of adaptation to life in the water are the animal traps in *Aldrovanda vesiculosa* and the utricles in *Utricularia* species with which the plants catch, digest and exploit smaller animals as an additional source of nitrogen. The formation of hibernacles (winter buds, turions) in numerous aquatic plants is to be seen as an adaptation to disadvantageous periods of vegetation. Many endemic aquatic plants develop such hibernaculums which drop to the bottom during autumn where they survive the cold season. During the following spring they will again rise to the surface and develop new shoots.

Interesting in this context is the behavior of some Lemnaceae. During late summer they develop modified small limbs with greatly retarded intercellulars and increased firmness which leads to an increase in their specific weight. The plants consequently lose their ability to float and drop to the bottom. In spring the limbs will recommence growth and again rise to the surface.

Apart from the typical features of adaptation of life within water mentioned here, the numerous pollination mechanisms of aquatic plants have to be mentioned (see also "Flower Biology") but will not be dealt with at this stage.

Description of Selected Natural Habitats

THE RIO GUAPORÉ (BRAZIL)

Biotope No. 1

The Rio Guaporé has its source in the Brazilian state of Mato Grosso, near the border with Bolivia. Its riverbanks are the only place where primary forests are still found. The starting point for the excursion in August 1987 was the little town of Vila Bela on the upper course of the Guaporé (about 60°W, 15°S), where the river features a wide range

of species and dense plant populations in its flood areas and tributaries.

Ecological Data of the Upper Rio Guaporé

In its upper course the Rio Guaporé is a clear water river. In this area the wet season extends from mid September to the end of April. The high-water period accordingly falls into our European 6-month-long winter; the low-water period coincides with our summer. The highest temperatures are reached during the wet season. For the city of San Luiz de Cáceres, 250 km away, the average daily maximum in the warmest month (March) measures 32.8 °C, and the average daily minimum during the coldest month (July) measures only 14.6 °C (absolute minimum 3.8 °C). The data helps to explain the surprisingly low water temperature of the Rio Guaporé of 20 °C recorded in August. It can be concluded from the water analysis (Table 3, Biotope No. 1) that the Guaporé is a very soft, nutrient-deficient (oligotrophic) waterway in which aquatic plants are nevertheless able to find a sufficient nutrient supply to sustain growth.

At many locations on the riverbed, the soil base is washed out and consists of fine white sand. Emerged plants of the riverbank and flood areas, however, grow mainly on muddy loamy soil. Dense plant populations are found mainly on open and shallow parts of the riverbank where intense solar radiation is also possible.

During low tides, the water level of the Rio Guaporé drops during the dry period by a maximum of 1.5 m. Plant species located on the banks of the waterway, for example, the large-growing *Echinodorus* species *E. paniculatus* and *E. grandiflorus* subsp. *grandiflorus*, are found emerged only a few centimeters underwater. During high water, these species will temporarily grow in a depth of 1–1.5 m and are partially able to adapt to the raised water level and the associated reduc-

tion in light by developing longer petioles. It is assumed that plants growing several meters away from the riverbank, for example, the smaller *Echinodorus* species *E. tenellus*, *E. bolivianus* and *E. grisebachii*, are found in relatively shallow water during high water periods where they develop submersed leaves. These light-requiring and small-remaining sword plants grow in those locations in nature where they will still continue to receive sufficient light to support adequate growth even during high-water periods, i.e., in an area which is only just reached by the river during maximum high tides. These small to medium-sized species thus occupy a different ecological niche compared, for example, to the larger *Echinodorus* species.

Plant Societies and Species Diversity

The diversity of aquatic and marsh plants in the vicinity of this river is exceptionally high. Alongside 5 *Echinodorus* species, 3 of which belong to the smaller to medium-sized species and 2 to the larger species, 15 other species from other genera were located: 11 in the river and 4 in the nearby flood areas.

Under closer scrutiny, the river displays a number of different living environments in which certain species tend to be found more often, e.g., species which have adapted to the prevailing ecological conditions to a specific degree. In the following, these living environments will be portrayed in order to convey an insight into the ecology and sociology of several aquatic and marsh plants which are of interest to aquaristics. The sedge belt, often several meters wide, found at many places in the Rio Guaporé and its flood areas, is not included.

The zone accommodating the amphibious growing species constitutes an important living environment. On the Guaporé, the five *Echinodorus* species already mentioned are among these, as well as *Limnophila indica*

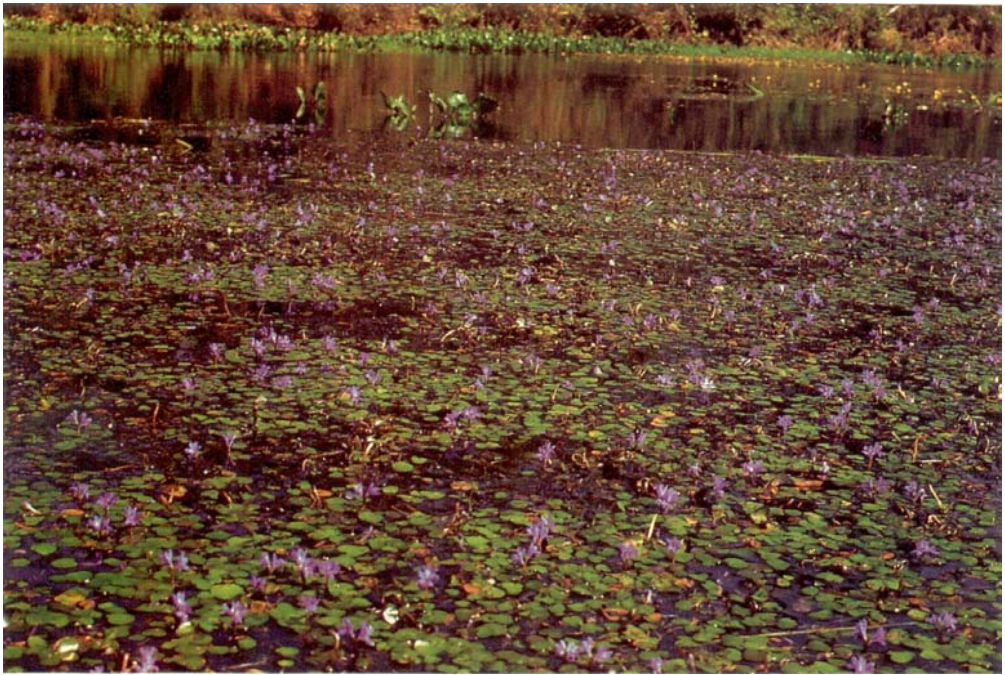
(introduced) which, on the one hand, can be found in up to 50 cm of depth during low water, and at the same time produces emerged flowering populations.

Adjacent to this zone is a plant community made up of submersed plants which flower above the water surface. Among these are *Cabomba furcata* which is often found in association with *Limnophila indica*. *Cabomba furcata* grows in the placid sunny border areas of the river in depths of more than 50 cm. Larger populations are found mainly in subsidiary branches and quiet coves with slow-moving water. A species which is found quite often in the Guaporé is *Ottelia brasiliensis*, which also only grows submersed and only sends its flowers to the water surface. During low water it can be located in both very shallow water, for example on sunny

sand banks, as well as in depths of almost 2 m. It can be assumed that these plants will stand in more than 3 m of water during high-water periods. According to the author's observations, *Ottelia brasiliensis* occupies a similar ecological niche to *Limnophila indica* and *Cabomba furcata*; *Ottelia brasiliensis* seems to prefer locations with strong currents and far deeper water, whereas *Limnophila* and *Cabomba* are more likely to be found in more placid zones of shallow water. This does not preclude all three species occasionally occurring next to each other at the same location under appropriate conditions. Common to all these species obviously is their preference to populate spots that are fully sunlit. The overall picture of the river landscape on the Guaporé is essentially defined by a belt of *Eichhornia*, consisting of

Eichhornia azurea, *Echinodorus paniculatus* and *Echinodorus grandiflorus* grow on this riverbank on the Rio Guaporé (Brazil).





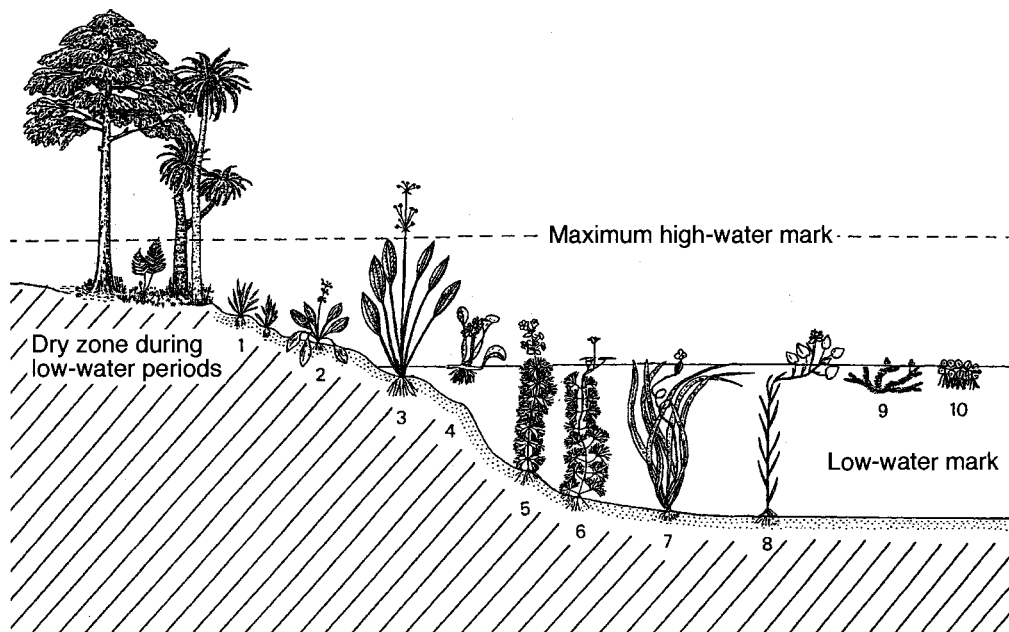
Impressive dense populations of *Eichhornia diversifolia* in a floating plant zone on the Rio Guaporé.

Diagram 1 Schematic representation of the distribution of plant populations in different living environments in the Rio Guaporé at low-water levels (excluding the marsh zone). The following species were selected to represent the different living environments and their respective plant populations: *Echinodorus tenellus* (1), *E. grisebachii* (2) and *E. paniculatus* (3) are typical of the river-bank zone; *Eichhornia azurea* (4) is common in the *Eichhornia* belt; *Limnophila indica* (5) represents amphibious species; *Cabomba furcata* (6) and *Ottelia brasiliensis* (7) represent those submersed plants flowering on the water surface; *Eichhornia diversifolia* (8) typifies the floating plant belt; *Egeria najas* (9) is characteristic of those submersed plants floating freely in the water; and *Salvinia auriculata* (10) is an example of those species inhabiting the floating plant zone.

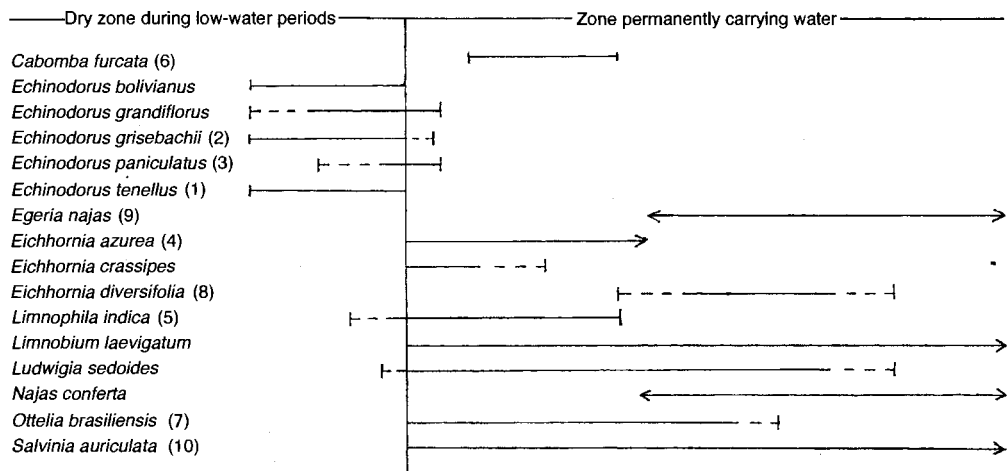
Diagram 2 Simplified graphic representation of the living environments of aquatic and marsh plants in the Rio Guaporé at low-water levels (excluding species inhabiting the marsh zone). In reference to Diagram 1 the continuous lines represent the most important area or zone of presence of the respective species, which is dependent on the river's water levels and the degree of moisture in the substrate, thereby limiting it accordingly.

The arrows indicate presence also in adjoining living environments. The broken lines point to a rare, limited occurrence in the respective environment. The vertical dividing line marks the border between the dry zone during low-water levels and the permanent water zone.

1



2



Eichhornia azurea and *Eichhornia crassipes* and which stretches along the embankment zones of the waterway. The prevailing ecological conditions, however, don't seem to be optimal for *E. crassipes* since the plants were unusually frail for tropical conditions and found to exist only in small groups. The *Eichhornia azurea* specimens, in contrast, displayed a surprisingly strong habit. The meter-long, tangled shoots were anchored to the bank and stretched from there into the river. In areas with a strong current, the populations are smaller compared to the waterways' quieter fringe zones. The belt of *Eichhornia* often borders on the belt of floating leaf plants or the area of floating plants.

The belt of floating leaf plants in the Guaporé can be found primarily in the numerous shallow and quiet fringe waters as well as in the current-deficient coves on the banks. Next to the real-floating leaf plants it can, however, also be interspersed with genuine aquatic plants, for example, *Egeria najas* and *Najas conferta*. In the Guaporé's belt of floating leaf plants *Eichhornia diversifolia* and *Ludwigia sedoides* species can be found, species which shaped this habitat during the Brazilian winter with their floating leaf shoots carrying numerous flowers. In contrast to *Eichhornia diversifolia*, *Ludwigia sedoides* populates the free-water zone as well as those areas of the riverbank having no currents. It is also able to produce emerged leaves.

The free-water zone with submersed, free-floating plants in the water is made up mainly of *Egeria najas* and *Najas conferta*. Whereas the strong current areas in the center of the Guaporé are free of any plant growth, one can often find mass groups of both these species in tranquil subsidiary arms or current-deficient bays which have the characteristics of stagnant waterways. The tender shoots of *Egeria najas* and *Najas conferta* float in dense groups underwater in locations fully exposed to the sun.

Besides the *Eichhornia* populations on the

riverbanks, the author found only two floating plant species in the actual riverbed of the Guaporé: *Limnobium laevigatum* and *Salvinia auriculata*. Both floating plants are rare in the Guaporé and will occur only occasionally, so the ecological conditions for both species are obviously not optimal.

Plants of the Marsh Zone

Even though marsh areas are directly exchanging water with the Guaporé for at least some of the time, they nevertheless form a separate individual living environment since they contain stagnant water, in contrast to the river's flowing water. Whereas, for example, *Echinodorus paniculatus* and *Ludwigia sedoides* are also found in the marsh zone, species that prefer currents are completely absent from it. Instead, several other aquatic plants can be found there which obviously seem to prefer stagnant water and therefore avoid the riverbed. Among these are *Hydrocleys nymphoides* as well as *Utricularia breviscapa* and *U. hydrocarpa*. The mentioned species exist in association in marshy locations in the most confined areas possible. The soil in these habitats is boggy and shaded by surrounding trees.

FLOODING AREA OF THE RIO SIPAO (VENEZUELA)

Biotope No. 2

The Rio Sipao is a north-flowing confluent of the middle Orinoco in Venezuela. Studies were conducted in a large flooded area of this river, located a few kilometers away from the town of Maripa in the direction of Caicara. The waterway was fast-flowing, loamy, and clouded in its middle sections. In many places, however, little calm bays have formed in which dense populations of *Eichhornia diversifolia*, *Bacopa* sp. and *Tonina fluviatilis* could be found growing in knee-deep water. The populated locations were usually in the

sun and were hardly shaded by any trees. The soil was sandy but mostly covered by a thick level of dead plant matter.

The fish fauna consisted of cichlids (*Apistogramma*, *Aequidens*, *Papiliochromis*) and salmon (*Aphyocharax*, *Pyrhulina*).

MARSH AREAS IN THE RIO ARO (VENEZUELA) RIVER SYSTEM

Biotope No. 3

This biotope is located in Venezuela, about 80 km from the city of Bolivar, on the road to Maripa. It is a marsh area in the river system of the Rio Aro, a north-flowing confluent to the middle Orinoco. Dense populations of many marsh and aquatic plants, e.g., *Cabomba furcata*, *Ludwigia inclinata* featuring verticillate leaves, *Bacopa reflexa* as well as *Sagittaria* sp., grew in stagnant water about 30–50 cm deep. The soil consisted of brown loam. The marsh area was surrounded by palm trees, with the palms being partially shaded, partially in the sun. The only fish caught were small *Copella*. The water at this location was acid, soft, and displayed—as a unique feature—symptoms of a creeping over-fertilization (ammonium, phosphate, and a lot of carbon dioxide) which was likely to have been caused by cows grazing the surrounding meadows.

LAKE IN THE RIO PARANÁ (ARGENTINA) CATCHMENT AREA

Biotope No. 4

Between the towns of Resistencia and Ramada Paso (Argentina), about 30 km before the latter, there is a large lake within the catchment area of the Rio Paraná into which a small stream enters. In July 1993, this stream formed a 1-m long, knee-deep ditch with very slow-moving, brown-colored, clear water. The edge of the lake as well as this little ditch were thickly populated with *Limnobium lae-*

vigatum, *Hydrocotyle ranunculoides*, *Myriophyllum aquaticum* and flowering *Cabomba caroliniana* var. *flavida*. The uppermost layer of the substrate was boggy, with sand located under it. Most of the plants grew in sunny places, only some sections being shaded by isolated trees. Conspicuous in the test results, which were recorded during the cold season, was the low temperature of the very soft water relatively rich in oxygen. The local fish fauna consisted of cichlids (*Cichlasoma*, *Crenicichla*, and *Apistogramma*), catfish (*Corydoras* and *Hoplosternum*) and tetras (*Copella*, among others).

RIVER IN THE RIO URUGUAY (ARGENTINA) CATCHMENT AREA

Biotope No. 5

Studies were done on plant populations in a smaller river about 30 km past the city of Santo Tomé in the direction of La Cruz (Argentina). This waterway, as well as the adjacent flood area, featured thick populations of aquatic and marsh plants as well as an unusually large diversity of species within a small space. *Eichhornia azurea* and *Hygrophila guianensis*, among others, were found in the quick-flowing water in a depth of 1–2 m with *Nymphoides* sp. also present in water about 3 m deep. On the edge of the river, in a slightly weaker current, *Egeria najas*, *Myriophyllum aquaticum*, *Eleocharis* sp. and flowering *Cabomba caroliniana* var. *caroliniana* could be found in water with a maximum depth of 1 m. Emerged shoots from *Myriophyllum aquaticum*, *Hygrophila guianensis* and *Ludwigia* grew on the water surface. On the river's edge the soil was loamy. All plants at the researched locations were subjected to intensive sunlight because the biotope was not shaded by any surrounding vegetation on the riverbank.

Apistogramma and tetras (*Hyphessobrycon*, *Copella*) were also found.

RIO YANAYACU (PERU)

Biotope No. 6

The Rio Yanayacu is a confluent to the Uyacali. The biotope from which the water sample was taken in July 1990 consists of a quiet cove. A thick layer of floating plants, such as *Ceratopteris pteridoides*, *Ceratophyllum demersum*, *C. submersum*, *Eichhornia crassipes*, *Limnobium laevigatum*, *Ludwigia helminthorrhiza*, *Phyllanthus fluitans*, *Pistia stratiotes*, *Ricciocarpus natans*, *Salvinia auriculata* and *Utricularia foliosa*, was found on the banks in slow-moving water. Due to the too small sample taken, it was not possible to determine the phosphate content. For the same reason, data on iron and manganese concentrations are also absent. Worth noting is the extremely low content of heavy metals.

The local fish fauna consisted of cichlids (*Apistogramma*, *Crenicara*, *Pterophyllum*) and a variety of tetras.



A dense layer of floating plants (*Limnobium laevigatum*, *Pistia stratiotes* and *Salvinia auriculata*) has formed on a riverbank and edge of the Rio Yanayacu (Peru) where there is hardly any current.

THE EAST AFRICAN RIFT VALLEY LAKES: LAKE MALAWI AND LAKE TANGANYIKA

Biotope No. 7

With their numerous colorful cichlids, the two East African lakes, Lake Malawi and Lake Tanganyika, form a fish paradise for aquarists. The following description and listing of aquatic plants collected from both lakes by the author shows that—contrary to popular opinion—the plant populations are not rare at all. The overall number of species present, though, is low despite the size of the lakes.

Ecological Data on Lake Malawi and Lake Tanganyika

Lake Tanganyika and Lake Malawi are located within the East African Rift Valley. Their banks are characterized by tremendously steep coastlines as well as rocks and pebbles, reed banks and sand zones. In the course of evolution, different societies of life forms have developed in these ecologically different areas. For lovers of cichlids specific to both Lake Malawi and Lake Tanganyika, the most interesting biotopes are found in the rock and pebble littoral. Because the soil there is unsuitable for higher aquatic plants, and free-floating aquatic plants, too, cannot resist the strong wave movement which is occasionally comparable to the surf on ocean coastlines, no aquatic plants are found in these interesting fish biotopes. Biotopes with plant growth are located in the transitional zone between boulder or pebble and sand zone, in the reed banks and in the sand littoral or, in other words, everywhere water movement is not as strong, for instance in quiet coves where plants can obtain a hold in the soil.

Due to the special ecological conditions, i.e., water readings which are rather extreme for tropical conditions (see Table 3, biotope

No. 7), as well as the strong current and wave movement and the great water depth, an effective process of selection took place in the lakes. Only species that were highly specialized or very adaptable and resistant were able to survive.

The water sample from Lake Tanganyika was taken by W. Staeck near Kalemie on the central west coast.

Plant Societies

The only floating plant in the Rift Valley lakes is the well-known *Pistia stratiotes*. However, it seems to grow only in locations that are protected to a certain degree by coves or islands. But even there it doesn't find ideal living conditions and thus cannot reproduce in large numbers, as is known to occur in marsh areas, due to the surf. All other aquatic

plants in both Lake Malawi and Lake Tanganyika grow exclusively submersed and are either rooted in the soil or float freely above the water bed.

Populations of *Valisneria spiralis* var. *denserrulata* can be found most often in both lakes. The living environment of the *Valisneria* species is the sand zone, as well as the transitional zone between pebble and rock zone. The plants grow in a depth of 0.5–4 m (rarely up to 6 m) and are firmly rooted in the sand soil. They are found growing protected by stones and also in open sand coves, the beaches of which are often covered with torn off *Vallisneria* leaves after a storm. Compared to *Vallisneria spiralis*, which are cultivated in aquariums, these plants have very hard leaves which is probably due to the extreme water chemistry prevalent in both lakes. Recovered samples developed similarly soft

The sand zones in Lake Tanganyika are typical living environments for aquatic plants.



leaves as the ones known to aquaristics, which clearly shows that *V. spiralis* reacts very changeably in its habit to different environmental factors and that it is a very adaptable and robust species.

Two other species often found in both lakes are *Ceratophyllum demersum* and *Myriophyllum spicatum*. Of all species evident in the lakes, the former will penetrate to the greatest depth: populations of this species will still grow in 10 m of depth whereas *Myriophyllum* is only found in a depth of about 3 m. Both species are often found growing close together in one location, obviously without obstructing each other's growth. Especially conspicuous in both species were their short internodes as well as the already mentioned leaf structure in *Vallisneria spiralis*, whereby a totally different appearance is formed compared to the cultivated plants. The shoots of *Ceratophyllum demersum* display a very compact growth within their natural habitat. Since their density is obviously larger than that of the cultivated specimens, they will not drift freely in the water or on the surface where they would be subjected to strong wave movement and would soon succumb, but on the substrate bed instead where the water movement is weaker. The fact that the unusual appearance of the plants was a consequence of their adaptation to the special conditions of their living environment became evident when the recovered shoots behaved just like the known cultivated specimens after a very short time and floated on the water surface in the aquarium.

Also among the plants often found in both Lake Malawi and Lake Tanganyika are *Potamogeton pectinatus* and *Potamogeton schweinfurthii*. Both often exist in association, or they form large submersed meadows with the already mentioned species. They often populate nearly the same ecological niche. Preferred habitats are protected sand coves or the transitional zone from the pebble to the sand zone. On the open coastline, however, the

plants seem to be entirely absent due to their lack of resistance towards the powerful surf. Both species exist in a depth of about 0.5–4 m. The leaves of *P. pectinatus* are only 1 m wide and very hard, obviously again an adaptation to the strong water movement. *Potamogeton schweinfurthii*, with stems of up to 3.5 m in length, is the largest plant in the lakes. In this species, too, the hard and coarse leaf blades are worth noting. Especially conspicuous in both *Potamogeton pectinatus* and *P. schweinfurthii* were lime deposits on the leaves which can be attributed to the extreme water values in the lakes.

Of special interest, too, was the find of *Hydrilla verticillata* at Ndole Bay in the southern part of Lake Tanganyika. There the plant formed large, herbaceous populations in the sand zone which were rooted into the substrate by up to 1 m and stretched almost as far as the water surface. *Hydrilla verticillata* is well-known in aquaristics; the habitus of plants in Lake Tanganyika, however, varies distinctly from the appearance of cultured plants known by the same name (see also description on pp. 302–303). In Ndole Bay, the author also found *Najas horrida* in association with *Hydrilla verticillata*, a very conspicuous plant because of its habitus. A site together with populations of *Najas marina* subsp. *armata* in a reed zone in the vicinity of Monkey Bay in Lake Malawi was also found. Even though *Hydrilla verticillata*, *Najas horrida* and *Najas marina* subsp. *armata* are comparatively rare in both lakes, they seemed to be widely prevalent in that area.

The hard leaf and stem structure is worth noting in all aquatic plants found in the two lakes, an observation which can be clearly interpreted as an adaptation to the prevalent ecological conditions.

In contrast to the numerous endemic cichlid species, there are no endemic aquatic plants in either lake, but only exclusively those species that have a large distribution because of their adaptability.

LAKE ON MAFIA (TANZANIA)

Biotope No. 8

The small island of Mafia lies about 20 km off the Tanzanian mainland. In the north there are two lakes, the larger of which was researched. It featured rich plant populations which, because of the low water level, were not limited to the banks but were spread over the entire lake. Most of the lake was unshaded. Thick groups of *Ceratophyllum demersum*, *Utricularia inflexa* and *U. stellaris* grew in stagnant water and floated freely. Rooted into the substrate were numerous flowering samples of *Nymphaea lotus* and, on the banks, *Ceratopteris cornuta*. *Pistia stratiotes* and dense populations of *Salvinia* floated on the water surface. The strong alkaline pH-value of this lake as well as its very high conductivity (base rich in calcium) were conspicuous.

RIVER BIOTOPE WITH *APONOGETON MADAGASCARIENSIS* (MADAGASCAR)

Biotope No. 9

Aponogeton madagascariensis has without doubt been the most popular aquarium plant for many years. Because its continuous cultivation in the aquarium succeeds only rarely and the depth of variation of this species is exceptionally large, detailed ecological data can contribute answers to many open questions regarding a separation of different varieties or subspecies within this species. The most important known information on the ecology of *Aponogeton madagascariensis* has been summarized on pp. 132–133. A detailed analysis of the water of biotope No. 2 was undertaken. This habitat is located about 1 km

Aponogeton madagascariensis in its native habitat on Madagascar (biotope No. 9).



Table 3: Water values from several selected native habitats.

	Biotope No.					
	1	2	3	4	5	6
	Rio Guaporé Brazil	Rio Sipao Venezuela	Rio Aro Venezuela	Rio Paraná Argentina	Rio Uruguay Argentina	Rio Yanayacu Peru
Date	July 1987	14/08/89	13/08/89	12/07/93	15/07/93	01/08/90
Water temperature	20	27	28	13	10.6	25
Air temperature	—	29.5	30.5	15	13	—
Time	—	—	12:00	12-14:00	12:00	—
pH-value	6.38	5.99	6.06	7.02	6.78	7.5
Conductivity (at 20 °C)	22	12.2	22.6	35	18	205
Carbonate hardness (KH)	0.69	<0.5	1.0	0.76	0.33	5.50
Total hardness (GH)	0.41	<1.0	<1.0	0.51	0.31	5.11
Calcium hardness	0.41	0.13	0.51	0.51	0.31	5.11
Magnesium hardness	0	0.10	0.07	0	0	0.77
Carbon dioxide (CO ₂)	10	19.3	32.4	2.5	1.9	5.9
Oxygen (O ₂)	—	—	—	70	90-99	—
Sodium (Na)	1.69	0.83	1.26	1.0	1.1	3.9
Potassium (K)	0.35	0.50	1.54	3.4	0.2	2.2
Iron (Fe ^{2+/3+})	0.21	—	—	—	—	—
Ammonium (NH ₄ ⁺)	—	0.07	0.32	traces	0.1	0.14
Chloride (Cl ⁻)	—	1.0	0.7	0.9	0.4	4.3
Sulfate (SO ₄ ²⁻)	—	n.d.	0.2	1.2	0	4.4
Nitrate (NO ₃ ⁻)	<3	n.d.	n.d.	0	0.6	0
Nitrite (NO ₂ ⁻)	—	<0.16	<0.16	0	0	0
Phosphate (PO ₄ ³⁻)	0	n.d.	0.12	0.1	0	—
Zinc (Zn)	—	7.1	21.6	24	27	7.0
Cadmium (Cd)	—	n.d.	n.d.	n.d.	n.d.	n.d.
Lead (Pb)	—	2.6	6.2	3	1	n.d.
Copper (Cu)	—	1.9	4.0	10	10	0.1

n.d. = not detectable

Table 3: Water values from several selected native habitats *continued*.

	Biotope number					
	7	8	9	10	11	12
	Lake Tanganyika (Kalennie) Zaire	Lake (Mafia) Tanzania	River Madagascar	Sepik River Papua New Guinea	River Papua New Guinea	Tasek Bera Malay Peninsula
Date	July 1982	January 1981	03/01/87	06/07/88	22/07/88	—
Water temperature	in °C	30	23.2	—	27	23–31
Air temperature	in °C	32	27.5	—	30	—
Time	—	14:00	10:00	—	12:30	—
pH-value	9.5	7.8	6.45	6.50	6.70	5.33
Conductivity (at 20 °C)	593	1054	30	84	82	14.2
Carbonate hardness (KH)	18.4	31	0.75	2.5	2.4	0.17
Total hardness (GH)	11.03	>30	0.53	2.5	2.4	—
Calcium hardness	—	—	—	1.8	1.1	0.05
Magnesium hardness	—	—	—	0.7	1.3	0.06
Carbon dioxide (CO ₂)	<2	10	10	—	—	14.9 (07:00 hrs)
Oxygen (O ₂)	50.8*	—	—	—	—	26
Sodium (Na)	61	5.56	3.3	4.3	4.7	0.86
Potassium (K)	31	0.44	0.6	0.7	1.3	0.56
Iron (Fe ^{2+/3+})	n.d.	0.05	0.05	0.02	0.02	0.64
Ammonium (NH ₄ ⁺)	0	0.1	0.1	0.10	0.10	0.304
Chloride (Cl ⁻)	31	6.9	—	traces	traces	1.93
Sulfate (SO ₄ ²⁻)	traces	1.20	—	traces	traces	3.19
Nitrate (NO ₃ ⁻)	0	—	5	5	7	0.107
Nitrite (NO ₂ ⁻)	—	—	0.05	<0.05	<0.05	0.0074
Phosphate (PO ₄ ³⁻)	0.09	—	0.3	<0.05	<0.05	0.624
Zinc (Zn)	n.d.	—	7	365	6	—
Cadmium (Cd)	n.d.	—	n.d.	—	—	—
Lead (Pb)	n.d.	—	8	5	n.d.	—
Copper (Cu)	n.d.	—	12	18	12	—

n.d. = not detectable. *Laboratory data: all water samples (except biotopes 8 and 12) were analyzed in the laboratories of the Tetra company.

away from the township of Beforona on the identically named river at an altitude of 900 m. Narrow-leaved plants of *Aponogeton madagascariensis* var. *madagascariensis* grew in knee-deep, slightly turbid water in a strong current, with the leaves hardly touching the water surface. The substrate consisted of sand rich in loam and mixed with gravel, larger stones and boulders. *Aponogeton madagascariensis* was found under a bridge as well as unshaded in loosely associated groups. Readings with a luxmeter (tolerance 1%) on 3 January 1987 at 10:00 h produced the following data: under slightly cloudy open skies (sun clearly visible, small white clouds) 70,000 lx, and 15,000 lx under the bridge in the shade; several minutes later, under a near cloudless sky and intensive sun radiation, the luxmeter showed a reading of 146,000 lx. The brown coloring of the leaves points to the plants growing under stronger light in their natural location, compared to cultivation, because the retrieved samples developed olive green leaves only at a later stage in the aquarium. It can be assumed that the water level at this location drops during the dry period to such an extent that the species' leaves flood to the water surface. This studied biotope, however, almost certainly does not completely dry up. Samples probably also grew in deeper water but were not visible due to the loamy, cloudy and murky water.

SEPIK RIVER NEAR ANGORAM (PAPUA NEW GUINEA)

Biotope No. 10

The Sepik River in Papua New Guinea is a river several hundred meters wide. Possibly because of its murky and clouded water as well as its quick current, only floating plants were found in this river, occurring increasingly in coves with hardly any current. Dur-

ing a boat trip which lasted 2 days and led from Ambunti downstream to Angoram, the following species were found, more or less always in large population groupings: *Salvinia molesta* (with sporocarps), *Pistia stratiotes* and *Azolla pinnata*, which flooded the water surface, as well as individual samples of *Ceratopteris thalictroides* and *Hydrocharis dubia*, which was often rooted on the riverbank. The water analysis of this biotope shows that the plants live in a very soft water, deficient in electrolytes and nutrients, and with a low conductivity. Whereas the content of the major plant nutrients, nitrogen and phosphorus, is very low, the high content of zinc is conspicuous.

RIVER BIOTOPE WITH *APONOGETON LORIAE* (PAPUA NEW GUINEA)

Biotope No. 11

Aponogeton loriae is a very rare aquatic plant which is endemic in Papua New Guinea. The studied biotope is located on the road from Port Moresby in the direction of the Vaimauri Plateau, 61 km from the airport of the Papua New Guinea capital. There *A. loriae* grows in dense populations in a small river that is about 2–4 m wide. The clear water flows slowly at a speed of about 25 cm/s. Whereas the water was knee-deep at the river's edge (without a distinct shallow water zone), it reached a depth of up to 1 m in the center. The plants were anchored in muddy, loose soil which was interspersed with a bit of gravel and a few stones, and could easily be plucked from the substrate soil. The location was unshaded. Conspicuous in the water analysis was the relatively high content of magnesium and potassium.

The fish fauna consisted of *Melanotaenia papuae* and *M. goldiei*.

TASEK BERA

Biotope No. 12

Tasek Bera is a 60 km² low-lying marsh area on the Malay Peninsula in the southwestern part of the State of Pahang. It is crisscrossed by many channel-like waterways and forms an important environment for aquatic and marsh plants. Furtado and Mori (1982) studied numerous ecological aspects of this biotope and summarized their 4 years of research in a comprehensive publication. Even though the author is not personally familiar with Tasek Bera, some essential research results should be summarized because this ecological data is of interest to aquarists. It is there that the largest populations of *Cryptocoryne purpurea* are found.

The marsh area, densely covered in parts by *Lepironia articulata* and *Pandanus heli-copus*, and containing several lake-like areas of open water, is crisscrossed by numerous waterways as well as a main channel which has a weak current with a speed of 0.25 m/s. The dark brown water, which the authors compare to the black water of the Amazon region, is very clear and has a visibility between 1 and 2.5 m, depending on the time of year. Its surface temperature varies between

23 and 31 °C; readings on the bottom measured 23.0–26.6 °C. The water is very acidic and mineral-deficient, pH-testing revealed an average value of 5.33. The minimum read 4.5, and the maximum, depending on the testing method, read 5.2 and 6.8, respectively. With an average value of 2.09 mg/L the content of dissolved oxygen is rather low. The bottom is sandy but covered, however, with a thick layer of peat which is mixed with non-decayed plant material, wood and mud. Under the influence of heavy monsoon, rainwater levels will vary considerably by up to 5 m.

The following known marsh and aquatic plants were found in the studied area: *Blyxa aubertii* var. *echinosperma*, *Cryptocoryne purpurea*, *Eleocharis ochrostachys*, *Hydrilla verticillata*, *Ludwigia prostrata*, *Nymphoides indica*, *Potamogeton wrightii*, *Scirpus confervoides* and *Utricularia aurea*. Jacobsen (1986) also mentions the presence of *Barclaya motleyi*. The predominant aquatic plant in Tasek Bera is *Cryptocoryne purpurea* which is found in dense populations in the channels and in open water up to a depth of more than 1 m. They are more lush in semishaded areas compared to exposure to full sunlight. Water values listed in Table 3 represent average values resulting from numerous tests.

The Importance of Ecological Factors in the Cultivation of Aquarium Plants

The chapter on natural habitats of aquatic and marsh plants dealt with environmental factors which exert an essential influence on the plants' photosynthesis and growth. It can be concluded from the observations made that nature, as our teacher, can in many respects adopt a certain model function for the culture of aquarium plants. For aquarists this results in the challenging task of drawing the right conclusions not only from research of natural habitats, but also from the results of scientific experiments in laboratories and open areas. The goal to be achieved is the optimum cultivation of the plants in an aquarium.

In the following chapter, the importance of ecological factors for the maintenance of aquarium plants will be discussed. Attempts have been made to give general recommendations and suggestions in cases where it seems useful and appropriate.

Aquarium Temperature

Temperature in an aquarium is often underestimated in its importance as an ecological factor. As explained in detail on pp. 3–4 it has an important influence on the plants' metabolism. If some aquarium plants don't really want to grow and develop, the cause is often looked for in the lighting set up, in the water values or in the supply of nutrients, but it is common that an unsuitable temperature level is responsible for such bad and slow growth. *Cabomba caroliniana*, for example, can be kept at temperatures between 20 and 25 °C

without any problems. At consistently higher temperatures, however, the shoots will soon perish. The bad growth of the plant in high temperatures is, therefore, not surprising because the species occurs in areas with a distinct seasonal climate. There, *Cabomba caroliniana* populates waters that display relatively low temperatures for most of the year. The question of optimum temperatures in an aquarium cannot be answered in general terms because each plant prefers a very specific and unique temperature range. Even though most aquarium plants can be maintained between 24 and 26 °C, this range does not always constitute the optimum environment. To facilitate the selection of the correct water temperature for the specific species kept in the aquarium, the temperature tolerances of the most important aquarium plants have been compiled in a table. The minimum, optimum and maximum temperatures can be read in Appendix 1. Data on the minimum and optimum temperatures constitutes reliable values derived from day-to-day operations and gathered on the basis of long-standing experience with the cultivation of aquarium plants in hothouses as well as aquariums. Maximum temperatures are based on, among others, numerous tests conducted in natural habitats. The maximum values of many species are possibly even higher than is currently assumed.

According to the current state of knowledge about the natural habitats of aquatic and marsh plants, it can basically be assumed that a moderate difference in temperature be-

tween day and night is conducive to plant growth. At the same time, considering the multitude of maintained aquarium plants from subtropical and temperate zones, it is recommended that the aquarium temperature be reduced by a few degrees during winter, which can be vital and essential for the continuous upkeep of the *Aponogeton* species. When translating these suggestions into everyday practice, the living requirements of those fish kept in the aquarium must, of course, also be taken into consideration. For fish, daily and seasonal variations in temperature are generally conducive and, in many cases, stimulating for their spawning behavior.

Light in the Aquarium

The fundamental importance of light for many growth processes in plants is discussed extensively on pp. 4–13. In their natural habitats the species have, over the course of evolution, adapted to the daily and seasonal changes in sunlight in order to make optimum use of the available light for photosynthesis. In contrast, plants in the aquarium rely on artificial light sources which, in addition, radiate continuously all day in an unnatural way. Most of the aquarium plants kept, though, are defined by the ability to adapt to this highly modified environment. It should be remembered that there are also aquatic plants that have not previously been successfully cultivated in the aquarium. One reason for this failure could be their lack of adaptability to static artificial lighting.

In early aquaristics, aquariums were often located close to a window where plants were exclusively subjected to daylight. Whereas growth was excellent during summer and many floating plants especially prospered lushly, many plants succumbed to conditions of very weak light intensity and very short lighting periods during winter. The uneconomical use of lighting with incandescent

bulbs, too, is no longer up-to-date. Today, there is a large range of lamp types available to the aquarist from which he or she has to make the right choice to suit individual requirements.

For aquarists interested in solid plant growth, the choice of lamp type is made mainly according to two criteria: one, they have to feature a color spectrum suitable for the plants' photosynthesis; on the other hand, plants and fish are supposed to be displayed in lighting comfortable to human vision. What are the differences?

For a better understanding of this problem a few fundamental explanations of light are provided as follows.

Visible "white" light contains all spectral colors (from violet to blue, green, yellow, orange to red) which are each characterized by a specific wave length. This light is located in the range of 380 to 780 nm (nanometers). Over one hundred years ago, it was discovered that different light colors had different effects on plants. It was also found, however, that the spectral colors were received differently by the human eye compared to the plants. The latter require the entire light spectrum for the purposes of photosynthesis, preferably the red (around 700 nm) and, to a lesser extent, the blue (around 450 nm) spectrum range. In contrast, the maximum sensitivity of the human eye lies in the green-yellow spectral zone at 555 nm. Photosynthesis, however, displays a marked decline within this range. For plant growth, light utilization (efficiency) of the lamps alone is not the only relevant factor. The color spectrum ranges of the lamps are also important. Special plant lamps, for example, Sylvania Gro-Lux or Osram L-Fluora, were designed in such a way that they achieve maximum values in both red and blue spectrum ranges. This "red" light, however, is often perceived by humans as unnatural and is, therefore, only acceptable to most users in conjunction with other lamp types.

Remarkably, plants, within certain limitations, are able, because of their assimilatory pigmentation, to adapt to light colors (chromatic adaptation) as was shown in numerous scientific experiments using different colored light (see Gessner 1955). However, plants first have to adapt to a change in light quality, a process for which they probably need a couple of weeks. Some *Cryptocorynes* quite often react in an extreme way to a change in light color and intensity, displaying total decomposition of their leaves. Even when many plants display a proven and certain adaptability to light changes, one should not draw the conclusion that any arbitrarily chosen lamp will have the same enhancing effect on plant growth, and that the respective light spectrum is irrelevant. Such an opinion would totally contradict all previous knowledge about plant photosynthesis gathered from numerous scientific experiments. The importance and relevance of “plant-friendly” lamps because of

their positive effect both on growth, as well as development of the pigmentation system (e.g., enhancement of the brown and red coloring agents carotenoids), remains highly controversial. For this reason the emphasis, when choosing lamp types, should always be laid on light quality, and aesthetic aspects should only be of secondary importance.

CHOICE OF LAMP TYPES AND LIGHT COLORS

There are a number of lamp types available to the aquarist for the purpose of illuminating plants and fish. For the hobbyists interested in solid plant growth, there is the initial basic question whether to use fluorescent tubes or high-pressure lamps (incandescent lamps, halogen incandescent lamps and mixed light appliances will not be dealt with here because of their negligible relevance and poor light utilization). The next consideration—as pre-

Dense and diversely planted aquariums are beautiful to observe.



viously explained—concerns the choice of light color that features a light spectrum with a high proportion of red focused on the plants' photosynthesis but, at the same time, also has a high degree of light exploitation as well as good quality color reproduction.

FLUORESCENT LAMPS

The advantages of fluorescent lamps are especially high light exploitation (higher degree of efficiency than high-pressure lamps), long durability, good color reproduction, good value for money and low energy consumption (high efficiency). The choice of light colors in fluorescent lamps is greater than that in high-pressure lamps.

Typical for fluorescent lamps is the fact that they provide balanced lighting of the entire aquarium in contrast to discharge lamps. A conclusion as to under which light plants and fish achieve a better effect, however, is purely subjective. The utilization of fluorescent lamps is around 7500 hours. A too high surrounding temperature, which can easily arise in lamps enclosed in hoods or reflectors, has to be avoided. The maximum light radiation lies around 20–25 °C. Surrounding temperatures deviating greatly from these figures will rapidly reduce light utilization and efficiency. Bad reflectors, too, considerably reduce light intensity. Self-adhesive aluminum foil has good reflectory qualities and is very inexpensive and of good value.

The new generation of three-banded spectrum (tri-phosphor T8) lamps with a diameter of 26 mm features a higher light exploitation compared to the "older" lamps with a diameter of 38 mm. Further development and expanded application in aquaristics of the modern compact fluorescent lamps is both trendsetting and desirable. These lamps are distinguishable by their compact design, very high light exploitation and long life-span. For the purposes of aquarium plant cultivation, warm-tone lamps produced by several manufac-

turers as well as special "plant bulbs" featuring a high content of red light are especially recommended. Obtaining individual special light colors is, however, not always easy.

Recommended warm-tone lamps (color temperature between 2700 and 4000 Kelvin) are the light colors with the international indications 827, 830, 930 and 940, as well as the corresponding compact lamps Dulux 830 and 827. If required, these can be combined with neutral white fluorescent lamps (e.g., 840, 940 or 184).

The specially developed plant bulbs Osram 77 L-Fluora, Sylvania Gro-Lux and Philips Aquatelle 89, have a lower efficiency than many other L-lamps, and today are also used to a lesser degree than previously because of the availability of other good light sources. However, their positive effect on plants due to their high red and blue content cannot be discounted.

DISCHARGE LAMPS

Mercury vapor high-pressure lamps and halogen metal-vapor (metal halide) lamps have been increasingly used in aquaristics over the last couple of years. For most aquarists using this type of lamp, two aspects are usually decisive: aquariums opening on top (limited accessibility also by free-hanging fluorescent lamps) permit unusual effects; however, the selective spotlighting of the aquarium creates an appealing play of light and shade. A necessity also often arises to adequately illuminate especially deep aquariums. In these considerations the question of suitability of the light colors for plant growth are not sufficiently taken into account.

The disadvantages of discharge lamps are especially their high purchase costs, a comparatively small light exploitation compared with fluorescent lamps, the very limited choice of light colors and a disadvantageous compatibility with other lamp types or light colors. Also, the undesirable high-water evap-

oration in “open” aquariums and the consequently high humidity in the room should not be underestimated. The “dazzling” light of high-pressure lamps is also often considered to be irritating and interfering.

MERCURY VAPOR HIGH-PRESSURE LAMPS

Mercury vapor high-pressure lamps have a low light exploitation and a relatively bad color reproduction. An advantage of this lamp type, however, is the high life-span of around 9000 hours. For the lighting of plant aquariums, warm-tone lamps with a high content of red light are primarily considered. The most suitable is the light color Osram HQL Super de Luxe, only after which others such as the warm white-light colors Osram HQL de Luxe, Philips HPL Comfort, Radium HRL de Luxe and Sylvania HSL Comfort should be considered for use.

HALOGEN METAL-VAPOR LAMPS

In comparison to mercury vapor high-pressure lamps, light exploitation and color reproduction in metal halide lamps have been improved considerably. A disadvantage of the latter, however, is the comparatively low exploitation period of about 6000 hours. It is especially important for the user to know that halogen metal-vapor lamps emit UV radiation of around 2–5%. For this reason, the lamp may not be used uncovered but has to be fitted with a cover glass or discs which filter and absorb damaging UV radiation. During very high light intensity, a special UV filter has to be used. Negative experience with this type of lamp is possibly based on the absence of a cover glass. The destruction of pigmentation in the plants can occur as a consequence of excessive UV radiation.

In halogen metal-vapor lamps, too, the choice of light colors is, so far, very limited and the spectral range necessary for the

Most aquarium plants love light and require a high light intensity for optimum growth.



plants' photosynthesis is not sufficiently considered. Recommended primarily are warm-tone lamps from several manufacturers with the light colors Osram WDL, Philips HPI, Radium WDL and Sylvania WDL.

REQUIRED AMOUNT OF LIGHT

In order to adequately address this question, the author conducted numerous tests in natural habitats using a luxmeter (see Table 1). The results of these tests are also reflected in Appendix 2. Such test data is, of course, not exactly transferable to the aquarium environment, which obviously cannot be expected. For one, daylight features a different and changing spectrum compared to artificial light sources; also, the spectral range relevant for the plants' photosynthesis cannot be captured using a luxmeter which is tuned to the sensitivity of the human eye. Such test results, though, can still permit various conclusions as to the light requirements of plants in the aquarium and can, therefore, be useful and important in daily aquarium practice.

According to the studies undertaken by Sauer (1989), the light intensity on the water surface of an aquarium generally ranges between 10,000 and 30,000 lx. Already in a depth of 40 cm in a newly installed aquarium, a loss of light of 69% was registered. Tests conducted by the author resulted mostly in even lower readings. In aquariums that have operated for some time, light intensity is considerably reduced and changed negatively by the increase in coloring and clouding matter in the water. For this reason alone a regular water exchange is useful. Furthermore, it must also be considered that red light is absorbed first by the water, which is why, in very deep aquariums, this photosynthetic effective range only reaches the substrate in minimal quantities. Only very few plants, especially those that grow in deep water in their natural habitats, are optimally adapted to these conditions. The choice of suitable species for aquariums with a height of over 60

cm is thus drastically reduced. For an aquarist interested in solid plant growth, the first rule should be not to use very deep aquariums in order to create an advantageous light climate for the plants right from the outset.

If the test data of the natural habitats (Table 1) is compared to data obtained from aquariums, it can be clearly concluded that sun plants—and these constitute the majority of plants kept in aquariums (compare Appendix 2)—receive a considerably higher average light intensity in the natural biotope than in the aquarium. Furthermore, if the fact is taken into consideration that the majority of plants in their natural habitats are found in a maximum water depth of 30 cm, or above water in moist ground, these species can hardly be damaged by too intensive artificial lighting within the aquarium, as is often stated. It is hardly ever possible to subject the aquarium's light-resilient plants to too much light. However, considering the variety of species that are found in an aquarium within very limited confines, one has to clearly differentiate between plants with low light requirements (weak light or shade plants) and those with high light requirements (strong light or sun plants), and the aquarist has to try to accommodate both types. As clearly outlined on p. 8, shade plants achieve their highest assimilation at a low light intensity and can be damaged and die off due to too high light radiation. The requirements of shade plants thus have to be considered in the overall lighting of an aquarium. These needs can easily be met by choosing a shaded location in the aquarium, e.g., near side and rear panels.

The degree of light intensity cannot optimally meet the light requirements of both shade and sun plants simultaneously. Each aquarist has to select the degree of light intensity on an individual basis. As a rule, a "golden middle course" will have to be taken which has to meet and satisfy the needs of a variety of species. This, however, generally implies that extremely light-appreciating plants cannot optimally develop. The plant

aquarist should, therefore, always select a higher luminosity and allocate shade-loving plants to a less bright spot in the aquarium.

Many aquarists have the understandable desire to be provided with guiding values for the necessary light intensity of their aquarium. The often employed parameter of watts per liter, however, is an inaccurate value, even when considering different aquarium dimensions, with which one can quite easily do entirely without. Also, the author has often asked herself how the installation of fluorescent lamps can take place on the basis of figures of one watt per liter of water. The number of lamps resulting from this calculation can usually not be accommodated in the lighting compartment! A better solution than the watt/liter data is the testing of the light intensity using a luxmeter or, alternatively, an exposure meter in consideration of light colors used. This solution, too, is generally impractical for the aquarist, is too expensive,

and, furthermore, is unsatisfactory because the resulting values have hardly any meaning or relevance.

The most important pointer to optimum growth and correct lighting is provided by the plants themselves. They react, for example, to a favorable or unfavorable light environment with typical changes in their appearance. Check for yourself if the shoots display a strongly elongated growth with extended internodes (etiolation), if the stems lose their lower leaves, if the plants remain much smaller than indicated in the species descriptions given in this book, if they develop less luxuriantly than seen in the photos, if red coloring is unsatisfactorily pronounced, and if no red stem tips have developed which are typical for many well-illuminated plants. If you basically have to answer these questions in the affirmative then you should definitely increase your aquarium's light intensity.

It was stressed that special care has to be

Close-up of a Dutch aquarium displaying lush plant growth.



taken of shaded plants because they could be damaged under certain circumstances through excessive luminosity. Practice, however, shows that this danger is rarely prevalent because the usual aquarium lighting is designed as too weak in any case.

Things look different, however, in the typical Dutch aquariums which became famous for their excellent plant growth. The secret of these aquariums lies in a very high light intensity which is achieved through a maximum number of mountable fluorescent lamps. Under close scrutiny the preferred use of demanding and light-requiring plants becomes evident. These intensely illuminated aquariums can be considered as a yardstick for optimum plant maintenance. If you are interested in a similar and quick plant growth you should follow this path and not save on light intensity. Such aquariums, however, are not only very demanding with regard to care and maintenance, because the rapid plant growth necessitates continuous trimming and replanting, but also have a high energy demand. An entirely practicable alternative, as proven by practice, involving a far lower energy consumption, consists of selecting only aquarium plants that are satisfied with low-to-medium light intensities. This way an aquarium of Dutch standards can be realized.

In conclusion, it should be stressed that satisfactory plant growth can only be established if the interrelation of all growth factors like temperature, substrate and nutrient conditions are taken into account.

DAILY LIGHTING PERIODS

The question about the daily lighting period can best be answered if one visualizes the conditions to which aquarium plants are subjected within their natural habitats. Almost all cultivated aquatic and marsh plants exist in the tropics and subtropics between the equatorial zone and a geographical latitude of 30° . In the vicinity of the equator the daily lighting

period measures a constant 12 hours. In a geographical latitude of 10° the length of day will vary according to the season between 11:30 and 12:40 hours, at 20° between 11:00 and 13:20 hours, and at a 30° geographical latitude between 10:12 and 14:05 hours. In this area plants under an open sky will thus be subjected to a daily lighting period of about 10 to 14 hours. In the course of evolution plants have, to a large degree, adapted to this day-night rhythm. For species existing in deeper water the length of day will be shorter than on land because of the light reflection on the water surface during a lower positioning of the sun.

It has previously been concluded from this assumption that the lighting period in the aquarium has to last only 8–10 hours. This conclusion, however, has to be strenuously contradicted since its implementation can lead to a considerable loss of plants! The above data has to be considered in a far more differentiated way: for one, it has to be taken into account that the shortest lighting period of 10 hours at a latitude of 30° does not continuously last over the entire year, but only during a short span lasting a couple of weeks during “winter” and thereafter again slowly increases to 14 hours. On the other hand only a relatively limited number of aquarium plants permanently exist in greater water depths where reflection, in fact, does considerably shorten the underwater day. For all other species, however, i.e., most aquarium plants, the reflections on the water surface have no essential effect on the lighting period.

As is the case with many other factors one would have to differentiate between different species with regard to the question of the optimum lighting period. Since this is impossible due to the, in many cases, insufficient knowledge about natural habitats, a middle course, which satisfies just about all plants, is suggested. This compromise consists of a minimum lighting period of 12 hours. The

maximum lighting period is less critical and can be around 15 hours. Assimilation performance, however, cannot be increased beyond a certain lighting period which is why its extension will not have any positive influence. Furthermore, it also has to be considered that a very low light intensity can be balanced through extending the lighting period.

To accommodate as many plants as possible in the aquarium the recommended daily lighting period lies between 12 and 13 hours. A reduction to as low as 10 hours daily can be handled temporarily by many plants, but studies conducted by the author also showed that several species collapsed entirely after several weeks under such conditions.

The seemingly curious and alien plant-damaging call for a "rain day," in other words the switching off of the aquarium lighting for one day per week, also must be strenuously contradicted. Even if it should rain uninterrupted in the tropics for an entire day, which is very rare, light intensity is thereby not reduced to 0.

The Aquarium Substrate

Most cultivated aquarium plants are marsh plants which draw their nutrient requirements to a large extent from the substrate through an extensive root system and only to a limited degree from the surface of the plant. Only in genuine aquatic plants are the roots reduced to such an extent that their function mainly lies in the plant's anchoring and only to a lesser extent in the absorption of nutrients. These plants exist almost exclusively on ions freely available in the water, where, however, they occur in much smaller quantities than in the substrate.

Even though a lot has been said in the past about the quality of the substrate it can not be disputed that the substrate has an important

function for the nutrition of aquarium plants. If optimum plant growth is the set goal, the choice of substrate material containing sufficient nutrients has to be considered in setting up an aquarium. Liquid fertilizers, added to the aquarium water, only serve as an additive and are no substitute for a nutrient-rich substrate.

The following factors have to be considered when choosing a substrate:

- The substrate should contain little or no substances which could rot (e.g., humus).
- The pore volume has to be sufficiently large so as not to impede aeration and water movement within the soil but also enable the roots to easily penetrate. Only then is an optimum exchange of substances by the plants guaranteed.
- A nutrient-rich substrate should be used.
- The substrate should feature an acid to neutral reaction (check with minimum 6% hydrochloric acid; in case of strong foaming the substrate contains excessive lime). Only few aquarium plants (e.g., *Cryptocoryne affinis*, *C. crispatula* or *Vallisneria* species) react to a substrate's alkaline pH-value with improved growth compared to an acid milieu.

In the chapter on the substrate as a source of nutrients (pp. 13–14) it was pointed out that, in the natural habitat, loam soils (mixture of sand and clay) with a high content of humus have the most favorable effect on plant growth. Soil analyses (see Horst 1986) also show that the nutrient depot in the soils of natural waters is generally higher than in aquarium substrates. However, conditions in natural locations can be transferred only in a limited way to the aquarium because, in contrast to the natural habitat, there are far fewer soil organisms in the aquarium providing good aeration, and, furthermore, the substrate also lacks a sufficient current. The ratio of water to substrate, too, is considerably smaller

in the aquarium compared to the natural environment where rotting processes have a different effect than in an artificial biotope.

In fact some aquatic plants are able to adapt to their natural living conditions in such a way that they can even exist quite well in muddy, badly aerated and oxygen-deficient anaerobic soils, possibly even preferring this sort of milieu. The number of aquatic plants found in such soils is, however, limited to very few species, for example, some water lily plants and *Ludwigia* which, due to numerous morphologic adaptations (large cavity system, rich aeration tissue and respiratory roots), nevertheless allow root respiration. It has to be emphatically stressed that most aquatic plants cannot prosper in such an extreme milieu. Even though some soils in which many aquarium plants grow in their natural habitats often hold a content of

humus substances, it can be shown from soil profiles that sufficient aeration and oxygen supply are provided because it is usually a mixture of different soil components.

Because the soil in natural locations often contains humus, this realization in the past occasionally led to the portentous conclusion that organic material in large quantities had to be added to the substrate to obtain good plant growth in the aquarium. Experience in cultivation, and also some experiments conducted by the author, however, have repeatedly shown that the use of a lot of organic material as substrate in the aquarium can lead to excellent growth results in the initial months, with plant populations subsequently collapsing due to the substrate becoming strongly compressed, as well as lack of aeration. In the same way, the exclusive use of loam, clay, laterite or similar soil substrates in the aquar-

Due to morphological adaptation, *Nymphaea micrantha* is able to prosper in soils low in oxygen content (native habitat in Senegal).



ium is to be fundamentally rejected because an inescapable dying off of the roots within a couple of months will be the consequence for the reasons mentioned.

As a consequence of the interrelationships outlined above, rough, coarse, unwashed lime-deficient sand is recommended as the main component of the substrate. This can be covered with quartz gravel with a maximum grain size of 1–3 mm. Depending on the plants' nutrient requirements a small quantity of loam or clay or commercially available laterites (usually with added trace elements) can be added to the sand (don't use all three) in order to boost the substrate's nutrient depot for the plants. When using such additives there is always the danger that, over time, they will compress and condense the substrate too much. There are several ways to counteract such compression and hardening in the long term:

- Using a substrate heating system or the installation of timers on the fluorescent lamps under the aquarium floor is recommended. The achieved heating of the substrate effects a slight increase in water movement and thereby aeration of the substrate. The same effect can be achieved if the aquarium is positioned (with a gap of a few centimeters) above a central heating element.
- Keeping dog periwinkles (*Melanoides tubercularia*) is useful. The reproduction of the snails, however, can be explosive if provided with a good substrate climate, necessitating their regular removal. This is possible, for example, by using a piece of apple connected to a piece of string, positioned on the aquarium floor, around which the snails will gather after a while.
- Occasional and partial loosening of the substrate, for instance during cleaning or planting, also has a very growth-enhancing effect.

These measures, however, will not prevent the substrate's depletion, over the course of

time, in nutrient content. Unfortunately aquarium dealers do not offer any comparable fertilizer preparations for the substrate, similar to ones that have been available for years for pot plants. Fertilizer rods or granulate fertilizers for potted plants should only be used in aquariums with extreme care and in a limited and controlled dosing.

Water in the Aquarium

THE INTERRELATIONSHIP OF CARBON COMPOUNDS, PH-VALUE AND CARBONATE HARDNESS

Carbon constitutes a vital element for the nutrition of higher plants. In contrast to terrestrial plants which obtain their carbon requirements exclusively from the carbon dioxide content of air, aquatic plants supply themselves with this nutritional element essentially from the different inorganic carbon compounds in water (CO_2 = carbon dioxide, H_2CO_3 = carbonic acid, HCO_3^- = hydrogen carbonate, CO_3^{2-} = carbonation, $\text{Ca}(\text{HCO}_3)_2$ = calcium hydrogen carbonate).

Carbon dioxide, which transforms to carbonic acid by combining with water, constitutes one of the most essential nutrients for the plant's photosynthesis. With a low pH-value there are predominantly both free carbon dioxide and carbonic acid present. If carbon dioxide is extracted from the aquarium water through the plants' assimilation process this will—next to other factors, for example, the fish's respiration—result in an increase in the pH-value. As soon as the free carbon dioxide in the water has been exhausted, the plants will behave very differently. Whereas in some species growth will cease (for example, in all *Fontinalis antipyretica* studied so far), other aquarium plants are able to also assimilate and utilize the hydrogen carbonate ions (biogenic decalcification), resulting in a fur-

ther increase in the pH-value. The outcome is a precipitation of the insoluble calcium carbonate (CaCO_3) which becomes visible by the lime crusts on the plants' leaf surfaces. Scientific research has proven that the pH-value can be increased to about 11 through the consumption of hydrogen carbonate ions by aquatic plants. Many species that depend on the supply of free carbon dioxide, will, however, cease their growth already at an earlier stage. Previous failures in the cultivation of rare species adapted to specific living conditions possibly have their cause in this.

Numerous studies of natural biotopes show that most aquarium plants live in a weak acid, calcium- and salt-deficient water which contains a sufficient supply of free carbon dioxide and carbonic acid. Even though many of these plants are adaptable within certain limitations and have a relatively wide pH-tolerance, they probably still prefer an environment as described above. Other aquatic plants, however, due to their extreme dependency on free carbon dioxide, are not, or are only to a limited degree, able to extract hydrogen carbonate from the water. For their photosynthesis a sufficient supply of free carbon dioxide, above all, is essential in the aquarium. Only a relatively small number of tropical aquatic plants populate natural habitats with calcium-rich water and an alkaline pH-value. Plants in these waters are generally characterized by their ability—during photosynthesis—to additionally extract the necessary carbon dioxide from the present calcium hydrogen carbonate ions. The consequence from these chemical-biological connections, which result from numerous biotope and laboratory studies, is the necessity to set and adjust a pH-value in the aquarium which can meet the different requirements of the largest number of plants possible. Such a pH-value should lie roughly in the range between 6.2 and 7.2.

Strongly assimilating aquarium plants consume a lot of CO_2 which is why it is often necessary to add this nutrient and furthermore

to maintain the pH-value in the above range. To enable fertilization with CO_2 , dealers offer different apparatus. It has to be stressed, however, that a necessity for additional CO_2 supply is given only when the aquarium is densely planted as well as illuminated and the natural production of carbon dioxide, e.g., through the respiration of the fish and oxidation processes, is insufficient for the nutritional upkeep of the plants, which is indicated by a calcium-lime precipitation. Regular testing and control of the pH-value demonstrate the value of CO_2 fertilization. It is important to know in this context that high concentrations of carbon dioxide are toxic for fish and that there also are fish species that cannot handle low pH-values. Regular measurements using CO_2 tests (follow instructions issued by the manufacturer) are, therefore, essential in maintaining an optimum CO_2 content.

However, for the cultivation of aquarium plants, not only familiarity with the interrelationship between pH-value and the water's carbon dioxide content is important, but also the connection between carbonate hardness (also referred to as alkalinity or acid-binding capability) and carbon dioxide. The higher carbonate hardness the more carbon dioxide is required to maintain the calcium hydrogen carbonate in soluble form, in other words to prevent the precipitation of lime. For this reason it is often useful to remove the mostly high carbonate hardness from the tap water. For instance, partial desalination through a weak acid cationic exchanger or full desalination is recommended. The treated water can be balanced to a favorable pH-value between 2 and 8 °dH by mixing it with tap water. Aquarium water with an even lower carbonate hardness has a very low pH stability and is primarily required for the breeding of some soft water fish species, but not for the cultivation of most aquarium plants. Waters with a carbonate hardness above 15 °dH generally constitute an unfavorable living environment for optimum plant growth because the pH-

value can only be adjusted to a small degree due to its high stability.

THE SUPPLY OF NUTRIENTS IN THE AQUARIUM

Always typical of natural waters with rich plant populations is the presence of all the vital nutrients important for growth. If even a single nutrient is missing or is present in insufficient supply it will, according to Liebig's Minimum Law (1855), constitute the one growth-impeding factor. In contrast to natural water, tap water contains many of the essential nutrients for plants—such as iron, potassium, manganese, sodium, etc.—in inadequate quantities or not at all. Other nutrient components, on the other hand, like nitrogen and phosphorus, are present in mostly high concentrations. Therefore, it is occasionally necessary to add fertilizer to the aquarium water which contains all available nutrients for plant growth in a favorable combination. Furthermore, it is occasionally necessary to remove existing deficiencies—e.g., iron deficiency—through a special fertilizer containing trace elements. Because the range of commercially available fertilizers is large, a specific recommendation cannot be given. Basically, though, the application of such preparations should be done carefully and sparingly. Initially a dose smaller than that recommended by the manufacturer should be administered and the reaction monitored. An excessive supply of nutrients often leads to a catastrophic growth of algae.

Finally, it should not be forgotten that nutrients are absorbed in different quantities and composition by every plant species. To determine the nutrient requirements of a specific aquarium plant, scientific laboratory experiments are necessary, which until now, had mostly not been conducted. The results could form the basis for an optimal nutrient supply (which until now has been impossible to precisely target) and facilitate the easier detec-

tion of occurring deficiency symptoms in aquarium plants. A forward-looking and progressive aquaristics is called upon to confront such questions with more vigor.

WATER CIRCULATION

As explained in detail on pp. 14–16, water movement has an important function for the plants' photosynthesis. For this reason—and contrary to all other recommendations—care has to be taken that sufficient water movement is provided in planted aquariums. It becomes especially important when the aquarium is only thinly populated by fish and water circulation stagnates. Attention also has to be paid to the fact that, regarding water movement, the requirements of individual aquarium plants differ widely as well. Conclusions can be drawn from ecological data found in the descriptions of the individual species.

The required water movement is generally best achieved through the use of a filter with a low to medium output. In aquariums of more than 500 L contents, the installation of two filters is recommended, one of which runs very slowly and functions on a biological basis, whereas the second one primarily looks after the mechanical cleaning of the water and at the same time results in good water circulation. Switching off the filter overnight, as is occasionally recommended, not only constitutes animal torture due to a rapidly developing oxygen deficiency, especially in densely planted aquariums, but also has negative effects on the gas exchange and plant metabolism due to the stagnation of the water.

THE IMPORTANCE OF OXYGEN

It is undisputed that oxygen has an important function in the aquarium. In the aquarium oxygen producers stand opposite oxygen consumers, the latter including mainly the plants during the dark phase as well as all

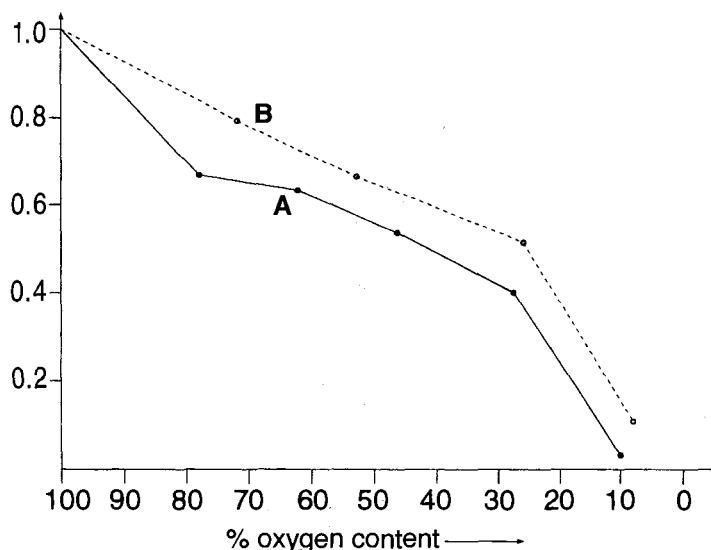


Diagram 3 Relative respiration intensity in higher aquatic plants under conditions of a decreasing oxygen content. A. *Fontinalis antipyretica*; B. *Lagarosiphon major* (according to Gessner and Pannier 1959).

microorganisms. The share of the oxygen consumed by fish is, in contrast, comparatively negligible. During the day the aquarium's oxygen content will increase essentially as a result of the plants' assimilatory activity and will peak in the evening. Furthermore, oxygen absorption by the water through movement on the water surface can occur. As a result of intensive assimilation by the plants, an occasional high over-saturation of the water by several hundred percent can take place. For example, the author registered an oxygen content of 198% in a pond densely populated with *Elodea canadensis*. This value, however, indicates an imbalance, namely the fact that the formation of assimilatory oxygen takes place quicker in water than the oxygen release into the atmosphere and the oxygen consumption by the organisms in the water. Such an over-saturation is, however, never achieved in an aquarium.

The organisms' oxygen needs increase with temperature because the respiration in-

tensity also increases with temperature. On the other hand the saturation value of oxygen in water is highly dependent on temperature. This saturation value registers at 9.4 mg/L at 20 °C, 8.6 mg/L at 25 °C and –8.0 mg/L at 30 °C.

Since the mid 1980s the importance of oxygen in the aquarium and its effect on plant growth has and is being controversially debated. One specific author repeatedly voiced a certain unsupportable opinion, even though numerous experts have countered with convincing arguments on many occasions. Still this author has continued to repeat this dubious and dangerous thesis even in most recent times (Krause and others 1990) in magazine articles and books in a rather stubborn way. In the following I would like to outline the most important arguments and statements he used in support of his thesis:

A low oxygen content apparently considerably enhances growth in submersed aquatic plants and also is the most conspicuous fea-

ture of aquariums with a prospering plant population. In aquariums with a high oxygen content nutrient gaps and growth stagnation are very likely to occur. Aquariums with well-growing plants will regularly show a very low oxygen content between 3 and 4 mg/L (mornings) and 6 mg/L (evenings). An oxygen content that does not exceed 5 mg/L in the evening is targeted because plants can suffer under a high oxygen content. If the oxygen content is above the value it is recommended to let the filter run more slowly, to reduce light intensity, to generously feed and to plant more densely in order to enhance mutual shading. This author has discovered through testing of her own that tropical plant biotopes regularly display low oxygen contents (between 3.5 and 5.5 mg/L). He further stipulates that most aquarium fish are accustomed to surprisingly low oxygen content. Lush populations of aquatic plants in nature are, according to him, mostly coupled to the outflow of groundwater because the cause lies in the high nutrient supply of the nearly oxygen-free groundwater. Sensitive nutrition gaps form downstream which prevent further plant growth. So much for a brief summary of the most important assertions.

In the following, counter-arguments are given that will contradict these assumptions. They are, for one, based on secure scientific data as well as on numerous tests which were conducted in aquariums as well as many natural habitats by several authors, including this author. Furthermore, the effects of a targeted increase in the oxygen content, effected by oxidators, on plant growth in the aquarium was observed over a period of many years.

The counter-arguments:

- Scientifically conducted studies on numerous aquatic plants show that the respiratory intensity of higher aquatic plants is dependent on the water's oxygen content. Their respiration will drop off when the oxygen content drops, whereas water over-saturated with oxygen will lead to a distinct increase in respiration on the part of the aquatic plants (Gessner 1959). The respiration of the roots behaves likewise for which the oxygen content can quickly turn into a limiting factor which is why good aeration of the substrate (not only with terrestrial plants but also with most aquatic plants) has to be ensured. Since the respiration intensity of a plant is an indicator for its metabolism, i.e., also for its speed of growth, a high oxygen content in the aquarium water will have a favorable effect.
- The assertion that tropical plant biotopes are mostly oxygen-deficient is incorrect. Numerous tests have shown that natural waters with dense plant growth can display not only a low but also a very high oxygen content which lies above saturation (between 4 and 14 mg/L, in black water streams also between 2.3 and 3.5 mg/L, see also Horst 1986). Furthermore, the assertion that especially lush plant growth is mostly coupled to groundwater sources has to be firmly contradicted. The author observed countless biotopes without groundwater sources, e.g., small temporary waterways featuring dense plant populations or rivers which displayed a continuous, massive presence of aquatic and marsh plants over a distance of several kilometers.
- During the dark phase plants are reliant on an external oxygen supply. If the oxygen content of the aquarium is very low overnight, it can drop to levels not only fatal for fish, but also have a negative impact on the growth of plants due to reduced respiration.
- Due to their strong assimilation a high oxygen concentration will always be the result of many fast-growing plants in the aquarium; the latter can be considered a

barometer for an optimum aquarium. Oxygen readings in so-called "Dutch aquariums," famous for their excellent plant growth, show—under conditions of a normal technical input but intensive lighting and CO₂ fertilization—an increase in the oxygen content of about 70% in the morning to up to 130% saturation in the evening. With these observations, though, it has to be differentiated and taken into consideration that the differing growth speed of the individual plant species influences the oxygen content in varying degrees. An aquarium with predominantly slow-growing species will display a lower oxygen production than one featuring exclusively fast-growing species.

- Nutrient deficiency can occur both with lower as well as higher oxygen values. The oxygen content of several aquariums was artificially increased by using oxidators. The aquariums were then observed over several years. Not only was a visibly improved plant growth registered but another positive side effect developed, namely the growth of blue-green algae being completely terminated in a few cases. This context is clearcut; the reasons for it, though, remain unexplained. In the studied aquariums only an occasional fertilization (every 4 weeks at the most) was necessary, and not as a consequence of nutrient oxidation but because of an increased nutrient consumption due to the strong growth of the plants.
- A reduction of precipitated nutrients as well as an improved availability of plant nutrients will only occur under oxygen values so low that they are dangerous and often fatal for all the aquarium's organisms. Today's fertilizers for aquatic plants contain chelating agents (complexing agents) which bind slightly oxidating nutrients.
- It has been scientifically proven for many years that a high oxygen content in water

has a directly enhancing influence on plant growth and is an important factor for the propagation and biotope attachment of individual species. The occurrence of species from the Podostemaceae and Hydrostachyaceae families is, for example, restricted to tropical waterfalls because their respiration intensity and their oxygen requirements are exceptionally high. The plants will die if oxygen values are too low, the most important cause for the failure of cultivation experiments in the aquarium. *Aponogeton madagascariensis* (Kiener 1963), too, only grows in clear, fast-flowing waters and not in stagnant ones because of its high oxygen needs. It can be assumed that many aquatic plants preferring to live in rapid-flowing water also display this biotope attachment or link due to their high oxygen requirements.

The following point also underlines the necessity for a high oxygen content in the aquarium:

The oxygen content of water is of fundamental importance for the activity and reproduction of microorganisms (e.g., bacteria) since these are responsible for the self-cleaning process of waters (oxidation of toxic substances to nontoxic end products). With an increasing O₂ content their reproduction rate will also increase and with it oxygen absorption as well. In a high oxygen content environment in an aquarium, plant and animal waste products (fish feces, food scraps, and dead plant matter) are thus oxidated more rapidly to form nontoxic substances. A high oxygen content is, therefore, desirable.

All consumers of oxygen in the aquarium (plants, fish, microorganisms, etc.) produce carbon dioxide, one of the most important nutrients for plant growth. A high oxygen consumption, however, is only made possible by a high oxygen content. High oxygen usage improves not only the nutrient climate but simultaneously leads to a reduction of the

pH-value which is generally desirable in most instances.

There are, however, a few fish species where it was proven that they do exist in a low oxygen environment. But since a variety of fish species are kept in the aquarium the oxygen level has to conform to the highest requirements and not the lowest. When oxygen content is too low it creates stress conditions for many fish and has to be interpreted as animal cruelty. A sudden filter breakdown will then quickly lead to the fish's demise.

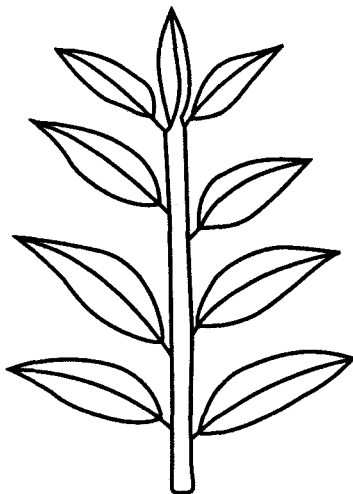
CONCLUSION

The oxygen content of water exerts an important influence on the life of plants, animals and microorganisms because it quite often constitutes the deciding factor for their survival. Through optimal plant growth oxygen values of up to 130% of saturation can be registered in the aquarium. This value represents a level which is not damaging to fish or plant growth. On the contrary, it is scientifically indisputable that a high oxygen con-

tent has a positive effect on all forms of life in the aquarium and that an extremely low oxygen level in water is always an indicator for a negative, harmful environment.

A high oxygen content in a plant aquarium requires a resupply of nutrients more often. This resupply, however, is conditional on the optimal thriving of the plants, which results in an increased nutrient consumption, and to a lesser extent on the precipitation of nutrients.

Oxygen reduction always entails a deterioration in the environmental conditions of all organisms. Therefore, all measures taken to intentionally reduce the oxygen level are dangerous, unbiological and are to be rejected outright. A stable oxygen content must be aimed for, with minimum levels of 5 mg/L in the mornings and 8.6 mg/L in the evenings, which corresponds to about 60 and 100% saturation at 25 °C. This high oxygen content can primarily be achieved through the optimum assimilation of the plants. Other supporting measures are, for example, the removal of dying and decaying plant matter, a regular water exchange, etc.



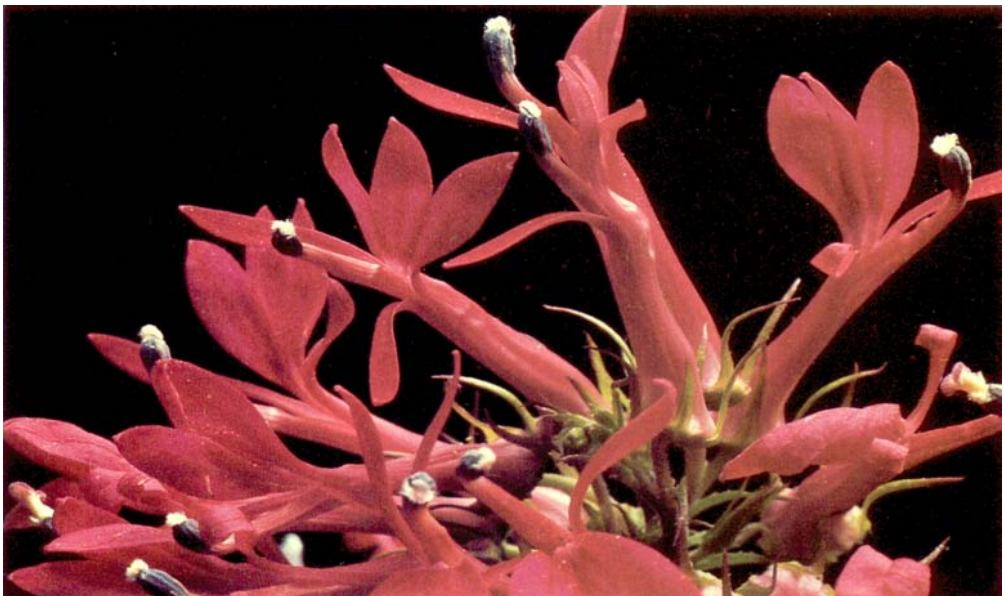
Flower Morphology

It has become increasingly evident over the last couple of years that the general interest shown by aquarists in plant biology and flower morphology has increased strongly. This is due to a variety of reasons. Flower formation is, on the one hand, seen as the ultimate crowning achievement of a successful cultivation process. Flower characteristics, on the other hand, also constitute indispensable identification aids. The following chapter is designed to provide the reader with a simple description of the flower structure and different forms of inflorescence, essential for a wider understanding of the subject.

Flower Structure

Complete flowers consist of sepals, petals, stamens as well as carpels. Sepals, which are usually of a green color, primarily serve to protect the internal flower organs during the budding stage. Petals are usually very conspicuous in form and color, thus functioning as a lure for pollinating insects. Calyx and corolla together form the perianth. If sepals and petals are similar in structure the perianth is called perigon and its constituting parts are referred to as tepals (e.g., in *Aponogeton*). In a gamophyllous corolla one differentiates be-

Flowers of *Lobelia cardinalis* are especially conspicuous in their coloration.



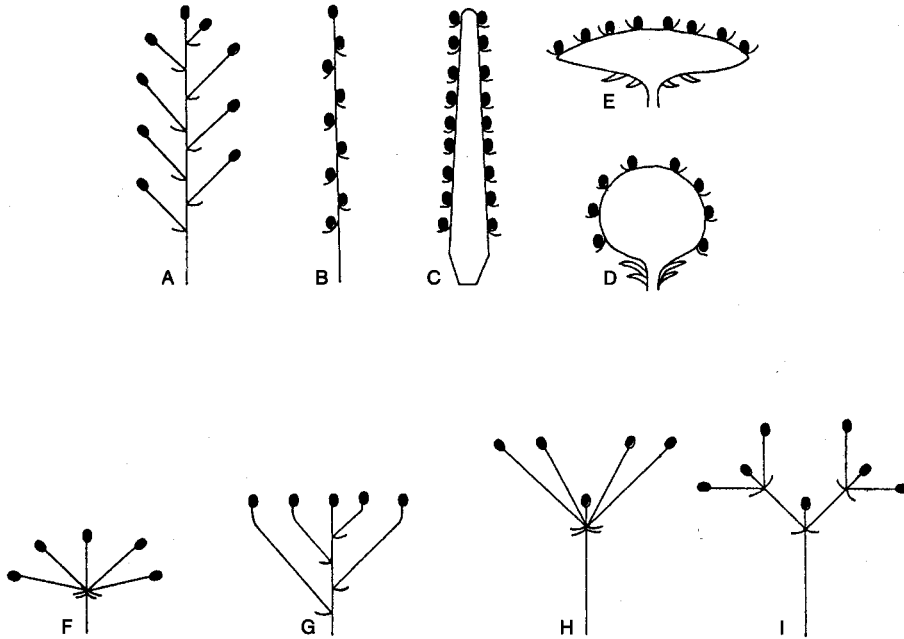


Diagram 4 Simple inflorescences. A = raceme, B = spike, C = spadix, D = capitulum, E = calathium, F = umbel, G = umbelliferous raceme, H = pleichoasium, I = dichasium.

tween the tube, the edge, which is often partitioned into sections, and the throat (e.g., in *Bacopa*, *Lindernia*, and *Hemianthus*). Sepals as well as petals can be free or adnate. The stamens are made up of the filament and the

anther. The latter is divided into two compartments (thecae), each theca again being partitioned into two pollen sacs in which the pollen is produced. The two thecae are linked through a connecting piece (connective) to which the filament is attached. In the interior of the flower we find the pistil which in turn consists of the ovary, the style and the stigma. The ovary accommodates the ovules which will develop into seeds after fertilization. The ovary will then swell and the fruit will begin to form.

Flowers which have the full complement of reproductive organs—including stamens and carpels—are referred to as being *bisexual*. If either stamens or carpels are absent the flower is referred to as being *unisexual*. In this case flowers are *male* (without carpels) and *female* (without stamens). Usually both male and female flowers are found on one and the same plant, which is then called *monoecious* (e.g., *Cryptocoryne*). If, however, they

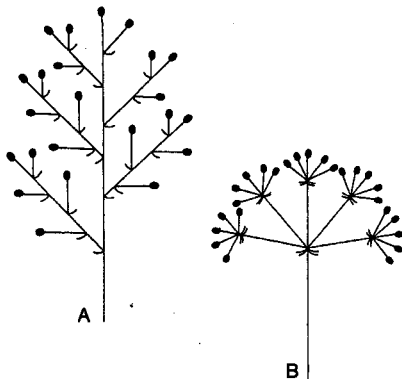


Diagram 5 Composite inflorescences. A = panicle, B = compound/composite umbel.

are distributed over different plants, they are called *dioecious* species (e.g., *Vallisneria*).

Forms of Inflorescence

In most instances several flowers are united in forming inflorescences, only occasionally are they arranged individually. One differentiates between *racemic inflorescences*, featuring one main axis, and *cymose inflorescences* with several axes.

The *raceme* belongs to the category of racemic inflorescences in which petiolate flowers of roughly the same length are arranged on one main axis. In contrast to the raceme the *spike* features sessile flowers, from which the *spadix* can be distinguished by a thickened main axis. A shortening of the main axis leads to a capitulum, also called calathium, when it is a lot wider and surrounded by involucre leaves. A raceme in which all

flowers are roughly found at the same height, is called a *corymb*. In contrast a shortened main axis results in an *umbel* if all solitary flowers are petiolate and stem from one central point in a radial way. Through the branching of the side axes the raceme becomes a *panicle*. This is called a *corymbose cyme* if all flowers are located on the same level. If, in an umbel, all solitary flowers are exchanged for umbels, the result is referred to as a *compound umbel*. A *compound spike* exists when the side axes display the shape of spikes.

In *cymose inflorescences* the main axis ends with a terminal flower and is also shorter than the side axes which originate at a point below and are able to branch out.

Depending on the number of side axes one differentiates between other forms of inflorescence: *monochasium* with one side axis, *dichasium* with two side axes, and *pleiochasium* (often referred to as cyme) featuring more than two side axes.

Flowers of *Utricularia foliosa* are set in a raceme.



Flower Biology

The flower biology of many aquatic plants is unique within the flora. The following chapter is designed to provide an insight into the often fascinating pollination mechanisms and also to be an incentive to delve further into this very interesting topic.

Pollination by Animals, Wind, Water

Pollination is defined as the transfer of the pollen onto the stigma of the carpels. It generally occurs through animals as well as wind or water. If a flower is pollinated with pollen from another flower *cross-fertilization* takes place. *Self-pollination* occurs if a flower is pollinated by its own pollen or by pollen from the same plant.

Flowers are commonly pollinated by insects such as bees, butterflies, and others (*zoidiogamy*). They are attracted by the color of the flowers and conspicuously shaped floral organs (visual stimulants) as well as odorous substances. When visiting a flower insects will, in most cases, discover pollen and nectar, which serve as nutrition, thereby quite unintentionally conducting pollination.

Anemogamy or *wind pollination* is another frequent occurrence in the plant world during which pollen is transported through wind. A prerequisite for this method is, for example, a smooth and dry pollen which has to be produced in large quantities in order to ensure that pollination takes place.

In most aquarium plants, the majority of which are marsh plants and flowers or inflo-

rescences which are formed outside the water, pollination occurs through insects and/or wind. The author was able to observe butterflies, flies, beetles and bees during pollination of the *Echinodorus*, *Nymphaea* and *Sagittaria* genera in their native habitats. Interesting, too, is the impressive pollination mechanism of *Victoria amazonica*. If one opens a white, day-old flower at the natural location in the Amazon region (on the second day it will have turned a deep red), one will often find large beetles within them. These are attracted by odorous substances, the conspicuously white flower color as well as a temperature higher by about 10 °C (due to increased respiration) compared to the surrounding temperature. They enter the flower on the first evening once it has opened. Because the flower closes during the day, thereby trapping the beetles inside, they are only able to continue on to another flower the next evening, where they will deposit the foreign, imported pollen onto the stigma. Cross-pollination thus takes place, because the stigma will only be receptive to pollen during the first night. The pollen of its own flower will only mature when the stigma have again lost their susceptibility.

In some "genuine" aquatic plants, e.g., *Potamogeton* and *Myriophyllum*, which form their inflorescences close above the water surface, wind pollination will often occur in their natural environment. It is worth noting that flowers and inflorescences in such species are very inconspicuous and far less specifically shaped than plants reliant on pollination through insects, as is the case in the *Nuphar* and *Nymphaea* genera.

Pollination through water (hydrophily) occurs in very few aquatic plants. Adaptation to this medium developed in the course of evolution in the form of a strong specialization, which is specifically evident in the fact that luring and stimulation features (such as flower color, shape, and size) as well as the number of flowers and floral organs are very limited or reduced. Occasionally the flowers don't even disseminate odorous substances; they have entirely lost their function as instruments of attraction for insects.

Only in a few aquatic plants, e.g., *Ceratophyllum* and *Najas*, is the pollen floating in water actually transported by water to the (female) stigma. The perianth in these species is either greatly reduced (*Ceratophyllum*) or entirely absent (*Najas*). In other aquatic

plants the water only serves as a method of transportation for the pollen or the male flowers which float on the water surface and are driven to the female stigma by wind. In some species, which raise their unisexual flowers above the water surface, pollination occasionally also takes place through rain-water.

During cultivation of aquarium plants in paludariums or in greenhouses the natural pollinating agents will usually be absent so that artificial pollination has to be conducted in order to achieve seed development. Transmission of pollen is easily completed using a fine brush or finger. In some *Aponogeton* seed formation was also achieved through the use of fruit flies which were encased in a plastic bag over the inflorescence.

The flowers of *Victoria amazonica* are pollinated by large beetles (photographed on the Amazon near Manaus).



Flower Biology in Hydrocharitaceae

Unique in our flora is the secretive flower biology within the Hydrocharitaceae family, well-known to aquarists through the genera *Egeria*, *Elodea*, *Hydrilla*, *Lagarosiphon*, *Ottelia*, and *Vallisneria*. Within the 16 genera and more than 100 species, which are exclusively aquatic plants, one will discover entirely different mechanisms of pollination, the research and study of which has not been completed to this day.

The regularly noticeable unisexuality of the flowers and the often occurring dioecious plants are conspicuous. There are, however, also species which are either male or female

or even display bisexual flowers, as is the case in *Ottelia alismoides*. It is interesting to note that despite a considerable reduction in the flower organs the flowers of some species still have the ability to perform pollination and produce seeds (cleistogamous), even though the flowers do not open under water.

The appearance of cleistogamous flowers in *Ottelia alismoides* and *Blyxa aubertii* is well-known to aquarists, but also in other species in other genera, e.g., *Barclaya longifolia* (Nymphaeaceae).

Many flowers within Hydrocharitaceae are comparatively small and inconspicuous. They are nevertheless visited regularly by insects which are lured by odorous scents leading them to trigger pollination. The insects are often rewarded with nectar which is secreted

The conspicuous coloration of *Nymphaea rubra* flowers, found in a thermal lake near Héviz (Hungary), serves to lure insects.



by special glands. Sometimes, though, e.g., within the species belonging to the *Blyxa* genus, insects are not attracted or rewarded with any nectar.

In nearly all Hydrocharitaceae the visit by insects plays a vital role in the pollination process. Substantiated observations, though, regarding the species of the pollinating insects are only available for a few plants. Occasionally small flies were seen to visit the flowers of various species. The only species within this cognate circle which are pollinated through the wind, and not insects, are *Limnobium spongia* and *L. laevigatum*, this fact having been established through observations during cultivation and in the plants' native habitats.

A pointer to wind pollination occurring in these species is also the absence of odorous substances and nectar, as well as a very dry pollen which is easily transported and carried away by wind movement.

The flowers in Hydrocharitaceae are very delicate. To prevent them from being destroyed by wave movement the plants have specifically adapted to the medium water and developed special features. If, for instance, the female flowers of *Hydrilla verticillata* are submersed by water, the petals will close and the stigma will remain dry due to an enclosed air bubble. In *Egeria* the flowers are lifted above the water surface if water movement is very strong.

Within the Hydrocharitaceae family only few species utilize water as a method of transport to perform pollination. In *Elodea* the unmoistened pollen floats on the water surface and is carried by water movement to the female flowers which also float on the water surface. The female flower is surrounded by a small depression which helps in attracting male pollen.

In the well-known genera *Vallisneria* and *Lagarosiphon* the male flowers themselves constitute the method of transportation and transmit the pollen directly onto the stigma

belonging to the female flowers floating on the water. Water is indirectly part of the pollination procedure. In *Vallisneria* var. *americana*, a multitude of male flowers is released from a short spathe which then rises to the water surface as buds. There they will open, their tepals bending back, with the male flowers now being driven by water movement towards the female flowers. The female flowers float individually on the water surface on a long, spirally twisted pedicel. Because the stigma are arranged sideways, they are unreachable for the pollen. Only under the water's wave movement will the pollen access the stigma.

As outlined for *Vallisneria* the male flowers of the *Lagarosiphon* genus float on the reflexed tepals on the water surface. Three fertile stamen are horizontally arranged; three staminodes (sterile stamen) in an upright position form a "sail." Using this they drift towards the female flowers which lie slightly depressed (or in a small depression) on the water surface and thereby transmit the pollen onto the stigma.

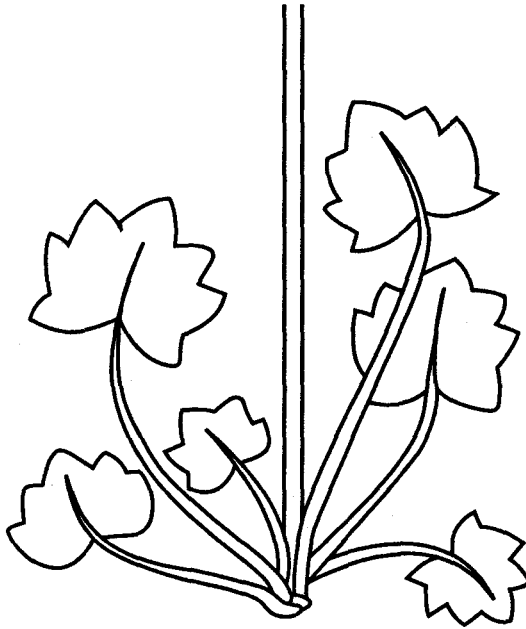
Among aquatic plants the pollination mechanisms of the monotypic genus *Hydrilla* are unique, which is why they are worth being mentioned here as well. Each male spathe contains only one male flower. To mature the spathe will break open; the gas-filled bud will rise to the water surface and will float on the water for about 1.5 hours. It then opens abruptly through an interesting unfolding mechanism and flings its pollen in a radius of about 20 cm. The female flower will form a broad funnel on the water surface, which is positioned in such a way that only the top edges touch the water surface. The interior of this funnel contains the stigma. If the pollen is then thrust out of the anther of the male flower, a part of it will fall directly into the funnel of the female flower and is thereby transmitted to the stigma.

Even though the Hydrocharitaceae have developed very complicated pollination mech-

anisms, fruit are only rarely found in their natural habitats, which is generally due to the irregular distribution of the sexes.

The fascinating pollination mechanisms of Hydrocharitaceae described above are, in part, even more complicated than in the brief

description given. Further study of this interesting topic can provide a more detailed insight into the secretive diversity of the flower biology of aquatic plants. Publications by C.D.K. Cook (1982 and 1994/1995) are highly recommended for further reading.



Sexual Propagation of Aquarium Plants

Sexual propagation is understood to mean reproduction by sexual means, occurring through seeds in flowering plants as well as other higher plants. Prerequisites for sexual propagation are flower formation, pollination, fertilization, as well as the production of fruits and seeds (refer also to the chapters “Flower Morphology” and “Flower Biology”).

Even though there are only a few aquarium plants that occasionally produce flowers in submersed cultivation, and propagation through seeds is predominantly conducted by aquatic plant nurseries, the topic of sexual propagation deserves a short chapter, especially due to the fact that some plants only reproduce sexually.

Sowing and Growing

The most important prerequisites for successful sexual propagation to take place are, obviously, mature and germinable seeds. The right point in time for the harvest of seeds is usually when the fruits open up and release the mostly brown seeds. For a variety of reasons an immediate sowing is sometimes undesirable. In such cases it is essential to know how long the seeds will retain their germinability. For many aquarium plants there is, however, insufficient information available about this. Comparative studies putting the age of the seeds in relation to the germination rate are so far unknown for aquarium plants. It is known that, for example, in some *Echinodorus* species, several seeds many years old are still germinable. In contrast, the

seeds or fruits of *Aponogeton* and *Cryptocoryne* species will float for a short time on the water surface, where they will basically germinate immediately, otherwise losing their germinability rather quickly. Temperature, too, is a major factor for germination. In aquarium plants tropical temperatures of 30 °C and higher will often lead to higher germination rates than lower temperatures.

It seems surprising with the multitude of aquarium plants that fruit formation in cleistogamous flowers can only be seen in very few species. Aquarists are most familiar with the formation of fruit in *Barclaya longifolia* and *Ottelia alismoides*, but it also occurs in *Blyxa*, *Hydrothrix* and often in *Ludwigia* species. In *Barclaya* and *Ottelia* the mature fruit will suddenly burst open, with the seeds dispersing throughout the aquarium, where they will usually fail to germinate due to insufficient light. With the aid of a nylon stocking slipped over the fruit, the mature seeds can be easily collected in order to conduct controlled sowing at a later stage. This method can, of course, also be used for other species, e.g., *Aponogeton crispus*.

There are several different methods to perform sowing. In marsh plants the seeds are usually sown in moist soil and under conditions of high humidity. The substrate can also consist of a different soil if this contains sufficient nutrients. Good lighting is also essential. The seeds from aquatic plants are left to germinate in water. The mature seeds from *Barclaya* and *Ottelia*, for example, will develop roots and leaves after only a few days in water. The embryos are then set into small pots or bowls containing a loam-sand mixture

and introduced into water under good lighting. With a little care a small pot can also be located on the aquarium's edge. This pot is covered with gauze or any other wide-meshed fabric to avoid snails and fish damaging the very tender and delicate small plants. With increasing plant size the gauze can be removed. After several weeks it can often be noted that the growth of the juvenile plants suddenly stagnates, possibly due to nutrient deficiency. In such cases the author was able to restimulate growth by removing the plants from the substrate and after trimming the roots, replanting them in a different location.

The sowing and growing of juvenile plants through seeds is generally protracted, laborious and rarely pays off in the end. For these reasons sexual propagation is used by aquatic plant nurseries in only a few species. It is, however, useful in cases where vegetative propagation is possible only in insufficient

quantities, or where reproduction is possible only through seeds (e.g., *Aponogeton*).

Cultivation of Aquarium Plants

Cultivation of aquarium plants is defined as a process of selection of variations which are genetically different. The aim of the cultivation of aquarium plants is to obtain new plants for aquaristic purposes which are conspicuously different in their coloration and appearance from the original species. In addition improved growth performance is desired. Such methods are well established in the cultivation of ornamental and useful plants; they are, however, relatively new in aquaristics. Often genetically different parent plants are used in the cultivation of hybrids

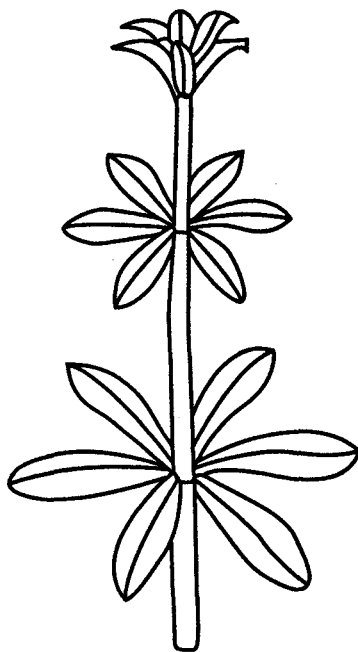
Breeding of *Isoetes velata* var. *sicula* through spores.



(well-known in *Echinodorus*). Furthermore, new plants can also be produced and selected through natural or induced mutation. *Cabomba caroliniana* 'Silver-Green' and *Echinodorus schlueteri* 'Leopard' have, for example, come about through incidental mutation.

Cross productions should be clearly marked as such by a multiplication symbol (×). The

introduction of a cultivar name is also possible. A prerequisite for the introduction of a cultivar, though, is the genetic consistency of a plant, i.e., the transfer of all features from one generation to the next must be guaranteed. Cultivar names must be drawn from a living language and enclosed in single quotation marks.



Vegetative Propagation of Aquarium Plants

Vegetative propagation means reproduction by nonsexual means. In the following chapter different methods of reproduction will be described which are part of the daily practice of aquarium maintenance and which can also easily be performed by the layman without the use of any extra facilities.

Cuttings

A large number of aquarium plants form creeping or upright growing shoots. These stem plants can be split up into stem axis (stem) nodes, on which the leaves are arranged in differing phyllotaxis and internodes. Most stem plants are characterized in the aquarium by a very high degree of lateral branching which has its origin in the leaf axils. These lateral branches can be cut off and used as cuttings so that reproduction in general does not pose a problem. *Ludwigia* and *Hygrophila* species, for example, but quite a few other aquarium plants, too, count among those species featuring an intensive formation of lateral shoots.

The group of stem plants, however, also contains species that only develop lateral shoots but where, at the same time, a more intense reproduction is desired. To enhance the development of lateral shoots the strong stems can be cut into segments (part or shoot cuttings) each featuring two to four nodes. When partitioning the plant it is best to use a scissors or knife to cut just below the node where root formation will occur later on. Leaves are also removed from this node in order to prevent rotting in the substrate. The

stem tip of the parent plant will continue to grow unbranched as a cutting. The remaining part cuttings are planted into the substrate where, after only a few days, they will generally form adventitious shoots usually at the highest node.

Trimming stem plants that have grown too high can be done easily in the aquarium. The shoot tip is severed and again planted; the rest of the stem can also be segmented or can remain in the soil where it will again branch out.

Species of the *Ceratophyllum*, *Egeria*, *Elo-dea*, *Hydrilla*, *Lagarosiphon* and *Najas* genera mostly grow below the water surface in their natural habitats and form no roots or only a few roots which they use to anchor themselves in the soil. Flooding growth causes the shoots to tend to branch out a lot, and they will reproduce through fragmentation (separation into part segments), so that vegetative propagation of the species mentioned is not complicated.

Runners

Reproduction through scions, too, which occurs on more or less long runners (lateral shoots with extended internodes) of strong parent plants, is of great relevance in aquaristics. Cryptocorynes, small-growing *Echinodorus* species as well as representatives of the *Vallisneria* and *Sagittaria* genera produce scions. Some floating plants, too, reproduce in this way. Known examples for an especially productive propagation are *Eichhornia*

crassipes and *Pistia stratiotes*, but also *Trapa natans*, *Hydrocleys* and *Limnobium* species.

Propagation through scions rarely poses problems for the aquarist. Care must be taken, though, to ensure that the scions are not severed too early from the parent plant because this would lead to no or at least stunted growth. Whereas *Cryptocorynes* should be disrupted as little as possible in their growth, thinning out dense populations and replanting scions becomes necessary in *Echinodorus* and *Sagittaria* species.

Division

Numerous aquarium plants develop a more or less thickened rhizome, i.e., a rhizome which enables the survival of a disadvantageous vegetation period in natural habitats by acting as a storage organ. The rhizome in *Anubias barteri*, for example, is very long, comparatively thin and branches regularly. In contrast the rhizomes of the large-growing *Echinodorus* species are conspicuously thick, only a few centimeters long and a branching can only occasionally be seen in strong parent plants. To increase the reproduction rate long rhizomes may be divided using a sharp knife into 2–3-cm long segments which should display several plumules, if at all possible. These rhizome segments can float freely on the aquarium's water surface under intensive lighting until new plants develop from the dormant buds.

Propagation through the division of rhizomes is relatively productive in *Anubias* species; in *Echinodorus* species, however, it will not always be successful.

Adventitious Plants

The formation of adventitious plants on leaves, petioles, roots and inflorescences of the parent plant is well-known to aquarists.

Propagules on the margins can often be seen in ferns such as *Ceratopteris* and *Microsorium*, whereas in pond lilies, such as *Nymphaea micrantha* and *Nymphaea* × *daubenyana*, they are found on the leaf base, ensuring easy vegetative propagation in these species. In *Microsorium* shoots will also form in large quantities on the roots hanging in the water.

Detached leaves floating on the water surface will form adventitious plants at the fractures, which can be severed after attaining a sufficient size, e.g., in *Hygrophila* species, *Gymnocoronis spilanthoides* and others. Some species, for example *Samolus valerandi*, *Rorippa aquatica* and *Physostegia purpurea*, develop leaf axillary plants on the peduncles.

Especially important for a productive propagation is the formation of adventitious plants on the inflorescences of many *Echinodorus* species. Depending on the individual species these will form in differing quantities on the whorls (refer also to the induction of flowering in *Echinodorus* species on pp. 239–240). If peduncles form underwater on sword plants, it is recommended to press these below the surface, despite their attempt to protrude the water surface. The formation of adventitious plants will then usually occur quicker and more intensely than when above water where

Today many aquarium plants are being cultivated through tissue culture.



the plant offspring can easily dry out and not form any roots due to usually low temperatures and low humidity. After reaching a size of about 5 cm and producing a few roots, the adventitious plants may be severed and replanted.

Of the family of Aponogetonaceae, only *Aponogeton undulatus* displays this unusual vegetative propagation through propagules which are formed instead of the rare inflorescences.

Bulbils and Brood Tubers

Reproduction through bulbils and brood tubers is very common in the cultivation of ornamental and useful plants. Among aquarium plants tubers are known to occur only in the species belonging to the *Aponogeton* genus; in most cases, though, they are incapable of producing brood tubers.

Bulbils are occasionally formed on strong specimens of the *Crinum* genus; this form of reproduction, however, is rarely productive. The development of bulbils in the aquarium is more common especially in *Crinum calamistratum*.

Propagation of Certain Floating Plants

The vegetative reproduction of certain small-growing floating plants is quite interesting, which is the reason why they deserve separate discussion at this point. *Phyllanthus fluitans* as well as *Azolla* and *Salvinia* species develop numerous lateral shoots which will separate from the parent plant after reaching a certain length (fragmentation) or, alternatively, break up into their individual branches after their older parts have died off.

Lemna, *Spirodela*, *Wolffia* and *Wolffiella* display a very unusual propagation in that

their daughter limbs grow from lateral or basal pockets on the parent plant. Under advantageous growth conditions the reproduction rate of these plants is very high, resulting in the water surface in the aquarium becoming overgrown and clogged up within a short time.

Propagation by Tissue or Meristem Culture

A modern method of vegetative propagation is achieved through the help of cultivation in test tubes, a practice that has already found application for a long time with useful plants (e.g., strawberries, beets, and orchids) and which is also being increasingly used in aquatic plant nurseries.

Reasons in favor of tissue culture in aquatic plant nurseries are, for one, the more rapid reproduction compared to conventional methods, and also the considerably reduced requirement for space. Furthermore, some rare species, for example, *Aponogeton* and *Crinum* specimens, which can only be produced in insufficient numbers or not at all under normal cultivation conditions, can be reproduced in such great quantities using tissue culture that any importation from native habitats will soon become unnecessary. Another important advantage in the application of tissue culture is that juveniles grown from meristems (growth tissue) are usually genetically identical (clones) and are identical to the original plant. This, for example, enables the reproduction in a test tube of especially decorative hybrids, which otherwise do not sexually reproduce, or in which a genetic splitting during seed reproduction might be expected, with the plants thus being able to be preserved. In the breeding of useful plants (e.g., in cloves) it is also of great importance that juveniles resulting from suitable meristems are virus-free.

The application of tissue culture demands a high financial outlay by the aquatic plant nurseries, based on the purchase of complicated apparatuses, laboratory instruments, which are required for sterile work practices, and air conditioned rooms. Above all a comprehensive biological knowledge base in the field of tissue reproduction is necessary because the individual aquatic and marsh plants differ in their reaction to the quantitative ratio of supplements and additives in the nutrient mediums, with a special series of experiments always being a necessary prerequisite for almost every species.

For this very reason only the larger plant nurseries in Europe (alongside some aquarists) are involved in this future-oriented and promising method of reproduction.

Practical Application of Propagation by Tissue or Meristem Culture

Suitable tissue, which has the capacity for continuous cell division, is removed from the parent plant. In most cases it is growth tissue from the stem or root tips. These meristems are disinfected so that they are free from fungi and bacteria, and are then transferred onto a sterile nutrient medium. The most important components of the nutrient solution are water, minerals, organic substances, as well as certain vitamins and plant hormones. By adding agar-agar (a colloidal substance extracted from red algae) the nutrient base is transformed into a gelatinous form so that the meristems are unable to drop to the bottom. The tissue parts now grow through cell division, resulting in a collection of nondifferentiated cells (callus tissue), called callus. These calli can, in turn, be cultivated further by transmitting them onto other nutrient media. If the nutrient solution contains a plant hormone which aids the formation of shoots,

numerous very small plants will develop from these vegetatively reproduced single cells, which, after reaching a certain size, are transferred to another nutrient solution in order to enhance their root formation. Sometimes nutrient media are used which simultaneously trigger shoot and root growth. Once the little plants are big enough they are partitioned, either reapplied or removed from the petri dishes or test tubes and relocated from the sterile environment to the hot house where they continue to be cultivated until they are large enough to be sold. The biggest problems facing tissue culture are infections through microorganisms, such as bacteria and fungi, which can quickly destroy the cultures.

Tissue culture is by no means used exclusively for rare species or species which are difficult to reproduce by conventional, costly methods. It is also used for stem plants which in turn can easily be propagated vegetatively through cuttings. Next to the initially mentioned general reasons in favor of propagation through tissue culture, producers also list a more bushy and compact habitus of meristem plants compared to conventional methods, which is why meristem plants can be better marketed. This reason does not immediately seem rational, the differences are, however, clearly visible when comparing

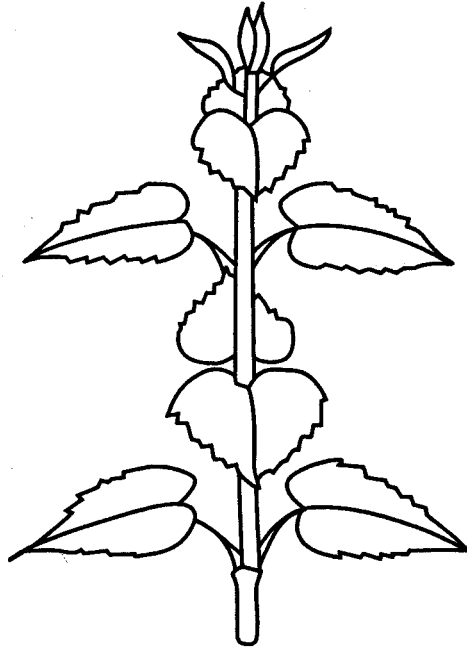
Tissue section of a *Cryptocoryne* with shoot.



plants from normal propagation with those obtained through meristem culture.

Even though there are still many nurseries in Europe in which propagation through tissue culture is not practiced, this form of vegetative multiplication will, in the future, have the best chances in the market. There is also

the legitimate hope that especially decorative but presently rarely kept plants, for example, the cross *Aponogeton* $\times$ *rigidifolius*, can be made available to a larger circle of hobbyists. Even today the demand for aquarium plants is increasingly being met through the application of tissue culture.



The Correct Choice of Aquarium Plants

The comprehensive range of plants available from dealers can mislead aquarists into selecting aquarium plants according to visual characteristics and not according to species requirements. Failures in cultivation are, therefore, often a consequence of such action. In order to be able to make the correct choice of aquarium plants it is necessary to familiarize oneself with the requirements and features of the individual species. To facilitate the right decision within the wide range of aquarium plants some general hints are provided in the following chapter.

Most plants kept in aquariums are marsh plants, usually originating from above-water cultivation in nurseries and being offered in this form in aquarium dealerships. Aquarists often, and quite unwarranted, view emersed cultivated plants very negatively, because many plants rid themselves of their emersed leaves during replanting underwater, which, of course, can lead to problems during the setting up of new aquariums. However, emersed cultivation of aquarium plants has big advantages over the submersed maintenance: on the one hand the marsh plants will grow considerably more quickly above water, and are less vulnerable or sensitive during and after the transfer into a different and new environment. On the other hand lower operating costs (heating and lighting) in nurseries also mean lower prices, which benefit the aquarist. Furthermore, European nurseries have to compete with the cheap mass imports from Asian and South American countries. Because emersed plants first have to adapt to a submersed lifestyle, it is useful, if possible, to also include acclimatized and established

submersed cultivated and fast-growing species in the setting up of a new, larger aquarium. These can, for example, be obtained from aquarist friends, plant exchanges or fairs, regularly organized by aquarist associations in larger towns. When using “genuine” aquatic plants the problem of readaptation to a submersed environment will not occur, which is why they should be used in new aquariums.

Don't be afraid of taking along a book on aquarium plants when making your purchase and making your selection according to the information provided. The dealer will be more capable of offering advice and suggestions if you can provide him/her with photos of the desired species as well as their scientific names.

Aquarium plants are often sold in bundles, and some aquatic plant nurseries have fortunately adopted the method of providing the bundles with a label indicating the name as well as tips on maintenance. This can certainly facilitate the choice for the purchaser.

Genuine Aquatic Plants

Only some of the aquarium plants available are so-called “genuine” aquatic plants which also exist continuously submersed in their native habitat. Some even flower underwater; others, in turn, form their inflorescences close to the water surface. The Hydrocharitaceae family, for example, with the genera of *Blyxa*, *Egeria*, *Elodea*, *Hydrilla*, *Hydrocharis*, *Lagarosiphon*, *Limnobium*, *Ottelia*, *Stratiotes* and *Vallisneria*, contains exclusively aquatic plants. Representatives of this family which

are kept quite often are the species belonging to the genus *Vallisneria*, which can all be recommended without exception. *Egeria densa* is also part of the permanent contingent available at dealers; this species, however, is mainly suited for cold-water aquariums or garden ponds. *Stratiotes aloides*, too, which is occasionally commercially available, is generally used as a cold-water plant. All other species belonging to these genera are, unfortunately, only rarely available.

Only real aquatic plants are available from the *Aponogeton* genus as well. Some fast-growing recommended species are *Aponogeton boivinianus*, *A. crispus* and *A. ulvaceus*, which are also suited for new aquariums because they develop numerous leaves in quick succession. *Aponogeton madagascariensis* is an exception and is very popular because of

its lattice-like leaf structure but is very sensitive in cultivation.

Other recommended and commonly available aquatic plants are *Crinum thaianum* and *C. natans* as well as several different pond lilies (*Nymphaea*). Some floating plants occasionally found in dealerships have only limited use in aquariums because they will progressively grow smaller in cultivation. Among these are *Eichhornia crassipes*, *Pistia stratiotes* and *Salvinia* species.

A larger number of easy to maintain "genuine" aquatic plants, such as *Ceratophyllum*, *Potamogeton gayi*, *P. wrightii*, *Zosterella dubia*, *Utricularia*, *Najas* and *Nymphoides* species, are, regrettably, only rarely found. If the opportunity to purchase one of the above arises at some stage, it should definitely be grasped.

An impressive biotope on Bali with dense populations of *Ottelia alismoides*. The plants exist unshaded under intense sunlight.



Distinguishing Aquatic and Marsh Plants

Under close scrutiny some species, for instance *Ceratophyllum* and *Utricularia*, can already be identified as “genuine” aquatic plants by discovering the absence of any roots. In most cases they also have, as a typical feature, fragile, thin, often dissected and fine-structured aquatic leaves, the function of which is to enlarge the surface area. The submersed plants have only a very thin epidermis (outer skin), which enables the absorption of gas, water and nutrients. The supporting tissue in stems and leaves is accordingly usually weak. If one looks at a cross-section through a submersed stem—*Ammannia* or *Limnophila* are suitable examples—the clearly marked or pronounced form of the intercellular spaces is evident: air tubes and air storage

spaces, which provide a solid gas diffusion, can be made out quite clearly. This feature, together with a little experience, enables the easy recognition of aquatic plants and submersed growing marsh plants.

A conspicuous characteristic of aquatic plants are the often transparent leaf blades found in several *Aponogeton* species. Other plants have quickly adapted their leaf structure to the fast-flowing water in their native habitats by developing ribbon-like and bulate leaves, for example, some species belonging to the *Crinum*, *Cryptocoryne* and *Vallisneria* species.

Fast-Growing Marsh Plants

Marsh plants make up the major part of the range of aquarium plants. In their natural habitats they grow both submersed (under water)

***Anubias barteri* var. *caladiifolia* at a waterfall in Limbe (Cameroon). The plant is excellently suited for large aquariums holding cichlids.**



as well as emerged (above water). Dependent on seasonal variations in the water levels many marsh plants develop differently structured leaves under water as an adaptation to their submersed existence to those formed above the water surface. A good example of this is *Hygrophila difformis* whose emerged leaves display an undivided shape whereas the submersed shoots appear totally different and have pinnatisected leaf blades.

As mentioned before, aquarium dealers mainly offer emerged cultivated plants. In order to choose the right aquarium plants it is necessary to learn how to distinguish between the forms living above and below the water surface. If one is not familiar with the individual species, this task seems exceptionally difficult at first. There are, however, several features that quickly indicate if the relevant plant has grown under water or not. The

chapter on genuine aquatic plants has already pointed out the typical structure of aquatic leaves. Fast-growing marsh plants kept underwater also feature thinner and more delicate leaves compared to terrestrial forms, as well as a relatively soft and often sponge-like stem. If plants reared in the aquarium are removed, most species will let their leaves hang down limply, which also happens with the stem in stem plants. In contrast terrestrial plants usually display stiff upright leaves and stems.

Another conspicuous characteristic of submersed cultivated plants is the lacking pubescence. *Alternanthera reineckii*, *Bacopa caroliniana*, *Hygrophila difformis* and *Limnophila aquatica*, for example, only display a distinct pubescence above water, and are otherwise glabrous.

Fast-growing and recommended species

In its native habitat in Cameroon *Anubias barteri* var. *glabra* often grows emerged on stones. It will, however, adapt well to submersed conditions.



which are often commercially available and only require a short period of adaptation to a submersed environment are the representatives of the *Bacopa*, *Ceratopteris*, *Hydrophila*, *Limnophila*, *Ludwigia* and *Echinodorus* genera.

Other undemanding aquarium plants are *Heteranthera zosterifolia*, *Lobelia cardinalis*, *Rotala rotundifolia* and *Shinnersia rivularis* as well as several *Cryptocoryne* species.

Demanding but well-growing aquarium plants are *Ammannia* and *Nesaea* species as well as *Alternanthera reineckii*, *Didiplis diandra* and *Hemianthus micranthemoides*. They require a longer time to adapt and initially drop their emerged leaves during their period of adaptation to a submersed environment, but then proceed to rapidly resume growth under optimum conditions.

Slow-Growing Marsh Plants

Among this group are *Anubias* species which have been available over the last couple of years and which are especially suited to cichlid aquariums due to their hard leaf structure. When touching and feeling an emerged leaf the difference in aquatic leaves will quickly become evident: it is leathery and stiff, not transparent and unpartitioned. If *Anubias* is removed from the water the leaves will remain in their upright position and will not hang down in a limp fashion. Even though the *Anubias* species that are commercially available adapt well to a submersed environment care should be taken when purchasing specimens so that they grow slowly, the period of adaptation thereby taking considerably longer than with many fast-growing species. The same also goes for the popular ferns *Bolbitis heudelotii* and *Microsorium pteropus*. When setting up a new aquarium it is therefore rec-

ommended to initially begin with fast-growing species (also as a precaution to prevent the development of algae) which can then progressively be replaced with slow-growing species. Occasionally aquarium stores also stock *Lagenandra*, *Aglaonema* and *Spatiphyllum* species which are often confused with the *Anubias* species. These plants, however, generally do not grow under water (*Lagenandra praetermissa* is an exception being suitable only for higher aquariums), and their purchase is not recommended.

Plants Unsuitable for Aquariums

Even though the available range of well-growing aquarium plants has increased continuously over the last couple of years, species totally unsuitable for underwater cultivation continue to be made commercially available in aquarium shops. They will not grow submersed and will die after only a few days. Most of these plants are traded under exotic fantasy names, for example "underwater palm," and are conspicuous by their bright coloration which is why they continue to be bought by aquarists. The disappointment after discovering that they will not grow in the aquarium is usually great. Species unsuitable for submersed cultivation are offered from the following genera: *Chamaedorea*, *Chlorophytum*, *Commelina*, *Cordyline*, *Cryptanthus*, *Dracaena*, *Fittonia*, *Hemigraphis*, *Selaginella* and *Syngonium*. *Acorus* and *Lagenandra* species as well as *Alternanthera sessilis* and *Bolbitis heteroclita* are only temporarily suitable for submersed cultivation, but can be kept without complications in a paludarium (marsh aquarium).

The following survey is designed to assist in making the right choice of aquarium plants:

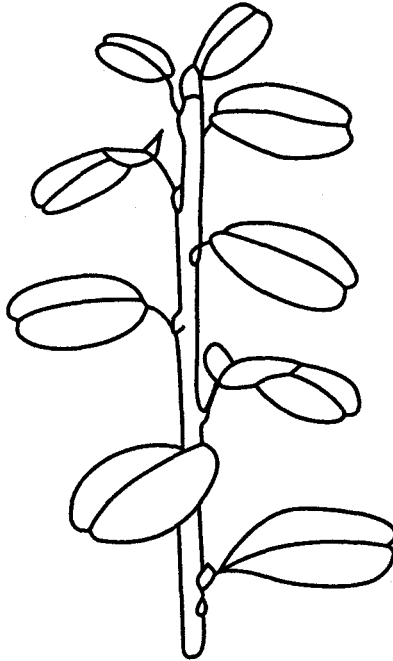
Typical features of genuine aquatic plants, floating plants or submersed cultivated species:

- The leaves are lacerate, finely structured, strap-shaped, occasionally fragile and thin, sometimes transparent, bullate or cancellate.
- The stem is mostly soft (can it be compressed?) and, if it is fleshy, displays clearly visible air tubes and storage spaces (cross-section).
- Leaves, often the stems as well, will hang down limply after removal from water.
- The plants are glabrous or have minimal pubescence.
- The plants have air cushions (*Eichhornia*

crassipes and *Limnobium*), float on the water surface or develop floating leaves.

Typical features of terrestrial plants, slow-growing marsh plants or species totally unsuitable for aquarium culture:

- The leaves are strong, leathery and not or hardly transparent.
- The stem is hard.
- Leaves and stems do not hang down limply after removal from the water but will remain upright instead (not in species displaying creeping growth).
- The plants often display pubescence.
- The plants have a conspicuous coloration.



The Design of Plant Aquaria

Before laying out a plant aquarium, one should first think about how to give it shape and where to place plants along the side panes and back wall. This is especially important for a harmonious effect. In order to make them natural looking, for example, structured plates made of pressed natural cork or synthetic resin are available in pet shops. Recommendable and, what's more, inexpensive, are polystyrene plates in which you can burn or melt a relief-like pattern and then paint black with nontoxic paint. Small-leaved forms of *Microsorium pteropus* and *Anubias barteri* var. *nana* can be used for planting on these decorative plates. The rhizomes are pinned down to the structured plates with short, curved pieces of PVC-covered wire. *Anubias*, *Microsorium* and *Bolbitis* can also be used for planting on stones and roots, as can mosses and algae balls. The latter can best be tied down with thin nylon thread. A fashionable, very effective planting is created with a cushion of commercially available *Riccia*, which, following the examples of Japanese aquarium art, is tied down with a hairnet.

Before choosing and buying the desired plants, it has proved useful to make a drawing (planting scheme) which indicates where the plants will be placed, either singly or in groups. In setting up the planting scheme, a plant street should first be planned, reaching diagonally from the front preferably far to the back in a sloping way. Such a street not only produces a striking three-dimensional effect, but also has a pronounced optical effect. In Dutch aquaria, which are often used as an example for plant lovers, the undemanding and slow-growing *Lobelia cardinalis* and the

more light-requiring *Saururus cernuus* are often used in a plant street. Sometimes the fast-growing species *Alternanthera reineckii* and *Hygrophila corymbosa* are also used. With a bit of skill, species like *Isoetes velata*, which have a rosette-like growth, or the adventitious plants of *Echinodorus bleheri*, can be used in a plant street. Never plan the beginning of a plant street exactly in the middle of the aquarium as this divides the aquarium optically into two halves, harming the total effect. Furthermore, attention should be paid to designing a preferably dense and close grouping. Do not economize on plant material! An unusual and attention-drawing eye-catcher is formed by a second, parallel plant row consisting of plants clearly different in both color and shape.

The next thing to decide is which solitary plants should be used. Solitary plants are those species which are used singly and give good optical effects. All other species are always used in groups. Especially recommended as solitary plants are the large-growing sword plants, *Echinodorus bleheri*, *E. parviflorus*, *E. cordifolius*, and *E. uruguayensis*, and also some *Echinodorus* cultivars like *Echinodorus* 'Rubin', *E.* 'Ozelot', and *E.* 'Rosé'. The color forms of *Nymphaea lotus* and *Crinum* species are quite decorative. Some species of the genus *Aponogeton* also have great decorative value as solitary plants. In very small aquaria with a capacity less than 60 L, one usually has to refrain from using solitary plants as they dominate the aquarium. However, in larger aquaria, one should also be satisfied with only a few solitary plants.

Now to plant the aquarium's front section. This is a very difficult job since the choice of available fast-growing, but at the same time undemanding, foreground plants is not very large. Well suited are the stolon-producing species *Echinodorus tenellus*, *E. quadricostatus*, and *Sagittaria subulata*, which rapidly cover the bottom like a lawn. Just as undemanding are *Eleocharis acicularis* and various *Lilaeopsis* species; the latter should always be bought in large amounts as they grow slowly. *Cryptocoryne parva*, *C. × willisii*, *C. wendtii*, and *C. walkeri* are also decorative and slow-growing, but are satisfied with an average lighting intensity. Absolutely recommendable as a foreground plant is *Anubias barteri* var. *nana*. Extremely light-demanding and therefore only fit for the experienced plant lover is the Australian *Glossostigma elatinoide*s. The planting of small foreground plants often leads to the largest problems. Your patience will be especially put to the test with the fragile shoots of *Glossostigma* and *Marsilea*, since they become loose time after time. A pair of blunt tweezers can be of great help. At last, when planting the foreground plants, one will notice that sand or fine-grained gravel is more appropriate for planting than gravel with a diameter of more than 3 mm. It takes a lot of effort and time to plant the smallest sword plant, *Echinodorus tenellus*, because each small plant should be planted singly, not together with others in the same planting hole. This also applies to the somewhat bigger, stolon-producing species like *Echinodorus quadricostatus* and *Sagittaria subulata*.

After the plant street, solitary plants, and foreground plants have been drawn on the planting scheme, one needs to start thinking about which middle and background plants should be used. Strongly recommended, small-leaved stem plants for the middle parts are *Bacopa caroliniana*, *B. monnieri*, *Hygrophila polysperma*, *Hemianthus micranthemoides*,

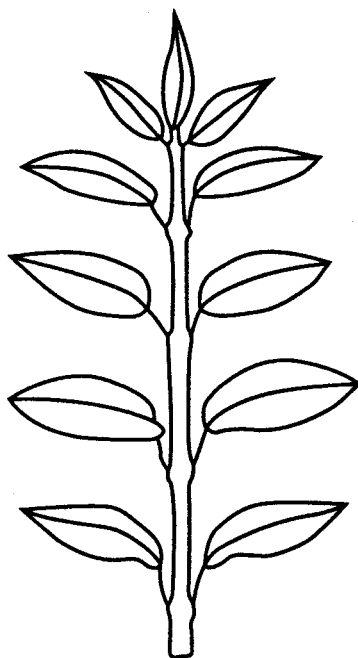
and *Heteranthera zosterifolia*. Ranking among the more tender and very light-demanding plants are *Didiplis diandra* and *Micranthemum umbrosum*. Depending on the size of the aquarium, the following species are fit for planting in the middle or background: *Limnophila* species, *Ludwigia* hybrids, *Rotala rotundifolia*, *Hygrophila difformis*, and various shape and color forms of *Hygrophila corymbosa*. Light-demanding and tender plants are *Cabomba* and *Myriophyllum* species, *Eichhornia azurea*, and the intense red-colored *Alternanthera reineckii*, *Ammannia gracilis*, and *A. senegalensis*.

Of the large number of species with a rosette-like growth, the following are especially well suited for middle and background planting: most of the *Echinodorus* species and cultivars, although many of them are very light-demanding. Others include almost all commercially available *Cryptocoryne*s, which grow well at lower light intensities, but in the aquarium need several months to take root. Also highly recommended are *Vallisneria* and *Ceratopteris*.

In the realization of middle and background planting, a few basic rules must be followed. For example, stem plants will catch the eye only if planted in a gradually sloping way. A larger group always looks stronger than a smaller one. Fleshy-leaved, strong shoots (e.g., *Ammannia gracilis* and *Eusteralis stellata*) are planted singly and at such a distance that they will neither impede nor shade each other. Also most of the ground-covering species, like *Cryptocoryne* and the stolon-producing *Echinodorus*, should always be planted in larger groups in order to achieve a harmonious effect. To create a large contrast, similarly shaped or colored species should not be planted next to each other. For example, it is not wise to place the similarly shaped species of *Myriophyllum* and *Cabomba* together, or the red *Ammannia gracilis* next to the red-brown *Cabomba furcata*.

Therefore, the most important rule of planting is to create striking contrasts with the help of plant colors and shapes. Please note when buying plants that more money is spent for dense planting than for fish! Furthermore,

take into consideration that most of the plant species (excluding solitary plants) will only catch the eye effectively if planted in larger groups. Therefore, always buy several bunches or pots of each species!



Aquarium Plants from A to Z

All plants pictured in this section are in the aquarium unless otherwise stated.

Acorus calamus

Linné (1753)

Family: Acoraceae.**Synonyms:** Numerous, see Engler (1905).**Etymology:** *Acorus*: Greek plant name; *calamus*: tube, reed, refers to the reed-like leaves.**Distribution:** Originally Asia and North America, a triploid race naturalized in Europe and North America (Great Lakes region in the U.S.), cultivated as an ornamental plant.**Description:** Perennial, sturdy marsh plant with a creeping, highly branched rhizome. Distichous leaf arrangement, sword-like, linear, acuminate, 50–100(–180) cm long and 1–3 cm wide.

Peduncle trigonal. Spathe leaf-like, adnate with peduncle, forming an extension, erect, persistent. Spadix diagonally projecting, 4–10 cm long, 0.6–1.5 cm thick, densely flowered, coming into flower begins at the base. Bisexual flowers, trimerous; 6 tepals, in 2 circles, about 2.5×1 mm in size, green; 6 stamens, filament 2.5 mm long, ovary oblong-cylindrical 3×1.25 mm in size, with a very short style and small stigma. Fruit is a berry, on maturity dirty white in color, with brown stigma remains.

Culture: This impressive marsh plant, which used to be commercially available, is not suitable for aquariums but is excellent for planting in the outer edges of garden ponds. It produces strong rhizomes. A nutrient-rich substrate as well as a sunny, warm location are essential. These hardy European plants are triploid and don't produce any fruit. Several varieties have been identified.

Ecology: It grows on the banks or edges of standing or slow-flowing waters on a nutrient-rich and boggy substrate.

Other: According to Engler the rhizome of *Acorus calamus* serves as a medicine against epidemics and stomach ailments and also in the production of perfumeries, toothpowder, and beerwort. It is also used as a liqueur, drug and potency-enhancing substance. The fruit is not a red berry (see above and Bogner, Aqua-Planta 16 [2/1991]: 71) as mistakenly mentioned in the literature.

***Acorus calamus* growing on the edge of a pond.****Inflorescence of *Acorus calamus*.**

Acorus gramineus

Solander (1789)

Family: Acoraceae.

Synonyms: *Acorus calamus* Loureiro, *A. humilis* Salisbury, *A. tatarinowii* Schott; for var. *pusillus* (Siebold) Engler: *A. pusillus* Siebold.

Etymology: *Acorus*: see *A. calamus*; *gramineus*: gramineous, refers to the grass-like leaves; *pusillus*: tiny, minute, minuscule.

Distribution: Eastern Asia to Japan; var. *pusillus*: Japan.

Description: Perennial plant with a creeping, highly branched rhizome, up to 1 cm thick. Leaves are distichous, linear, 30–50 cm in length and 0.5–1 cm wide, cuspidate, stiff, dark green in color; different color formations with white or pale yellow longitudinal stripes; var. *pusillus*: leaves up to 10 cm long and 5 mm wide.

Structure of the inflorescence as in *Acorus calamus*, but with a spadix up to only 5 cm long (rarely more) and 3–4 mm thick. Fruit is a green berry.

Culture: *Acorus gramineus* is a continuously commercially available, very slow-growing, light demanding and sturdy plant. Variety *pusillus* is more likely to be suitable for

aquariums; it reaches a growth height of only about 10 cm. The plants do, however, tend to die off after a couple of months. In aquariums with plant-consuming cichlids, *Acorus gramineus* can, however, temporarily be useful. Use in a cold-water aquarium, on the edges of ponds, in a paludarium or in a terrarium is preferable.

Whereas *Acorus gramineus* var. *pusillus* prefers lower temperatures around 18–23 °C, the white-green and yellowish green striate color formations—often referred to with the commercial name of *variegatus*—can also handle higher temperatures. These color formations are used for decorative purposes in bowls and basin dishes and do not like a continuously submersed culture. When using *Acorus gramineus* in garden ponds, they have to be covered with dead foliage during winter because they have limited strength.

***Acorus gramineus* var. *pusillus*.**

Alternanthera reineckii

Briquet (1899)

Family: Amaranthaceae.

Synonyms: *Achyranthes reineckii* Standley.

Etymology: *Alternanthera*: *alternus* = alternating, *anthera* = anther, referring to alternating fertile and infertile stamen; *reineckii*: after E.M. Reineck.

Distribution: South America

Description: Marsh plant with an erect, highly pubescent red stem, 10–30 cm long. Leaves sessile or petiolate up to 0.5 cm, decussate. Leaf blades are entire, ovoid, pointed, emersed 2.5×1.2 cm in size, green, submersed 2×1 cm in size, upperside green to reddish green, underside pink-colored. Margin not undulate.

Inflorescence sessile, axial spikes, in groups of 1–5 with numerous densely arranged flowers. Bracts ovoid, white; 4 tepals, glabrous, white; 4 stamens. Short style. Numerous seeds.

Culture: *Alternanthera reineckii* is a demanding, light-hungry aquarium plant. Should the lower leaves begin to rot with an otherwise healthy stem tip, this will always be due to light deficiency. Only under conditions of

sufficient light intensity will the leaf topside be a reddish green color. A fine-grained, nutrient-rich substrate is best for initial planting and root formation of the sensitive stem. The pH-value should be weak acid. *Alternanthera reineckii* will not grow taller than 10–30 cm and therefore constitutes an ideal plant for location in the foreground. The optimum temperature range lies between 17–25 °C. Inflorescences and seeds are numerous in emersed cultivation.

Ecology: Populates flooded areas, riverbanks and edges of ponds. W. Staeck and the author located the species on numerous occasions in Bolivia and Argentina at two locations: 1) Bolivia (8/1991), small stream, water almost stagnant, substrate sandy-boggy, unshaded; temperature 17 °C (air 18 °C at noon), pH 6.5, GH 4 °dH, KH 11 °dH, 125 μ S/cm; and 2) Argentina (7/1993), submersed in the remaining water of what was formerly a river, water almost stagnant, substrate loamy-stony, sunny-shaded; temperature 15.5 °C (air 14 °C at 14:00 h), pH 6.1, GH 2 °dH, KH < 1 °dH, 35 μ S/cm.

***Alternanthera reineckii*.**

***Alternanthera reineckii* 'Red' and 'Green'**

Family: Amaranthaceae.

Cultivar name: The variety names 'Red' and 'Green' introduced here refer to the coloring of the submersed leaf blades.

Distribution: Unknown.

Description: Both growth forms can only be distinguished by the coloring of the submersed leaves. Emerged leaves up to 9 mm petiolate. Emerged blade oblong to lanceolate, acuminate, narrowed base, up to 6.5 cm long, 1.0–1.4 cm wide, upperside olive green, underside whitish green coloring. Margin smooth. Submersed leaf blade up to 10×1.8 cm in size, with a hardly undulate margin. In the red cultivar the leaf's upperside is red to blood red; in the green cultivar it is olive green to hardly reddish, although never deep red. Flower description as in *A. reineckii*.

Culture: Two light-hungry, decorative growth forms of *A. reineckii* that are under healthy conditions and an adequate nutrient supply will grow rapidly. Water hardness is of little importance for healthy growth but should be weak acid. A nutrient-rich, fine-grained substrate as well as an adequate CO₂ supply are

recommended for the maintenance of these cultivars. Even under conditions of good growth and high light intensity, the leaves tend to rot. A free-standing location is therefore essential for the shoots not to interfere with and hamper each other's growth. A well-growing cluster of plants within an aquarium is a delightful sight and certainly attracts the attention of viewers. The best impression is achieved with a graded or terraced plant arrangement at an angle from the fore- to the background. For quick propagation the stem tip is severed and replanted. The part remaining in the substrate will usually produce several lateral shoots.

Other: *Alternanthera reineckii* 'Red' was introduced around 1975 as *A. sessilis* and is used quite often. The cultivar 'Green' first appeared in Czechoslovakia and was first mentioned in aquaristic literature in 1976. It is relatively rare.

Alternanthera reineckii 'Green'.



Alternanthera reineckii 'Red'.



Alternanthera reineckii
'Purple'

Family: Amaranthaceae.

Commercial name: *Alternanthera* "lilacina," *Telanthera* "lilacina."

Cultivar name: The cultivar 'Purple' introduced here was chosen to most closely resemble the invalid but naturalized commercial name, which in turn refers to the intense purple color of the leaf's underside.

Distribution: Unknown

Description: Growth form with a 50–60 cm-long, erect stem axis. Leaf blades up to 1.5 cm petiolate, wide lanceolate to ovoid, acute, decurrent base, emerged up to 7.5×1.5 cm in size, upperside olive green, underside whitish green in color. In a submersed state, all shoots attached to the nodes are more stocky and thickset than under emerged conditions. Submersed leaf blades are up to 9.5×3.1 cm in size, light red to wine red to deep dark red on the upperside, and a strong purple on the underside. The margin is never undulate. Flower description as for *A. reineckii*.

Culture: This demanding and often cultivated plant is only slow-growing, even under ideal conditions, and is not quite as light-

hungry as the other growth forms of *A. reineckii*. Growth is, however, much improved under conditions of high light intensity where the internodes are only a few millimeters long, so that growth is stocky and the shoots don't have to be trimmed that often. A grouping of this form is suitable for planting in the foreground. Under light deficiency, the internodes will stretch so that the plant will then be better suited for placement in the middle or the background section of the aquarium. The substrate should be nutritious and loose. The many fine and, for this form, very typical roots which form at every node, serve, like the roots within the substrate, the plant's nutrient absorption and are therefore not to be severed. The pH-value should be within the acid range since—under conditions of CO_2 deficiency—a lime deposit will quickly form on the leaves due to biogenous decalcification, which will strongly impact upon assimilation. In no other growth form is this feature as distinctly prevalent. Propagation is through cuttings.

Inflorescence of *A. reineckii*.





Alternanthera reineckii 'Purple'.

***Alternanthera reineckii*
'Pink'**

Family: Amaranthaceae.

Commercial name: *Alternanthera* "rosae-folia."

Cultivar name: The cultivar name of 'Pink', introduced here, is awarded on the basis of the commonly used commercial name.

Etymology: As in *A. reineckii*.

Distribution: Unknown

Description: Caulome erect, up to 60 cm long. Leaves up to 1.7 cm petiolate, decussate. Leaf blade oblong-elliptic to ovoid, acuminate, with decurrent base. Emerged blade up to 10 × 3 cm in size, upperside olive green, underside whitish green; margin smooth. Submersed leaf blade up to 10.5 × 3.5 cm in size, upperside light red to red, underside deep purple in color; margin highly undulate. Flower description as in *A. reineckii*.

Culture: *A. reineckii* 'Pink' is the largest and most decorative among the known growth forms and also the easiest to maintain. Its most conspicuous feature are the intensely red-colored shoots with which beautiful contrasts can be achieved within the aquarium. Growth is usually unproblematic. In order to

achieve strong shoots, a nutrient-rich substrate as well as high light intensity are recommended. If the shoots lose their leaves at the lower nodes, or should the internodes become too large, light intensity should be increased. Good growth results can be achieved in both soft and hard water, although plants will prosper best in a slightly acidic environment. It is also worth mentioning that the cultivar will react positively to strong water movement. Temperature range is 22–28 °C, and optimum range is 24–27 °C. Due to this rapid growth, 3–5 strong specimens are quite adequate for planting in the middle or back-drop zones of the aquarium. Propagation is through cuttings. Emerged cultivation in all growth forms can take place on the window sill in dry room air. Inflorescences occur only in the terrestrial variety.

Other: Quite often commercially available.

***Alternanthera reineckii* 'Pink'.**

Alternanthera sessilis
(Linné) De Candolle (1813)

Family: Amaranthaceae.

Synonyms: *Gomphrena sessilis* Linné (1753), *Illecebrum sessile* Linné, *Alternanthera triandra* Lamarck, *A. repens* Gmelin, *Achyranthes alternifolia* Linné fil., *A. denticulata* R. Brown.

Etymology: *Alternanthera*: see *Alternanthera reineckii*; *sessilis*: sessile, refers to the sessile inflorescences.

Distribution: In all warm countries on earth.

Description: Annual or perennial, amphibious plant with an erect or floating stem axis. The 3–10-mm thick, round to angular stem is more or less branchy and—with floating shoots—will root on all nodes. The decussate, entire leaves are 0.5–1.2 cm long petiolate and very variable in form and size. The leaf blades are linear-lanceolate to oblong, aciculate and narrowed at the base; in dry locations they are also oval with a rounded apex. The blade can reach a size of 6–9(–15) × 1.5(–3) cm. The margin is smooth. Only on the leaf axes and on two opposite sides of the stem is there short, white pubescence, arranged in narrow rows. Otherwise the plant is glabrous. The venation is pinnately veined with distinctly visible midrib. Stem and leaf upperside are wine red to dark red or reddish green in color; the leaf underside appears deep purple.

The terminal or axial, inconspicuous inflorescences are ovoid and shortened up to 5-mm long spikes, which consist of numerous densely arranged solitary flowers. They are surrounded by two about 0.5-cm long bracts. Each solitary flower has five white single-ribbed sepals which are colored a pale red-dish purple at the base, are aciculate, 3.5 mm long and 2 mm wide at the base. The number of stamens varies between 2 and 5. The numerous fruit are reverse cordate, aliferous and 2 × 1.5 mm in size.

Culture: *Alternanthera sessilis* is occasion-

ally commercially available. It is not suitable for permanent culture in aquariums but is, however, a recommended and rapidly-growing plant in paludariums. With its wine red coloring, it forms an excellent contrast to green-leaved species. The paludarium's substrate should preferably not be too dry. Temperature can range between 15 and 30 °C. Shoots will still grow healthy under minimal light. The internodes will, however, be long-stretched under these conditions, which does not make for a nice appearance. Under sufficient light, stocky, thickset and decorative shoots will form. This plant can be propagated through lateral shoots or seeds.

Ecology: *Alternanthera sessilis* grows in very different locations, for example, in rice paddies and wet ditches, on the edges of small ponds and also in completely dry places. It is found predominantly in lowlands but also at altitudes up to 1200 m. Often it grows as a weed in ditches. This plant is also cultivated as a vegetable.

Other: An occasionally used commercial name is *A. variegata*.

Alternanthera sessilis with inflorescences.



Ammannia gracilis

Guillemin & Perrottet (1833)

Family: Lythraceae.

Synonyms: *Ammannia diffusa* Hiern, non Willdenow.

Etymology: *Ammannia*: after the botanist P. Ammann (1634–1691); *gracilis* = gracile.

Distribution: Senegambia.

Description: Marsh plant with an erect or ascendent, fleshy, glabrous, up to 60 cm-long stem. Sessile leaves, decussate, margin entire. Emerged blades linear to obovate, emerged 2–6 cm long, 1.0–1.8 cm wide, olive green. Submersed blade lanceolate, 7–12 cm long, 0.7–1.8 cm wide, upperside olive green to brownish red, underside deep violet.

The inflorescence is a short petiolate dichasium with 3–7 flowers. Calyx 2 mm long; 4 petals, pale lilac, 2.5–4 × 2–3 mm in size; 4–8 stamens. Ovaries globular, red. Style up to 0.5 mm long; stigma capitate. Fruit is a bilocular, 2–3-mm globular capsule with almost round seeds.

Culture: With its cognac brown color, *A. gracilis* is a sought-after aquarium plant which prospers best if well illuminated. Good indicators are the leaves on the lower nodes

which will turn black under conditions of insufficient light intensity. A nutrient-rich substrate is also necessary for a successful cultivation. The species grows best in soft water at a temperature above 24 °C. For a cluster arrangement, 3–5 stems, planted individually with enough distance between them in a terraced form, will suffice. The shoots display a strong desire to protrude from the water so that transformation to a terrestrial form is easy. A high temperature and a lot of light will accelerate flower formation. Propagation through seeds, however, is rather laborious.

Ecology: Grows in a sandy soil on riverbanks and in flood areas. In Senegambia, the author found conspicuously stocky shoots as an adaptation to a sandy (nutrient-deficient) and only moderately moist substrate, an intense solar radiation, high temperature and low humidity—in contrast to the “soft” and much larger greenhouse specimens.

***Ammannia gracilis*.**

Ammannia senegalensis

Lamarck (1791)

Family: Lythraceae.

Synonyms: *Ammannia diffusa* Willdenow (non Hiern), *A. filiformis* De Candolle, *A. salsuginosa* Guillemin & Perrottet.

Etymology: *Ammannia*: see *Ammannia gracilis*; *senegalensis*: originating in Senegal.

Distribution: From Senegambia to South Africa, in eastern Africa to Abyssinia and lower Egypt.

Description: As in *A. gracilis*. Differentiating features: emerged stem up to 40 cm in height. Leaf blade 2–6 cm long, 0.8–1.3 cm wide. The margins are usually more or less strongly recurved downwards so that the leaf surface is arched.

Inflorescence with 1–3(–5) flowers, less densely arranged than *A. gracilis*. Individual flower with 4 petals, constantly 4 stamens and an almost sessile stigma.

Culture: *Ammannia senegalensis* is, like *A. gracilis*, a demanding, light-requiring plant which is also suitable for small aquariums. Overall, the cultivation of this species is less problematic because growth in the aquarium is more rapid and propagation by lateral

shoots more productive. A nutrient-rich substrate and a light location, however, are also essential. The optimum temperature range is 22–28 °C. Submersed specimens only appear decorative if planted as a group. Propagation is through cuttings or seeds.

Ecology: *Ammannia senegalensis* grows in wet and moist locations, in flooded areas, as a weed in rice paddies and occasionally also in saline soils.

Other: Data provided in scientific literature on the number of petals and stamen do not coincide with the observations made by the author on cultured specimens. Koehne (1903) mentions 0–4 petals and 8 stamens for *A. gracilis*, for *A. senegalensis* also 0–4 petals and 4, rarely 5–8 stamens (compare the descriptions for both species). In the future, both species will possibly be summarised as one single species because of the few and partially inconsistent differentiating features.

***Ammannia senegalensis*.**



Flower of *A. senegalensis*.



Anubias afzelii

Schott (1857)

Family: Araceae.**Synonyms:** None.**Etymology:** *Anubias*: after the Egyptian god Anubias; *afzelii*: after the Swedish botanist Adam Afzelius (1750–1837).**Distribution:** Senegal, Guinea, Sierra Leone, Mali.**Description:** Robust marsh plant with a creeping, one 1-m long and up to 4-cm thick rhizome. Petiole up to 70 cm long, about 8–15 mm thick, sheathed. Geniculum up to 3 cm long. Blade entire, leathery, lanceolate-narrow ovoid to elliptic, up to 44 cm long and 18 cm wide, glabrous or underside with little pubescence. Apex acuminate or obtuse; base narrowed, obtuse or truncate. Margin smooth. Coloration light to dark green, young leaves occasionally also colored reddish brown.

Peduncle up to 35 cm long. Spathe erect, fleshy, narrow ovoid to lanceolate, mucronate, up to 9 cm long, green; on maturity opened a little to semiopen for several hours, rarely entirely open. Spadix up to 12 cm long, with about one-third of the male segment extending outward from the spathe; 5–6 adnate stamens; thecae located on the side of the

***Anubias afzelii* in its habitat near Kounkané.**

synandrium. Inflorescence dense with 4–8 × 2-mm large irregular berries. Berry with 4–17, in ripe condition brown, up to 2.5 × 1.5-mm large seeds.

Culture: *Anubias afzelii* is a sturdy marsh plant which reaches a height of up to 1 m in both its natural location as well as in the greenhouse, but which usually remains smaller. Cultivation in a spacious paludarium is unproblematic; the rhizome can be inserted into the substrate of the water section and the leaves let to grow out of the water (semiaquatic cultivation), or the plants may be cultivated entirely emersed. High humidity and repeated spraying are advantageous for good growth. This plant grows very slowly in the aquarium but is perennial and, from all larger *Anubias* varieties, is the most suitable for submersed cultivation. Most suited for planting are smaller specimens of 10–20 cm in height, which can be better adapted to submersed culture than larger plants. The optimum temperature range is 22–26 °C. Young specimens, propagated from seeds, can also be used. The light requirements of *A. afzelii* are low. Soft to medium-hard water is recommended. The quickest propagation is achieved through rhizome partitioning. Sexual reproduction through seeds is also possible. The seeds germinate quickly, but it will take at least 6 months before the young plants will have reached a size of 5–10 cm.**Ecology:** *Anubias afzelii* grows in its natural location as a marsh plant, mostly on riverbanks and streams. The author found the species in Senegal (near Kounkané), growing in dense populations on both the banks of a dry river in deep shade, and also several meters from the river in bright sunlight and very dry soil (see photo) where the plants formed magnificent communities.**Other:** The species also often produces seeds through self-pollination.

Anubias barteri

Schott var. *barteri* (1860)

Family: Araceae.

Synonyms: None.

Etymology: *Anubias*: see *A. afzelii*; *barteri*: after the collector Charles Barter.

Distribution: Southeast Nigeria, Cameroon, Equatorial Guinea (Bioko).

Description: Marsh plant, up to 40 cm in height. Rhizome about 0.5–1 cm thick. Petiole up to 30 cm long, sheathed. Geniculum up to 1.5 cm long. Leaf blade lanceolate to narrow ovoid, usually up to 15 × 7 cm in size, leathery, medium to dark green. Apex acute; base round or slightly cordate. Margin often undulate. Peduncle 5–40 cm. Spathe opened wide on maturity, recurved, later closed, 1.5–6 cm long. Spadix 1.5–7 cm long; 3–6(–8) adnate stamens; thecae lateral on the synandrium. Berries flat-globular; seeds 0.5–1 × 0.4–0.8 mm in size.

Culture: *Anubias barteri* var. *barteri* is—like the other varieties of this species—a slow-growing, highly recommended marsh plant with a good capability to adapt to submersed living conditions. The culture is possible in both soft and hard water. As with

all *Anubias*, too strong lighting should be avoided. The rhizome can either be inserted into sand or coarse-grained substrate or be attached to decorative material for the purpose of greening the aquarium. Due to its leathery leaves, which generally remain untouched by cichlids, *A. barteri* varieties are especially recommended for the decoration of cichlid aquariums. Optimum temperature range is 22–26 °C. *Anubias barteri* is a good paludarium plant.

Ecology: The *Anubias barteri* varieties populate shady or semishaded locations in fast-flowing waterways in which they occur emersed or semiaquatic and only occasionally entirely submersed. The populations often grow on stones or logs, rarely in the substrate.

Other: One growth form is available under the name of *Anubias* “coffeefolia.” Its petioles and young leaves are often brownish in color and the leaf blades are slightly bullate.

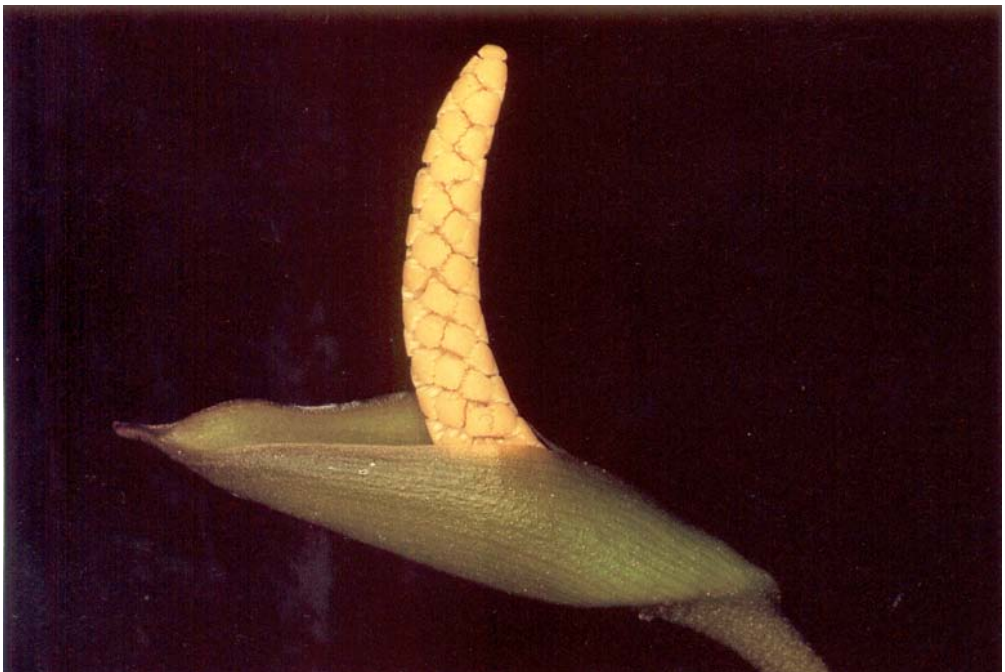
Further reading: Crusio (1979, 1987).

Emersed plants of *Anubias barteri* var. *barteri*.





Emerged plant and inflorescence of *Anubias barteri* "coffeefolia."



Anubias barteri

Schott **var. *angustifolia*** (Engler) Crusio (1979)

Family: Araceae.

Synonyms: *Anubias lanceolata* f. *angustifolia* Engler (1915).

Etymology: *Anubias*: see *Anubias afzelii*; *barteri*: see var. *barteri*; *angustifolia*: narrow-leaved.

Distribution: Guinea, Liberia, Ivory Coast, Cameroon.

Description: Marsh plant with a creeping rhizome. Leaves emerged up to 10 cm, submersed up to 25 cm long petiolate, sheated. Geniculum about 1 cm long. Leaf blade linear to very narrow elliptic, emerged 10–30 cm long and 1.5–4 cm wide, leathery, deep dark green in color, submersed about 15 cm long and 2.5 cm wide, medium green, often with a reddish brown petiole. Apex acute to cuspidate, base decurrent. Margin not undulate.

Flower description: see *Anubias barteri* var. *barteri*.

Culture: An unproblematic, slow-growing marsh plant, *A. barteri* commercial availability is relatively limited. Despite the slow

growth, this variety is highly recommended for cultivation within an aquarium because it adapts without any problems to different water values. For optimum growth, a medium-level light intensity is adequate. Within the aquarium, *Anubias barteri* var. *angustifolia* usually does not grow more than 10–15 cm; it may, however, reach a respectable height of up to 40 cm. Its use, depending on the size of the tank, is therefore recommended for the central to rear planting area. As with other *A. barteri* varieties, var. *angustifolia* is excellently suited for cultivation in cichlid aquariums as well as a paludarium plant. Temperature range is 22–26 °C. Propagation is through rhizome partition. For more data on cultivation refer to var. *barteri* and var. *nana*.

Ecology: Nothing is known to the author on the specific ecology of this plant but its ecological requirements are probably similar to other varieties.

Other: Distinguishing the plant from other *Anubias barteri* varieties is easily possible, due to the linear to narrow elliptic leaf blades.

Emerald plants of *Anubias barteri* var. *angustifolia*.



Anubias barteri

Schott var. *caladiifolia* Engler (1915)

Family: Araceae.

Etymology: *Anubias*: see *Anubias afzelii*; *barteri*: see var. *barteri*; *caladiifolia*: *Caladium*-leaved, refers to the species *Caladium*.

Distribution: Southeast Nigeria, Cameroon, Equatorial Guinea (Bioko).

Description: Sturdy marsh plant with a creeping up to 2-cm thick rhizome. Petiole up to 40(–54) cm long, up to 4 mm thick, sheathed, geniculum up to 2 cm long. Leaf blade lanceolate-narrow ovoid to ovoid, up to 24 × 16 cm in size, leathery, light to dark green. Apex obtuse or acute; base truncated or slightly cordate at first, in larger leaves cordate. Margin usually not or only just slightly undulate.

Flower description: see *A. barteri* var. *barteri*.

Culture: Of all varieties within this species, *A. barteri* var. *caladiifolia* will grow the largest. It is especially recommended for emersed cultivation in paludariums where leaves with a cordate blade base will form. Although cultivation in the aquarium is not difficult, growth is slower and the plants generally re-

main smaller in size. This variety will prosper in soft as well as hard water, but the optimum is maintenance in a soft, slightly acid environment. Its use is recommended only for very high aquariums. This variety is especially suitable for cichlid aquariums. Optimum temperature range is 22–26 °C.

Ecology: In their natural location, one will often find these plants semiaquatic in large populations in fast-flowing waters, at water falls, but also on the edges of flowing waters in the substrate or on stones; only rarely does one find totally submersed specimens, which will then be only small-growing. The variety will prosper both in full sunlight and in shade. In its natural location in Cameroon (Limbe, see photo p. 79) the author recorded the following water values: 25 °C, pH 7.8, GH 4.5 °dH, KH 3.5 °dH, 22 µS/cm, Fe²⁺/Fe³⁺ not detectable. Inflorescences and infructescences could be found only in isolated cases during the month of February.

***Anubias barteri* var. *caladiifolia* in its native habitat in Cameroon (Limbe).**



Anubias barteri

Schott **var. *glabra*** N.E. Brown (1901)

Family: Araceae.

Synonyms: *A. lanceolata* N.E. Brown (1901), *A. minima* Chevalier.

Etymology: *Anubias*: see *A. afzelii*; *barteri*: see var. *barteri*; *glabra*: glabrous.

Distribution: Guinea, Liberia, Ivory Coast, Nigeria, Cameroon, Equatorial Guinea (Bioko), Gabon, Congo.

Description: Marsh plant with a creeping, up to 8-mm thick rhizome. Petiole up to 35 cm long, 2–3 mm thick, sheathed. Geniculum up to 2 cm long. Leaf blade very narrow elliptic to lanceolate-narrow ovoid, up to 23 cm long and 9 cm wide, usually much smaller in an aquarium, leathery, medium to dark green in color. Apex acute or cuspidate; base obtuse, truncated or slightly cordate. Margin usually slightly undulate.

Flower description: see *A. barteri* var. *barteri*.

Culture: In the aquarium *A. barteri* var. *glabra* grows relatively slowly, but is nevertheless a well-growing perennial plant. The specimens can grow without additional water movement, but a certain level of water cir-

ulation seems advantageous for optimum growth. Moderate lighting is quite sufficient. A slightly acid, soft to medium-hard water with temperatures between 22–26 °C is recommended for cultivation. In submersed conditions, this variety usually remains low in height, whereas plants in emersed cultivation can reach a height of about 60 cm. For its use refer to *Anubias barteri* var. *barteri* and var. *nana*.

Ecology: The author recorded the following data at two locations in Cameroon: 24/30 °C, pH 5.5/5.9, GH < 1 °dH, KH < 0.1 °dH, 40 µS/cm, Fe²⁺/Fe³⁺ not detectable. Dense populations of *Anubias barteri* var. *glabra* can be found equally both in deep shade or in full sunlight. The plants are often attached quite firmly to rocks lying in the water (see photo p. 80) or grow only with rhizome in the water. They can, however, also be located entirely emersed only in moist substrate. During February pupas of flies were often discovered in the numerous inflorescences and infructescences.

***Anubias barteri* var. *glabra* in its natural location in Cameroon.**



Anubias barteri

Schott **var. *nana*** (Engler) Crusio (1979)

Family: Araceae.

Synonyms: *Anubias nana* Engler (1899).

Etymology: *Anubias*: see *A. afzelii*; *barteri*: see var. *barteri*; *nana*: dwarf-like.

Distribution: Cameroon (Victoria).

Description: Marsh plant. Rhizome 5–8 mm thick. Petiole 3–8 cm long, 1–3 mm thick, sheathed. Geniculum 0.5–1 cm. Leaf blade narrow ovoid to ovoid, about 4–8 cm long, 3–4 cm wide, leathery, medium to dark green. Apex acute; base round to slightly cordate. Margin slightly undulate.

Flower description: see var. *barteri*.

Culture: An undemanding and popular, slow-growing marsh plant with excellent adaptability to aquarium conditions. Both soft and hard, weak acid or alkaline water are equally suitable for cultivation. The plants will prosper best under weak to medium light. Intensive lighting is not recommended because there is a high danger of algae infestation due to slow growth. This variety, featuring a height of 5–15 cm, is excellently suited for location in the aquarium foreground. During planting, care should be taken that rhi-

zomes are situated above the substrate level because specimens that are inserted too deep grow badly. These plants are especially recommended for the greening of decorative materials. Cichlid aquariums equipped exclusively with *Anubias* can be very impressive. Variety *nana* constitutes an ideal plant for breeding aquariums without a substrate because it is so sturdy, it will grow while floating freely in the water. Propagation is through rhizome partition and temperature range is 22–28 °C.

Ecology: There is hardly any ecological data available or any habitats known. This variety seems to grow in semiaquatic communities in a fast-flowing river in the town of Victoria (Cameroon). Since this location is a protected area no plants were removed by the author for identification purposes. Water analysis (February): temperature 25 °C (air temperature 27 °C), pH 7.8, GH 4.5 °dH, KH 3.5 °dH, 220 µS/cm, Fe²⁺/Fe³⁺ not detectable.

***Anubias barteri* var. *nana*.**

Anubias gigantea

Hutchinson (1939)

Family: Araceae.

Synonyms: *Anubias gigantea* Chevalier var. *tripartita* Chevalier (nomen nudum), *A. hastifolia* Engler var. *robusta* Engler.

Etymology: *Anubias*: see *A. afzelii*; *gigantea*: gigantic, relates to leaf size.

Distribution: Guinea, Sierra Leone, Liberia, Ivory Coast, Togo, Cameroon.

Description: Sturdy marsh plant featuring a slowly growing, 1.5–3-cm thick rhizome. Petiole up to 65(–83) cm long, sheathed. Geniculum 1–2.5 cm long. Leaf blade leathery, very variable in shape, from hastate to trilobular; middle lobe lanceolate to narrow ovoid, 10–30 cm long, 6–17 cm wide, lateral lobe up to 25 cm long, 0.5–9 cm wide. Margin smooth. Coloration medium green.

Peduncle up to 50 cm long. Spathe 4.5–13 cm long, on maturity open for several hours, not recurved. Spadix 5–19 cm long, almost equal to about a third longer than the spathe, 4–6(7–8) adnate stamens. Thecae laterally on the synandrium. Seeds examined only once, up to 1.8×1.2 mm in size.

Culture: A very slow-growing marsh plant

with a moderate adaptation to submersed conditions. The variety is rarely commercially available. Due to its size, it is especially recommended for paludariums and has only a limited suitability for aquariums. The plants normally require an extended period of acclimatization. Propagation is through rhizome partition.

Ecology: According to Crusio (1987), the species grows semiaquatic on the banks or beds of streams, mostly in sunny locations. Flowering period is from February to April.

Other: Three growth forms are in culture and can be easily differentiated through their consistent leaf shapes. The first has hastate, in their contour almost trigonal leaf blades; the second features hastate, distinctly trilobular blades with about 8–9-cm wide basal lobes; and the third has lanceolate leaf blades (similar to *Anubias heterophylla*) with up to 14 cm long and up to 1.5-cm wide basal lobes.

Emersed plant of *Anubias gigantea*.



Anubias gillettii

de Wildeman & Durand (1901)

Family: Araceae.

Synonyms: None.

Etymology: *Anubias*: see *A. afzelii*; *gillettii*: after the collector J. Gillet (1866–1943).

Distribution: Nigeria, Cameroon, Gabon, Congo, Zaire.

Description: Marsh plant with an up to 1 cm-thick rhizome. Petiole up to 40 cm long, 2–3 mm thick, with a short sheath, settled by small acanthas in more sturdy specimens. Geniculum about 1 cm long. Leaf blade leathery, initially slightly cordate or auriculate, older leaves sagittate to hastate; middle lobe up to 30 cm long, 15.5 cm wide, narrow oblong to oblong, acute to cuspidate; lateral lobe up to 10 cm long, acute to obtuse. Margin smooth. Coloration light to medium green.

Stem of the inflorescence up to 22 cm long. Spathe 1–3 cm long, briefly opened on maturity. Spadix with 2.5 cm length almost as long as the spathe; 3–5 adnate stamens. Thecae on the upper margin of the synandrium. Seeds up to 1 × 0.5 mm in size.

Culture: A high degree of humidity has to be prevalent for emersed cultivation. Whereas

the plants grow very large in marsh culture, they remain considerably smaller in the aquarium so that they can quite easily be confused with varieties of *A. barteri*. Although *A. gillettii* also makes do with low light levels, it will display improved growth in a medium light intensity environment. Sturdy specimens display distinct lateral lobes. For more information on culture also refer to *A. afzelii*.

Ecology: In its native location this species grows on the banks of rivers, usually with its rhizome in the water or in hardly moist substrates. In Cameroon (February) the author occasionally found small to medium-sized specimens, also fully submersed. Inflorescences were rarely found.

Other: *Anubias gillettii* can easily be confused with frail specimens of *A. hastifolia* and *A. pyraertii*. Inflorescences are essential for a definite species identification.

Emersed specimen of *Anubias gillettii*.



Anubias gracilis

Hutchinson (1939)

Family: Araceae.

Synonyms: None.

Etymology: *Anubias*: see *Anubias afzelii*; *gracilis*: slim, delicate.

Distribution: Guinea, Sierra Leone.

Description: Marsh plant with slowly growing, 1–1.5-cm thick rhizome. Petiole up to 60 cm long, with a very short sheath. Geniculum up to 1–1.5 cm long. Leathery blades, hastate, usually almost trigonal in its outline, 10–40 cm in length and 10–20 cm wide, apex acute; basal lobes round. Margin smooth. Medium green coloring.

Peduncle 6–15 cm long. Spathe 1.5–3 cm long, opened wide, recurved. Spadix up to 3 cm in length, equal in length or a little shorter than the spathe; 6–8(9) adnate stamens; thecae lateral on the synandrium. Male segment of the spadix 2–4 times the length than its female counterpart. Seeds are not known.

Culture: *Anubias gracilis* is rarely commercially available, which is mainly because the species grows rather large and subsequently requires spacious aquariums. It has only a limited suitability for a continuous culture

underwater; it does, however, constitute a very recommendable paludarium plant. The substrate may consist of soil or a mixture of sand, clay and beech leaf mold. Hydroponics, too, is possible. Previous experience indicates no special requirements regarding water values in the aquarium. The plants will possibly grow best in soft water, even though healthy growth is also possible in water of medium hardness. Light requirements are very low. Within an aquarium, *Anubias gracilis* will grow best if both rhizome and roots are not inserted into the substrate but are left to hang freely in the water. Specimens cultivated in this manner nevertheless require many months to completely acclimatize. Propagation is through partitioning of the rhizome.

Ecology: At its natural habitat, *A. gracilis* will lead a partially submersed existence during the wet season (similar to *Anubias gillettii*).

Further reading: Crusio (1979, 1987)

Emerersed plants of *Anubias gracilis*.



Anubias hastifolia

Engler (1893)

Family: Araceae.

Synonyms: *Anubias hastifolia* var. *sublobata* Engler, *A. auriculata* Engler, *Amauriella auriculata* (Engler) Hepper, *A. haullevilleana* de Wildeman, *A. laurentii* de Wildeman, *Amauriella obanensis* Rendle, *Amauriella talbotii* Rendle, *Amauriella hastifolia* (Engler) Hepper.

Etymology: *Anubias*: see *Anubias afzelii*; *hastifolia*: hastate.

Distribution: Ghana, Togo?, Nigeria, Cameroon, Zaire.

Description: Marsh plant with a slowly growing, creeping rhizome, up to 1.5 cm thick. Petiole up to 63 cm in length, sheathed, echinate in sturdier specimens. Geniculum up to 1 cm long. Leaf blade leathery, from hastate to nearly 3-parted middle lobe lanceolate to narrow ovoid or obovate, up to 26×12 cm in size, acute to cuspidate; lateral lobes up to 21×7 cm large, acute or obtuse. Margin flat. Dark green coloration.

Peduncle 8–24 cm long. Spathe 2–4.5 cm long, briefly opened on maturity, not recurved. Spadix 1.5–4 cm in length; 4–6 ad-

nate stamens; thecae covering the apex of the synandrium or at least the top half. Seeds up to 2.5×1.6 mm in size.

Culture: This robust marsh plant has only a limited adaptability to the continuous submersed conditions within the aquarium. Cultivation in spacious paludariums, however, is recommended. There, under conditions of high humidity, the plants should only be subjected to moderate lighting. During planting care has to be taken to ensure the rhizome can develop by creeping above the substrate. Vegetative propagation occurs by partitioning of the rhizome, sexual propagation is also possible, however the plant will flower only rarely.

Ecology: Populates shaded locations on the banks of small waterways in forests. In Cameroon, the author found the species growing emersed at the edges of streams, rooted in a moist substrate, but not in the water itself, whereas *A. gillettii* was also found partially submersed during the same time of year (February).

Other: *Anubias hastifolia* in its vegetative state cannot be definitely differentiated from *A. pynaertii*.

Anubias hastifolia on the banks of a stream in Cameroon.



Anubias heterophylla

Engler (1879)

Family: Araceae.

Synonyms: *Anubias congensis* N.E. Brown, *A. congensis* var. *crassispadix* Engler, *A. affinis* de Wildeman, *A. engleri* de Wildeman, *A. bequaerti* de Wildeman, *A. undulata* hort. (nomen nudum).

Etymology: *Anubias*: see *Anubias afzelii*, *heterophylla*: featuring different leaves.

Distribution: Cameroon, Equatorial Guinea, Gabon, Congo, Angola (Cabinda), Zaire.

Description: Marsh plant with an up to 2 cm thick rhizome. Petiole up to 66 cm long but usually much shorter, sheathed. Geniculum 0.5–2.5 cm long. Blade leathery, narrow elliptical to lanceolate, 10–38 cm long, 3–13 cm wide. Apex acute; base acute to round, short sagittate or hastate. Basal lobes short or absent, round. Margin flat and hardly undulate. Medium green coloration.

Peduncle 5–27 cm long. Spathe 1.5–4.5 cm long, opened wide on maturity, not recurved. Spadix 1.5–4.5 cm long, hardly or semiprotruding from the spathe; 4–5 adnate stamens; thecae lateral on the synandrium,

occasionally only in the upper region. Small seeds, up to 1.5×1 mm in size.

Culture: *Anubias heterophylla* is a slow-growing and relatively rare marsh plant with a good adaptability to aquarium cultivation. It is highly recommended for spacious paludariums. In the aquarium, the species will remain considerably smaller than if growing emersed. Depending on the aquarium size, this *Anubias* may be used for the middle and rear planting zones. The plants will possibly grow best in soft water, even though healthy growth can also succeed in water of medium hardness. A medium light intensity is recommended. Propagation is through partitioning of the rhizome. Sexual propagation by seeds is possible as well.

Ecology: At its natural location, *A. heterophylla* will sometimes lead a partially submersed existence. It populates shaded locations.

Other: Three growth forms are known which differ from each other in their leaf shapes.

Further reading: Crusio (1979, 1987)

Emersed plant of *Anubias heterophylla*.



Anubias pynaertii

de Wildeman (1910)

Family: Araceae.

Synonyms: None

Etymology: *Anubias*: see *Anubias afzelii*; *pynaertii*: after the collector Léon A. Pynaert (1876–?).

Distribution: Cameroon, Gabon, Congo, Zaire.

Description: Marsh plant with a creeping, up to 1.5-cm thick rhizome. Petiole up to 35(–45) cm long, with a short sheath. In robust specimens the petiole will be distinctly echinate, otherwise almost glabrous. Geniculum 1–2 cm long. Leathery leaf blade, hastate to 3-parted; middle lobe lanceolate to narrow lanceolate, up to 26 cm long and 5–6(–14) cm wide, acute; lateral lobe up to 16 cm long and 3–4(–7) cm wide, acute. Margin flat or slightly undulate. Medium to dark green coloration.

Peduncle 7–27 cm long. Spathe 2–3.5 cm long, recurved when mature, subsequently again closing. Spadix 2.5–3.5 cm long; 4–6 adnate stamens. Thecae lateral and also on the tip of the synandrium. Seeds up to 2.4 × 1.5 mm in size.

Culture: *Anubias pynaertii* possesses only a limited adaptability to submersed conditions and is therefore relatively unsuited for continuous cultivation in the aquarium. As is valid for all *Anubias* varieties, *A. pynaertii*, too, is a worthwhile paludarium plant which, however, grows quite slowly. It should receive only moderate light and requires a high humidity environment and warmth for healthy growth. Soil or a mixture of sand, clay and beech leaf mold can be used as a substrate. Vegetative propagation takes place through partitioning of the rhizome. Sexual propagation by seeds is possible as well, but requires a lot of effort.

Ecology: The plants populate shaded areas on the banks of slow-moving streams and rivers.

Other: *Anubias pynaertii* in its vegetative state cannot be definitely differentiated from *A. hastifolia*. Definite identification is only possible through the specific concrescence of the stamens.

Further reading: Crusio (1979, 1987)

Emerged plants of *Anubias pynaertii*.



The *Aponogeton* Genus

APONOGETONACEAE FAMILY

Genus Characteristics

All species of *Aponogeton* have a tuber or rhizome with which they can store reserve substances. Among the cultivated plants *A. rigidifolius* is, in a certain sense, an exception since this species does not have a tuber but a conspicuously long and thin rhizome. The Aponogetonaceae produce submersed as well as floating leaves, only in rare instances—as for example, in *A. tenuispicatus* or occasionally *A. crispus*—do they have emerged leaf blades. All leaves are arranged in a rosette.

The inflorescence develops on a long stem and unfolds above the water. It is initially surrounded by a spathe which splits and releases a varying number of spikes. These spikes are more or less many-flowered. Individual flowers are small, sessile and generally feature two conspicuously colored tepals, six stamens and three carpels. In a few species variations from the structure do occur. Several dioecious species are also known (male only or female only plants). The male plants have only a rudimentary and sterile gynoeceum (totality of carpels), whereas tepals and stamens are missing in female plants. Apomixis (seed production without fertilization) also occurs occasionally.

Even though cultivated *Aponogeton* species often form inflorescences within the aquarium, subsequent seed production will only rarely occur. This is unfortunate since, for one, vegetative propagation is hardly possible, and, second, the imported plants will still quite often have been collected from natural locations. (These days, however, more and more species are propagated through in vitro cultivation.) For successful fertilization to take place, the mature pollen has to be transferred onto the stigma. This, for example, can be done with a brush. Good results

were also achieved using fruit flies which managed the pollen transportation within a closed plastic bag draped over the inflorescence (e.g., in *A. boivinianus*). Despite all efforts, such a massive fructification, which is quite common with many species within their respective native habitats, will only rarely succeed. This is due to the fact that many species are self-sterile and therefore require inflorescences from two plants for pollination to take place. But even when taking all circumstances into consideration success will often be absent. Humidity, too, might in fact play a larger role during pollination than has previously been assumed. During sexual propagation care has to be taken that the seeds from *Aponogeton* species never dry out.

Distribution of *Aponogeton* Species and Their Occurrence in Aquaristics

The *Aponogeton* family currently consists of 44 species which are distributed throughout

Vegetative propagation in *A. rigidifolius*.





***Aponogeton longiplumulosus*: the spathe bursts open.**

the tropics and subtropics of the Old World. Even though 17 species are found in Africa, only one of them, *A. distachyos*, has been continuously maintained as a plant in garden ponds. Several of the 11 Madagascan species have been introduced as new aquarium plants over the last couple of years. At present, the following plants from Madagascar are in culture: *Aponogeton boivinianus*, *A. longiplumulosus*, *A. madagascariensis* and *A. ulvaceus*. *Aponogeton bernierianus*, *A. capuronii*, *A. decaryi* and *A. tenuispicatus* have been imported on several occasions but haven't achieved any wider distribution because they are difficult to maintain. From the 16 representatives of this genus from Asia and Australia, *A. crispus*, *A. elongatus*, *A. rigidifolius*, *A. robinsonii* and *A. undulatus* are useful aquarium plants. *Aponogeton jacobensii*, *A. natans* and *A. loriae*, too, were cultivated

several times but have not proven themselves under aquarium conditions.

Natural Locations of *Aponogeton* Species

Almost all *Aponogeton* species go through resting and growth phases within their natural locations. The sequence of these phases are triggered by the ecological conditions prevalent in the respective living environments. During growth periods the plant will deposit proteins, fats, carbohydrates and mineral substances in the storage organ. During the resting period the tuber survives in the soil in order to again sprout during the following vegetation period. Tubers in *Aponogeton* species have a high resistance to drying out. This ability to store water is exploited, for instance, in the annual export of thousands of *A. crispus* specimens, since they are freighted in large bags in a totally dry state. Special care has to be taken, however, to prevent the tubers from contracting. At the same time, the vegetative point must not be damaged.

In previous aquaristic literature the assertion—which is wrong in this form—has been disseminated, stating that all cultivated *Aponogeton* species are subjected to a periodical drying out of waterways in their natural habitats. It is subsequently being suggested that at the onset of the resting period—indicated by the plant through the retraction of its leaves—the tuber should be removed from the aquarium and be stored in a cool and more or less moist state for several months. According to the author's experience, obtained at numerous locations, these assertions and conclusions will often lead to maintenance not appropriate to biotope conditions, with the result that plants eventually die off. These erroneous ideas, widespread among the aquarist community, can quite possibly be traced back to the first mass import of *A. crispus* in the early 1950s, since the above assertions do in fact mostly apply to this spe-



Top: violet flowering form of *A. ulvaceus*.
Below: female inflorescence of *A. decaryi*.



cies. They were erroneously applied to other species imported later. In order to achieve a maintenance in accordance with biotope-specific requirements, the ecological conditions in which *Aponogeton* species prosper have to be viewed in a more differentiating manner than has previously been the case. Therefore a description of specific features of different types of waters accommodating *Aponogeton* varieties is provided at this point. In the sections on the individual species the known ecological conditions are listed, enabling the reader a classification into different categories. Data on cultivation will help to contribute to a successful, species-specific maintenance. It should be noted, though, that because of a lack of ecological data it is difficult to classify some species into the system.

Basically one can distinguish between four different categories of types of waters accommodating *Aponogeton* species.

It has to be noted that some species can be found in more than one type of waterway.

Type 1 Stagnant, temporary waters (periodically drying out)

Type 2 Stagnant, permanent waters (usually not drying out)

Type 3 Flowing, temporary waters (periodically drying out)

Type 4 Flowing, permanent waters (not drying out)

Water Body Type 1 (Stagnant, Temporary)

This type of waterway features more or less *pools or small lakes without any noticeable* in- or outflow and whose water level is subject to strong seasonal variation. Usually these waters will completely dry out during rain-deficient periods, causing all plants above the ground to die off with only the tuber remaining in the soil. With the onset of the rainy season, the tuber will again sprout because of its storage of reserve substances.

The time span from the beginning of the wet season to complete drying out of the pools varies from species to species, depending on their geographical distribution. Accordingly, the rest periods also vary in duration.

Recommendations for Cultivation of Species Inhabiting Type 1—

The tuber of *Aponogeton* species found in the tropics and in stagnant, temporary waters, are subjected to high temperatures during the rest period, rendering the previous recommendation to store the tuber during the rest period at a low temperature level completely incomprehensible. Of course, the natural environment cannot be completely emulated, but an effort can be made to maintain the plants in accordance with natural biotope conditions. In order to comply with a species-specific maintenance, the tuber has to be stored in a more dry than moist surrounding at a temperature ranging between 20 and 25 °C, even though temperatures up to 30 °C might actually correspond to natural conditions. One option is to plant the specimens in pots within the aquarium, subsequently remove them from the water at the start of the rest period, keep them in a heated room and, after having more or less dried out, occasionally sprinkle them with very little water. More commonly recommended is the cultivation of the plants in the substrate of the aquarium since they will prosper better than in pot cultivation. At the start of the rest period, the tuber should be removed from the aquarium and cleaned thoroughly. In some *Aponogeton* species, the tuber can be stored completely dry for many weeks. However, to ensure that it does not totally dry out it can be put into a pot filled with soil or artificial clay gravel and occasionally sprinkled; it is, however, not allowed to be kept in a moist state because this might easily cause rotting.

The following species described in this book definitely stem from this type of waterway: *A. abyssinicus*, *A. crispus*, *A. decaryi*, *A. natans* and *A. ulvaceus*.

Type 2 (Stagnant, Permanent)

This type features stagnant water which is subjected to seasonal variations in water level, but does not dry out entirely.

Recommendations for Cultivation of Species

Inhabiting Type 2—Plants from stagnant, permanent waters should basically be treated just like species inhabiting permanent, flowing waters (Type 4). So far the author can classify only certain populations of *A. crispus* and *A. ulvaceus* into this type. *Aponogeton crispus*, for example, is prevalent on the artificially installed water storage tanks on Sri Lanka which usually do not run dry. However, the species also grows in stagnant, temporary waters (Type 1). Previous experience with cultivation shows that it progresses through a resting period but, after a few weeks, will sprout new leaves without the tuber having been removed from the aquarium. In order to prevent the tubers from becoming

exhausted too rapidly, it is better to occasionally remove them from the aquarium.

Type 3 (Flowing, Temporary)

Previously, it has been known, or assumed, that very few *Aponogeton* species grow in rivers which occasionally dry out during rain-deficient periods. Since there are hardly any recorded observations of this plant group, a definite classification this in category of body of water is difficult simply because flowing waters which dry out are very rare. *Aponogeton boivinianus* and *A. ulvaceus* probably exist in such waters. With regard to the seasonal changes, the living conditions in these waters correspond in several aspects to those found in stagnant, temporary waters (Type 1).

Recommendations for Cultivation of Species

Inhabiting Type 3—Species from temporary, flowing waters can basically be treated as described for Type 1. Since it can be assumed

Temporary pool with *Aponogeton crispus* in Sri Lanka.



that the rivers—depending on the duration of the rain-deficient period—don't dry out every year, the species belonging to this type of body of water do not necessarily have to have a regular rest period. Here, too, the species should be provided now and again with a rest period in order to prevent the tuber from becoming exhausted too rapidly.

Type 4 (Flowing, Permanent)

This type constitutes the most important living environment for *Aponogeton* species in cultivation. Contradicting this, however, is the fact that such biotopes were practically nonexistent in earlier instructions on cultivation. Previous recommendations from other authors to always remove the tuber from the substrate during the rest periods is, according to my observations, contrary to the ecological conditions in the plant's natural locations. This is especially true for those species which

grow in permanent, flowing waters. The *Aponogetonaceae* which are classified in this group go through growth and rest periods in their natural habitats, which are dependent on dry and wet seasons. These periodic phases in this special group within the species, however, are not linked to the drying out of waterways (compare Type 1) but rather to the strong seasonal variation of the water level. During the wet season, the level is high and the current strong. Furthermore, hardly any light will reach the plants because of the loamy turbidity of the water, resulting in growth stagnation due to insufficient light. Once the water level progressively drops towards the end of the wet season, the plants will again sprout, flower and produce seeds through the gradual increase in light intensity. In addition, the inflow of cooler water from the atmosphere and the mountains during the wet season will cause a reduction in the growth speed in the plants. The plants' rest-

Aponogeton rigidifolius in moving waters in Sri Lanka.



ing period therefore does not coincide with the dry period, but—contrary to the popular opinion disseminated in aquaristics—with the wet season instead. Accordingly, the growth and reproductive phase of the plants occurs during the dry season. In this context, though, it has to be remembered that the occurrence of seasons within tropical regions varies to such a large extent that resting and growth periods may differ in duration. So far there is no research on if and how long the tuber of different *Aponogeton* species stemming from permanent, flowing waters can remain in a dry state without incurring any damage.

The following species in culture can definitely be grouped into this type of body of water: *A. bernierianus*, *A. capuronii*, *A. jacobsonii*, *A. longiplumulosus*, *A. madagascariensis*, *A. rigidifolius*, *A. robinsonii* and *A. ulvaceus*.

Recommendations for Cultivation of Species Inhabiting Type 4—According to my observations at natural locations, the tuber in those species from permanent, flowing waters should not be removed from the aquarium substrate. A higher water level, occurring during the wet season, cannot be emulated in the aquarium. But since light deficiency and a low water temperature obviously constitute the determining factors for the changed growth rate during the resting period, one can attempt to simulate these conditions within the aquarium. Consequently, the author recommends providing shade for plants in the aquarium during the resting period by using a piece of dark paper on the cover panel, and also reducing the temperature by a few degrees in accordance with the individual requirements of the species concerned. If such maintenance is impossible within an aquarium with a wider community of plants, this leaves only cultivation in pots if one wants to enjoy the plants for as long as possible. In pot cultivation the resting phase should be “enforced”

in a separate aquarium, which should be kept very dark and maintained at an appropriate temperature.

Further Reading—Readers who are interested in further information on the *Aponogeton* species are referred to the following important publications:

Bruggen, H.W.E. van (1985): Monograph of the genus *Aponogeton* (Aponogetonaceae). Bibliotheca Botanica 137. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

Bruggen, H.W.E. van (1990): Die Gattung *Aponogeton* (Aponogetonaceae). Aqua-Planta, Sonderheft No. 2. VDA-Arbeitskreis Wasserpflanzen, Berlin.

Other *Aponogeton* Species and Their Distribution—The following *Aponogeton* species are also known, but have not previously been or have rarely been kept for aquaristic purposes (after van Bruggen 1985):

- Aponogeton afroviolaceus* Lye
Kenya, Tanzania, Zambia, Zimbabwe
- Aponogeton angustifolius* Aiton
South Africa (Cape of Good Hope)
- Aponogeton appendiculatus*
H.W.E. van Bruggen
India
- Aponogeton azureus* H.W.E. van Bruggen
Namibia
- Aponogeton bogneri* H.W.E. van Bruggen
Zaire (Shaba Province)
- Aponogeton bruggenii* Yadav & Govekar
India
- Aponogeton bullosus* H.W.E. van Bruggen
Australia (Queensland)
- Aponogeton cordatus* Jumelle
Madagascar
- Aponogeton desertorum* A. Sprengel
Angola, Botswana, Mozambique, Namibia,
South Africa, Zaire, Zambia, Zimbabwe
- Aponogeton dioecus* Bosser
Madagascar (Mandritsara)
- Aponogeton fotianus* Raynal
Chad (Golé)

Aponogeton hexatepalus

H.W.E. van Bruggen
Western Australia (Perth)

Aponogeton junceus Lehmann

Angola, Lesotho, Namibia, South Africa,
Zambia, Zimbabwe, Zaire

Aponogeton lakhonensis A. Camus

Cambodia, China, India, Indonesia (Sula-
wesi), Thailand, Vietnam

Aponogeton natalensis D. Oliver

Botswana, South Africa

Aponogeton nudiflorus Peter

Ethiopia, Somalia, Kenya, Tanzania

Aponogeton queenslandicus

H.W.E. van Bruggen
Australia (Queensland)

Aponogeton ranunculiflorus

Jacot Guill. & Marais
South Africa (Lesotho and bordering Natal
Province)

Aponogeton rehmannii D. Oliver

Botswana, Kenya, Mozambique, Namibia,
South Africa, Zambia, Zimbabwe

Aponogeton satarensis

Raghvan, Kulkarni & Yadav
India (Satara district)

Aponogeton stuhlmannii Engler

Kenya, Namibia, South Africa, Tanzania,
Zaire, Zambia, Zimbabwe

Aponogeton subconjugatus

Schumacher & Thonning
Cameroon, Chad, Congo, Ghana, Mali,
Nigeria, Senegal, Sudan, Uganda

Aponogeton troupinii Raynal

Chad, Central African Republic

Aponogeton vallisnerioides Baker

widely distributed in tropical Africa

Aponogeton viridis Jumelle

Madagascar

Aponogeton womersleyi H.W.E. van Bruggen

Papua New Guinea (Fly River district)

Aponogeton abyssinicus

A. Richard (1851)

Family: Aponogetonaceae.

Synonyms: *Aponogeton leptostachyus* E. Meyer var. *abyssinicus* (Hochstetter ex A. Richard) Engler & Krause, var. *minor* Baker, *A. boehmii* Engler, *Ouvirandra hildebrandtii* Eichler, *A. braunii* Krause, *A. oblongus* A. Peter.

Etymology: *Aponogeton*: modified from the species name *Potamogeton* (anagram); *abyssinicus*: originating from Abyssinia.

Distribution: East Africa, from Ethiopia to Malawi and Zaire.

Description: Amphibious plant. Root stock tuberous or oblong, up to 2.5 cm diameter. Submersed leaves initially strap-shaped, up to 12 cm long and 6 mm wide, continuing lanceolate to obovate, up to 8.5 cm long, 2.6 cm wide and up to 10 cm long petiolate. Blade thin and slightly transparent, with a narrowing or decurrent base and acute or obtuse apex. Adults floating, up to 50 cm long petiolate. Floating leaf blade linear to ovoid, rarely cordate, up to 16 cm long and 5 cm wide, usually considerably smaller. Emerged leaves shaped like the floating leaves, slightly leathery and shorter petiolate.

Peduncle up to 45 cm long, angled, dark red to green coloration, slightly pubescent underwater, almost glabrous above water, not swollen under the inflorescence. Spathe 1.0–1.6 cm long, caducous. Inflorescence featuring two 1.5–5-cm long spikes with omni-lateral flowers; 2 tepals, violet or white coloration; 6 stamens (none in apomictic plants); 3 carpels (up to 7 in apomictic plants). Fruit up to 7 × 2.75 mm large, with (4–) 7–10 seeds, sized 1–2 × 0.75 mm, double testa.

Culture: *Aponogeton abyssinicus* is a rarely imported plant, the maintenance of which is entirely possible in an aquarium. For cultivation, preferably soft water as well as nutrient-rich and loose substrate is recommended. The best water temperature ranges between 24–

28 °C. In the aquarium, the white-flowering form of *A. abyssinicus* forms a 15-cm wide and 10-cm tall rosette consisting of light green leaves, so that it may be considered for the foreground. The floating leaves, which only rarely form in aquariums, should be removed so that the later leaves will again remain short petiolate. An emersed or semi-aquatic keeping is possible under conditions of high humidity. Best cultivation results are achieved in shallow water. Propagation can occur only sexually through the very tiny seeds. Though they mostly germinate well, the rearing of the young plant is, in fact, extremely difficult and requires a lot of effort.

Ecology: *Aponogeton abyssinicus* populates shallow, usually temporary waters up to an altitude of 2700 m. White-flowering plants (usually violet-flowering) were collected by the author in the Selous Game Reserve, Tanzania, where very few specimens were located only on the edges of a permanent water in shallow depth, occasionally also completely emersed in a moist substrate.

Further reading: van Bruggen (1985, 1990); Kasselman (1983b).

Flowering *A. abyssinicus*.

Aponogeton bernierianus

(Descaisne) Hooker fil. (1883)

Family: Aponogetonaceae.**Synonyms:** *Ouvirandra bernieriana* Descaisne (1837), *Aponogeton quadrangulare* Baker.**Etymology:** *Aponogeton*: see *A. abyssinicus*; *bernierianus*: after the collector Bernier.**Distribution:** Eastern Madagascar.**Description:** Aquatic plant with a 3-cm thick tuber or thick and branchy rhizome. Leaf blade up to 13 cm petiolate, strap-shaped, highly bullate and undulate, up to 50(–120) cm long and 1.5–6.5(–10) cm wide, dark green coloration.

Peduncle up to 75 cm long, tapering towards the inflorescence. Spathe up to 15 mm long, caducous. Inflorescence with 3–15 up to 8-cm long spikes with omnilateral flowers; 2(3) white tepals; 6 stamens; 3(4) carpels with 2 ovules each. Fruit about 10 × 7 mm. Seed about 7 × 4 mm in size, simple testa (van Bruggen 1985).

Culture: *Aponogeton bernierianus* has been collected on only a few occasions. Maintenance in an aquarium is difficult and successful only in a few, rare instances. For a suc-

cessful culture, the ecological conditions will have to be taken into consideration (soft, cool and strong water movement).

Ecology: The species grows in rivers and streams with more or less fast-flowing water, up to an altitude of 1200 m in shady or sunny locations. At one location near Andasibé (Madagascar), studied by the author, flowering plants grew during the dry season in 60-cm deep, clear water. Three months later, the water level at this location measured more than 1.7 m during the wet season (the plant's rest period). The water had turned loamy and turbid and the current was ripping. A locally conducted water analysis in January 1987 during the wet season resulted in a water temperature of 20.6 °C, a pH-value of 5.8, as well as a total and carbonate hardness reading of less than 1 °dH.**Other:** Two forms are known, one featuring narrow, the other wide leaf blades. In the past flowering plants have been collected during almost every month.***Aponogeton bernierianus* on Madagascar.****Natural location of *A. bernierianus*.**

Aponogeton boivinianus

Jumelle (1922)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: see *A. abyssinicus*; *boivinianus*: after the collector Boivin.

Distribution: Northern Madagascar, Nosy Bé, Mayotte.

Description: Aquatic plant. Tuber up to 3 cm diameter. Leaf blade up to 13(–22) cm petiole, strap-shaped, highly bullate and undulate, slightly leathery, up to 30(–60) cm long, 1.5–5(–8) cm wide, dark green, young leaves light green or brown in color.

Peduncle up to 70 cm long, spongy swollen toward the inflorescence. Spathe up to 4.5 cm long, caducous. Inflorescence with 2, rarely 3, up to 20-cm long spikes with omnilateral flowers; 2 white or pink tepals; 6 stamens; 3(4) carpels with (3–)6(7) ovules. Fruit up to 8 × 4 mm. Seeds about 3 × 1 mm in size, simple testa (van Bruggen 1985, 1990).

Culture: For the purposes of aquarium keeping *A. boivinianus* is one of the most beautiful and most recommended of the members of the *Aponogetonaceae* family. The plants can be kept without problems in soft to medium-

hard water as well as a slightly acid to slightly alkaline pH-range. The substrate should be loose and rich in nutrients. Just as in natural locations, a strong water movement has a positive effect on plant growth. The optimum temperature range is 22–25 °C. Fully grown adult specimens can attain an impressive size which is why spacious aquariums are a necessity. For continuous maintenance, it is recommended that as soon as the plants signal the onset of the rest phase by retracting their leaves, either reduce the amount of light and, if possible, lower the temperature by 2–3 °C, or store the tuber, slightly moistened, at room temperature. Alternating both measures might correspond to optimum conditions.

Ecology: The species populates flowing waters which probably only dry out occasionally. Water values can vary quite considerably (see van Bruggen 1990).

***Aponogeton boivinianus*.**



Aponogeton capuronii

H.W.E. van Bruggen

Family: Aponogetonaceae.**Synonyms:** None**Etymology:** *Aponogeton*: see *A. abyssinicus*; *capuronii*: after R.P.R. Capuron (1921–1971).**Distribution:** Southeastern Madagascar.**Description:** Aquatic plant with an up to 10 × 2-cm thick rhizome. Leaf blade 7–20 cm long petiolate, slightly leathery, 20–40 cm long and 3–4.5(–8) cm wide, flat or highly bullate and undulate, dark olive-green coloring. Apex acute, base round, cuneate or slightly cordate.

Peduncle 40–60(–300) cm long, swollen toward the inflorescence. Spathe up to 1.5 cm long, caducous. Inflorescence with 2, seldom 3 up to 14 cm long spikes with omnilateral flowers; 2 white tepals; 6 stamens; 3–4 carpels with 2(–4) ovules each. Fruit about 6 × 3 mm in size, with a terminal beak. Seeds up to 3.25 × 1.5 mm in size, simple testa (van Bruggen 1985).

Culture: A decorative *Aponogeton*, though with limited adaptability to living conditions in the aquarium. It was imported on a few occasions, but successful cultivation was theexception. A specimen featuring bullate leaf blades has been cultivated successfully for more than 20 years by J. Bogner in the Botanical Gardens Munich. The plant is kept in soft, weak acid water in a shaded location. According to this data, *Aponogeton capuronii* does not require a specific rest phase.**Ecology:** The species grows in rivers with fast-flowing water. In February 1968, Bogner discovered plants in the Mandromondromotra River (Madagascar) in a depth of 20–30 cm. When the author visited this location in December 1986, the river had a water level of nearly 2 m. The plants had hardly any juvenile leaves, which hinted at limited growth activity. Water values of this location were as follows: temperature 27.3 °C (air 30 °C at 13:30 h), pH 6.0, GH/KH < 1 °dH, Fe²⁺ = 0.05 mg/l, NO₂[–] not detectable. The substrate consisted of sand and gravel mixed with coarse, yellow clay.**Other:** Forms specific to some locations and featuring bullate, undulate and flat blades have been identified.***Aponogeton capuronii* at its location on Madagascar.****Native environment of *A. capuronii*.**

Aponogeton crispus

Thunberg (1781)

Family: Aponogetonaceae.

Synonyms: *Aponogeton echinatum* Roxburgh.

Etymology: *Aponogeton*: see *A. abyssinicus*; *crispus*: crisped, refers to the margin.

Distribution: Southern India, Sri Lanka.

Description: Variable aquatic plant. Tuber up to 5 cm in size. Submersed leaf blade up to 10 cm petiolate, strap-shaped, with undulate and crisped, rarely flat margin, up to 50 cm long, 4.5 cm wide, light to dark green or reddish brown coloration. Blade of the floating leaves up to 20 cm long, 5 cm wide.

Peduncle up to 75 cm long, thickened towards the inflorescence. Spathe up to 2.5 cm long, caducous. Inflorescence usually features an up to 13-cm long spike with omni-lateral flowers; 2 white, pink or light violet tepals; 6 stamens; 3 carpels with 2 ovules each. Fruit up to 18 × 7 mm, seeds up to 12 × 5 mm in size. Simple testa (van Bruggen 1985, 1990).

Culture: *Aponogeton crispus* is a fast-growing tuberous plant which is regularly exported in large quantities from Asia. The

species loves soft, slightly acid water with temperatures ranging between 25–32 °C, but can also be kept in medium-hard to hard water with simultaneous CO₂ fertilization in place. In a nutrient-rich substrate it will quickly reach a height of 30–50 cm so spacious aquariums are recommended. To ensure maintenance specific to the species, the tubers have to be stored outside the aquarium at room temperature in a rather drier than moist environment because they would otherwise exhaust relatively quickly. This is not essential for every rest phase, but should happen now and again.

Ecology: The species normally inhabits temporary pools or small lakes which can dry out completely during seasons with little rain. In Sri Lanka it also populates artificially installed “tanks.” The following data was recorded in two pools accommodating massive communities of *A. crispus* in January 1985 in Sri Lanka: 1) 32 °C, pH 6.6, GH/KH < 1 °dH, 222 µS/cm, rH 188 mV; and 2) 31 °C, pH 7.1, GH 3 °dH, KH 2 °dH, 290 µS/cm, rH 178 mV. The substrate consisted of solid clay, the water was turbid.

Aponogeton crispus.



Brown form of *A. crispus*.



Aponogeton crispus 'Kompakt'

Family: Aponogetonaceae.

Etymology: *Aponogeton crispus*: see under *A. crispus*; 'Kompakt' = cultivar name given by the aquatic plant nursery H. Barth, Dessau.

Distribution: No natural distribution.

Description: Aquatic plant. Tuber small. Leaves up to 5 cm petiolate. Petiole trigonal, up to 5 mm wide. Blade narrow ovoid to lanceolate, transparent, slightly leathery, up to 15 cm long and 6 cm wide, light green or mildly brown in coloration. Apex obtuse rounded; base obtuse. Margin undulate. Midrib solid, up to 4 parallel ribs on each side.

Culture: This interesting cultivar, created through a process of selection by the aquatic plant nursery H. Barth, Dessau, appears especially decorative through its outspread light green leaves. Due to its rapid growth, this demanding plant requires intense lighting, regular nutrient additives and a nutrient-rich substrate. Also CO₂ fertilization is recommended. Water hardness seems to be of minor importance for successful cultivation. The author managed to achieve good growth in medium-hard water as well. The optimum

temperature range lies between 24 and 28 °C. The tuber's nutrient reserves are exhausted after two to three months of rapid growth so that the plant will put in a rest phase. A well-growing specimen will grow to a width of 15–25 cm and a height of 10–15 cm, so that this cultivar, in contrast to *A. crispus* and *A. crispus* × *rigidifolius*, can be considered for planting in the aquarium foreground. Inflorescences will only occasionally appear in the aquarium. Commercial propagation is accomplished through tissue culture.

Other: In one important shipment, a plant was discovered that differed from other plants in that it featured a wide and slightly undulate leaf blade and was reminiscent of *A. ulvaceus*. The plants reared from the seeds from this specimen were subjected to further selection over a period of 6 years until this compact cultivar was created. It is meanwhile being propagated through tissue culture.

Further reading: Barth (1988).

Aponogeton crispus 'Kompakt'.



Aponogeton crispus × *rigidifolius*

Description: Aquatic plant, up to 60 cm tall. Leaves up to 30 cm petiolate. Blade up to 30 cm long, 3–4.5 cm wide, slightly leathery, medium to dark green. Apex round; base acute or decurrent. Margin slightly undulate.

Peduncle up to 80 cm long, eventually thickening towards the inflorescence. Spathes about 2.5 cm long, caducous. Inflorescence an up to 18-cm long spike with omnilateral flowers; 2 white or pale violet tepals; 6 stamens; 3 carpels. Fruit without seeds.

Culture: *Aponogeton crispus* × *rigidifolius* combines the positive growth characteristics of both parent plants in an ideal manner. On the one hand, the crossing grows fast and without any problems as does *A. crispus*; on the other hand, like *A. rigidifolius*, it requires no rest phase in the aquarium. Due to its rapid growth and considerable circumference, the plant occupies a lot of space in the aquarium. Even if the leaves are reduced, growth is not significantly impaired. According to the author's experience, cultivation poses no problem in medium-hard water with pH-values of 7–7.6. A medium light intensity is sufficient, although high light intensity causes the for-

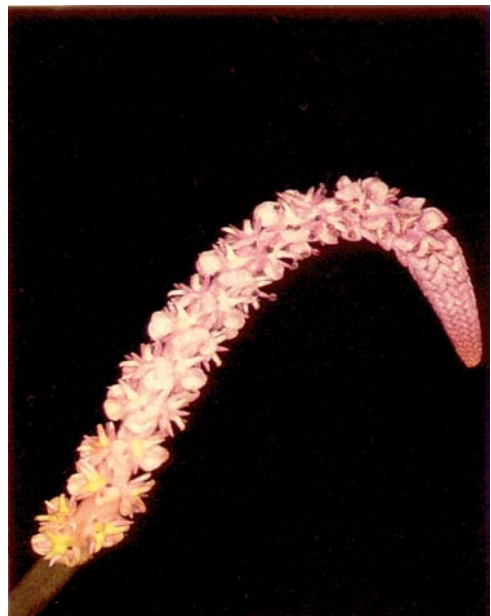
mation of more robust leaf blades. Optimum temperature range is 24–28 °C. The crossing is recommended only for larger aquariums (300 L and more). Vegetative propagation occurs in more robust specimens through the formation of juveniles on the rhizome.

Other: This magnificent but rare crossing was created in the aquatic plant nursery Tropica (Denmark). Since it is unclear which species adopted the male (pollen) or female (ovule) function in the crossing, the alphabetical sequence in the naming process was adopted in accordance with the accepted rules of nomenclature. The crossing is sterile and therefore cannot be generatively propagated. Vegetative propagation through tissue culture remains desirable, being a method which would offer the additional option of entirely doing away with any importation of *A. crispus* and *A. rigidifolius*, since these two species—for aquaristic purposes—can, without any problem, be substituted with hybrids, which seem to be far better suited to the cultivation conditions in aquariums.

Aponogeton crispus × *rigidifolius*.



Inflorescence of *A. crispus* × *rigidifolius*.



Aponogeton decaryi

Jumelle (1943)

Family: Aponogetonaceae.

Etymology: *Aponogeton*: see *A. abyssinicus*; *decaryi*: after R. Decary (ca. 1890–1973).

Distribution: Southern, southwestern and central Madagascar.

Description: Aquatic plant. Tuber up to 1.5(–3) cm in size. Juveniles submersed, spatulate to spoon-shaped, petiole about 2–3 times the length of the spathe, light green. Adult leaves floating, up to 30 cm petiolate; blade of male plants up to 7 × 3.5 cm, females up to 4 × 2.5 cm in size.

Plants dioecious. Peduncle up to 30 cm long, hardly swollen. Male spathe up to 10 mm, female spathe up to 7 mm long, caducous. Inflorescence 2-spiked. Male inflorescence up to 9 cm long. Male flower with 2 tepals, 6 stamens, 3 sterile rudimentary carpels. Female inflorescence up to 3.5 cm long. Female flowers naked, with (2)3 carpels with 2 ovules each. Fruit up to 6 × 1.75 mm, seed about 3 × 0.75 mm in size, simple testa.

Culture: *Aponogeton decaryi* is a rarely imported species, which has only a limited suitability for aquarium culture. The author could

achieve good growth in medium-hard water with a neutral pH-value. First, submersed leaves will form, so that the plants initially appear quite decorative in the foreground. After a few weeks, though, floating leaves will develop which are hardly desirable in an aquarium. Also, while the growth phase is very short, the rest period is very long, resulting in the necessity to remove the tuber from the substrate and to store them dry. Floating leaves and inflorescences will only reach the water surface in low-set aquariums.

Ecology: The species populates shallow waters, rivers, marsh areas or pools which remain dry for most of the year.

Other: In 1990, near Antsaholova, J. Bogner located the female plant of *A. decaryi* which turned out to be apomictic.

Further reading: van Bruggen (1990, 1991).

***Aponogeton decaryi*.**

Aponogeton distachyos

Linné fil. (1781)

Family: Aponogetonaceae.

Synonyms: *Aponogeton distachum* var. *la-grangei* André.

Etymology: *Aponogeton*: see *A. abyssinicus*; *distachyos*: 2-spiked, refers to the 2-spiked inflorescence.

Distribution: South Africa (Cape Province), naturalized in many countries, also found in southwestern Europe.

Description: Amphibious plant. Tuber up to 6 cm diameter. Floating leaves up to 1 m long petiolate. Blade up to 23 cm long and 7.5 cm wide, medium green coloration.

Peduncle up to 80 cm long, hardly swollen towards the inflorescence. Spathe up to 3 cm long, caducous. Inflorescence with two very conspicuous up to 4.5-cm long spikes. Flowers unilateral, set in 2 rows, with a very large white tepalum, 8–16 stamens and 2–6 carpels with about 4 ovules each. Fruit up to 22×6 mm, seeds up to 17×5 mm in size, simple testa (van Bruggen 1985, 1990).

Culture: *Aponogeton distachyos* has been cultivated regularly in botanical gardens for many years. The plant is also often commer-

cially available from the garden pond trade. This *Aponogeton*, however, is not suited for cultivation in tropical aquariums because, on the one hand, it can not handle high temperatures in the long run and, on the other hand, it forms only floating leaves. In garden ponds, however, it is an easy-to-maintain plant which might (even in autumn and mild winters) produce inflorescences. It is best to plant the tuber in a pot which can be taken inside during winter. Propagation through seeds is unproblematic. *Aponogeton distachyos* has limited hardiness.

Ecology: In its native habitat, *Aponogeton distachyos* often grows in dense populations in both stagnant and flowing waters. They are generally temporary waters which may dry out completely. Van Bruggen mentions that the plants may also grow and flower in emersed condition.

Aponogeton distachyos in a pool during summer.



Aponogeton elongatus

Bentham (1878)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: see *A. abyssinicus*; *elongatus*: extended, stretched.

Distribution: North, East, and northwestern Australia.

Description: Aquatic plant. Tuber up to 2.5 cm in size. Leaves petiolate, ribbon-like, soft, light green, yellowish green to reddish brown in color. Van Bruggen distinguishes 4 forms: 1) *f. strigosus*: tuber echinate (only in this form). Leaves up to $40 \times 0.5\text{--}5$ cm, flat or undulate. Floating leaves up to 11×1.7 cm; 2) *f. latifolius*: leaves up to $50 \times 1.2\text{--}5$ cm, less than 10 times as long as wide, smooth or undulate. Floating leaves up to 16×4.5 cm; 3) *f. elongatus*: leaves $15\text{--}30 \times 1.2\text{--}2.5$ cm, 10–15 times as long as wide, undulate. Petiole much shorter than the blade. Floating leaves up to $10 \times 1.5\text{--}2$ cm; and 4) *f. longifolius*: leaves up to 55×2.5 cm, more than 20 times as long as wide, flat or undulate. Petiole about as long as the blade. Floating leaves not identified.

Peduncle up to 1.5 m. Spathe up to 1.5 cm

long, caducous. Spike up to 20 cm long, scented, flowers omnilateral; 2 light green or yellow tepals; 6 stamens; 3 carpels, 4–8 ovules each. Fruit $5\text{--}6 \times 3\text{--}4$ mm. Seeds up to 4×1.75 mm, simple testa.

Culture: Whereas *A. elongatus* was only occasionally commercially available a few years ago, it is today only rarely imported. On several occasions, the author managed to cultivate specimens of *f. latifolius*. The plants require intense light and will develop into more or less strong specimens, depending on the substrate. Optimum growth occurred in medium-hard water (GH 10–12 °dH, KH 5–10 °dH) and pH-values between 7 and 8, and CO₂ fertilization was not necessary. Inflorescences and infructescences formed often. A rest phase is obligatory after a growth period of about 6 months, because otherwise the tuber will rot.

Ecology: *Aponogeton elongatus* grows in stagnant or flowing waters in shaded and sunny places. Differentiated information about the ecology of the individual forms is unavailable.

***Aponogeton elongatus* f. *latifolius*.**

Aponogeton jacobsenii

H.W.E. van Bruggen (1983)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: see *A. abyssinicus*; *jacobsenii*: after the Danish botanist Niels Jacobsen (1941–).

Distribution: Sri Lanka (Central Plateau).

Description: Aquatic plant. Rhizome tuberous or up to 22 cm long, 4.5 cm thick. Leaves up to 22(–35) cm petiolate, leathery, submersed or featuring floating leaves. Submersed blade ovoid or rounded trigonal, up to 25(–30) cm long, 5–8 cm wide, light to dark green or deep red-brown coloration. Margin slightly undulate. Floating leaf blade up to 7 × 2 cm in size.

Peduncle up to 80 cm long, hardly thickened. Spathe up to 19 mm long, caducous. Inflorescence an up to 18-cm long spike, flowers omnilateral; 2 white, rarely pink-colored tepals; 6 stamens; 3 carpels with 2 ovules each. Fruit up to 13 × 5 mm in size. Seeds up to 9 × 3 mm in size, simple testa.

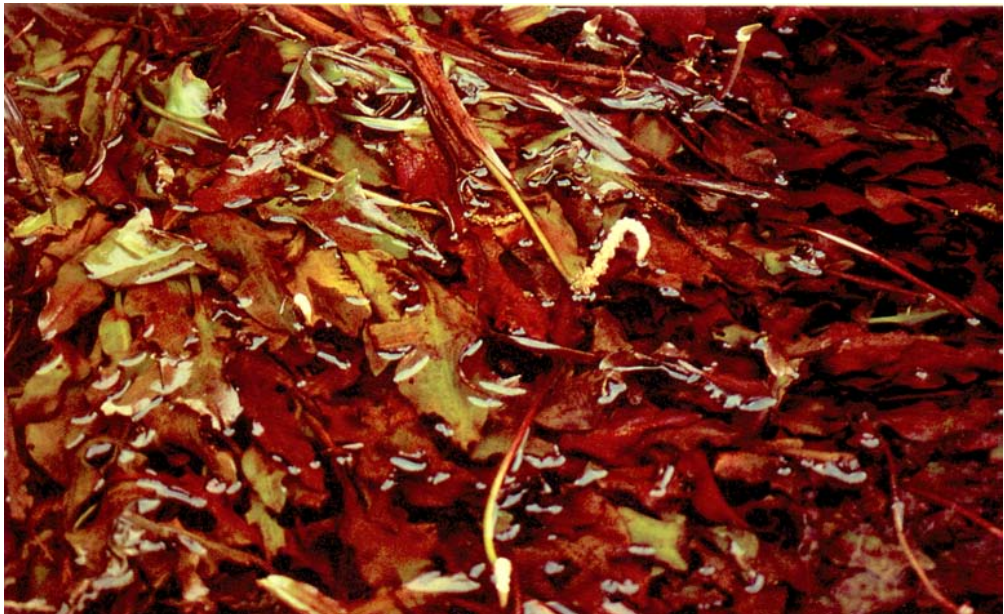
Culture: *Aponogeton jacobsenii* does not prosper in the high temperatures of a tropical aquarium and is therefore of only limited use

to aquaristics. It is not a very adaptable species, which is also indicated by the small area of distribution. Temporary emersed cultivation in high humidity is possible, though specimens remain considerably smaller than in submersed conditions. It can be assumed that the species does not require a rest period.

Ecology: *Aponogeton jacobsenii* populates rivers with a strong current, or ponds and lakes with stagnant water, between altitudes of 1650 and 2300 m. Two such locations are as follows (Sri Lanka, January 1985): 1) Horton Plains, savannah landscape, Belihul Oya River, dense populations, unshaded, in fast-flowing water 30–80 cm in depth; temperature 16 °C, pH 7.7, GH/KH < 1 °dH, 21 µS/cm, rH 234 mV. Substrate rocky-loamy; and 2) Hakgala Botanical Gardens (released): individual specimens in almost stagnant water, sunny-shaded, also emersed; temperature 20 °C, pH 7.35, GH/KH < 1 °dH, 100 µS/cm. Substrate loamy, solid.

Other: For a long time, *A. jacobsenii* was erroneously considered identical to *Aponogeton crispus*.

***Aponogeton jacobsenii* in its native habitat (Horton Plains, Sri Lanka).**



Aponogeton longiplumulosus

H.W.E. van Bruggen (1968)

Family: Aponogetonaceae.**Synonyms:** None**Etymology:** *Aponogeton*: see *A. abyssinicus*; *longiplumulosus*: *longi* = long, *plumulosus*: featuring a plumule.**Distribution:** Northwestern Madagascar.**Description:** Aquatic plant. Tuber up to 2 cm in size. Leaf blade up to 18 cm petiolate, ribbon-like, slightly transparent, fragile, with a highly undulate margin, up to 40 cm long, 1.5–4 cm wide, medium to dark green.

Peduncle up to 150 cm long, distinctly thicker towards the inflorescence. Spathe up to 2 cm long, caducous. Inflorescence with (1)2(3–4) up to 12.5-cm long spikes with omnilateral flowers; 2 tepals, usually conspicuously pink to violet, more rarely white; 6 stamens; 3(4–6) carpels with 2(4) ovules each. Fruit up to 4×1.5 mm in size. Seeds up to 3×1 mm, simple testa.

Culture: *Aponogeton longiplumulosus* is a recommendable and easy-to-cultivate species, the keeping of which requires spacious aquariums. Through its undulate margins it seems especially decorative. Plants in the

aquarium will prosper best if cultured in soft to medium-hard, acid to neutral water. The temperature should lie in the range between 22–26 °C. A suitable substrate consists of unwashed, coarse sand. In contrast to the natural location, cultivation in the aquarium does not require strong water movement. Inflorescences will often form in the aquarium; seed development, however, seems to be rare. The species will have regular rest phases in the aquarium. It will, however, sprout again after a few months.

Ecology: According to the data supplied by Bogner, *A. longiplumulosus* grows in rocky substrates in rivers which carry water all year round and feature a strong current. The water produced the following values: pH 5.8–6.2, GH 7.8 °dH, KH 4.6 °dH, conductivity 186 $\mu\text{S}/\text{cm}$ at 20 °C, chloride 1.6 mg/L.**Other:** Bogner first imported live plants into Germany in 1970. Only in 1983 did specimens become commercially available more regularly.**Inflorescence of *A. longiplumulosus*.*****Aponogeton longiplumulosus*.**

Aponogeton loriae

Martelli (1897)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: explanation in *A. abyssinicus*; *loriae*: after Lamberto Loria.

Distribution: Papua New Guinea (Port Moresby).

Description: Aquatic plant. Rhizome up to 4 × 2 cm in size. Leaf blade up to 40 cm petiole, strap-shaped, up to 70 cm long, 2–4 cm wide, slightly leathery, with an undulate edge, olive green to red-brown in color. Similar to *A. rigidifolius*.

Peduncle up to 90 cm long, not thickened below the inflorescence. Spathe up to 22 mm long, persistent or caducous. Inflorescence an up to 18-cm long spike with omnilateral flowers; 2 tepals, yellow; 6 stamens; 3 carpels with 4–8 ovules each. Fruit up to 6 × 3 mm, seed up to 4 × 1 mm in size, simple testa.

Culture: In July 1981 the author collected *A. loriae* in New Guinea, and distributed them among friends who tested the plant's suitability for aquarium culture. All plants initially displayed excellent growth, then, however, progressively died off after 1–2 years of

cultivation in each case. Unfortunately, seedling could not be achieved during this period, nor could propagation by tissue culture, so that the plants have again disappeared from aquariums. According to the observations made, *A. loriae* seems to be a plant that can be cultured easily at first and grows at a medium pace. It remains unclear what caused its eventual collapse. *Aponogeton loriae* is comfortable with moderate lighting. The substrate should be nutrient-rich. Cultivation was successful in medium-hard water, measuring pH-values within the alkaline range (7.4–7.7) **Ecology:** *Aponogeton loriae* grows in streams and small rivers with fast-flowing water (flow speed of 25–30 cm/sec). The biotopes probably don't dry out. At the locations visited, the plants were anchored in water up to a depth of 1 m in boggy, loose substrate, partially interspersed with gravel and stones. The water was crystal clear. For a detailed water analysis of this location refer to p. 42, biotope No. 11.

Further reading: Kasselmann (1989a).

Aponogeton loriae.



Aponogeton madagascariensis

(Mirbel) H.W.E. van Bruggen (1968)

Family: Aponogetonaceae.

Synonyms: *Uvirandra madagascariensis* Mirbel (1803), *A. fenestralis* Hooker f., *A. henkelianus* H. Baum, *A. guillotii* Hochreutiner, and others.

Etymology: *Aponogeton*: see *A. abyssinicus*; *madagascariensis*: originating from Madagascar.

Distribution: Madagascar, presumably Grande Comore as well as Mauritius (naturalized).

Description: Aquatic plant. Tuber up to 3 cm diameter or oblong rhizome. Leaves differ in fenestration due to missing leaf structure. Blade up to 60 cm long and 1.5–16 cm wide. Giant form up to 100 cm long and 18 cm wide. Dwarf form with round leaves which are only 3–4 cm long and 1–2 cm wide.

Peduncle up to 1.3 m long. Spathe up to 2.5 cm long, caducous. Inflorescence featuring 1–6 spikes, up to 9(–20) cm long. Flowers omnilateral, with 2–3 white, pink to violet tepals; 6 stamens; 3–6 carpels with 2–4 ovules each. Fruit up to 8.5 × 5 mm in size. Seeds up to 3.5 × 1.25 mm; simple testa.

Culture: Due to its unusual fenestrated leaf structure, *A. madagascariensis* has undisputedly been one of the most popular aquarium plants for many years, even though a prolonged and satisfactory culture in the aquarium has rarely been achieved. It is therefore generally not recommended to the “average aquarist,” but should only be kept by specialists who can consistently meet the high requirements of this species in the long term: a low temperature level, strong water movement, soft, acid water, nutrient-rich substrate, medium light intensity and regular rest phases (no dry period!). See notes on ecology for further information. Since *A. madagascariensis* has recently become commercially available from tissue cultivation, previously held reservations against the purchase of the plants have been largely invalidated because the natural populations are thus no longer decimated.

Ecology: The species features a large species-internal range of variations. The individual populations are subjected to extremely different conditions, which is why the ecological aspects have to be looked at and assessed individually for every variety. A summary

***Aponogeton madagascariensis* var. *henkelianus*.**



of previously published data reads as follows (van Bruggen 1990): the plants grow in both small forest streams and fast-flowing rivers, and, in exceptional cases, in stagnant water, on basalt, calcarous rocks as well as on sand, in both deep shade and under intense sunlight, up to an altitude of 1800 m above sea level. Water values follow: temperature 18–26 °C, pH 5.0–7.3, GH < 1 to 8 °dH, 30–780 µS/cm.

A description of two locations of *A. madagascariensis* var. *madagascariensis* which were studied by the author on Madagascar are as follows: 1) 1–2-m wide stream, shaded, fast-flowing, clear, shallow water. Substrate was coarse sand, mixed with more or less large stones as well as rocky boulders. Water analysis follows (January 1987): water temperature 18.5 °C, air temperature 23 °C, pH-value 5.6, GH/KH < 1 °dH, Fe²⁺ not detectable; and 2) River, about 10 m wide, knee-deep, slightly turbid water with a strong current. Substrate: highly loamy sand mixed with gravel, stones and rocky boulders. Loose communities, partially shaded, partially sunny. Light at 10:00 h under light cloud cover (above the water): 70,000 lx, under intensive sun radiation: 146,000 lx. Water temperature

23.2 °C. Both habitats of this variety continuously carry water. In parts, the water level was so high and the current so strong that plants were invisible due to the loamy turbidity. For water analysis of this location see p. 41, biotope No. 9, photo p. 39.

Other: Van Bruggen described the three forms of *A. madagascariensis* cultivated most often as varieties. Variety *madagascariensis* is a narrow-leaved type in which the leaf tissue between the veins has not entirely disappeared and the cavities often have a rounded shape. Variety *henkelianus* and var. *major* are two wide-leaved forms in which the leaf is reduced right down to the veins; their cavities have a slightly rectangular shape. Variety *major* has a consistent fenestration, whereas that of var. *henkelianus* is irregular due to transversal veins.

Further reading: Albers (1988); van Bruggen (1985, 1990, 1998); Eggers (1996); Kasselmann (1987a); Kiener (1963).

Aponogeton madagascariensis var. *madagascariensis*.



Aponogeton natans

(Linné) Engler & Krause (1906)

Family: Aponogetonaceae.

Synonyms: *Saururus natans* L. (1771), *Aponogeton monostachyon* L. f., and others.

Etymology: *Aponogeton*: see *A. abyssinicus*; *natans*: swimming.

Distribution: Sri Lanka, India.

Description: Plant usually existing in water, rarely entirely emerged. Tuber up to 2 cm in size. Juveniles submersed, up to 5 cm petiole; blade lanceolate, up to 6.5×1.5 cm, light green; margin undulate. Adults floating; blade up to 11.5×3 cm in size, with cordate base, light green; margin flat.

Peduncle up to 45 cm long, not thickened. Spathe up to 15 mm long, caducous. Inflorescence is a 9-cm long spike with omnilateral flowers; 2 tepals, up to 2×1 mm in size, white, pink or violet; 6 stamens; 3 carpels with about 8 ovules each. Fruit up to 4×2.25 mm in size, with a long beak. Seeds about $1.75 \text{ mm} \times 0.75 \text{ mm}$, double testa.

Culture: This delicate and rare *Aponogeton* hardly forms any submersed leaves but predominantly floating leaves instead, rendering it hardly suitable for aquaristics. However,

cultivation in low, intensively illuminated aquariums in soft water at high temperatures is possible. The species probably requires regular rest phases. Even though easily germinating seeds form abundantly on the inflorescences due to apomixis (*A. natans* has the smallest seeds of the genus), rearing of the embryos is very difficult.

Ecology: *Aponogeton natans* inhabits stagnant, temporary waters at high temperatures, usually unshaded, up to an altitude of 800 m. Individual specimens are occasionally found entirely emerged. Water values of the studied locations in Sri Lanka (January 1985) are as follows: 1) Small permanent water storage tank with flowering and fructifying plants: temperature 31°C , pH 9.3, GH/KH $< 1^\circ\text{dH}$, $90 \mu\text{S/cm}$, rH 140 mV; and 2) Temporary pool with stagnant water, dense populations: pH 6.95, GH and KH far above 10°dH , $4010(!) \mu\text{S/cm}$.

Further reading: van Bruggen (1985, 1990).

Aponogeton natans in its natural location in Sri Lanka.



Aponogeton rigidifolius

H.W.E. van Bruggen (1962)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: see *A. abyssinicus*; *rigidifolius*: with stiff leaves.

Distribution: Sri Lanka.

Description: Aquatic plant with long, thin, branchy rhizome. Leaves strap-shaped, up to 60 (–120 cm) long, 3 cm wide, olive to dark green under intense light also reddish brown-colored. Margin flat or undulate.

Peduncle up to 100 cm long, hardly or not thickened. Spathe up to 2 cm long, caducous. Inflorescence simple-spiked, up to 15 cm long, with omnilateral flowers; 2(3) white tepals; 6(–8) stamens; 3 carpels with 2 ovules each. Fruit up to 12 × 6 mm. Seeds up to 12 × 5 mm in size. Simple testa.

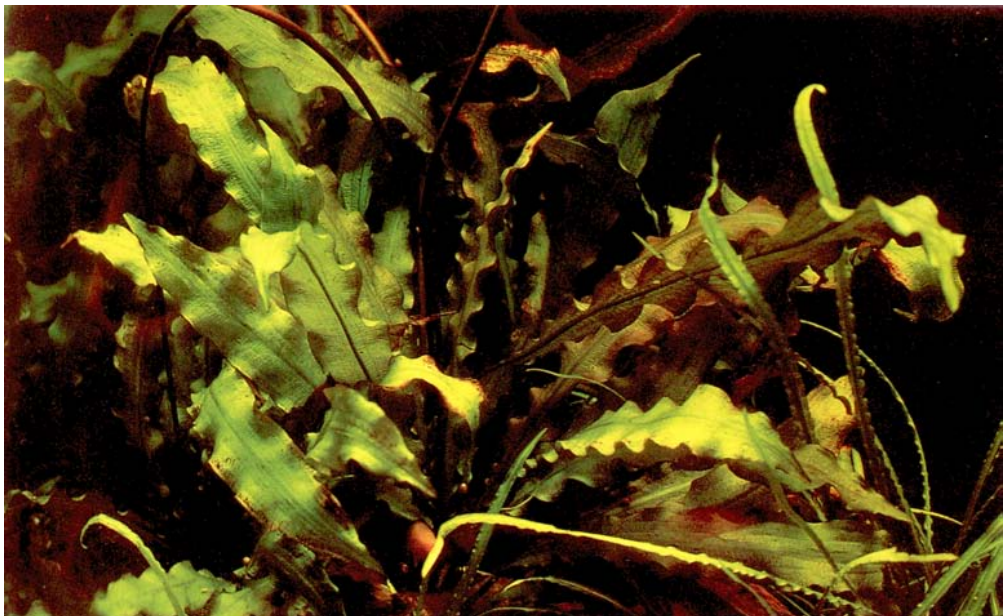
Culture: *Aponogeton rigidifolius* can best be cultivated in soft to medium-hard water, with a pH-value within the slightly acid range seeming especially advantageous (CO₂ fertilization). Furthermore, constant water movement is essential for keeping this plant, so a place near the filter would be optimal. The plant belongs to the group of demanding and

light-requiring species. A very essential aspect in the evaluation of its suitability is the fact that this plant produces a long, thin rhizome and requires no rest period. Though the species displays slow development in the aquarium, it will, however, over many months, mature to a magnificent plant. The author was never able to culture any seeds (self-sterile?), vegetative propagation on older specimens, however, will succeed through branching of the rhizome. When purchasing, care should be taken that the plants have a minimum size of 10 cm. The rhizome will take time to develop.

Ecology: Water analyses (summarized), conducted in Sri Lanka (1/1985), read as follows: temperature range 23–28 °C, pH 6.2–6.9, GH/KH < 1 °dH, 24–43 µS/cm, rH 210–263 mV. The populations always grew in slow-flowing to fast current waters up to 1.5 m depth. Locations were shaded and sunny; the substrate consisted of sand or a sand-gravel mixture.

Further reading: Kasselmann (1991a).

***Aponogeton rigidifolius*.**



Aponogeton robinsonii

A. Camus (1911)

Family: Aponogetonaceae.

Synonyms: *Aponogeton eberhardtii* A. Camus (1914).

Etymology: *Aponogeton*: see *A. abyssinicus*; *robinsonii*: after C. Robinson (1871–1913).

Distribution: Central and South Vietnam.

Description: Aquatic plant. Tuber up to 3.5 cm in size. Leaf blade up to 50 cm petiolate, ribbon-like, transparent, up to 29(–40) cm long, 2.5–3.5(–4.5) cm wide, olive to dark olive green, juveniles also reddish. Margin slightly undulate. Floating leaves up to 19 × 4.5 cm in size. Margin flat.

Peduncle up to 1.65 m long, not or hardly thickened. Spathe 2–4.5 cm long, caducous. Inflorescence 2-spiked, spike 9–15 cm long, unilateral flowers; 2 white tepals; 6 stamens; 3(4) carpels with 2–4(5) ovules. Fruit up to 15 × 4 mm. Seeds up to 14 × 3 mm in size, simple testa.

Culture: This relatively rarely cultivated plant can be kept in an aquarium over several years without any problems. Even though this *Aponogeton* occurs in very soft water in its

native habitat, it can still be cultivated successfully in medium-hard to hard water. A weak acid to neutral environment is advantageous. The substrate should be loose and rich in nutrients. Strong water movement (close to filter!) enhances strong plants. In order to achieve an optimum decorative effect with this *Aponogeton*, aquariums with a minimum height of at least 50 cm are recommended, with the long petioles being hidden by other plants. *Aponogeton robinsonii*—in contrast to other species—does not experience a distinct rest period when kept in an aquarium. Inflorescences occur frequently. Propagation is through seeds.

Ecology: The plants in their native habitats grow in rivers with slow-flowing water in a boggy or stony substrate. Readings revealed a total hardness of 1 °dH and a pH-value of 6.5.

Other: I. Hertel imported the species in 1981 for aquaristic purposes. Due to a great variability H.W.E. van Bruggen, the species' prime researcher, considers *A. eberhardtii* and *A. robinsonii* as conspecific.

Inflorescence of *Aponogeton robinsonii*.



Aponogeton robinsonii.



Aponogeton tenuispicatus

H.W.E. van Bruggen (1968)

Family: Aponogetonaceae.

Synonyms: None

Etymology: *Aponogeton*: see *A. abyssinicus*; *tenuispicatus*: thin- or fine-spiked.

Distribution: Madagascar (Masoala Peninsula).

Description: Marsh plant. Rhizome up to 5 × 1.5 cm in size. Leaf blade submersed or emersed, 4–8 cm petiolate, ovoid, slightly undulate, leathery, 10–13(–17) cm long, 3–4(–5) cm wide, dark olive green. Upperside rough.

Peduncle up to 25 cm long, not thickened. Spathe up to 12 mm, caducous or persistent. Inflorescence 1- or 2-spiked, up to 15 cm long, featuring omnilateral, very small flowers; 2 light green tepals; 6 stamens; 1–3(–4) carpels, 2 ovules each. Fruit up to 5 × 3 mm. Seeds about 2.5 × 1.5 mm in size, simple testa.

Culture: The maintenance of this rare *Aponogeton* was considered especially difficult up until a few years ago. Specimens which were imported in 1990 and always flower 2-spiked can, in contrast, be kept relatively

successfully. The author was able to successfully cultivate this species in medium-hard, slightly acid water (CO₂ fertilization). The plants received a medium light intensity with the temperature range hovering between 26–28 °C. Jacobsen (1993) reports on a highly satisfactory culture with especially robust specimens which were cultivated in beech leaf mold. According to information supplied by him, the water was soft and acid. Emersed cultivation as well as successful sexual propagation by seeds was conducted without any problems. The inflorescences, however, will reach the water surface only in low-set aquariums (water level 20 cm maximum). In contrast to most *Aponogeton* variations, the species forms a rhizome. There are no rest phases within the aquarium.

Ecology: In February 1969, J. Bogner collected simple-spiked *A. tenuispicatus* on a boggy bank of a small, shaded waterway with slow-flowing water within its typical location. Water temperature was 30 °C, GH 0.40 °dH, 60 µS/cm (at 20 °C), 18.5 mg Cl⁻/l.

Further reading: van Bruggen (1990, 1991); Jacobsen (1993).

***Aponogeton tenuispicatus*.**



Aponogeton ulvaceus

Baker (1881)

Family: Aponogetonaceae.

Synonyms: *Aponogeton ambongensis* Jumelle, *A. ulvaceus* var. *ambongensis* Jumelle, *A. violaceus* Lagerheim.

Etymology: *Aponogeton*: see *A. abyssinicus*; *ulvaceus*: similar to the *Ulva* genus.

Distribution: Madagascar.

Description: Aquatic plant. Tuber up to 3 cm in size, echinate, tuber often absent. Leaf blade up to 50 cm petiolate, strap-shaped, transparent, soft, undulate, slightly twisted, rarely flat, up to 45 cm long, 2–8 cm wide, light green.

Peduncle up to 80 cm, highly thickened below the inflorescence. Spathe up to 5 cm long, caducous. Inflorescence 2-spiked, up to 15 cm, omnilateral flowers; 2 white, yellow, or violet tepals; 6 stamens; 3 carpels with 4–6 ovules each. Fruit up to 5 × 3 mm. Seeds 3 × 1 mm in size, simple testa.

Culture: *Aponogeton ulvaceus* belongs to the popular and frequently available Aponogetons. Cultivation in both soft as well as medium-hard water, which should display a weak acid to neutral reaction (additional CO₂

supply), is easy to achieve. Regular fertilization as well as a nutrient-rich substrate are recommended for more robust and strong specimens. The optimum temperature range is 24–27 °C. Well-growing plants usually feature 30–40 leaves; the author even counted 90 leaves with a length of 95 cm, as well as a multitude of inflorescences and infructescences on a violet-flowering specimen. Whereas this specimen has been growing continuously in an aquarium for several years, the white- and yellow-flowering plants require regular rest periods. In the white- and yellow-flowered forms fertilization will succeed only rarely (cross-pollination is essential), but is more easily achieved in the violet form (self-fertile).

Ecology: This species occurs in stagnant to fast-flowing, soft but occasionally also loamy water, up to 80 cm deep, in both sunny as well as shady locations, up to an altitude of 1250 m. It populates temporary and permanent waters.

Other: A live-bearing form has been known since 1981, but is rare.

Violet-flowering form of *A. ulvaceus*.



White- and yellow-flowering form of *A. ulvaceus*.



Aponogeton undulatus

Roxburgh (1832)

Family: Aponogetonaceae.

Synonyms: *Aponogeton stachyosporus* de Wit, and others.

Etymology: *Aponogeton*: see *A. abyssinicus*; *undulatus*: undulate.

Distribution: India, presumably also Bangladesh, Burma, Thailand, Malaysia (Johore) and Indonesia (Kalimantan).

Description: Aquatic plant. Tuber up to 2.5 cm. Leaf blade up to 35 cm, petiolate, ribbon-like, up to 25 cm long, 0.8–4.2 cm wide, medium green coloration, with pellucid markings. Slightly undulate margin. Rarely features floating leaves, blade up to 70 cm petiolate, up to 20 × 3.5 cm in size..

Peduncle up to 55 cm long, thickened below the inflorescence. Spathe up to 17 mm long, caducous or persistent. Inflorescence an up to 11.5-cm long spike with omnilateral flowers; 2 tepals, white or pink, relatively large, caducous; 6 stamens; (2)3(4) carpels with 2 ovules each. Fruit 5–8 × 4 mm. Seeds up to 8 × 3.5 mm in size, simple testa.

Culture: Surprisingly, this aquatic plant is only rarely available commercially, even

though it is more suited to aquarium culture than most other *Aponogeton* species. The advantage of this species is not only its unproblematic growth, but also its vegetative propagation, unusual for Aponogetons: in place of the rare inflorescences, adventitious plants develop on up to 35-cm long petioles, which will soon form a little tuber which will separate or may be severed after about 2–6 weeks. Soft to medium-hard water is best suited for cultivation. CO₂ fertilization, a lot of light and nutrient-rich substrate are recommended. Temperature range is 22–28 °C. Several individual specimens, arranged in dense formation, achieve the best visual effect. They grow in aquariums mostly without a rest period.

Ecology: Not much is known about the native habitat. *Aponogeton undulatus* is supposed to occur in ponds and to flower during July, August and November.

Other: *Aponogeton stachyosporus* de Wit from Jahore is a smaller version of *A. undulatus*, featuring narrow leaf blades.

Aponogeton undulatus with adventitious plants.



Inflorescence of *A. undulatus*.



Azolla caroliniana

Willdenow (1810)

Family: Azollaceae.

Synonyms: *Azolla cristata* Kaulfuss, *Salvinia azolla* Raddi, *Azolla densa* Desvaux, *A. portoricensis* Sprengel.

Etymology: *Azolla*: from *azo* (Greek) = drought and *olloyo* = to kill, points to the dying off of the fern during drought periods; *caroliniana*: originating from Carolina (North America).

Distribution: North, Central and South America, naturalized in Europe, two discovery cases in Asia.

Description: Aquatic plant, floating on the water surface or rooted in bog; 0.7–2.5 cm in size. Horizontal stem, hardly fork-branched. Alternate leaves, densely distichous and overlapping, scalous. Each leaf is divided into 2 lobes: the upper lobe is located above water and assimilates, is thick, 1.5×0.7 –1.1 mm in size, almost acute, with a narrow, colorless margin, green or a deep red-brown coloration (autumn-colored), papilloes pubescent top-side; pubescence 2-celled, water-repellent. The upper lobe features a cavity, opened downwards, in which the blue algae *Ana-*

baena azollae leads a symbiotic existence with *Azolla*. The lower lobe is dipped into the water and is thin and colorless.

Sporocarps are located on the lower lobe of older specimens. Microsporocarp (male, larger than the female) with 8–40 petiolate globular microsporangia which contain many spores, these in turn are joined to form 3–6 groups (massuli). Massuli covered with densely horizontally striped glochidiums (petiolate barbs which assist anchoring). Macrosporangium with only macrospore. Chromosome number $2n = 48$.

Culture: Refer to *Azolla filiculoides*.

Ecology: *Azolla caroliniana* is more rare in native waters than the larger *A. filiculoides*, which is mainly due to the moderate formation of spores and fruit, which are, however, essential for the development of new plants in spring. Both species love nutrient-rich water. Water analyses were conducted at two natural locations in Peru during July 1990: 1) Rio Nanay, little water movement, larger populations of *A. caroliniana* with *Utricularia foliosa*, water temperature 25 °C, GH and KH < 1 °dH, pH 5.8, 10 µS/cm; and 2) Rio Yanayacu (Ucayali catchment area), bay with only little water movement, on the bank a thick layer of floating plants consisting of *A. caroliniana*, *Ceratopteris pteridoides*, *Eichhornia crassipes*, *Limnobium laevigatum*, *Phyllanthus fluitans*, *Pistia stratiotes*, *Ricciocarpus natans*, *Salvinia auriculata*, *Utricularia foliosa*. For a detailed water analysis see biotope No. 6 on p. 40.

Other: The blue algae *Anabaena azollae*, which exists in a symbiotic relationship with *Azolla*, is able to bind the air nitrogen. It is due to this that *Azolla* is used for fertilization of rice paddies. At the same time, the genus *Azolla* has a high nutritional value, and is therefore suitable as cattle and fish food. In some areas *Azolla* is utilized to prevent mosquito plagues. In India *Azolla* is served fried, and in Africa the plants are supposed to be a component in the manufacture of soap. In

Azolla caroliniana.



New Zealand *Azolla* is used as a medicine against throat infection.

Further reading: Lumpkin and Plucknett (1980).

Azolla filiculoides

Lamarck (1783)

Family: Azollaceae.

Synonyms: *Azolla magellanica* Willdenow, *A. squamosa* Molina, *A. arbuscula* Desvaux.

Etymology: *Azolla*: see *Azolla caroliniana*; *fliculoides*: similar to a small fern.

Distribution: North, Central and South America, introduced in Europe, isolated in South Africa, Australia, China, Japan, New Zealand.

Description: As indicated for *A. caroliniana*, but distinguishable through the following features: stem pinnately branched. Plant 1–2.5(–10) cm long, larger than *A. caroliniana*. Upper lobe 2.5×0.9 –1.4 mm in size, obtuse, with a wide, colorless margin, blue-green to deep red-brown, with 2-celled hairs. Microsporocarp with 35–100 microsporangiums. Massuli 5–8. Glochidium not horizontally striped. Chromosome number $2n = 48$.

Culture: *Azolla fliculoides* and *A. caroliniana* are both extremely well suited as floating plants for garden ponds. For an optimum

cultivation they require nutrient-rich water with hardly any movement, and a bright, sunny location. Whereas *A. fliculoides* easily produces spores from which new plants will emerge in spring, *A. caroliniana*, which only rarely develops spores, has to hibernate in a bright, cool place over winter. In autumn, in low temperatures, the plants will change their color to red-brown through the formation of anthocyanins. Cultivation in tropical aquariums is often rather difficult.

Ecology: Water analyses were conducted at three tropical locations: 1) Brazil (3/1986): Amazon river near Manaus, water temperature 27–27.5 °C, pH 6.5–7.2 GH/KH < 1 °dH, 20–100 µS/cm; 2) Brazil (8/1987): marshy area, water temperature 27 °C (air temperature 34.5 °C at 14:00 h), pH 6.9, GH/KH < 1 °dH, 15 µS/cm; and 3) Venezuela (8/1989): large pool, water temperature 33 °C (air temperature 34 °C at 10:30 h), GH 3 °dH, KH 5 °dH, pH 7.3, 250 µS/cm.

Other: *Azolla fliculoides* can usually be distinguished from the similar *A. caroliniana* by the fact that *A. fliculoides* is larger, grows more loosely and that the shoot tips protrude beyond the water surface, whereas *A. caroliniana* lies flat on the water surface.

***Azolla filiculoides*.**



Azolla nilotica

Mettenius (1867)

Family: Azollaceae.**Synonyms:** None.**Etymology:** *Azolla*: see *A. caroliniana*; *nilotica*: growing on the Nile River.**Distribution:** Central and east Africa.

Description: Aquatic plant, floating on the water surface or rooted in mud, the stem usually growing to a length of 1.5–6 cm (rarely longer than 35 cm), thereby becoming larger than other *Azolla* species. The bushy roots, too, with a length of 1.5–5(–15) cm differ distinctly from other *Azolla* species described here. Horizontal stem, without lobes, very small scaling, alternately branched, about 1–1.5 mm thick. Leaves alternate on the lateral shoots, distichous, loosely arranged, scaly. Upper lobe 1–1.3 mm long, with a wide, colorless margin, green to bluish green (no anthocyan formation); lower lobe larger than the upper lobe, transparent, greenish in the center, colorless on the outside.

Sporocarps usually in fours. Massuli without glochidiums (compare description of *Azolla caroliniana*).

Culture: *Azolla nilotica* is a rare and, be-

cause of its size, an especially conspicuous *Azolla* species which is in strong need of light and warmth. Attempts at aquarium cultivation have so far always failed. Maintenance in a hothouse during summer at a low water level in a boggy substrate is possible. A warm, sunny location is essential. Winter survival poses difficulties.

Ecology: *Azolla nilotica* populates stagnant, shallow waters. The author once located large populations of this delightful fern in Tanzania in an unshaded and drying out pool, both floating as well as rooted in wet bog.

Other: All in all, the genus *Azolla* numbers six species and 25 fossil species. Apart from the four species described here, *A. mexicana* Presl. from North, Central and South America and *A. microphylla* Kaulfuss from South America and the Galapagos Islands have also been identified.

Azolla nilotica.



Azolla pinnata

R. Brown (1810)

Family: Azollaceae.

Synonyms: *Azolla imbricata* (Roxburgh) Nakai, *A. africana* Desvaux, and others.

Etymology: *Azolla*: see *Azolla caroliniana*; *pinnata*: pinnate.

Distribution: Africa, Madagascar, Asia, Australia, New Guinea.

Description: Aquatic plant, 1.5–2.5 cm in size. Stem with pinnate lateral twigs which become shorter towards the tip, contour trigonal. Leaves 1–2 mm long, acute or round. Upper lobe with 1-celled hairs, green to a strong red-brown coloration. Description otherwise as in *A. caroliniana*. Massuli without glochidiums.

Culture: *Azolla pinnata* is more appreciative of warmth than *A. caroliniana* and *A. filiculoides*. Cultivation in shallow water over a boggy substrate poses no difficulty during summer. Winter survival for *A. pinnata* is possible only in a very bright, warm location.

Ecology: The species populates nutrient-rich waters (e.g., pools on animal pastures) with stagnant or hardly noticeable water movement. The author studied two locations in

Papua New Guinea (7/1988): 1) boggy lake, dense populations: temperature 31 °C (at 12:30 h), GH 11 °dH, pH 7.5, 510 µS/cm; and 2) Sepik River, individual *A. pinnata*: temperature 29 °C, GH 5 °dH, KH 6 °dH, pH 7.1, 275 µS/cm. On Madagascar *A. pinnata* often grows on rice paddies. Data of one location (12/1986): temperature 27.5 °C (air 28 °C, 14:00 h), GH 3 °dH, KH 2 °dH, pH 6.5, Fe²⁺ 0.2 mg/L. Substrate contained laterite, boggy-loamy.

Other: Phosphorus and iron are the most important factors for the growth of *Azolla* (Lumpkin and Plucknett 1980). The plants survive within a pH-range of 3.5–10, the optimum value, however, lies between 4.5–7. The maximum growth occurs either under high light intensity (60,000 Lux) and a high pH-value (9–10) or at low light intensity (15,000 lx) and a low pH-value (5–6). The optimum temperature for *Azolla pinnata* lies around 20–30 °C, the plants will, however, die off below 5 °C and above 45 °C.

Azolla pinnata in its natural habitat in Papua New Guinea.



Bacopa caroliniana

(Walter) Robinson (1908)

Family: Scrophulariaceae.**Synonyms:** *Obolaria caroliniana* Walter (1788), *Monniera amplexicaulis* Michaux, *Bacopa amplexicaulis* (Michaux) Wettstein, and others.**Etymology:** *Bacopa*: plant name derived from the indigenous population of Guyana; *caroliniana*: originating from Carolina.**Distribution:** Southern and middle U.S.**Description:** Marsh plant, up to 60 cm tall, with creeping or ascendent, hardly branchy shoots. Stem up to 4 mm thick, fleshy, emerged strong pubescence, submersed glabrous. Leaves decussate, amplexicauline, entire. Blade ovoid to wide ovoid, 2–3 cm long, 8–20 mm wide, shiny, fleshy, light green to olive green, brownish under intense light. The plant smells aromatic.

Flowers solitary, axillary, blue or faint purple, rarely white. Bracts 2 mm. Calyx 5-lobed, 6–8 mm long; outer sepals lanceolate to ovoid, inner sepals narrow lanceolate. Corolla gamophyllous, campanulate, up to 1.1 cm long; 4 stamens, 2 measuring 6 mm, 2 are 5 mm long. Style 6 mm long.

Culture: Although *B. caroliniana* belongs to the light-requiring species, it is otherwise undemanding. It grows in both unheated room aquariums or paludariums as well as in tropical aquariums up to 25 °C. It can handle higher temperatures only temporarily. Pure sand, to which a little loam can be added, will suffice as substrate. The species will display better growth in soft rather than hard water. To achieve a good visual appearance, *B. caroliniana* should be arranged in a terrace in the foreground or in the middle section of the aquarium. During summer, emerged cultivation on the edges of ponds—in which case flowers will often develop—poses no difficulties either.**Ecology:** *Bacopa caroliniana* grows in marshy areas, at the edges of small streams, sometimes submersed in shallow water, but usually semiaquatic (photo p. 8). Water analysis of one habitat in Mexico (8/1985): temperature 29 °C, pH 6.9, GH 3 °dH, KH 3 °dH, Fe and NO₂⁻ not detectable, NH₄⁺ 0.5 mg/L. Communities semiaquatic at the edge of a larger pond.**Emerald shoot of *B. caroliniana* with flowers.*****Bacopa caroliniana*.**

Bacopa crenata

(Beauvois) Hepper (1960)

Family: Scrophulariaceae.

Synonyms: *Herpestis crenata* Beauvois (1819), *H. calycina* Benthham, *H. thonningii* Benthham, *Bacopa calycina* Engler ex De Wildeman, *Moniera calycina* Hiern.

Etymology: *Bacopa*: see *Bacopa caroliniana*; *crenata*: crenate, refers to the margin.

Distribution: West Africa from Senegal to Angola, Tanzania, Madagascar.

Distribution: Marsh plant, up to 30 cm tall, decumbent or ascendent. Stems 2–5 mm thick, round, fleshy, nonpubescent. Decussate leaves, in submersed culture rarely with 3–5-merous whorls. Leaf blade lanceolate to ovoid, sessile, 1.5–6 cm long, 0.5–2 cm wide, emersed grass green to dark green, submersed light green coloration. Apex round; base obtuse. Distinct midrib. Margin serrate to crenate.

Solitary flowers, 2–4 mm petiolate. Bracts 1 mm long; 5 sepals. Corolla white to slightly pink upper lip with 2 lobes; lower lip with 3 lobes, slightly yellow inside; 4 stamens. Style 2.5 mm long. Capsule bilocular, 5 × 2.5 mm in size; numerous seeds, dark brown.

Culture: *Bacopa crenata* is a useful but very demanding, slow-growing plant which achieves a height of 10–20 cm in the aquarium. High light intensity is necessary for successful maintenance. A not too coarse, nutrient-rich substrate will assist with rapid root development. Soft to medium-hard, weak acid water with temperatures of 23–28 °C is most advantageous. Since propagation by lateral shoots is only very limited within aquariums, cuttings for the purposes of group planting can be best cultured within emersed culture. *Bacopa crenata* is especially recommended for paludariums. Here plants will readily develop flowers and fruit. Seeds will germinate after a few days in moist soils.

Ecology: *Bacopa crenata* exists in a boggy environment, in moist and wet locations, but also grows in quite dry conditions under intense sunlight. In 1981, the author located the species on the islands of Mafia and Zanzibar in very soft and weak acid water.

Bacopa crenata.



Flower of *B. crenata*.



Bacopa lanigera

(G. Don) Wettstein (1891)

Family: Scrophulariaceae.

Synonyms: *Bramia lanigera* G. Don, *Herpestis lanigera* Chamisso & Schlechtendal, and others.

Etymology: *Bacopa*: see *B. caroliniana*; *lanigera*: wearing wool.

Distribution: Brazil.

Description: Marsh plant with decumbent or erect shoots. Stem 2–5 mm thick, fleshy, thick wooly pubescence. Leaves decussate (rarely trimerous whorls), sessile, amplexicauline, glabrous. Leaf blade ovoid to wide ovoid, 2–3.2 cm long, 1.7–2.8 cm wide, with a round apex and distinct midrib. Margin emersed crenate, submersed almost completely entire. Coloration light green to medium green with distinct white ribs, occasionally also totally green.

Solitary flowers, axial. Pedicel 5–15 mm long, pubescent. Bracts 1 mm long; 5 sepals, pubescent. Corolla 2-lipped, 5-lobed, up to 1 × 0.8 cm in size, deep blue-violet coloration. Upper lip with 2 lobes, lower lip with 3 lobes, with a yellow spot within the corolla; 4 sta-

mens, shorter than the corolla. Style about 5 mm long; stigma 2-lobed.

Culture: *Bacopa lanigera* has been cultivated for many years, and is also occasionally commercially available; it is, however, hardly or not at all suitable for aquarium culture. Emersed keeping in a paludarium, though, is recommended. There, the plants require a nutritious substrate as well as intensive lighting in order to develop optimally. Flowers will form regularly. The strong pubescence might sometimes recede, which is especially the case in stagnating, moist air. The intense aromatic scent of this *Bacopa* is particularly conspicuous, especially when stems and leaves are crushed between the fingers. Even though other *Bacopa* species also display this characteristic, *Bacopa lanigera* can usually be easily recognized by this.

Ecology: The species grows in moist and boggy locations in stagnant water.

Other: Two varieties were described, both distinguishable by only minor characteristics (leaf shape, calyx and corolla).

Emersed shoot of *Bacopa lanigera*.



Flower of *B. lanigera*.



Bacopa madagascariensis

(Bentham) Pennell (1946)

Family: Scrophulariaceae.**Synonyms:** *Herpestis madagascariensis* (1836).**Etymology:** *Bacopa*: see *B. caroliniana*; *madagascariensis*: originating from Madagascar.**Distribution:** Madagascar.**Description:** Marsh plant with decumbent or ascendent up to 1-m long shoots, hardly branchy. Stem up to 4 mm thick, slightly grooved, fleshy, glabrous. Leaves decussate, almost amplexicaul. Blade lanceolate to narrow ovoid, 1–3 cm long, 0.5–1.3 cm wide, light green. Apex acute to obtuse. Margin slightly crenate (similar to *B. crenata*).

Solitary flowers, up to 2 cm petiolate. Bracts 2–3 mm long; 5 sepals. Corolla 5-lobed, violet, about 11 × 10 mm in size; 4 stamens, shorter than the corolla. Style about 6 mm long, protruding from the stamens.

Culture: *Bacopa madagascariensis* is a good culture plant in both aquariums and paludariums. With a submersed growth of 5–15 cm, it represents an ideal plant for the aquarium's foreground. Medium to strong light in-tensity is an important prerequisite for successful cultivation. If the plants are provided with inadequate lighting they will lose their lower leaves with increasing growth height. Even though *Bacopa madagascariensis* exists in very soft, acid water in its natural habitat, it can also still be cultured in medium-hard, slightly alkaline water, in which case, though, the plants will remain noticeably smaller. Washed sand will suffice as a substrate. Temperature should be 24–28 °C.**Ecology:** On Madagascar, the author often found the species in streams, flooded areas or small pools and lakes, both submersed or semiaquatic in the water and emersed at the water's edge. The nutrient-deficient, often sandy substrate was always found to be moist or wet. On occasions, the upper layer also consisted of boggy, peatish and iron-containing sediments. Several water analyses (12/1986, summarized) were taken: temperature 28 °C (air 27 °C), GH/KH < 1 °dH, pH value 4.8–6.0 Fe²⁺ 0.2 mg/L. The shoots grew under intense sunlight (116,400 lx at 10:30 h).*Bacopa madagascariensis*.Flower of *B. madagascariensis*.

Bacopa monnieri

(Linné) Pennell (1946)

Family: Scrophulariaceae.**Synonyms:** *Lysimachia monnieri* Linné (1756), *Gratiola monnieri* L., *G. monniera* L., *Herpestis monniera* Kunth (nom. ill.), *Bacopa monniera* Wettstein (as *monniera*, nom. ill.).**Etymology:** *Bacopa*: see *Bacopa caroliniana*; *monnieri*: named after the botanist G.L. Le Monnier, Paris.**Distribution:** Widely distributed within the tropics and subtropical regions of Africa, Asia, Australia and America. Occasionally introduced in Europe.**Description:** Creeping or ascendent, up to 40-cm tall marsh plant. Stem and leaves glabrous. Leaves decussate, sessile or indistinctly petiolate. Blade narrow oblong to narrow reverse oval, mostly narrow spatulate or cuneate, entire or rarely slightly crenate, with a round apex, 10–25 mm long and 3–10 mm wide, light green to dark green coloration.

Axial flowers, 1–3.5 cm long petiolate. Bracts narrow linear, 3 mm long. The solitary flower has a 5-lobed, 5–6-mm long calyx, a corolla, about 10 mm in length and featuring

5 lobes, 4 stamens, the two longer of which protrude from the corolla, and a style with a capitate stigma which is longer than the stamens. The wide, campanulate corolla is a pale pink, white or (more rarely) pale blue in color.

Culture: *Bacopa monnieri* is a very recommendable and undemanding aquarium plant. The species grows well in soft or hard, weak acid or alkaline water; the author managed to obtain especially robust specimens in hard water with an alkaline reaction. Cultivation is possible even in slightly brackish water. A medium light intensity is adequate for a healthy growth. Fine gravel or sand in which the shoots can find a hold more easily is recommended as a substrate. The slightly stiff-appearing plant will hardly branch in submersed conditions. If the shoot tips are severed, the stem, which remains in the substrate, will soon sprout again. At least 10 shoots—as an effective group—should be planted in a benched setting in the foreground. *Bacopa monnieri* is not only suited for use in warm water aquariums, but also in unheated room aquariums, and—during summer—at the edges of garden ponds, since a temperature range of 15–30 °C can be tolerated. During emersed cultivation in conditions of high humidity, the shoots will regularly develop small white or pink-colored flowers during summer. Propagation through seeds is very laborious.**Ecology:** The author found *Bacopa monnieri* in numerous natural habitats on Madagascar, in Mexico and Indonesia, always in moist and wet locations, usually semiaquatic. In Java it also occurred in sub-brackish water. Flowering semiaquatic shoots grew unshaded at the edge of Lac Elapa on Madagascar in slightly turbid water on a sandy substrate. A water analysis taken in December 1986 produced the following result: water temperature 30 °C (air temperature 32 °C at 11:30 h), pH 6.0, GH and KH < 1 °dH, Fe²⁺ and NO₂⁻ not detectable.***Bacopa monnieri*.**

Bacopa myriophylloides
(Bentham) Wettstein (1891)

Family: Scrophulariaceae.

Synonyms: *Herpestis myriophylloides* Bentham (1846).

Etymology: *Bacopa*: see *B. caroliniana*; *myriophylloides*: similar to the genus *Myriophyllum*.

Distribution: Brazil (Minas Gerais state).

Description: Delicate marsh plant with an ascendent, or erect, glabrous or hardly pubescent, up to 20-cm long stem. Leaves opposite, seemingly verticillate, sessile, amplexicauline, linear-subulate. Leaf with 5–7 segments, these 3–6 mm long, 0.5–1 mm wide, medium green coloration. Submersed shoots very delicate and fragile. Leaf segments needle-like, soft, light green in coloration.

Solitary flowers, axial, 1–2 cm petiolate. Bracts about 1 mm long; 5 sepals. Corolla with 2 lobes, up to 8 × 8 mm in size, pale blue; 4 stamens, 2 measuring 4 mm and 2 at 6 mm in length. Stigma slightly 2-lobed. Style 5 mm long. Capsule 2-valved, seeds oblong.

Culture: *Bacopa myriophylloides* has only been available commercially for a couple of months. In its outer appearance, this *Bacopa*

is similar to a *Myriophyllum* species. It is a demanding plant that is difficult to cultivate in an aquarium. Important for satisfactory cultivation is a high light intensity as well as presumably soft and acid water. The submersed shoots are very fragile and quickly react to a lack of nutrients with a glazed appearance of the leaves and subsequent cessation of any growth. Algae are able to suffocate the shoots within a very short time. Be careful when adding chemical preparations! High humidity and good lighting are important for emersed cultivation.

Ecology: The author collected *B. myriophylloides* in the northern Pantanal in the State of Mato Grosso, Brazil. The plants grew in a marsh region under intense sunlight, as both terrestrial and—in shallow depths—aquatic plants. The substrate consisted of laterite-containing bog or mud. This location's water analysis (3/1986): temperature 28 °C (air temperature 27 °C at 10:00 h) pH-value 5.5, GH/KH < 1 °dH, 18 µS/cm.

***Bacopa myriophylloides* in its native environment in the Pantanal (Brazil).**



Baldellia ranunculoides

(Linné) Parlatores (1854)

Family: Alismataceae.

Synonyms: *Alisma ranunculoides* Linné (1753), *Echinodorus ranunculoides* (L.) Ascherson.

Etymology: *Baldellia*: after B. Bartolini-Baldelli (19th century); *ranunculoides*: similar to the genus *Ranunculus*.

Distribution: Europe, North Africa.

Description: Small marsh plant with leaves arranged in rosette formation. Juvenile leaves submersed, linear, gramineous, 0.5–7 mm wide, up to 55 cm long, without lateral veins. Adults floating or emersed, up to 20 cm petiolate, narrow elliptic to very narrow elliptic, usually 6–8 cm long, 1 cm wide, light green to medium green. Apex acute; base decurrent or acute.

Inflorescence with 1–2(4) whorls; each whorl with 9–13(–30) flowers. Flowers 3–11 cm petiolate, about 1 cm in size; 3 sepals, about 2 × 2 mm; 3 petals, about 6 × 4 mm, white or pale violet, yellow at the base; 6 yellow stamens; filaments 1 mm long. Numerous carpels, green, capitate arrangement.

Infructescence 5–7 mm in size; nuts 2.5 mm long, 1 mm wide, ribbed, green.

Culture: *Baldellia ranunculoides* is not suitable for cultivation in the tropical aquarium. It can be used, however, in illuminated cold-water aquariums, as well as for the planting of pond edges (in water up to 40 cm deep). It is often winter hardy. The optimum temperature is around 20 °C, but higher levels may be tolerated for a short time. At low water levels, floating leaves will develop first, emersed leaves will follow later. Propagation is possible through sowing the numerous seeds, in subsp. *repens* also through adventitious plant formation on infructescences with mature seeds. It is rarely commercially available and has been specifically listed as an endangered species.

Ecology: Grows on wet and moist locations, also in sub-brackish water.

Other: Two subspecies—subsp. *ranunculoides* and subsp. *repens* (occasionally also as individual species)—are distinguished, they can essentially be separated through the identification of different flower and fruit characteristics (petals, ovaries, nutlets).

Flowering specimen of *Baldellia ranunculoides*.



Barclaya longifolia

Wallich (1827)

Family: Nymphaeaceae.**Synonyms:** *Hydrostemma longifolium* (Wallich), Mabberley, *Barclaya pierreana* Gagnepain, *B. oblonga* Wall and others.**Etymology:** *Barclaya*: after the English botanist Robert Barclay (1751–1830); *longifolia*: with long leaves.**Distribution:** Burma, Andaman Islands, southern Thailand, India, Sumatra, New Guinea.**Description:** Aquatic plant with a tuberous or up to 6-cm long, thin, fleshy rhizome. Leaves in a rosette, 3–10(–20) cm petiolate. Leaf blade oblong, thin, 10–25(–35) cm long, 2–5(–10) cm wide, glabrous on the upperside, slightly mammillate on the underside. Juveniles with a round base, adults deep cordate to slightly hastate. Margin undulate. A red and a green variety are in culture, for which the author hereby introduces the cultivar names ‘Red’ and ‘Green’. In the more frequent ‘Red’ cultivar, the leaf uppersides are wine red to brownish red, and the underside is light violet; in the rare ‘Green’ cultivar, they are olive green upperside and light violet on the underside.

Pedicele up to 50 cm long; 5 sepals; 7–10 petals in 2–3 circles, only free in the upper part, olive green on the outside, purple-red to dark violet on the inside. Sterile stamens in about 2 rows, fertile, free stamens arranged in 3–6(–7) rows. Ovaries inferior; (8–)10–12(–14) carpels, radiate, their continuation adnate to a “disc,” these are free at the end so pollen can fall onto the carpels through the opening to the top (refer also to Stengel 1982/83). Fruit a berry with up to 300 about 1 mm globular brownish seeds, which are densely covered with long white spines. Fruit flesh initially slimy, sticky and glazed, on maturity solid, white to slightly pink.

Culture: A magnificent and demanding but recommendable aquarium plant which is best maintained in soft to medium-hard, acid water at temperatures of 25–28 °C. Also recommended is a nutrient-rich substrate (clay additive). Light is less important, but the plants must not be placed in too dark a location. The tender leaves are a welcome food for snails, so care must be taken. After a period of good growth and ample flowering, *Barclaya* will usually retreat in development, but will grow again after a few weeks. Under good cultivation conditions a plant may survive several of***Barclaya longifolia* ‘Red’.*****Barclaya longifolia* ‘Green’.**

such periods; new plants should nevertheless again be reared from seeds. If a lower, slower growth is desired in aquariums, it is recommended to set the plants into pots which are then inserted into the substrate. Growth will then proceed much slower and the plants will remain small for a longer period. Large specimens of *Barclaya longifolia* can be used as solitary plants; smaller plants can temporarily be terraced as a grouping.

Sexual propagation using seeds is very productive. Flowers will often develop under water in aquariums and will rarely open, but will nevertheless produce seeds (cleistogamy). After a maturing period of about seven weeks, the fruit will rot away and release the seed. It should be left to germinate under a lot of light because, under such conditions, the germination quota will usually be very high. The young plants are reared in a low-set aquarium under good lighting conditions. Initially they will grow quickly, but often a cessation in growth will occur after a couple of weeks. This difficult phase can best be bridged if the plants are then transferred. *Barclaya longifolia* generally handles the

transfer well and often subsequently “rewards” the change in environment with even further improved growth. A transfer should, however, not take place during the resting period. The plants will be ready to flower again after only 1 year. The rare, green-colored form can also develop excellently in the aquarium. It remains a little smaller, however.

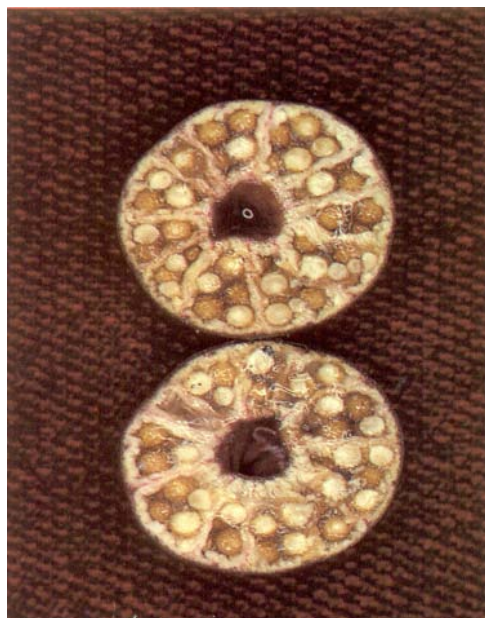
Ecology: According to Bader (1992), *B. longifolia* usually grows in loose to dense populations in sunny and semishady places in rapid-flowing, predominantly clear streams carrying soft, acid water. The substrate was sandy-loamy.

Other: The name of the genus *Barclaya* is a nomen conservandum (conserved name) and therefore takes priority over the older genus name *Hydrostemma*.

Transversal section through a flower of *B. longifolia*.



Transversal section through a fruit of *B. longifolia*.



Barclaya motleyi

Hooker filius (1862)

Family: Nymphaeaceae.

Synonyms: *Hydrostemma motleyi* (Wall.) Mabberley.

Etymology: *Barclaya*: see *Barclaya longifolia*; *motleyi*: after the discoverer J. Motley (?–1859).

Distribution: Sumatra, Malaysian Peninsula, Borneo (Sarawak).

Description: Aquatic plant. Petiole up to 17 cm long, 1–2 mm thick, pubescent. Leaf blade almost round, rarely lanceolate, base cordate, 5–10 cm long and almost as wide, entire, rough, upperside glabrous, underside pubescent, especially on the veins. Coloring upperside green to reddish, underside light olive green, reddish or rust brown.

Flowers similar to *B. longifolia*, but with a shorter pedicel, pubescent sepals and fewer stamens.

Culture: The aquarium culture of *B. motleyi* has so far not succeeded over an extended period. The plants require a very soft, acid water as well as a nutrient-rich, loose substrate with an acid reaction. The author was able to achieve the best cultivation results at a

free, bright location where some specimens grew over several months. The newly formed leaves, however, became smaller over time. Young plants develop on long runners. As in *B. longifolia*, the flowers are cleistogamous. Nothing has so far been reported on propagation by seeds.

Ecology: Apart from numerous trace elements, Horst (1986) registered the following water data in black water streams accommodating *B. motleyi*: temperature 25.5 °C, pH 4.4/5.2, GH 0.25 °dH, 18 µS/cm. A substrate analysis also revealed a low pH-reading of 5.8

Other: Apart from *Barclaya longifolia* and *B. motleyi*, *B. kunstleri* (King) Ridley and *B. rotundifolia* M. Hotta are currently classified as valid species. Hardly anything is known about their cultivation in aquariums.

Further reading: Schneider and Williamson (1996).

***Barclaya motleyi*.**



Blyxa aubertii

L.C. Richard (1814)

Family: Hydrocharitaceae.**Synonyms:** *Blyxa echinosperma* (C.B. Clarke) Hooker and others.**Etymology:** *Blyxa*: from *blyzein* (Greek) = to flow, referring to the locations of several *Blyxa* species which inhabit streams; *aubertii*: after the discoverer of the plant, Louis-Marie Aubert du Petit-Thouars (1758–1831); *echinosperma*: with echinate seeds.**Distribution:** Widely distributed in Asia, from India to New Guinea, Japan, Australia, var. *aubertii* also on Madagascar, isolated in Mozambique and Tanzania (Mafia), introduced to Louisiana (U.S.)**Description:** Annual aquatic plant. Leaves arranged in a rosette on a short, erect rhizome. Blade nonpetiolate, linear with long narrowed apex, usually up to 65 cm long, 0.5–0.7 cm wide, soft, fragile, colored light green. Distinct midrib, parallel lateral veins.

Flowers bisexual, usually long petiolate and solitary in a noninflated and exalate spathe. Hypanthium up to 15 cm long; 3 sepals, petals, stamens and carpels each. Petals white or reddish. Fruit an oblong capsule

with numerous elliptic seeds. Variety *aubertii*: seeds 1.25–1.8 mm long, smooth or ribbed, irregularly echinate, not caudate; var. *echinosperma*: seeds 1.5–2.0 mm long (without attachment), ribbed, distinctly spined, on one or both ends up to 5 mm long caudate.**Culture:** *Blyxa aubertii* is an expressedly decorative aquatic plant which is rarely commercially available because of its fragile leaves. The author managed to bring this plant home from many trips to the tropics and always cultivated it without incurring any problems. Although it develops best in soft, acid water, a satisfactory cultivation can also succeed in medium-hard, subalkaline water at temperatures of 20–28 °C. A nutrient-rich substrate will assist strong specimens, which can be quite eye-catching with their 50–100 leaves. A bright, free location is necessary for optimum culture. “Unsettled” and plant-consuming fish should not be incorporated with *Blyxa* because they damage the sensitive leaves. The inconspicuous flowers can also be found regularly in the aquarium. They develop either above the surface or, in case of a too high water level, submersed, and are then cleistogamous. Numerous seeds are produced.**Natural location of *Blyxa aubertii* in Sri Lanka.**

In the aquarium, *Blyxa aubertii* represents a short lived plant so that one has to organize propagation by seeds in time if one wishes to gain ongoing enjoyment from the plant. Occasionally, sexual propagation occurs through partitioning of the rhizome.

Ecology: On Madagascar, where *Blyxa aubertii* var. *aubertii* is often found in rice paddies, marshes and smaller lakes and streams with slow-flowing water, the author conducted several water analyses in December 1986, the results of which are summarized as follows: air temperature 27.5–28.5 °C, water temperature 27.5–31.5 °C, pH 6.0–6.6, GH < 1–3 °dH, KH < 1–2 °dH, Fe 0.05–0.2 mg/L, light intensity at one location 116,400 lx in intense sunlight. The substrate was boggy or boggy-loamy, often covered with iron sedimentation which was also found on the leaves of *Blyxa*. The author first identified *Blyxa aubertii* var. *aubertii* on the island of Mafia (Tanzania) in June 1982, where the plants grew in temporary pools and ditches in shallow water under intense sunlight. On Sri Lanka, too, rice paddies and marshy areas displaying iron precipitation are often typical biotopes of *B. aubertii* (see photo p. 13). The

water analysis of a stream (5/1985) with fast-flowing water resulted in the following data: pH 7.4, GH 21 °dH, KH 14 °dH, 1710 µS/cm, rH 179 mV.

Other: Cook and Lüönd (1983) described *Blyxa echinosperma*, which was, for a long time, listed in aquarium literature as an independent species, as a variety of *B. aubertii*. Both variations can be distinguished from one another only through their seeds. The main differences are in the var. *aubertii* non-caudate and in var. *echinosperma* (C.B. Clarke) Cook and Lüönd more or less long caudate seeds.

Blyxa aubertii.



Flower of *Blyxa aubertii*.



Bolbitis heteroclita

(Presl) Ching (1934)

Family: Lomariopsidaceae.

Synonyms: *Acrostichum heteroclitum* Presl (1825), and others.

Etymology: *Bolbitis*: *bolbos* = bulb, tuber; *heteroclita*: differently curved.

Distribution: Widely distributed in Asia, from India to Japan and New Guinea.

Description: Amphibious fern. Rhizome usually 3–7 mm thick, up to 15 cm long, creeping, densely covered with brown scales up to 5 × 1 mm. Petiole 1.5–3 mm thick, up to 20 cm long, scaly in the lower part. Sterile leaf blade, simple or with 1–3 unpaired pinnate leaves, in smaller specimens often 3-merous with petiolate terminal leaves; blade in culture usually not exceeding 25 × 17 cm. Pinnate leaves sessile or short petiolate, opposite or alternate, usually up to 10 × 5 cm in size, narrow ovoid, more or less caudate, entire, light green to dark green in color. Juveniles with serrate, toothed and sinuate margin. Fertile sporangiferous leaves are rare. Sporangiums evenly and densely spread over the leaf underside.

Culture: A hardly suitable species for aquar-

ium culture, but if an attempt at cultivation is made, soft, acid water, moderate lighting and a not too high temperature up to about 25 °C are recommended. Furthermore, the rhizome should not be inserted into the substrate, but attached to decorative materials such as stones and wood. The fern can also find excellent use in a paludarium where it will grow well on moist soil. The rhizome, however, should be above the planting substrate. In conditions of high humidity adventitious plants will occasionally develop which are formed close to the leaf apex.

Ecology: The species exists in soil, on rocks or at the bases of trees in the tropical rainforest at an altitude of 1750 m. Occasionally the species also grows in quick-flowing waters.

Other: *Bolbitis heteroclita* is known as a parent plant of several hybrids. The species is very close to *B. sinuata* (Presl) Hennisman; a differentiation is based essentially on the tissue structure of sterile leaves.

Emerald specimen of *Bolbitis heteroclita*.



Bolbitis heudelotii

(Fée) Alston (1934)

Family: Lomariopsidaceae.**Synonyms:** *Gymnopteris heudelotii* Fée (1845) and others.**Etymology:** *Bolbitis*: see *B. heteroclita*; *heudelotii*: after J.-P. Heudelot (1802–1837).**Distribution:** Widely distributed in Africa.**Description:** Amphibious fern. Rhizome 3–10 mm thick, up to 25 cm long, creeping, densely covered with brown 10 × 2-mm sized scales. Petiole 2–5 mm thick, 8–40 cm long, loosely scaly below. Emerged leaf blade pinnate, up to 50 × 25 cm; Pinnae alternate or opposite, more or less indented, slightly toothed, rarely completely entire, light green to dark green. Submersed leaves pinnatifid, large toothed, transparent, dark green.

Sporangiferous leaves (sporophylls) up to 100 cm long; pinnates almost entire to toothed. Sporangiums evenly and densely spread over the underside; large spores.

Culture: *Bolbitis heudelotii* is a popular and decorative fern plant. Generally, cultivation is not difficult if the following hints are taken. The species loves soft, acid water with pH-values of about 6.0–6.8. CO₂ fertilization haspositive effects. If the pH-value is within the alkaline range, leaves will often blacken and become stained. Though *Bolbitis* can grow well in an aquarium without strong water movement, the plants will nevertheless display clearly improved growth in moving water (e.g., close location to the filter). Moderate lighting is adequate. Vegetative propagation by lateral shoots and rhizome partition is unproblematic. On rare occasions, propagation by adventitious plants was observed. These will develop either directly on the pinnate tips of older leaves or on branchy tissue segments.**Ecology:** Grows in rivers with very fast-flowing water on stones and rocks, occasionally also in the substrate, both submersed and semiaquatic, under shade or full sunlight. The author measured the following water data at two locations in Cameroon: 24 °C, pH 5.5–5.7/7.2, GH 0.5/4 °dH, KH < 0.1/0.8 °dH, 40/120 µS/cm, Fe not detectable.***Bolbitis heudelotii*.****Emerged specimen of *B. heudelotii* in Cameroon.**

Cabomba aquatica

Aublet (1775)

Family: Cabombaceae.**Synonyms:** *Nectris aquatica* (Aublet) Willdenow, *C. schwartzii* Rataj.**Etymology:** *Cabomba*: presumably an indigenous name from the natives of Guyana; *aquatica*: existing in water.**Distribution:** Northern and central South America.**Description:** Aquatic plant, shoots up to 150 cm long. Leaves opposite. Leaf blade reniform to almost circular in contour, 3.0–8.5 cm long, 4.0–9.5 cm wide, 5-merous on the base, leaf segments di- and trichotomously dissected several times and with numerous capillary segments, so that each blade displays up to 500 segments, these in distinctly different levels. There exist populations with green or wine red-colored plants.

Flowering shoot with more or less numerous, long petiolate floating leaves. Blade entire, flat, peltate, wide elliptical to roundish, 2.5–4 cm long, 1.3–3.5 cm wide, upper-side green, partially with a touch of wine red coloration, underside wine red to pink-violet. Flowers 3–10 cm petiolate, 5–12 mm in size,

2 and 3-merous, with 2 or 3 yellow sepals and petals each, as well as 3, 4 or 6 stamens and 1–3 carpels. Petals depicting orange-yellow base patches, distinctly auriculate; 1–4 ovules. Seeds ellipsoid-ovoid, mammilate, up to 3.5 × 2.5 mm. The type *C. aquatica* “schwartzii” usually has dimerous flowers, occasionally trimerous flowers can also occur.**Culture:** There exist very different forms of *C. aquatica*. Known as the giant *Cabomba*, this green, under intense light also slightly red plant is often available from aquarium shops and has an especially high decorative status. It is, however, difficult to keep in the long run. A preferably salt-deficient, soft, moving water with a pH-value within the slightly acid range and a temperature of 23–25 °C is important. Light intensity has to be very high. Under optimum conditions, it is not uncommon for the plant to develop floating leaf shoots with trimerous flowers; fruit, too, can then be observed. The reddish plants with dimerous flowers, know as *C. aquatica* “schwartzii,” don’t display a satisfactory growth in cultivation due to their extreme ecological requirements. A variation, collected in Venezuela by W. Staeck, displaying**Reddish shoots of *C. aquatica* from Venezuela.****Green form of *C. aquatica*.**



Bimerous flower of *Cabomba aquatica*.



Flower of *Cabomba palaeformis*.



Flower of *C. furcata* (type "warmingii").



Flower of *C. caroliniana* var. *flavida*.

reddish shoots and trimerous flowers is also quite difficult to cultivate.

Ecology: The *C. aquatica* “schwartzii” type grows in the lower to upper catchment area of the Rio Negro (Brazil), as well as in strong-current and lake-like waters without noticeable water movement. The ecological conditions there are characterized by an extremely acid (pH 4.3–5.3) and mineral-deficient, very soft (GH and KH < 1°dH) water. In April 1992, W. Staeck collected reddish specimens of *C. aquatica* in the estuary of the Orinoco River in Venezuela (Rio Morichal Largo, Rio Uracoa). The plants existed in a strong current in clear, highly brown-colored water in locations receiving full sunlight. The substrate was sandy-boggy. Water values: temperature 30°C, GH/KH < 1°dH, pH value around 6, 30–50 µS/cm. The ecological conditions of the plant cultivated under the name of giant *Cabomba* are not known.

Other: In a revision of the *Cabomba* species, Ørgaard (1991) reclassified the—until then independent—species *C. aquatica* “schwartzii” into synonyms of *C. aquatica* and explained this among others with the multiple shapes of the flowers. She considers the dimerous

flowers of *C. aquatica* “schwartzii” only as an interspecific variation and consequence of mutation fixated in few populations. In her discourse, she continues to include only five species under the genus of *Cabomba*, four of which are aquaristically known and are described as follows: *Cabomba haynesii* Wiersma (1989) (Syn. *C. piauhyensis* Gardner f. *albida* Fassett) has been known for many years but has only been imported on very few occasions and is not in culture with aquarists. The species is distributed in Central and South America, but this data is considered to be very incomplete. *Cabomba haynesii* is characterized by opposite leaves as well as white and pink-purple red-colored flowers, usually with three stamens. The seeds are also supposedly as large or slightly larger than those from *C. furcata*.

Further reading: Kasselmann (1987b), Ørgaard (1991, 1992).

Cabomba aquatica (type “schwartzii”) on the lower reaches of the Paraná do Ariaú, Brazil.



Cabomba caroliniana

A. Gray (1837)

Family: Cabombaceae.

Synonyms: *Cabomba aubletii* Mich. (nomen nudum), *C. australis* Spegazzini, *C. caroliniana* A. Gray var. *paucipartita* Ramsh and Florsch., *C. pulcherrima* (Harper) Fassett and others.

Etymology: *Cabomba*: see *Cabomba aquatica*; *caroliniana*: originating from Carolina.

Distribution: Eastern U.S., southeastern South America, partially naturalized in Asia.

Distribution: Aquatic plant, shoots up to 1.50 cm long. Leaves usually opposite, rarely in 3-leaved whorls, 0.5–2.0 cm petiolate. Leaf blade semicircular to reniform in contour, 2–3 cm long, 3–6 cm wide, 5-merous at the base, leaf segments di- and trichotomously furcate several times so that each leaf has up to 200 segments. The plants are light green to medium green or pale wine red in color.

Flowering shoot with few floating leaves. These are peltate, linear, 15–20 mm long, 1.5–2 mm wide, green. Flowers trimerous, 6–15 mm in diameter. Sepals greenish or white on the outside, white on the inside, greenish

yellow at the base. Petals white (var. *caroliniana*), pale yellow (var. *flavida*) or purple-red (var. *pulcherrima*), distinctly auriculate, with yellow base patches; (3–)6 stamens; 2–4 carpels with 1–3 ovules. Seeds ovoid to oblong-ellipsoid, 1.5–3.0 × 1.0–1.5 mm thick, mammilate.

Culture: Among the cultivated species, *Cabomba caroliniana* is the most popular and the easiest to maintain. The species prefers soft, slightly acid water to prosper. Nevertheless, cultivation is also possible in medium-hard or hard water. Even though *C. caroliniana* has the lowest light requirements of all the *Cabomba* species, its light requirements should not be underestimated. Strong shoots with rapid growth will only be achieved under medium to strong lighting. Plants are often kept in too warm conditions which is why they will then exert themselves too quickly. The temperature should therefore only occasionally exceed 25 °C (ref. distribution and ecology). The delicate stems of *C. caroliniana* could easily be planted into a substrate consisting of sand and fine gravel.

Ecology: *Cabomba caroliniana* exists in stagnant and slow-to-fast-current waters in a

Cabomba caroliniana var. *caroliniana*.



Cabomba caroliniana var. *flavida*.



depth of up to 1.50 m. The author registered the following water data at different locations of var. *caroliniana*: 1) Sri Lanka (1/1985, released plants), location semishaded, GH 3 °dH, KH 2 °dH, pH 5.8, 91 µS/cm, rH 240 mV. The plants are consumed as vegetables by the local population; 2) Bolivia (8/1991): stream with stagnant water in the catchment area of the Rio Pirai, unshaded, water temperature 17 °C (air temperature 18 °C at noon), GH 4 °dH, KH 11 °dH, pH 6.5, 125 µS/cm; and 3) Argentina (7/1993): river with fast-flowing water, unusually robust specimens, loamy substrate, refer to the detailed water analysis on p. 40, biotope No. 5.

Cabomba caroliniana var. *flavida* populates similar living environments to var. *caroliniana*. Though the author was able to locate both varieties within the same area in north-eastern Argentina, they did not grow syntopically. Whereas var. *caroliniana* was found both in stagnant as well as fast-flowing waters, var. *flavida* grew almost exclusively in almost standing water. The shoots were clearly smaller than those from var. *caroliniana*. Water readings were taken at two of var. *flavida*'s locations: 1) Pool, almost stag-

nant, clear water, depth of about 1 m, plants highly algae-infested, sandy substrate, water temperature 12 °C (air temperature 20.5 °C at 11:30 h), GH < 1 °dH, KH 2 °dH, pH 6.0, 40 µS/cm; and 2) Dense populations in up to knee-deep water in a small stream which is a tributary to a lake, almost standing water, boggy-sandy substrate, location sunny-shady, plants thickly blanketed with decaying rot and algae, refer to the water analysis on p. 40, biotope No. 4.

Other: Next to the commonly cultured var. *caroliniana*, Ørgaard (1991) also distinguishes var. *flavida* Ørgaard and var. *pulcherrima* Harper, both of which are, however, only rarely cultivated.

There also exists a form of *C. caroliniana* var. *caroliniana* that features twisted leaf segments, referred to by its cultivar name of *Cabomba caroliniana* 'Silver-Green' and originated in the aquatic plant nursery H. Barth in Dessau, Germany. Unfortunately, however, it is rarely commercially available.

Flower of *C. caroliniana* var. *caroliniana*.



Cabomba caroliniana 'Silver-Green'.



Cabomba furcata

Schultes & Schultes f. (1830)

Family: Cabombaceae.

Synonyms: *Nectris furcata* Leandro (nom. nud.), *Cabomba piauihyensis* Gardner (1844); *C. warmingii* Caspary, *C. pubescens* Ule.

Etymology: *Cabomba*: see *C. aquatica*; *furcata*: fork-shaped, (bi)furcate, refers to the leaf blade.

Distribution: In the warmer regions of South America, occasionally in Central America.

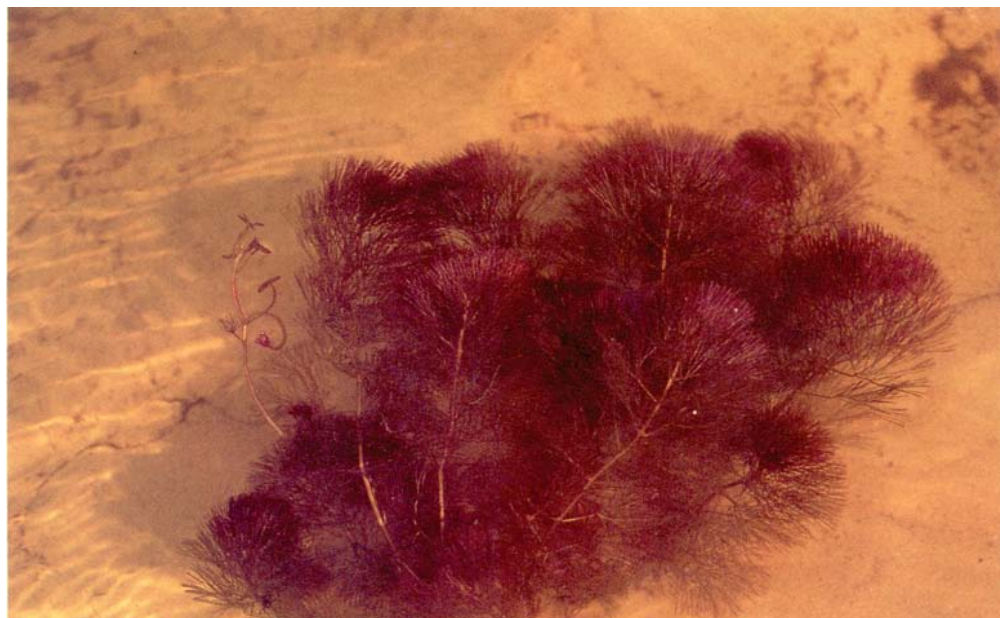
Description: Aquatic plant with 40–100-cm long shoots. Leaves usually in 3-leaved whorls, rarely opposite, 0.3–2.0 cm petiolate. Leaf blade reniform to almost circular in contour, 1.5–3.0 cm long, 2–6 cm wide, 5–7-merous at the base, leaf segments several times di- and trichotomously furcate and with up to 60 hair-like segments. Plants olive green to reddish brown, under intense light wine red coloration.

The flowering shoot has up to 6-merous leaf whorls and only few floating leaves. These are peltate, linear, 13–25 mm long, 1–3 mm wide (“warmingii” type less than 1 mm wide), olive green-colored. Flowers trimerous, 6–15 mm in size, each with 3 pale to deep

reddish or blue-violet, occasionally almost white, yellow at the base sepals and petals; petals slightly auriculate, with yellow base patches; (3–)6 stamens; (1)2–3(4) carpels with (1–)5 ovules. Seeds globular, 1–2 mm thick, echinate, can probably survive dry periods.

Culture: Of all the *Cabomba* species, *C. furcata* is the most difficult to maintain. Due to the deep brown-red coloration, the aquarist is repeatedly misled into trying this conspicuously decorative species. In the aquarium, in the long run, the shoots will only last in conditions of very soft, salt-deficient water with a pH-value in the neutral to highly acid range. Also important is intensive lighting and totally clear water. The substrate should be rich in nutrients. The optimum temperature range hovers between 24 and 30 °C. The shoots will decompose within a short time under bad growth conditions. In healthy plants propagation is very easy through lateral shoots. Several cuttings, arranged in terraced form, appear specifically decorative. The author made several failed attempts at cultivating the “warmingii” type.

***Cabomba furcata* in its native habitat on the Rio Guaporé (Brazil).**



Ecology: *Cabomba furcata* exists both in stagnant, temporary waters and in quiet places in rivers with slow-flowing water. In the tropical regions of South America, this typical soft water plant can be found very often. The author had the opportunity to take several water analyses in native habitats which are summarized here as follows: 1) Brazil (3/1986), marsh, standing water, water temperature 28–35 °C, pH value 5.5, GH/KH < 1 °dH, 18 µS/cm; 2) Brazil (refer to the complete water analysis of the Rio Guaporé on p. 46); 3) Venezuela (see the complete water analysis of biotope No. 3 with *C. furcata* and *Ludwigia inclinata* on p. 40); and 4) Bolivia (8/1991, analysis W. Staeck): Lago de Mandioré, stagnant, shallow water, sandy-boggy substrate, sunny, water temperature 25 °C at 14:00 h, GH 1 °dH, KH 4 °dH, pH 7.6, 60 µS/cm.

The “warmingii” type was found in sunny locations in the northern Pantanal (Brazil) in marsh areas featuring stagnant, shallow water. The shoots were rooted in the boggy-loamy soil or floated freely on the water surface. Several water analyses, which were conducted during the wet season in March

1986, resulted in the following data: water temperature 33–35 °C, pH 5.5, GH/KH < 1 °dH. During the dry season (8/1987), the shoots displayed isolated growth because many pools had dried out. At another location near Vila Bela, plants were found in a shaded pool with standing water under the following conditions: temperature 25 °C, pH 6.2, GH/KH < 1 °dH, 5 µS/cm.

Other: Ørgaard (1991) put both *Cabomba* “warmingii,” as well as *C. piauhyensis*—previously cultivated under a false name—into synonymy with *C. furcata*. A chromosome count revealed that the “warmingii” type is almost certainly a diploid form of *C. furcata*, which is smaller in overall size and displays a special adaptability to certain environmental conditions.

Further reading: Kasselmann (1988), Ørgaard (1991, 1992).

Flowers of *Cabomba furcata*.



Cabomba furcata (type “warmingii”).



Cabomba palaeformis

Fassett (1953)

Family: Cabombaceae.

Synonyms: None

Etymology: *Cabomba*: see *C. aquatica*; *palaeformis*: palaios (Greek) = old, *formis* = shaped.

Distribution: Central America.

Description: Aquatic plant with up to 1-m long shoots. Floating leaves peltate, linear. Flowers trimerous, about 6 mm in size. White sepals. Petals small auriculate at the base, yellow base patches, 1(2) carpels. Globular seeds, 2 mm, with long tubercles.

Cultivar 'Green': leaves opposite, grass green. Blade reniform, 2.5–5.0 cm wide, 1.5–2.5 cm long; 40–90 segments. Flowering shoot up to 10 cm long. Floating leaves 10–15 mm petiolate, up to 11 × 1.4 mm in size, 2 ovules.

Cultivar 'Red-Brown': leaves opposite or arranged in 4-merous whorls, red brown. Leaf blade reniform to almost circular, 2.5–5.5 cm wide, 2.5–4.5 cm long; 80–180 segments. Flowering shoot up to 2.5 cm long. Floating leaves up to 10 mm petiolate, up to 9 × 0.8 mm in size, upperside red-brown,

underside slightly pink-violet with 1(2) ovules.

Culture: Of all *Cabomba* species, *C. palaeformis* can be cultivated most easily in the aquarium. It prospers best in medium-hard to hard water with slightly alkaline pH-values. CO₂ fertilization is not necessary. Light requirements are in the medium range. In a nutritious substrate, new lateral shoots will continuously develop from the lower nodes, so that reproduction poses no problem. Flowering shoots together with floating leaves will regularly form on the water surface. The red-brown cultivar will grow quicker and turn out to be more bushy than the green one.

Ecology: Distributed in stagnant to very slow-flowing waters. The author collected the red-brown cultivar in the Laguna Noh (Mexico). The shoots grew both sunny and semishaded in the boggy ground up to a depth of 1 m, or floated on the water surface. Water values (8/1985): temperature 33 °C (13:00 h), GH 5 °dH, KH 6 °dH, pH value 6.9, Fe not detectable, NO₂ 0.1 mg/L, NH₄ 0.5 mg/L.

Further reading: Kasselmann (1988).

Cabomba palaeformis 'Green'.



Cabomba palaeformis 'Red-Brown'.



Cardamine lyrata

Bunge (1835)

Family: Brassicaceae.

Synonyms: None

Etymology: *Cardamine*: from (Greek) *kardamon* = cress; *lyrata*: lyrate (leaf shape).

Distribution: Eastern Siberia, northern China, Japan.

Description: Emerged stem creeping, up to 60 cm long, 1 mm thick, glabrous, often branchy, rooting on all nodes. Submersed shoots erect, up to 40 cm long. Alternate leaf arrangement, up to 2 cm petiolate; stipules small. Emerged blade reniform to almost round with cordate base and round apex, rarely impar pinnate with a large terminal lobe, up to 3 cm long, 2–3.5 cm wide. Submersed blades light green-colored, emerged light green to medium green, occasionally a weak red coloration. Margin crenate, slightly undulate.

Inflorescence a raceme with 10–30 petiolate flowers, 4 sepals, about 3 mm long, 4 white petals, 5–8 mm long, 6 stamens in 2 circles. Fruit a flat siliqua, the valves of which coil up in spiral form on opening. Seeds in large numbers.

Culture: This tender plant, often commercially available, is in the long run suited only for cultivation in cold-water aquariums or garden ponds. The plants can, however, temporarily survive higher warmth (up to 27 °C) without incurring any damage; then, though, smaller leaf blades and longer internodes will always develop, which is less decorative. Shoots can best be used in a sunny location, emerged in the marsh zone or submersed and floating in the shallow water of a garden pond. Propagation is through lateral shoots and seeds which are thrust from the siliqua.

Ecology: According to Wendt (1952–55), *C. lyrata*, as a marsh plant, populates meadows, moors and flooding areas. It exists on the edges of standing or flowing waters, where it invades the water and develops into a submersed form.

Other: Differentiating feature to the *Rorippa* genus: the siliqua is flat-topped in *Cardamine*, and the valves coil up on opening, whereas in *Rorippa* the siliqua is round and the valves don't coil.

***Cardamine lyrata*.**

Ceratophyllum demersum

Linné (1753)

Family: Ceratophyllaceae.

Etymology: *Ceratophyllum*: *keras* = horn, *phyllon* = leaf; *demersum*: sunken.

Distribution: var. *demersum*: worldwide; var. *apiculatum*: Northern Europe, India, Argentina, Zaire?, U.S.?, Cuba?; var. *inerme*: Northern Europe, Iraq, Ghana; var. *platycanthum*: Northern and central Europe, Far East, eastern Asia.

Description: Aquatic plant, free-floating under the water surface, rootless or anchored in the substrate with rhizoids. Stem more than 1 m long, often branchy, soft or hard, very fragile leaves arranged in 6–12-merous whorls, up to 4 cm in diameter, medium to dark green, occasionally reddish. Leaf usually furcate 1–2 times, with 3–4 segments, underside laterally echinate in 2 rows.

Monoecious plants, flowers unisexual, inconspicuous. Male and female flowers individual, more or less sessile. Perianth with 8–13 linear segments. Male flower with numerous (often over 20) stamens. Female flower with 1 carpel, epigynous ovary and long style. Fruit a solitary nut with 0 or 2

basal and 1 terminal spine, often also mammillate and featuring marginal spines.

Culture: *Ceratophyllum demersum* is an undemanding and recommendable aquatic plant which, depending on its origin, can be used either in garden ponds (hardy), in cold-water aquariums or in tropical aquariums. It loves medium-hard to hard, alkaline water with temperatures up to about 30 °C. Light requirements are moderate. The shoots can be left to float on the water surface within aquariums, or alternatively, being more decorative, be set as a bunch. Such planted specimens, though, will quickly reach the water surface so that they have to be trimmed regularly. Due to its rapid growth, *C. demersum* can find good use as a competitor for nutrients in an aquarium infested by algae. However, the plants will often react with decay to the supply of chemical additives. Because of the hard leaf structure, the species is especially suitable for cichlid aquariums. Flowers occasionally formed but fruit, on the other hand, is rare. Pollen is transferred through the water.

Ecology: The species populates stagnant and slow-moving, predominantly eutrophic waters, occasionally brackish water as well. De-

***Ceratophyllum demersum* var. *demersum* from Bolivia: fruit and aquarium plant.**



pending on the location's conditions *C. demersum* can vary widely in its habit. For example, in the East African lakes of Tanganyika and Malawi, the author located a form with an especially complex habit and an extremely hard leaf structure which had adapted ideally to its native habitat (strong water movement, hard, carbonate-rich alkaline water, see water analysis p. 41). In up to 10 m depth the plants—due to their compact growth (greater density, comparable to the winter shoots formed in native waters)—don't grow floating, but on the lake substrates instead, where water movement is less than on the surface. This typical growth form will not remain in the aquarium (Kasselmann 1989b). On the other hand, there are growth forms which display only minor modifications. Selected data on locations: 1) Zambia (8/1986): Lake Mweru Wantipa, water temperature 26.5 °C (air temperature 28 °C at 13:00 h), pH 8.4, GH < 1 °dH, KH 18 °dH, 6450 µS/cm. Substrate sandy-gravelly; 2) Papua New Guinea (7/1988): river with slow-moving water. Substrate gravelly-boggy. Water temperature 28 °C (air temperature 28 °C at noon), pH 7.6, GH and KH 12 °dH, 500

µS/cm; 3) Papua New Guinea: boggy lake water temperature 31 °C at 12:30 h, pH 7.5, GH 11 °dH, KH 15 °dH, 510 µS/cm; 4) Brazil, Amazon River near Manaus (3/1986): water temperature 27–27.5 °C, pH 6.5–7.2, GH/KH < 1 °dH, 20–100 µS/cm; 5) Peru (7/1990): Rio Yanayacu, slow-moving water, detailed water analysis on p. 40; 6) Mexico (8/1985): lagoon, water temperature 27 °C (air temperature 26 °C), pH 7.5, GH 6 °dH, KH 6 °dH, NO₂⁻ not detectable, NH₄⁺ 1.0 mg/L. Fe not detectable; 7) Argentina (7/1993): river, water temperature 18.9 °C (air temperature 33 °C at 15:30 h), pH 7.6, GH 25 °dH, KH 24 °dH; and 8) Mafia Island (12/1980): small lake, see p. 41 for the complete water analysis.

Other: Wilmot-Dear (1985) lists four varieties as well as three forms which differ only in their cover of spines and fruit surface structures.

Fruit of *C. submersum* var. *echinatum* (Peru).



Stamen with four pollen sacs (microscope photography).



Ceratophyllum submersum

Linné (1763)

Family: Ceratophyllaceae.

Synonyms: Numerous (see Wilmot-Dear 1985).

Etymology: *Ceratophyllum*: see *C. demersum*; *submersum*: submerged, refers to the plant's mode of existence.

Distribution: Subspecies *submersum*: world-wide; var. *submersum*: Europe, western Asia, Turkey, Yemen, China, Malaysia, tropical Africa, U.S. (rarely in large numbers); var. *squamosum*: China; var. *haynaldianum*: Hungary; subsp. *muricatum* var. *echinatum*: western Asia, southern Europe, India, China, eastern Asia, tropical Africa, South Africa, U.S., Central America, northern South America; var. *manschuricum*: Eastern Europe, China.

Description: Distinguishable from *C. demersum* by the following features: stems and leaves delicate, soft, green or reddish coloration. Leaf whorl 4–7 cm in diameter. Leaves usually 3–4 times furcate and equipped with 6–8 filiform segments sometimes featuring very fine denticles on the underside.

Flower characteristics as in *Ceratophyllum demersum*, with the male flower often having

fewer than 10 stamens. Most important differentiating feature is the fruit: basal spines are missing or flat, and usually not robust; margin entire, crenate, aliferous or echinate; surface smooth or mammilate.

Culture: *Ceratophyllum submersum* is a rather rare culture plant which is only seldom found in its native waters. Similar to *C. demersum* it, too, is undemanding and recommendable. Refer to *C. demersum* for details on culture and use. Unfortunately, the stems from *Ceratophyllum* tend to break off easily during transportation which is probably the reason for its rare appearance in aquarium shops.

Ecology: In its native habitat, *Ceratophyllum submersum* generally grows stagnant, rarely in slow-moving mesotrophic to eutrophic waters which can also be temporary. The species is more warmth-requiring than *C. demersum*.

Other: Wilmot-Dear (1985) distinguishes two subspecies with five varieties which differ only in the spine cover of their fruit and surface structure.

***Ceratophyllum submersum*.**



Ceratopteris cornuta

(P. Beauvois) Le Prieur (1830)

Family: Pteridaceae.**Synonyms:** *Pteris cornuta* P. Beauv (1806) and others.**Etymology:** *Ceratopteris*: *keras* = horn, *pteris* = fern, refers to the lobe that stand out like horns; *cornuta*: with horns.**Distribution:** Africa (Senegal to Sudan, southwards to Tanzania), Madagascar, isolated populations in Yemen (Sokotra Island), Saudi Arabia, Iraq, northeastern India, Burma, Indonesia, northern Australia.**Description:** Floating plants, then only with sterile leaves, or rooted in the substrate in wet locations, forming fertile leaves after a few intermediate leaves. Short, erect rhizome. Leaves shaped very differently, light green. Sterile leaves: petiole 4–18(–30) cm long, 1.5–5 (–8) mm thick. Blade 7–27 cm long, 6–20 cm wide, outline usually trigonal, more rarely lanceolate or reverse trigonal oblong, initially unpartitioned, lobular and sinuate with increasing age of the plant, pinnately parted after a medium growth stage. Numerous adventitious plants on the margin.

Fertile leaves: petiole up to 31 cm long, up

to 9 mm wide, not spongy thickened. Blade up to 47 cm long, up to 28 cm wide, pinnatisected. Margins recoiled downwards, with 1–3 rows of sporangiums. Sporangium with 32 spores.

Culture: This fast-growing, undemanding fern has, for many years, been among the aquarists' most popular plants. On the one hand, it is excellently suited as a floating plant in breeding aquariums where the finely divided roots and the floating leaves are preferred by labyrinth fishes for the construction of bubble nests; on the other hand, it can also be cultivated without any problems when being planted into the substrate. The water's hardness and pH-value play no decisive part during cultivation. Medium lighting intensity is adequate. Optimum temperature range is 22–28 °C. Generative propagation by spores is interesting and easy to achieve. The fern is cultivated in moist soil and high humidity until fertile leaves are developed which feature numerous sporangia in the downward-coiled margins. The spores look like "brown powder" and germinate well on moist soil and will rapidly grow to new fern plants.**Ecology:** Populates wet habitats, only occasionally located floating in stagnant or slow-moving waters. Details: Sri Lanka (1/1985): small river with slow-moving water, pH 7.8, GH 3 °dH, KH 2 °dH, 91 µS/cm, rH 240 mV. For detailed biotope description and water analysis, see Mafia Lake on p. 41.**Other:** The differentiation between the three *Ceratopteris* species described here is not easy, which is why many botanists are of the opinion that we are concerned with only one variable species (*C. thalictroides*). The fact is, however, that in comparative cultivation there are differentiating features with which the species can be distinguished from one another. A definite identification of plants collected from the natural environment is made difficult by the existence of hybrids in the overlapping habitational areas.***Ceratopteris cornuta*.**

Ceratopteris pteridoides
(Hooker) Hieronymus (1905)

Family: Pteridaceae.

Synonyms: *Parkeria pteridoides* Hooker (1825) and others.

Etymology: *Ceratopteris*: see *C. cornuta*; *pteridoides*: *Pteridium*-like.

Distribution: South America (Amazon region to Peru, Colombia, Venezuela), Central America (Panama to Guatemala); isolated populations in Brazil, northern Argentina, Paraguay; North Vietnam(?).

Description: Marsh plant. Rhizome up to 3 cm long, 2 mm thick, erect. Leaves shaped very differently, light green. Sterile leaves: petiole 1–8(–19) cm long, up to 2.5 cm thick. Blade 5–13(–19) cm long, 5–16(–24) cm wide, contour usually trigonal, from almost unpartitioned to palmate 3-lobed, with increasing age sinuate to pinnately parted.

Fertile leaves develop in specimens floating and rooted in the substrate. Petiole 4–8(–26) cm long, up to 3 cm spongy thickened. Blade 8–15(–30) cm long, pinnatisected. Margin recoiled downwards, with 2–4 rows of sporangiums. Sporangium with 32 spores.

Culture: In contrast to *C. cornuta* and *C. thalictroides*, which have proven to be excellent aquarium plants. *Ceratopteris pteridoides* is very difficult to keep and therefore found only rarely in culture, in contrast to information found in many aquaristic publications, an error which is obviously based on a confusion with *C. cornuta*. Maintenance is best achieved as a floating plant above a muddy substrate, under intense light, next to no water movement as well as emersed on slightly moist soil, which is where fertile leaves will also develop. Intensive development of adventitious plants is rare.

Ecology: In their native habitat, the plants will either float on the water surface or will root in wet locations in the substrate. Water analyses of two biotopes follow: 1) Brazil (3/1986): Amazon, near Manaus, water temperature 27 °C, pH 6.5–7.2, GH/KH < 1 °dH, 20–100 µS/cm; and 2) Peru (7/1990): Rio Yanayacu, quiet bay, see detailed water analysis in biotope No. 6 on p. 40 and photo p. 28.

Ceratopteris pteridoides with sporangiferous leaves on the Rio Yanayacu (Peru).



Ceratopteris thalictroides

(Linné) Brongniart (1821)

Family: Pteridaceae.**Synonyms:** *Acrostichum thalictroides* L. (1753) and others.**Etymology:** *Ceratopteris*: see *Ceratopteris cornuta*; *thalictroides*: similar to the genus *Thalictrum*.**Distribution:** Southeast Asia, northern Australia; isolated populations in Tanzania, Florida, Central America, northern to central South America.**Description:** Amphibious fern, with a short and erect rhizome, usually rooted in the substrate. Leaves shaped differently, light green coloration. Sterile leaves: petiole up to 15(–31) cm long, 2–5(–8) mm thick. Blade 3–20(–41) cm long, 1.5–10(–20) cm wide, lanceolate contour, rarely lanceolate-ovoid and trigonal, in its early development stage pinnately parted and pinnatisected. Margin with few adventitious plants.

Fertile leaves: petiole up to 25(–46) cm long, 2–8(–11) mm thick, not spongy thickened. Blade 10–55(–82) cm long, 3–25(–48) cm wide, pinnatisected. Margins coiled up

Ceratopteris thalictroides.

downwards, with 1–3 rows of sporangiums. Sporangium with 32 spores.

Culture: Cultivation of this decorative, undemanding fern plant is highly recommended. In contrast to *C. cornuta*, *C. thalictroides* grows better if it is planted in the substrate(!). It will take up a lot of space within only a few weeks and will quickly permeate the substrate with its strong roots. Under good growing conditions, the leaves will have to be regularly trimmed and too large specimens replaced with young plants. Adventitious plants will be more rare than in *C. cornuta*. Cultivation will succeed in both soft as well as hard, weak acid or slightly alkaline water. Provide a medium light intensity. Temperature range should be 22–28 °C. For details on generative propagation see *C. cornuta*.**Ecology:** Some water analyses of natural locations: Papua New Guinea (7/1988): small river, slow-to fast-flowing water, submersed plants in a shady-sunny location, water temperature 26 °C (air temperature 28 °C at 11:00 h), pH 8.4, GH 17 °dH, KH 25 °dH, 1100 µS/cm. Furthermore, a comprehensive water analysis from the Sepik River, biotope No. 10 on p. 41. Brazil (7/1987): marsh area, slow-flowing water, water temperature 22 °C (air temperature 27 °C at 10:00 h), pH 6.8, GH and KH < 1 °dH, 10 µS/cm. Venezuela (8/1989): pool, muddy substrate, water temperature 28 °C (air temperature 31 °C at noon), pH 6.6, GH 2 °dH, KH 4 °dH, 100 µS/cm.**Other:** In both *C. cornuta* and *C. pteridoides*, the pinnatisected leaves will develop only in a late developmental stage of the plant, whereas in *C. thalictroides* they will form early on.A fourth species, not introduced so far, is *C. richardii* Brongniart, which, compared to the three other species, does not count 32 spores but just 16 relatively large spores per sporangium. This species is found in Africa (from Senegal to Liberia, Sudan), Madagascar, North America (Louisiana, Florida), Central America (Guatemala), and South America (from Brazil to French Guiana, Venezuela).**Further reading:** Lloyd (1974).

Crassula helmsii

(Kirk) Cockayne (1907)

Family: Crassulaceae.

Synonyms: *Tillaea helmsii* Kirk (1899), *T. recurva* Hooker f., *Crassula recurva* (Hooker f.) Ostenfeld, non N.E. Brown, *Bulliardia recurva* Hooker f.

Etymology: *Crassula*: *crassus* = thick, thick leaf; *helmsii*: after R. Helms (1842–1914).

Distribution: Widespread in Australia, New Zealand, introduced to England.

Description: Small, perennial marsh plant with emerged creeping, submersed erect, very branchy shoots. Leaves decussate, sessile. Leaf blade linear to lanceolate, acute, fleshy, in terrestrial plants about 5–10 mm long and 1–2 mm wide, under water up to 15 mm long and 0.5–1 mm wide, colored light green. Venation indistinct.

Flowers bisexual, solitary, 2–3 mm petiole, about 3–4 mm in size; 4 green sepals; 4 white, trigonal, about 1 mm long petals; 4 stamens, slightly shorter than the petals; 4 carpels; short style.

Culture: *Crassula helmsii* is an inconspicuous and rarely cultivated plant which is suitable for cold-water aquariums and also, tem-

porarily, for tropical aquariums with a temperature of about 23 °C. Since the species is light-demanding, it should grow in the aquarium's foreground in a bright place. Substrate and water values are only of minor importance. In optimum growth conditions the shoots will branch abundantly. Emerged culture in a moist substrate, also in dry room air, is unproblematic.

Ecology: In Australia, *C. helmsii* inhabits quiet, shallow water in swamps and on riverbanks. In England, where the species was introduced as an ornamental plant, it has undergone an explosive distribution into nature over the last 25 years (Plain 1987) which has already led to the displacement of many endemic aquatic plants. In contrast to Australia, in England it is supposed to display even better propagation in fast-moving water, and supposedly also exists in alkaline lakes up to a depth of 3 m.

Crassula helmsii.



Emerged shoot of *C. helmsii* with flowers.



Crinum calamistratum

Bogner & Heine (1987)

Family: Amaryllidaceae.**Synonyms:** *Crinum natans* "crispus."**Etymology:** *Crinum*: from *krinon* = lily; *calamistratum*: crispate, curly.**Distribution:** Western Cameroon (near Kumba).**Description:** Aquatic plant with an oblong, 1–3-cm thick, up to 10-cm long bulb. Leaves rosette-like, strap-shaped, slightly twirled, 70–100(–200) cm long, 0.2–0.7 cm wide, dark green; margin crispate. Midrib distinct.

Peduncle up to 80 cm long, erect. Inflorescence with 1–3 well-scented flowers. Bracts about 3.5 cm long. Flower with an erect, 10–12-cm long, green perigone tube, 6 white, recurved, very narrow 6–7-cm long and 0.5–0.8-cm wide tepals as well as 6 stamens. Style about 7 cm long. Fruit not known.

Culture: *Crinum calamistratum* with its strongly crisped leaves is a specifically conspicuous bulbous plant which is occasionally imported. Cultivation requirements are not very high: soft to medium-hard water with a pH-value around 7 is recommended. The substrate should measure a height of at least 8 cmand should be rich in nutrients (e.g., loam additive). Strong water movement seems to enhance growth. *Crinum calamistratum* grows distinctly slower than *C. natans* and *C. thainum*, so that several months will pass before a vigorous specimen has developed. The plant reacts negatively to relocation and is suitable only for aquariums with a minimum height of 50 cm. Vegetative propagation through bulbils is possible only in strong specimens. Sexual propagation is unreported. **Ecology:** Practically nothing is known about natural habitats. The collector H. Gregory discovered the plant in June 1948 near Kumba, growing with submersed leaves in a river. The location had probably dried out during the previous months. The species seems to be distributed only very locally.**Further reading:** Bogner and Heine (1987).*Crinum calamistratum*.

Strong plant with many bulbils.



Crinum natans

Baker (1898)

Family: Amaryllidaceae.

Synonyms: None

Etymology: *Crinum*: see *Crinum calami-stratum*; *natans*: swimming, floating.

Distribution: West Africa from Guinea to Cameroon and southwards to Zaire.

Description: Strong aquatic plant with an almost globular, up to 4.5-cm thick bulb. Leaves rosette-like, strap-shaped, dark green coloration, up to 140 cm long and 2–5 cm wide, usually highly undulate, rarely almost flat; contour irregularly toothed. Midrib usually distinct.

Peduncle up to 75 cm long, erect. Inflorescence with up to 5 sweet-scented flowers. Bracts up to 3.5 cm long. Flower with an erect 10–18 cm long, green perigone tube, 6 white, slightly drooping, narrow lanceolate, 5–9 cm long, 0.9–1.6 cm white tepals as well as 6 stamens. Style longer than the stamens. Infructescence with 3–4 fruit. Fruit globular, shiny, up to about 2 cm in diameter, dark green, with a tip about 1 cm long. Seeds shaped irregularly, up to 1.7 cm long.

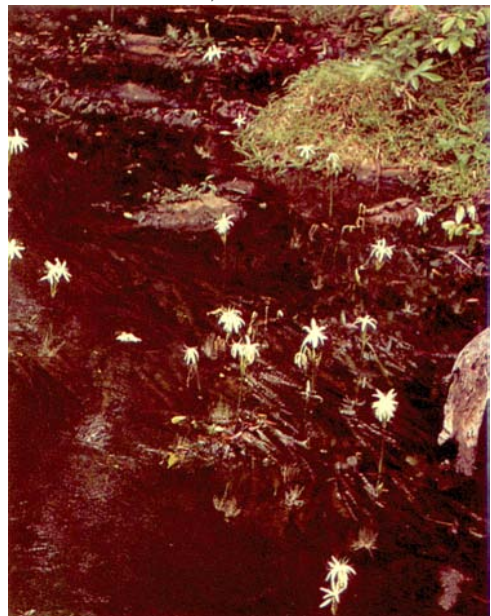
Culture: A large-growing, decorative species, *C. natans* is found only rarely in aquariums. Spacious aquariums should be available for cultivation so that the ribbon-like leaves can float on the water surface. In the aquarium, *C. natans* can be successfully cultivated in soft to medium-hard water with a pH-value around neutral. The substrate, in accordance with the large bulb, should have a minimum height of 10 cm and be coarse and rich in nutrients. Because the plants prefer fast-flowing water in their native habitats, strong water movement should also be provided in the aquarium. *Crinum natans* occasionally propagates vegetatively through bulbils on strong mother plants. Sexual propagation is both recommended and productive. The seeds will germinate well and the young

plants will quickly develop and reach a height of about 15 cm after about 10 weeks.

Ecology: The species populates very fast-flowing and strongly shaded water in rain-forest streams and rivers, but also grows in full sunlight, in gravelly and rocky or muddy substrates in altitudes up to 650 m. The author's water analyses in several locations in Cameroon produced the following results: temperature 24–30 °C, pH-value 5.5–7.8, GH 0.5–4 °dH, KH < 1–3.5 °dH, 35–220 µS/cm. Fe²⁺/Fe³⁺ not detectable. The beautiful and well-scented flowers, rising above and over the water surface, are impressive in their natural habitats. Rivers are often covered in an ocean of flowers, an enchanting sight which is not quickly forgotten.

Other: *Crinum natans* plants with differently wide and more or less highly undulate leaves have been located. Based on studies of the cultured plants, these features do not vary under identical conditions. Intermediate forms are found in nature, but can only be recognized as different ecotypes without any taxonomic status. A natural hybrid of *C. natans* and *C. jagus* possibly exists in Cameroon, featuring 2–2.5 cm-wide leaf blades (Nordal and Wahlstrøm 1980).

Biotope with *C. natans* in Cameroon.



Crinum thaianum

J. Schulze (1971)

Family: Amaryllidaceae.

Synonyms: None

Etymology: *Crinum*: see *C. calamistratum*; *thaianum*: originating from Thailand.

Distribution: Southern Thailand.

Description: Aquatic plant with an up to 7-cm thick bulb. Leaves rosette-like, strap-shaped, hardly or strongly twirled, soft, difficult to tear, 1–3 cm long, 1.5–2.5 cm wide, medium green. Margin denticulate, not undulate. Venation lacking a distinct midrib.

Peduncle up to 80 cm long, erect. Inflorescence with 5–7(–10) scenting flowers. Flower with an erect, 12–14-cm long, green perigone tube, 6 white, recurved 6.5–10-cm long and 0.8–1.1-cm wide tepals as well as 6 stamens. Seeds irregularly shaped, up to 2.5 cm long.

Culture: *Crinum thaianum* is a specifically adaptable and quick-growing species with only moderate light requirements. It will prosper in both soft and hard water at temperatures from 22 to 27 °C and requires a nutrient-rich substrate at least 8 cm deep in which the strong root system can spread out.

Side and rear panels, especially in high aquariums, can very effectively be decorated with *C. thaianum* by densely arranging several specimens next to each other. Due to quick growth, a dense thicket of long floating leaves will develop on the water surface after a short time. Propagation through bulbils in older plants is achieved more often than in *C. natans*. For details on sexual propagation see *C. natans*.

Ecology: Schulze (1971a) discovered the species in flowing waters rooted deep in the substrate in a water level of up to 2 m. The water was extremely soft, the temperature in April measured 27 °C at noon. The substrate consisted of solid loamy-gravelly sand or was rich in loam and mud. The locations were usually shady, but were temporarily exposed to full sunlight.

Other: A deviating form featuring strongly coiled leaf blades is occasionally available.

Crinum thaianum.



Crinum thaianum with twirled leaf blades.



The *Cryptocoryne* Genus

ARACEAE FAMILY

About Nomenclature

The most important work on the *Cryptocoryne* genus was done by Engler (1920), de Wit (1990), Rataj (1975b), Jacobsen (1976, 1980, 1981, 1982, 1985a, 1987a, 1991) and Jacobsen and Bogner (1986/1987). Rataj's revision was inadequate, and almost all his new descriptions were subsequently retracted as valid synonyms. De Wit, too, identified several new species, the descriptions of which were generally justified at the time. Over the last 20 years, through chromosome counts, pollen research, observations in native habitats, as well as comparative cultivation, the complicated relationships between individual species could be studied in closer detail, resulting in an improved understanding of the wider contexts. As a result, commonly used names were withdrawn and aquarists had to familiarize themselves with many new names. In this context the diligent and comprehensive publications by the Danish botanist Prof. Dr. Niels Jacobsen deserve wider attention. In them he clarified and resolved many taxonomic questions as well as problems involving cultivation. There is no other individual genus where aquarists and scientists display such a productive and fruitful cooperation as is the case with *Cryptocorynes*. The author therefore wishes to mention Josef Bogner, Jan Bastmeijer, and Hans Ehrenberg in this context, who have, among others, distinguished themselves by their tireless efforts in pursuing the clarification of issues regarding taxonomy and cultivation. The author's friend, the late Friedrich Möhlmann, too, who has achieved a lot of credit in the field of *Cryptocoryne* cultivation, remains forgotten.

The numerous collections of the last couple of years and newly concluded findings show quite clearly that the range of individual

species can, indeed, be very large. In the future, too, we will have to expect that species will be identified as polymorph species and that name changes will have to be made. The author will essentially follow the taxonomic results of Jacobsen. Later publications by other authors, however, also find consideration.

Of the 56 different species currently recognized, 37, plus one hybrid, will be discussed in comprehensive detail. Those *Cryptocorynes* which can be well maintained in aquariums find special consideration. In addition, several rare species, of which only little is known about their cultivation and which are kept only by a small group of specialists, have also been included.

Distribution of *Cryptocoryne* Species

The *Cryptocoryne* genus is native to tropical South and Southeast Asia as well as New Guinea. Most species occur only in a relatively small area. *Cryptocoryne ciliata* has the widest distribution, taking in an area from India to New Guinea. Details on the distribution of the individual species can be found in Table 4 on pp. 182–183.

General Features of the Genus

Habit—The *Cryptocoryne* genus comprises aquatic and marsh plants which generally propagate vegetatively through buried runners. All *Cryptocorynes* feature a usually creeping (rarely erect), more or less thick rhizome, on which the leaves are arranged in a rosette. They are (with the exception of the winter leaves in *C. retrospiralis*) divided into petiole and blade, and have an inconspicuous sheath at the base. In contrast to the *Lagenandra* genus, where the juvenile leaf blade is wrapped by both leaf margins (involute vernation), the blade in *Cryptocoryne* species is encoiled cornet-like from only one side (convolute vernation).

Inflorescences—With regard to their outward appearance, *Cryptocorynes* are very changeable in their reaction to exterior environmental influences; typical habits are therefore only rarely sufficient for a definite identification. The most important criteria for the differentiation of the species are the inflorescences. They can be only rarely observed in species submerged under water (exceptions are *C. affinis*, *C. cordata*). It is therefore generally necessary to cultivate *Cryptocorynes* in low water levels or as terrestrial plants in high humidity. Some species will easily flower under such conditions (e.g., *C. beckettii*, *C. cordata*, *C. wendtii*), others require a lot of patience as well as corresponding know-how on their individual requirements as to living conditions.

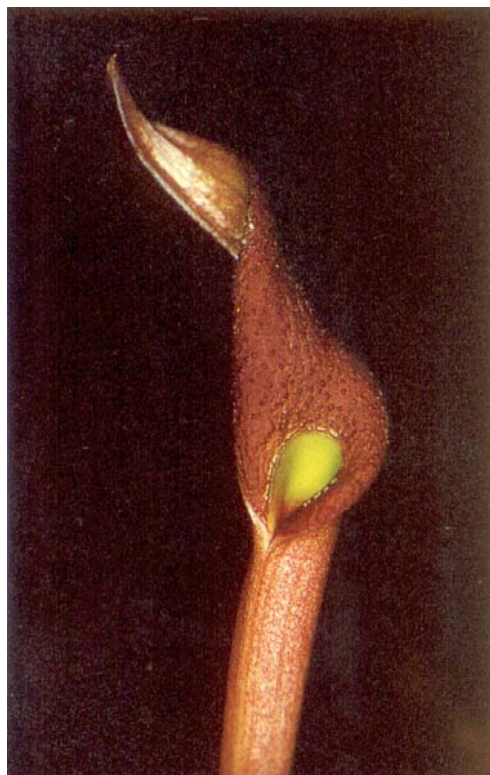
The inflorescence consists of a petiolate spathe which is widened at its base to form a

kettle. The latter holds the flower organs [*kryptos* (Gr.) = hidden, and *koryne* (Gr.) = cob]. Above the kettle, the spathe continues as a narrow tube, on the opening of which the limb will connect. One exception is *C. spiralis* in which a tube located between the kettle and the limb is absent.

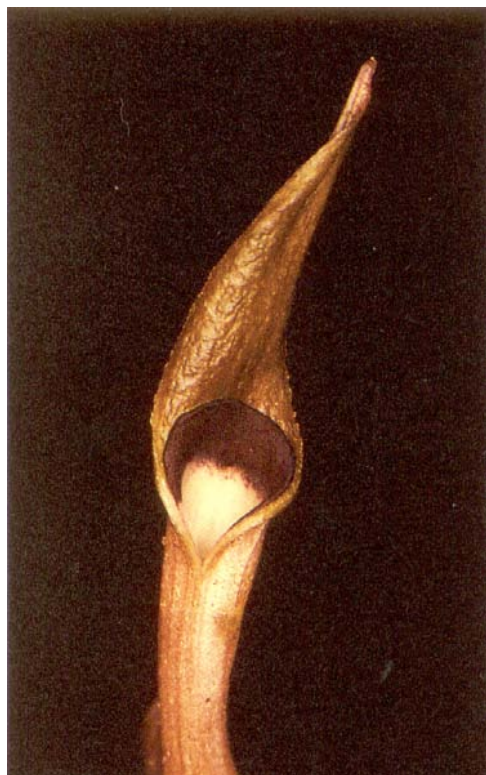
The structure of the kettle is especially interesting: 4–8 female flowers, arranged in a circle, are attached to the lower part of a spadix, with a few small olfactory bodies situated directly above, followed by a usually bare part of the spadix, with a more or less large number of male flowers set in whorls at its end. Kettle and tube can be closed by a moveable flap.

Color, shape and surface structure of the limb are the most conspicuous features of the inflorescence. The limb can be erect or reflexed, aciculate or caudate, smooth or twisted,

Limb of *Cryptocoryne* × *willisii*.



Limb of *Cryptocoryne beckettii*.



smooth, mammilate or wrinkled. In most cases the limb, which features a more or less distinct collar or throat at its opening to the tube, is conspicuously colored and has an important function in attracting insects to the plant.

The coloration of the limb was seen for a long time as one of the most important distinguishing features because one was still insufficiently aware of the range of variations of some species. The collections of the last couple of years, e.g., of *C. alba*, *C. minima*, *C. pontederifolia*, *C. spiralis* and *C. thwaitesii*, show, however, that coloration can vary strongly and that this feature deserves a lower degree of systematic importance attached to it than has previously been the case.

Pollination—The spathe will open during anthesis. Very small flies are attracted both through a sweet odor of carrion emitted by the olfactory bodies as well as the conspicuous coloration of the limb. They crawl through the tube into the opened kettle and, in doing so, deposit pollen carried along from other inflorescences on the receptive and moist (female) stigmata. At this point the male flowers of the visited inflorescence have not yet matured. After several hours the flap will move upwards and will close off the exit for one day, thereby entrapping those insects still in the kettle. Now the inflorescence will proceed into its male stage, i.e., the male flowers will mature, whereas the female flowers will cease to be receptive. During their roaming about inside the kettle, the slimy pollen will attach to the imprisoned insects. On the third flowering day, the flap will open again permitting the insects to fly on to the next inflorescence where they will rid themselves of the imported pollen, and will thus perform the act of cross-pollination.

These details on pollination are not based entirely on theory alone, as is occasionally claimed. Deviations, however, have been observed in several species.

In order to achieve artificial pollination,

two inflorescences are required. Using a razor blade, part of the kettle wall is removed in one inflorescence (which should be about 1 day old), thereby reaching the flower organs. Next, the pollen of an approximately 3-day-old inflorescence, the kettle of which is also cut open, is transferred to the (female) stigmata of the first inflorescence. After successful pollination the ovaries will swell. The fruit require about 6–9 months to fully mature. Just before maturity, the peduncle of the infructescence will conspicuously extend. Next, the syncarp will burst at its tip (an important difference to the *Lagenandra* genus in which the free berries open at the base) and release the seeds within a couple of hours. They will initially float to the water surface. The typical appearance of the seeds, as well as the surface structure of the fruit, has so far only been sufficiently studied in very few *Cryptocorynes* for the simple reason that neither fruit nor seeds are actually known in many species.

Other Features—Apart from the essential features mentioned here, the shape of the adnate ovaries and stigmata, the number of male flowers, as well as the very small pits in the inside kettle wall found in certain species—the importance of which has not been established—are all typical of the species.

Also worth mentioning is that even within one *Cryptocoryne* species there can be a large range of variations for specific features. For example, the color of the limb in *Cryptocoryne undulata* may vary from a cream color to yellowish to brownish, that of *C. alba* may be white, pink or dark red. The different races of one and the same species often also display large differences in their flowering and growth behavior. The numerous habitat forms of *C. wendtii*, for example, are not equally suited for cultivation purposes. There are also ecological types of *C. spiralis* which can easily be kept in aquariums, whereas others are totally unsuitable for cultivation under water.

The individual descriptions cannot always go into every detail of the differences between the ecological races. The author attempts, however, to address this issue whenever it is of relevance to the aquarist.

Number of Chromosomes—The differing number of chromosomes in *Cryptocorynes* is an essential aid in explaining the relationships within the genus. Additional conclusions on the evolution and relationships can be drawn from their distribution, morphology and ecology, thus enabling a classification into systematic groups. Table 4, listing all known numbers of chromosomes in *Cryptocorynes*, enables a good overview on the current state of hypotheses about the relationships and systematics of the species. In the future, genetic studies, i.e., DNA sequences, as have already been done here and there for

other plant genera, may contribute to a more detailed clarification of the relationships.

NATIVE HABITATS OF CRYPTOCORYNES

Our knowledge about the native habitats of *Cryptocorynes* has expanded considerably over the last couple of years. Among the many publications, those compiled by Schulze (1971b, 1978), Horst (1983, 1986), Jacobsen (1976, 1980, 1982, 1985a, 1986, 1991) and Jacobsen and Bogner (1986, 1987) deserve special mention. These studies show that *Cryptocorynes*, which probably all go back to a single common source (monophyletic), have, in the course of time, adopted rather different habitats during their evolution. Most will have only a very limited area of endemic distribution. Their habitats are

Natural habitat of *Cryptocoryne bogneri* in Sri Lanka.



generally more or less fast-flowing waters, their banks and edges, as well as pools that have remained after flooding, which may periodically dry out (temporary waters). Some *Cryptocorynes* exist in rivers which are subject to tidal influence by their proximity to oceans.

Among the most important ecological factors influencing the existence of *Cryptocorynes* are water chemistry, as well as the composition of the soil or substrate.

Published water analyses of native habitats distinctly show that water composition, especially the pH-value and hardness, are of very special importance for plant growth. Whereas the *Cryptocorynes* in Sri Lanka are usually found in waters featuring a weak acid to slightly alkaline pH-value, as well as predominantly medium-hard to hard water, the *Cryptocoryne* biotopes on Borneo and the Malay Peninsula are largely characterized by a very soft, extremely acid environment. It is thus hardly surprising that species from Sri Lanka (with the exception of *C. bogneri*, *C. thwaitesii*, *C. alba*) are better suited for aquarium cultivation than *Cryptocorynes* originating from typical black water biotopes on Borneo or the Malay Peninsula.

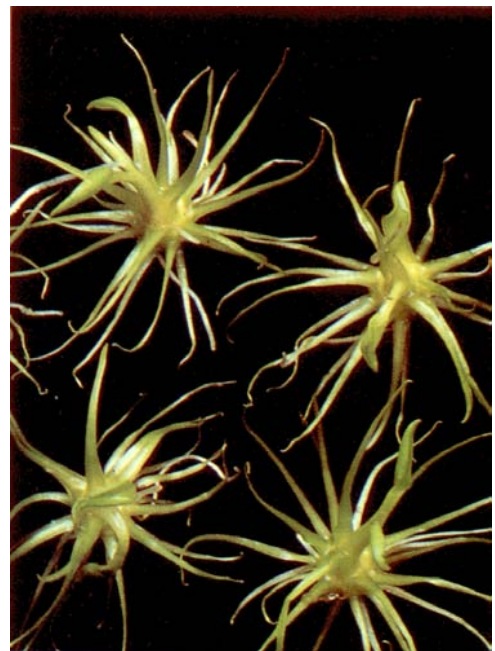
The condition of the substrate, too, is a vital ecological factor to which many *Cryptocoryne* species are highly tuned and adapted. Therefore, they often have only a limited tolerance for even minimal deviations from their optimum conditions. In their native habitats *Cryptocorynes* grow in very different soils. Species from streams and rivers in tropical rainforests exist in boggy and loamy, iron-holding soil, which displays a high degree of humic matter due to decaying foliage and rot. As regularly documented, the pH-values of the substrate are thus located in the strongly acid range. In contrast, in fast-flowing streams and rivers with a sandy-gravelly substrate, a usually weak acid reaction was recorded.

Apart from the individual factors of water chemistry and substrate, there is another es-

sential environmental factor, namely light intensity. Most *Cryptocorynes* from the Malay Peninsula (from Borneo and Sumatra) exist in semishaded to totally shaded locations; biotopes exposed to full sunlight are only occasionally found for *Cryptocorynes* from Sri Lanka.

The native habitats of *Cryptocorynes* are exceptionally different in their makeup, which is why generalizations are questionable because they lead to wrong perceptions and conclusions. A differentiating approach, therefore, which takes into consideration the ecological conditions of each and every *Cryptocoryne* species, is most important. It is for this reason that the native habitats of this highly specialized genus receive special attention in the descriptions of the individual species, taking into account all currently available information.

Seedlings of *Cryptocoryne ciliata*.



GENERAL RECOMMENDATIONS FOR CULTIVATION

Of the numerous *Cryptocoryne* species, only about 10–15 species are regularly available as aquarium plants. Even though the others, too, are mostly cultivated, they will remain accessible to specialists only because the majority of the more rare species grow under special ecological conditions within their native habitats (e.g., in a very acid environment) and will, therefore, not sufficiently adapt to aquarium conditions. Often, though, these *Cryptocorynes* will grow well in emerged culture where they may occasionally surprise their keeper with decorative inflorescences. It is not surprising that a large number of aquar-

ists have specialized in the emerged maintenance of *Cryptocoryne* species, and are focused on avoiding failure on the part of the cultivated plants which are often threatened in their native environment.

SUBMERSED CULTIVATION

Cryptocorynes are a regular component of aquarium flora. Commercially available most regularly are *Cryptocoryne affinis*, *C. beckettii*, *C. cordata*, *C. crispatula*, *C. parva*, *C. pontederiifolia*, *C. undulata*, *C. wendtii* and *C. × willisii*. In general these species can easily be kept in aquariums. Occasionally *C. albida*, *C. aponogetifolia* and *C. moehlmannii* are also kept, with *C. hutoroi* and *C.*

Table 4: Number of chromosomes and distribution of *Cryptocorynes*.
(according to Jacobsen 1977, Arends et al. 1982, Reumer 1983, and others)

Base number	Species	Number of chromosomes	Distribution
x = 10	<i>C. striolata</i> Engler	20	Borneo
	<i>C. keei</i> N. Jacobsen	20	Borneo
	<i>C. hutoroi</i> Bogner & Jacobsen	20	Borneo
x = 11	<i>C. ciliata</i> (Roxburgh) Schott	22, 33	India to New Guinea
	<i>C. spiralis</i> (Retzius) Wydler var. <i>spiralis</i>	33, 66, 88, 110, 132	India
	<i>C. spiralis</i> var. <i>cognatoides</i> (Blatter & McCann) Yadav, Patil & Bogner	66/72	India
x = 14	<i>C. wendtii</i> de Wit	28, 42	Sri Lanka
	<i>C. beckettii</i> Trimen	28, 42	Sri Lanka
	<i>C. undulata</i> Wendt	28, 42	Sri Lanka
	<i>C. walkeri</i> Schott	28, 42	Sri Lanka
	<i>C. × willisii</i> Reitz	28	Sri Lanka
	<i>C. parva</i> de Witt	28	Sri Lanka
	<i>C. nevillii</i> Hooker f.	28	Sri Lanka
	<i>C. cognata</i> Schott	28	India
x = 15	<i>C. pontederiifolia</i> Schott	30	Sumatra
	<i>C. moehlmannii</i> de Wit	30	Sumatra
	<i>C. villosa</i> N. Jacobsen	30	Sumatra
	<i>C. longicauda</i> Engler	30	Malay Peninsula, Sumatra, Borneo

Table 4: Number of chromosomes and distribution of *Cryptocorynes* continued.

Base number	Species	Number of chromosomes	Distribution
x = 17	<i>C. annamica</i> Serebryanyi	34	Vietnam
	<i>C. vietnamensis</i> Mühlberg & Hertel	34	Vietnam
	<i>C. amicum</i> de Wit & Jacobsen	34	Sumatra
	<i>C. gasseri</i> N. Jacobsen	34	Sumatra?
	<i>C. scurrilis</i> de Wit	68	Sumatra
	<i>C. diderici</i> de Wit	34	Sumatra, Malay Peninsula?
	<i>C. griffithii</i> Schott	34	Malay Peninsula
	<i>C. minima</i> Ridley	34	Malay Peninsula
	<i>C. purpurea</i> Ridley	34	Malay Peninsula
	<i>C. jacobsenii</i> de Wit	34	Malay Peninsula
	<i>C. zukalii</i> Rataj	34	Malay Peninsula
	<i>C. elliptica</i> Hooker f.	34	Malay Peninsula
	<i>C. schulzei</i> de Wit	34	Malay Peninsula
	<i>C. nurii</i> Furtado	34	Malay Peninsula
	<i>C. affinis</i> Hooker f.	34	Malay Peninsula
	<i>C. cordata</i> Griffith	34, 68, 85, 102	Malay Peninsula, Borneo
	<i>C. edithiae</i> de Wit	68	Borneo
	<i>C. grabowskii</i> Engler	68	Borneo
	<i>C. zonata</i> de Wit	68	Borneo
	<i>C. ferruginea</i> Engler	34	Borneo
	<i>C. fusca</i> de Wit	34	Borneo
	<i>C. auriculata</i> Engler	34	Borneo
	<i>C. bullosa</i> Engler	34	Borneo
	<i>C. pallidinervia</i> Engler	34	Borneo
	<i>C. usteriana</i> Engler	34	Philippines
	<i>C. pygmaea</i> Merrill	34	Philippines
	<i>C. aponogetifolia</i> Merrill	34	Philippines
	<i>C. coronata</i> Bastmeijer & van Wijngaarden	34	Philippines
	<i>C. versteegii</i> Engler		New Guinea
x = 18	<i>C. albida</i> Parker	36	Thailand, Burma
	<i>C. crispatula</i> Engler	36, 54	India to South China
	<i>C. retrospiralis</i> (Roxburgh) Kunth	36, 72	India
	<i>C. consobrina</i> Schott	36	India
	<i>C. thwaitesii</i> Schott	36	Sri Lanka
	<i>C. bogneri</i> Rataj	36	Sri Lanka
	<i>C. alba</i> de Wit	36	Sri Lanka
	<i>S. lingua</i> Engler	36	Borneo

The number of chromosomes is unknown in the following *Cryptocoryne* species: *Cryptocoryne cruddasiana* Prain from Burma, *C. decus-silvae* de Wit from the Malay Peninsula, and *C. dewitii* N. Jacobsen from New Guinea.

usteriana being added later as other recommended species. All mentioned *Cryptocorynes* can be kept satisfactorily in a substrate consisting of sand and gravel, to which a little loam or fertilizer may be added. Medium light intensity is recommended to achieve optimum conditions. Most species, though, will grow even under weak light but will display improved growth in a bright location.

Cryptocorynes are sensitive plants. Basically, in submersed cultivation, care has to be taken to ensure that they are relocated or transplanted as infrequently as possible. They will often react to disruptions with what is termed *Cryptocoryne* rot, meaning the sudden and rapid decay of the leaves. *Cryptocoryne* rot can also appear in healthy growing plants. This is, however, not a disease, as was previously thought, but a reaction to changed environmental conditions which lead to physiological disruptions of the plant. Even minimal variations in the water values, for example, due to a change of water or the exchange of a defective light tube, can be a trigger for *Cryptocoryne* rot which may lead to the total collapse of an entire plant group within only a few days. Subsequently, a lot of patience is required until the rhizomes, which have remained in the soil, will sprout again. Not all *Cryptocorynes* react in this extremely negative way to changes in their environment. For example, one can observe the sudden collapse of *C. undulata* while *C. wendtii* might display an entirely healthy growth. The best preventive measure against *Cryptocoryne* rot is to firmly establish a constant environment, e.g., to regularly perform a partial water exchange, to use fertilizer only in limited quantities and to administer it over a longer period.

EMERSED CULTIVATION

Nearly all *Cryptocorynes* can be cultivated above the water line in high humidity conditions. For this purpose, an empty aquarium

covered with a glass panel will do. Artificial lighting is sufficient. An easy cultivation method is to fill the aquarium with enough water to enable the plant pots to sit in water of up to about 1–3 cm. With the aid of a diffusor located in a separate container with water, air circulation and, at the same time, high humidity is created. In addition, the water may be fed slowly through a filter in order to achieve constant water circulation and movement, as well as nutrient supply.

Today, the cultivation of *Cryptocorynes* in paludariums will pose insurmountable problems to the keeper in only a few species (e.g., *C. bogneri*). The most important factor in emersed cultivation is the composition of the substrate. In general, those species which are easily cultured in aquariums can be kept in a mixture of sand, loam and gravel. Unfertilized peat can be used as an additive. Soil (loam, peat and fertilizer) and aquatic plant soil carry only a limited recommendation. Some species will even grow well hydroponically. In this case, fine gravel is used exclusively as plant substrate with additional use of a special hydroponics fertilizer, Lewatit HD 5. The fertilizer is either added to the water of the aquarium or fed into the aquarium through a separate water circulation system (Ehrenberg 1990). Those *Cryptocorynes* originating from waters where the substrate and water are characterized by a conspicuously low pH-value due to the presence of humic matter are more difficult to keep. Here, the use of beech leaf mold as substrate or as an additive has led to surprising growth success (Jacobsen 1992).

Even though a lot of progress has been made over the last couple of years in the area of cultivation problems, by far not all problems have been solved. Only few attempts at cultivating difficult *Cryptocoryne* species in aquariums were successful. There will therefore remain an ongoing, interesting and varied range of activities for the enthusiastic *Cryptocoryne* lover well into the future.

Cryptocoryne affinis

Hooker f. (1893)

Family: Araceae.

Synonyms: *C. haerteliana* Milk., *C. affinis* Hook. f. subsp. *haerteliana* (Milk.) Schöpfel.

Etymology: *Cryptocoryne*: (Greek) *kryptos* = hidden, *koryne* = spadix, refers to the spadix hidden in the kettle; *affinis*: related to, cognate with.

Distribution: Malay Peninsula.

Description: Marsh plant, submersed up to 40 cm tall, emerged much smaller. Leaves up to 20 cm petiolate. Blades lanceolate to narrow lanceolate, up to 23 cm long, 2–5 cm wide, more or less bullate. Apex acute; base acute or round. Coloration upperside olive green, occasionally brownish, underside usually wine red.

Spathe 5.5–32 cm, tube 1.5–15 cm. Limb 3–20 cm long, erect, cuspidate, 4–15 times spirally coiled, interior smooth, dark purple-red. A collar is absent. Female flowers usually 5–7. Male flowers about 50. Chromosome number $2n = 34$.

Culture: This undemanding *Cryptocoryne* has been cultivated in aquariums for over 50 years. Unfortunately, *C. affinis* is not that well

suited for emerged culture or quick propagation in nurseries, so that it is increasingly being displaced by *C. undulata*, *C. walkeri* and *C. wendtii*, species that are easier to cultivate. A moderate to medium light intensity is adequate. Optimum growth is achieved in medium-hard to hard, slightly alkaline water at a temperature of 22–26 °C. Washed sand is sufficient as a substrate. Propagation is very productive if growth is not interfered with. Several forms are being cultivated, they differ in growth height, leaf width and coloration. The species is very sensitive to *Cryptocoryne* rot. Inflorescences with long spathes are occasionally also formed under water.

Ecology: Jacobsen and Bogner discovered *C. affinis* in dense communities on sand banks of smaller waterways featuring a strong current. The splendid specimens grew submersed. The smaller emerged plants were colored red-brown in the shade, and bullate and green when exposed to the sun. The habitats are partially located in limestone regions. Refer also to the substrate analysis (Horst 1986).

Submersed leaves of *Cryptocoryne affinis*.



Emerged plant with inflorescence.



Cryptocoryne alba

de Wit (1975)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *alba*: white, refers to the white-colored limbs.

Distribution: Southwestern Sri Lanka.

Description: Marsh plant, 5–20 cm tall. Leaves up to 11 cm petiolate. Blade narrow elliptical to lanceolate or narrow ovoid, 3–10 cm long, 2–3.5 cm wide, upperside smooth or rough. Apex acute or round; base round to slightly cordate. Margin smooth, undulate or slightly crispate. Colorations of olive green, brown or red marmorate leaves are known, and, since 1990, another one with purely green leaves.

Spathe 4–11 cm long. Tube 0.3–1.5 cm long. Limb 3–7 cm long, more or less long caudate, not twirled, more or less erect, interior smooth or mammillate, white, pink or dark red coloration. Collar either missing or distinctly formed. Throat colored like the limb. Female flowers 4–6. Male flowers 20–50. Number of chromosomes: $2n = 36$.

Culture: The rare *Cryptocoryne alba* displays only limited suitability for submersed

cultivation in the aquarium. The species possibly requires an acid environment and not too strong lighting. As with *C. thwaitesii*, growth in emersed culture in nutritious, weak acid soil is satisfactory. Inflorescences are formed regularly.

Ecology: *Cryptocoryne alba* usually grows strongly shaded on stream edges in tropical rainforests in a loamy-muddy soil. The green-colored form was discovered by A. Waser in intensive sunlight in a loamy substrate.

Other: *C. alba* is closely cognate with *C. thwaitesii* and there are hardly any differentiating features. Until a few years ago, the color of the flower was considered an essential feature. At the beginning of the 1980s, the pink- and dark red-flowering plants of *C. alba* were introduced. More specimens were collected by Waser in 1990, among which one plant developed an inflorescence featuring a dark purple-red limb with a distinctive collar and a mammillate surface.

Emersed plants of *Cryptocoryne alba* with inflorescence.



Cryptocoryne albida

R.N. Parker (1931)

Family: Araceae.

Synonyms: *Cryptocoryne retrospiralis* (Roxburgh) Kunth subsp. *albida* (Parker) Rataj, *C. retrospiralis* var. *costata* (Gagnepain) de Wit, *C. costata* Gagnepain, *C. hansenii* S.Y. Hu, *C. korthausae* Rataj.

Etymology: *Cryptocoryne*: see *Cryptocoryne affinis*; *albida*: whitish, refers to the coloration of the limb.

Distribution: Burma, southern Thailand.

Description: Marsh plant, emerged up to 20 cm, submersed 5–10 cm tall. Leaves 2–15 cm long petiolate. The blade is linear to very narrow lanceolate, emerged 10–30 cm long and 1–2 cm wide, declinate, flat or slightly undulate, submersed short petiolate, usually about 5–10 cm long and 0.4–1.0 cm wide. Apex acute; leaf base decurrent. Margin entire or slightly toothed. The leaves vary a lot in color, ranging from light green to reddish brown or dark brown marmorated.

Spathe 8–20 cm long. Tube 5–15 cm long. Limb 1–4 cm long, aciculate, erect or slightly recurved, more or less spirally twisted, interior white to cream-colored with a gray mar-

gin. Limb and throat almost smooth and usually featuring many small brown-red spots. A collar is absent. Female flowers 4–7. Male flowers 80–120. Number of chromosomes $2n = 36$.

Culture: The two very decorative red-brown (synonym *Cryptocoryne costata* Gagnepain) as well as green growth forms of *C. albida* are rarely available in aquarium shops. Both forms will not always prosper satisfactorily in culture. Even under optimum conditions, the plant will only display moderate growth and reproduction, and will remain much smaller in submersed conditions than in their native habitats. Cultivation is successful in soft as well as medium-hard water with a pH-value of around 7. Soft water, however, seems to be more advantageous. The plants make do with little light and will grow better in a spaced out setting with medium lighting in the aquarium. Coarse sand as substrate is sufficient, a nutrient-richer, slightly acid substrate, enriched, for example, with loam will have a growth-enhancing effect. The optimum temperature range lies between 22 and 28 °C. Due to the low growth height in the aquarium, *C. albida* should find application as a

***Cryptocoryne albida*.**



group in the foreground. In contrast to submersed cultivation, both growth forms mentioned can be easily cultivated emersed and will also flower regularly. Above water, the rate of propagation is only low. In emersed cultivation, for example, a mixture of loam and sand can well be used as substrate.

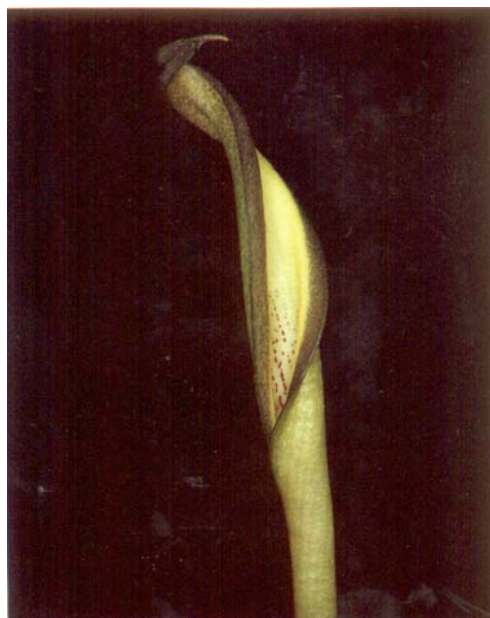
Ecology: Jacobsen (1991) reports on a natural location of *C. albida* which is considered representative. Dense populations grew in a 4-m wide river, both on banks on slow-moving water as well as out of the water on sand banks. The substrate consisted of sand and small pebbles. The water temperature measured 27°C. Plants found in free locations had dark green or more reddish leaves, whereas those growing in dense populations or in the shade featured light green leaves. All intermediate forms were discovered. In the shade the leaves were more or less erect, in full sunlight they lay flat on the substrate. The flowering stage is usually from December to February. Horst (1986) reports on plants anchored deep in the substrate, with the roots being irremovable in their entire length despite the use of tools. He recorded the following water values at one particular native habi-

tat: temperature 28.9°C, pH-value 7.2–7.3, GH 0.2°dH, KH 0.1°dH, 22.5 µS/cm, O₂ 10 mg/L, Fe 0.1 mg/L, nitrate and phosphorus were not detectable. A soil sample resulted in the following data: pH-value 4.9, P₂O₅ 2 mg/L, K₂O 4 mg/L, Mg 4 mg/L, Fe 78 mg/L, Mn 10.7 mg/L, Cu 0.5 mg/L, Zn 0.9 mg/L.

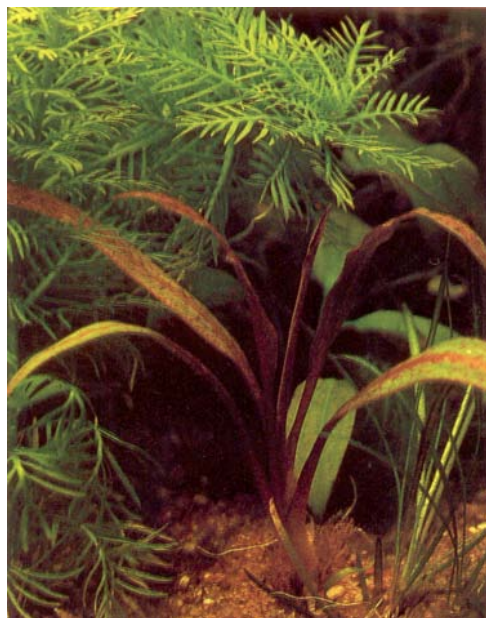
Other: Jacobsen (1980, 1991) showed that the variety range of *C. albida*—regarding both habit as well as appearance of the limb—is so wide that *C. albida* and *C. costata* cannot be distinguished from one another.

Cryptocoryne albida is closely cognate with *C. crispatula* and *C. retrospiralis*. Important differences concern the form and color of the limb.

Limb of *C. albida*.



Cryptocoryne albida (synonym *C. costata*).



Cryptocoryne aponogetifolia

Merrill (1919)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *aponogetifolia*: *Aponogeton*-leaved (genus *Aponogeton*).**Distribution:** Philippines (Luzon, Panay, Negros).**Description:** Aquatic plant. Leaves up to 100 cm petiolate. Leaf blade very narrow elliptical to strap-shaped, up to 50 cm long, 2–4 cm wide, very highly bullate, medium to dark green. Apex acute; base acute. Midrib distinct.

Spathe 13–25 cm long, up to 20 cm petiolate. Tube 7–17 cm long. Limb 4–6 cm, long caudate and twirled several times, erect, interior wrinkled, purple-red. A collar is missing. Throat zone smooth, purple-red. Female flowers 6–8. Male flowers 60–70. Number of chromosomes $2n = 34$.

Culture: *Cryptocoryne aponogetifolia* belongs to those *Cryptocoryne* species kept most frequently. Cultivation is unproblematic and is also possible in hard water, as well as a calcium-rich substrate. The species requires

little light. Due to the strong rhizomes and strong root development, a coarse-grained sand-gravel substrate with a height of at least 8 cm is recommended. The optimum temperature range is 21–27 °C. Once the plants have taken root they will quickly propagate through runners. Due to its over 1-m long leaves, *C. aponogetifolia* is especially suited for the planting of side and rear panels in very high aquariums. Inflorescences develop only in submersed plants but are rare in cultivation. Emersed keeping is not recommended.

Ecology: According to Schulze (1978) and Bogner (1984), the species prospers in rivers with fast-flowing water in depths of up to 2 m. The specimens usually grow submersed in dense populations in gravelly-sandy basalt soil or in residual soil of limestone in shaded or sunny places.**Other:** For less high aquariums, *C. hutoroi* and *C. usteriana*, both similar in appearance, are a good alternatives to *C. aponogetifolia*.***Cryptocoryne aponogetifolia*.**

Cryptocoryne beckettii

Trimen (1985)

Family: Araceae.

Synonyms: *Cryptocoryne petchii* Alston.

Etymology: *Cryptocoryne*: see *C. affinis*; *beckettii*: after T.W.N. Beckett (1838–1906).

Distribution: Central and southwestern Sri Lanka.

Description: Marsh plant, 10–25 cm tall. Petiole up to 15 cm long, often brown reddish in color. Blade narrow lanceolate to ovoid, 3–13 cm long, 1.5–4.0 cm wide, smooth or slightly undulate. Apex acute; base from truncate to mildly cordate. Margin undulate or slightly crispate. Coloration upperside from olive green to dark green and reddish brown to dark brown, sometimes marmorate, underside green, brownish or wine red.

Spathe 6–12(–20) cm long. Tube 3–10 (–16) cm long. Limb 1.5–4 cm long, not caudate, not or hardly twirled, erect or slightly recurved, interior smooth or moderately rough, yellowish to light brown with a brown to dark purple-red collar zone. Throat white or with irregularly purple-red spots. Female flowers 4–8. Male flowers 40–60. Chromosome number $2n = 28, 42$.

Culture: *Cryptocoryne beckettii* has been one of the most proven *Cryptocoryne* species for over 60 years. The culture corresponds to that of *C. wendtii* and is described in that species account.

Ecology: *Cryptocoryne beckettii* leads an amphibious existence on the shaded banks of streams and rivers. The species also supposedly occurs in the springwater of wells. Horst (1986) reports an untypical *Cryptocoryne* biotope—a fully sunlit stream within rice paddies—in which *C. beckettii* was associated together with *C. wendtii*. The following data was recorded: temperature 26 °C, pH 7.8, GH 4.5 °dH, KH 5.2 °dH, 148 µS/cm, Fe 0.27 mg/L. Even though the species has been collected regularly, other water analyses are unknown.

Other: The plant cultivated for many years as *C. petchii* is, in fact, a triploid form of *C. beckettii* with highly defective pollen (Jacobsen 1987a). Definitely identified native habitats of the triploid form are not known, though it possibly exists in southwestern Kandy.

***Cryptocoryne beckettii*.**

Cryptocoryne bogneri

Rataj (1975)

Family: Araceae.**Synonyms:** *Cryptocoryne bogneri* de Wit (only several months after Rataj's identification).**Etymology:** *Cryptocoryne*: see *C. affinis*; *bogneri*: after the discoverer Josef Bogner.**Distribution:** Southwestern Sri Lanka.**Description:** Marsh plant, 5–10 cm tall. Petiole 2–5(–12) cm long. Blade 3–8 cm long, 1.5–4 cm wide, smooth or slightly undulate, emerged ovoid, upperside rough, submersed lanceolate, smooth, olive green to dark green or brownish, often with red venation. Apex acute or obtuse; base truncate, round to mildly cordate. Margin submersed entire, emerged fine crispate.

Spathe (3–)4–6(–8) cm long. Tube 1–3 cm long. Limb (1–)2–3(–5) cm long, not aciculate, curved forward, mammillate on the upper edge, otherwise smooth, light yellow. A collar is missing. Throat zone light yellow. Female flowers 4–6. Male flowers 20–30. Chromosome number $2n = 36$.

Culture: Previous experience shows that *C. bogneri* displays little adaptability with its cul-

tivation, succeeding in only individual cases.

Ecology: So far, only two locations with very small populations are known. One habitat is Atweltota, where Bogner collected the species in 1973, and which was visited by the author in 1985. There, plants grew in a 0.5–1-m wide stream with a moderate current in 5–10-cm deep water. The substrate was rocky, and the stream bed was also interspersed with gravel, sand, loam and dropped foliage. Specimens growing in deep shade were found in both a submersed and an emerged state. Worth noting is the variability of the species because both green as well as brown leaves were present in one and the same plant. The water analysis of this location: temperature 23 °C, pH 6.6, GH/KH < 1 °dH, 28 µS/cm, rH 258 mV.**Other:** *Cryptocoryne bogneri* counts among the threatened species on Sri Lanka, since ecological changes taking place in the habitats are to be increasingly feared in the course of increasing cultivation of the habitat areas. The plant can be safely distinguished from *C. thwaitesii* and *C. alba* only by its inflorescence.

Cryptocoryne bogneri with inflorescence, found in its native habitat on Sri Lanka.



Cryptocoryne ciliata
(Roxburgh) Schott (1857)

Family: Araceae.

Synonyms: *Ambrosina ciliata* Roxb. (1819) and others.

Etymology: *Cryptocoryne*: see *C. affinis*; *ciliata*: fimbriate (limb).

Distribution: From India to New Guinea.

Description: Marsh plant, emerged 50–90 cm, submersed up to 50 cm tall. Diploid plants are stoloniferous, triploid forms develop short, erect runners which break off from the rhizome. Leaves up to 40 cm petiolate. Blade narrow lanceolate to narrow ovoid, 15–25(–50) cm long, 2–7(–20) cm wide, leathery, fleshy, stiff, vertical, smooth, medium green. Apex acute to mucrous; base cuneate, truncate or cordate.

Spathe 10–50 cm long. Tube 4–40 cm long. Limb very variable, 3–10 cm long, more or less aciculate, not twirled, more or less erect, interior rough to mammillate, pale yellow to brownish purple-red-colored; margin more or less long fimbriate. Collar yellow. Throat pale yellow, dotted red. Female flowers 4–8. Male flowers 20–120. Chromosome number $2n = 22, 33$.

Culture: Very large-growing, *Cryptocoryne* is usable only in high aquariums. The stiff, erect growth of the leaves is conspicuous. *Cryptocoryne ciliata* is suitable for the planting of both freshwater and brackish water aquariums, as well as for the keeping in paludariums. For cultivation in the aquarium, the substrate has to be rich in nutrients and a well-illuminated location is recommended. Optimum temperature range is 22–26 °C. Whereas the propagation rate is moderate in submersed conditions, runners will readily develop emerged. Flower and fruit formation are frequent. Propagation through seeds is very productive.

Ecology: *Cryptocoryne ciliata* populates locations in freshwater or brackish water in tidal zones in muddy soil. The author located the species on the east coast of Java, not far from the ocean in full sunlight, but also in very shaded places on Sulawesi.

Other: The subulate leaves of the seedlings are conspicuous. They help in anchoring the plant and are very resistant, which also explains the wide distribution.

Bursting fruit of *C. ciliata*.



Cryptocoryne ciliata in its habitat on Sulawesi.



Cryptocoryne cordata

Griffith (1851)

Family: Araceae.

Synonyms: *Cryptocoryne kerrii* Gagnepain, *C. siamensis* Gagnep., *C. blassii* de Wit, *C. evae* Rataj var. *evae*, *C. evae* var. *recordata* Rataj, *C. siamensis* var. *ewansii* Rataj, *C. siamensis* var. *kerrii* (Gagnep.) Rataj, *C. stonei* Rataj, *C. siamensis* Gagnepain var. *schneideri* Schöpfel.

Etymology: *Cryptocoryne*: see *C. affinis*; *cordata*: cordate (leaf blade).

Distribution: Malay Peninsula: western Malaysia to southern Thailand, one habitat on Borneo.

Description: Marsh plant, emerged up to 25 cm, submersed up to 60 cm tall. Leaves 5–45 cm petiolate. Blade from oblong, narrow elliptical to ovoid, 5–19 cm long, 1–5 (–10) cm wide, smooth or slightly bullate. Apex acute; base acute, obtuse, truncate or cordate. Leaf margin entire. Coloration of forms variable, upperside olive green, brownish to deep bronze, occasionally marmorate, shiny, underside green to deep wine red, shiny.

Spathe 5–30 cm long. Tube 2–22 cm long, limb 1.5–7 cm long, cuspidate, erect or re-

curved, interior smooth to slightly rough, usually bright yellow, occasionally also brownish to reddish brown (often along the edge). A collar is missing. Throat zone smooth, bright yellow. Female flowers 5–8. Male flowers 20–60. Chromosome number $2n = 34, 68, 85, 102$.

Culture: Several of the different varieties of *C. cordata* have been known for many years as excellent aquarium plants. *Cryptocoryne siamensis* and *C. blassii*, featuring ovoid leaf blades and a cordate base, and previously considered separate species, grow well and are often used in cultivation. They can be predominantly identified in their submersed state by their olive green upperside or rather bronze brown leaf coloration. According to Jacobsen (1979), the forms with cordate leaf blades are supposedly more difficult to cultivate. In culture, *C. cordata* prefers soft, acid water, weak to medium light intensity and a nutrient-rich calcium-deficient substrate. However, some forms, for example the *blassii-siamensis* types, are adaptable and even prosper in medium-hard, weak alkaline water as well. The optimum temperature range lies between 23 and 27 °C. After a long

Green-leaved type of *C. cordata*.





Cryptocoryne cordata (type "blassii").

period of adjustment well-growing specimens develop many runners. An emerged cultivation, too, e.g., in a sand-loam-peat mixture, is not difficult. Inflorescences often form emerged, occasionally also in the aquarium.

Ecology: *Cryptocoryne cordata* populates streams and small rivers with slow- to fast-flowing water. The dense communities grow in both intense sunlight and deep shade. Jacobsen (1985b) discovered plants in Johore in both a muddy substrate, composed of rotted leaves and twigs, and in sandy-gravelly substrate which was often covered by a high layer of dead foliage. Whereas the water is very acid (pH 4.5–6) and soft (0–2 °dH) on the Malay Peninsula and also brownish in color, Horst (1986) registered higher pH-values (5.5–6.3) in southern Thailand as well as an equally soft but clear water (GH and KH < 1 °dH) with a low salt content. Temperatures were 25–27 °C. The substrate analyses, published by Horst, are informative and show a conspicuously acid reaction by the substrate (pH 4.4–5.6).

Other: Jacobsen considers *C. kerii*, *C. siamensis*, *C. blassii* and *C. evae* only as local forms of one variable species.

Cryptocoryne cordata Griffith 'Pink-veined'

In 1972, P. Schneider (Switzerland) found a *C. cordata* specimen in an import shipment that featured a white to light pink-colored venation, which he propagated vegetatively. In 1985, Bogner and Jacobsen accorded the plant the status of a cultivar. Due to a generally accepted hypothesis the special characteristic has come about through mutation. Cultivation experience, however, shows that the degree of intensity is, to a large extent, dependent on the environment, i.e., is being influenced by the conditions in which cultivation takes place. Which specifically focused measures have to be taken, however, to achieve the most contrast-rich markings has been much debated, but was unable to be unequivocally resolved.

Cryptocoryne cordata 'Pink-veined'.



Limb of *C. cordata*.



Cryptocoryne crispatula

Engler (1920)

Family: Araceae.

Synonyms: 1.) var. *crispatula*: *C. retrospiralis* (Roxburgh) Kunth var. *crispatula* (Engler) de Wit, *C. bertilhanseii* Rataj; 2.) var. *flaccidifolia*: none; 3.) var. *balansae* (Gagnep.) N. Jacobsen: *C. balansae* Gagnep., *C. longispatha* Merrill, *C. kwangsiensis* H. Li; 4.) var. *sinensis* (Merr.) N. Jacobsen: *C. sinensis* Merr., *C. yunnanensis* H. Li; 5.) var. *tonkinensis* (Gagnep.) N. Jacobsen: *C. tonkinensis* Gagnep., *C. retrospiralis* (Roxb.) Kunth var. *tonkinensis* (Gagnep.) de Wit.

Etymology: *Cryptocoryne*: see *C. affinis*; *crispatula*: slightly crispate.

Distribution: Eastern India, Thailand, Laos, southern Vietnam and southern China.

Description: Marsh plant, emersed 10–25 cm, submersed 20–70 cm tall. Leaves up to 25 cm petiolate, very variable. Leaf blade narrow linear to lanceolate, 10–15 cm long, 0.2–4 cm wide, from smooth, undulate to highly bullate, flaccid or stiff, light to dark green, brownish and reddish brown. Apex acute; base narrowed, seldom round. Margin entire or denticulate.

Spathe 5–40 cm long. Tube 2.5–30 cm long, slightly twirled. Limb (1–)3–8 cm long, spirally twisted, interior smooth, white, cream-colored, pale blue or green coloration, with reddish to dark purple-red spots and stripes which occasionally entirely cover the surface or are also completely absent. No collar. Throat colored like the limb. Female flowers 4–6. Male flowers 30–130. Number of chromosomes $2n = 36, 54$.

Culture: The different varieties of *C. crispatula*—depending on their native living environment—obviously are differently suited to aquarium keeping. The best variety for use in submersed cultivation is var. *balansae*, which has also been regularly commercially available for many years. It is kept in different forms. These will prosper well in medium-hard and hard water with alkaline pH-values and will manage with a weak to medium light intensity. Variety *crispatula* var. *flaccidifolia* and var. *tonkinensis* are being kept fairly rarely. Not being cultivated is var. *sinensis*.

Ecology: The different varieties and ecological races of *C. crispatula* are highly adapted to the natural living conditions, especially

Cryptocoryne crispatula var. *balansae*.



changing water levels and light. Jacobsen (1980, 1991) studied several locations in Thailand. He noticed that more aquatic forms occur in rivers featuring a more constant water level and less pronounced variations, for example the long, angustifoliate forms with undulate or bullate blades, whereas rivers with seasonal changes in water levels accommodate the more amphibious forms, which are characterized by shorter, more or less smooth leaves. Intermediate forms between the different forms were found as well. Cultivated plants retained a fairly constant leaf shape. In the Mueak Lek river in February 1977, Jacobsen located *C. crispatula* var. *balansae* in water rich in lime at a temperature of 24 °C. The sturdier specimens were coated with a lime crust. In Phu Khieo National Park, *C. crispatula* var. *crispatula* occurred in fast-flowing water of the Huae Mae Chem river at 21 °C. In pools of a tributary, a temperature of only 16 °C was recorded. The substrate consisted mostly of big stones and rocks.

Identification key to the different varieties (according to Jacobsen 1991)

- 1) Leaves bulate or undulate 2
- 1a) Leaves smooth 4
- 2) Leaves 1–4 cm wide, bullate ... var. *balansae*.
- 2a) Leaves more narrow, 0.2–1.2 cm wide, undulate 3
- 3) Leaves 0.2–0.4 cm wide ... var. *tonkinensis*
- 3a) Leaves 0.4–1.2 cm wide ... var. *flaccidifolia*
- 4) Leaves rather stiff, 10–15(–20) cm long, 0.8–1.5 cm wide var. *sinensis*
- 4a) Leaves longer and/or narrower 5
- 5) Leaves very narrow, 0.2–0.4 cm wide, 20(–30) cm long, flaccid var. *tonkinensis*
- 5a) Leaves 0.4–1.6 cm wide, 15–50 cm long, rather stiff or flaccid 6
- 6) Leaves rather stiff, 15–40 cm long, margin smooth or denticulate var. *crispatula*
- 6a) Leaves flaccid, 20–50 cm long, margin smooth or slightly undulate ... var. *flaccidifolia*

Emerged plants of *C. crispatula* var. *crispatula* in Phu Khieo National Park (Thailand).



Cryptocoryne diderici

de Wit (1970)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *diderici*: after Dirk de Wit (father of the discoverer).**Distribution:** Sumatra.**Description:** Leaf blade 5–11 cm petiolate, ovoid with cordate base, 4–7 cm long, 2–4 cm wide, dark green to purple-red.Spathe 8–11(–20) cm long, limb short caudate, slightly recurved, not twirled, interior rough, light brown in color. Wide throat zone, slightly thickened, yellow. A collar is missing. Female flowers about 6. Male flowers 25–35. Number of chromosomes $2n = 34$.**Culture:** This rare *Cryptocoryne* has not been previously cultivated submersed. Emerged keeping is recommended in a substrate consisting of clay or beech leaf mold. Temperature should be around 25 °C.**Ecology:** Jacobsen and Bogner (1987) located *C. diderici* on the banks of a stream to the east of Muarabungo, Sumatra, the only place it was found.**Other:** Closely related to *C. cordata*.*Cryptocoryne diderici* with inflorescence.***Cryptocoryne ferruginea***

Engler (1879)

Family: Araceae**Synonyms:** *Cryptocoryne pontederiifolia* Schott var. *sarawacensis* Rataj, *C. sarawacensis* (Rataj) Jacobs.**Etymology:** *Cryptocoryne*: see *C. affinis*; *ferruginea*: rust-colored (limb).**Distribution:** Borneo (Sarawak).**Description:** Blade narrow ovoid to ovoid, with a truncate or cordate base, 3–12 cm long, 1.5–3 cm wide, upperside green, often horizontally striped, underside occasionally purple-red and more or less short pubescent.Spathe 10–15 cm, tube 1–2 cm, limb 8–11 cm long, very long caudate, more or less obliquely twisted, interior highly wrinkled, purple-red coloration. Collar blackish purple-red. Female flowers 5. Male flowers about 30. Number of chromosomes $2n = 34$.**Culture:** This rare *Cryptocoryne* can be satisfactorily kept only in soft, acid water with a temperature around 25 °C.**Ecology:** *Cryptocoryne ferruginea* occurs in muddy soil in slow-moving waters in the freshwater tidal zone.*Cryptocoryne ferruginea*: spathe with open ket-tle.

Cryptocoryne fusca

de Wit (1970)

Family: Araceae.

Synonyms: *Cryptocoryne tortilis* de Wit.

Etymology: *Cryptocoryne*: see *C. affinis*; *fusca*: red-brown, refers to the coloration of the limb.

Distribution: Borneo (southwest Kalimantan)

Description: Petiole up to 17 cm. Leaf blade narrow ovoid, up to 10 cm long, 5 cm wide, upperside light green, underside whitish green. Apex acute; base auriculate or cordate. Margin and leaf underside occasionally with dense pubescence.

Spathe 8–20 cm long. Limb erect, cuspidate, hardly to spirally twisted and opening with a small gap, interior highly mammillate, the margin featuring small denticles or protuberances, dark purple-red. A collar is missing. Female flowers about 5–6. Male flowers about 40–60. Number of chromosomes $2n = 34$.

Culture: In the 1950s, *Cryptocoryne fusca* was cultivated relatively often in the aquarium under the incorrect name of *C. longicauda*. Thereafter, the species completely

disappeared again. It has only been propagated again by *Cryptocoryne* lovers in recent years. Though the submersed cultivation of *C. fusca* is best achieved in soft, acid water, the author did manage to achieve satisfactory results in very hard, weak alkaline water. The use of a substrate with an acid reaction (peat) seems to be important in doing so. Optimum temperature range is about 23–27 °C. In an emersed cultivation, too, *C. fusca* is not demanding and can be easily kept in a mixture of sand and beech leaf mold.

Ecology: *Cryptocoryne fusca* populates the banks of rivers in the freshwater tidal zones.

Other: De Wit (1990) considers *C. fusca* and *C. tortilis* to be two separate species. According to him, there are supposed to be distinct differences in the length of the spathe and tube, color of the limb, structure of the kettle, shape of the nodes and olfactory bodies, as well as in the number of male flowers. According to the studies completed by Jacobsen (1979), however, it is only to be considered as one polymorphic species.

Further reading: Bastmeijer (1993).

Cryptocoryne fusca.



Spathe of *C. fusca*.



Cryptocoryne gasseri

N. Jacobsen (1979)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *gasseri*: after R.A. Gasser (Florida).**Distribution:** Native locations are unknown. Export shipments arrived together with *C. scurrielis* from Sumatra.**Description:** Leaf blade narrow ovoid with a slightly caudate base, up to 4 cm in length and 2.5 cm wide, highly bullate, dark green.Spathe about 4 cm, tube about 1–2 cm, limb 2 cm long, acuminate, reflexed far downwards, interior rough or slightly mammillate, light yellow. Margin of limb with small warts. Collar bulgy, narrow. Throat very small. Female flowers 4. Male flowers 30–40. Number of chromosomes $2n = 34$.**Culture:** A very rare, difficult-to-cultivate *Cryptocoryne*. Emerged cultivation is best using beech leaf mold. Cultivation in aquariums is unknown. The species is also considered to belong to *Cryptocoryne minima* (Bastmeijer 1996).***Cryptocoryne griffithii***

Schott (1856)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *griffithii*: after William Griffith (1810–1845).**Distribution:** Malay Peninsula.**Description:** Petiole 10–15 cm. Blade wide ovate with caudate base, 5.5–7 cm long, 4–5 cm wide, upperside dark green to purple-red, underside purple-red-colored.Spathe 5–15 cm long. Limb recurved, not twisted, short caudate, interior mammillate, purple-red. Collar narrow. Collar and throat purple-red. Number of chromosomes $2n = 34$.**Culture:** A rare, difficult-to-cultivate *Cryptocoryne* species, it grows only in very acid water. The use of beech leaf mold is recommended in emerged culture.**Ecology:** Jacobsen and Bogner (1987) report on two locations in which *C. griffithii* occurs in slow-moving waters in humus-rich soil together with *Barclaya motleyi*.Spathe of *Cryptocoryne gasseri*.*Cryptocoryne griffithii* with inflorescence.

Cryptocoryne hudsonii

Bogner and Jacobsen (1985)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *hudsonii*: after the collector Frans Hudson.

Distribution: Borneo (Kalimantan).

Description: Aquatic plant, 20–50 cm tall. Leaves 4–26 cm petiolate. Leaf blade very narrow elliptical, occasionally narrow oblanceolate, 7–30 cm long, 2–5 cm wide, highly bullate. Apex acute to acuminate; base round. Margin slightly undulate. Coloration medium green, often with brownish margin, underside slightly lighter, occasionally brownish. Venation distinct.

Spathe 9–30 cm long. Tube 5–20 cm long. Limb 3–6 cm, cuspidate, erect, several times spirally twisted, interior wrinkled, pale yellow to dirty dark red. A collar is missing. Throat yellowish, with purple-red dots. Female flowers 4–6. Male flowers (20–)40–60. Number of chromosomes $2n = 20$.

Culture: *Cryptocoryne hudsonii* is one of the most beautiful and most recommendable imports in the last couple of years. The highly bullate leaf blades, also known in *C. apo-*

noetifolia, are conspicuous. Compared to that species, *C. hudsonii* is far more suitable to most aquariums because of its limited growth height. Submersed cultivation will be successful in soft and medium-hard water. Gravel or sand are recommended as substrate, a little added loam usually promotes stronger growth. The water temperature can lie between 18–30 °C, the optimum is 24–26 °C. Propagation by runners is very productive. An emersed cultivation, in which the plants will develop considerably smaller leaves, is possible in high humidity, although hardly recommended. Inflorescences are rarely formed.

Ecology: *Cryptocoryne hudsonii* has previously been collected from only two locations, which is why hardly anything is known about its ecology. At one location the plants were found in a stream with fast-flowing water.

Other: *Cryptocoryne hudsonii* is especially similar to *C. aponoetifolia*, *C. bulbosa*, *C. keeii* and *C. usteriana*.

Further reading: Bogner (1990).

Cryptocoryne hudsonii.



Cryptocoryne keei

Jacobsen (1982)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *keei*: after the collector Henry Ong Kee Chuan.**Distribution:** Borneo (Sarawak, near Bau).**Description:** Aquatic plant, 10–20 cm tall. Leaves up to 9 cm petiolate. Blade lanceolate to narrow lanceolate, 3–12.5 cm long, 1.0–4.0 cm wide, highly bullate. Apex acute; base round or slightly cordate. Margin fine undulate. Coloration upperside dark green, in the depressions often brownish, occasionally bronze-colored, underside brownish to reddish. Venation distinct, underside occasionally reddish.

Spathe 3–6 cm long. Tube 1–2 cm long. Limb 1–3 cm long, cuspidate, recurved, more or less spirally twisted, interior mammillate, greenish, brownish or dark red-brown. A collar is missing. Throat finely spotted, top above yellowish or brownish, below pale purple-red. Female flowers about 6. Male flowers about 40. Number of chromosomes $2n = 20$.

Culture: A decorative, rare *Cryptocoryne*,

the permanent cultivation of which in an aquarium has been successful in only isolated instances. It was noticed on occasion that well-growing communities suddenly collapsed (Cryptocoryne rot), whereby the pollution of the water quite possibly played a role. In contrast to other *Cryptocorynes* from Borneo, *C. keei* can also be cultivated in alkaline, calcium-rich water. An emersed cultivation is difficult and will only succeed in conditions of very high humidity.

Ecology: Kettner (1992) reports on the only known native habitats. Dense communities grew in a 1–2-m wide stream with fast-moving water in a gravelly-sandy substrate. It was low water (March); the water level measured 20–30 cm. It can rise, however, to 2 m during the wet season. The pH-value read 6.8–7.3 (unusually high for Borneo, which is due to lime formations).**Other:** *Cryptocoryne keei* can be distinguished from *C. hutoroi* and *C. usteriana* by the mostly brownish coloration in the leaf depressions.**Further reading:** Ehrenberg and Bogner (1992).***Cryptocoryne keei*.**

Cryptocoryne lingua

Engler (1879)

Family: Araceae.**Synonyms:** *Cryptocoryne spatulata* Engler.**Etymology:** *Cryptocoryne*: see *C. affinis*; *lingua*: tongue, refers to the tongue-shaped leaf blade.**Distribution:** Borneo (Sarawak).**Description:** Marsh plant, 8–15 cm tall. Leaves with a 4–10-cm long, fleshy petiole. Blade narrow ovoid, ligular, 2–7 cm long, 1–3.5 cm wide, a little fleshy, flat. Apex acute; base obtuse or cuneate. Margin entire. Light green coloration. Indistinct venation.

Spathe 8–15 cm long. Tube 3–8 cm long. Limb 3–5 cm long, more or less long caudate, more or less erect, occasionally slightly twisted, interior smooth, in the lower part and in the throat bright yellow and covered with purple-red dots, in the upper part purple-red coloration. A collar is missing. Female flowers 4–6. Male flowers 20–50. Number of chromosomes $2n = 36$.

Culture: Even though *C. lingua* is flooded twice daily by water in its native habitat, the species is little suited for aquarium cultivation. Horst (1986) attempted a submersed cul-

tivation by imitating the tidal sequence but had no success even with that. An emersed cultivation, however, can be easily achieved in loam soil. Growth and propagation are very slow. Inflorescences develop regularly. **Ecology:** *Cryptocoryne lingua* populates nearly identical locations on Sarawak as *C. cilata*, namely the freshwater zones of rivers which are subjected to tides. According to Schulze (1971b), however, the biotopes of *C. lingua* are located farther upriver. There, the species grows grass-like and very shaded in large communities, deeply rooted in soft loam soil on the banks in a zone where rain-forest vegetation begins. Horst reports on a daily, twice-occurring rise and drop in water levels of more than 1 m, which is caused by the tidal rise in the ocean level. At one location, he registered the following water values at an air temperature of 32 °C: temperature 27 °C, GH 0.8 °dH, KH 1.3 °dH, pH 6.6, 32 µS/cm, Fe 1.5 mg/L, as well as many other trace elements.

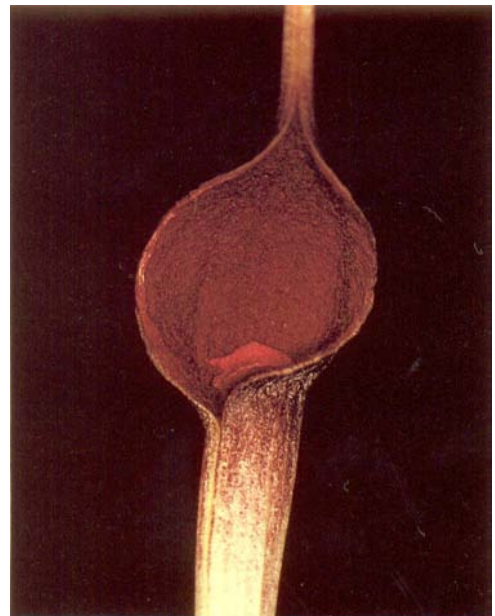
Emersed specimen of *Cryptocoryne lingua* with inflorescence.

Cryptocoryne longicauda

Engler (1879)

Family: Araceae.**Synonyms:** *C. caudata* N.E. Brown, *C. johorensis* Engler.**Etymology:** *Cryptocoryne*: see *C. affinis*; *longicauda*: long-tailed, refers to the long caudate limb.**Distribution:** Malay Peninsula (Johore), Sumatra and Borneo (Sarawak).**Description:** Marsh plant, emerged up to 20 cm, submersed up to 40 cm tall. Petiole 5–30 cm. Blade ovoid, 3–15 cm long, 3–10 cm wide, smooth to bullate, olive green, occasionally mildly purple-red. Apex acute; base cordate. Margin entire to fine crispate.Spathe 20–50 cm, tube 8–20 cm, limb 15–31 cm long, very long caudate, initially erect, later curved forward, wrinkly, dark purple-red. Collar lighter than the limb. Throat almost smooth. Female flowers 5–7. Male flowers 30–50. Number of chromosomes $2n = 30$.**Culture:** The species is obviously little adaptable to aquarium conditions. It possibly requires a very acid water, weak lighting and a

comparatively high temperature of over 25 °C. An emerged cultivation will best succeed in a soil with an acid reaction. Good results were achieved by using beech leaf mold.

Ecology: Jacobsen and Bogner (1987) report on a 4–6-m wide, muddy stream accommodating *C. longicauda*, which was often subjected to sunlight. Schulze (1971b) found *C. longicauda* in several locations on Sarawak: in a strongly shaded river, in sandy-loamy riverbanks associated with *C. zonata*; in a small forest river over 1 m deep; and in a narrow forest stream in which extensive communities grew in a water depth of up to 15 cm in soft loam soil.**Other:** Whereas *C. longicauda* is only known to exist in one location each on the Malay Peninsula and Sumatra, the species, on the other hand, is very common on Borneo. The plant cultivated in the 1950s and 1960s under the name of *C. longicauda* is, in fact, *C. fuscica*.**Further reading:** Jacobsen (1985a).***Cryptocoryne longicauda*, emerged with inflorescence.****Spathe of *C. longicauda*.**

Cryptocoryne minima

Ridley (1910)

Family: Araceae.

Synonyms: *Cryptocoryne zewaldiae* de Wit.

Etymology: *Cryptocoryne*: see *C. affinis*; *minima*: very small.

Distribution: Malay Peninsula.

Description: Petiole up to 12 cm long. Leaf blade very variable, lanceolate to ovoid, 5–7 cm long, 1.5–5 cm wide, smooth or slightly bullate, light green, brownish or purple-red. Apex acute; base acute, round or slightly cordate.

Spathe 3.5 cm, tube 0.5 cm, limb 2 cm long, cuspidate, recurved backwards and downwards, not twisted, interior mammillate, colored very differently, from light yellow, light to dark brown and purple-red. Collar distinct, bulging. Throat very small. Female flowers 4 (5–6)7. Male flowers 15–35. Number of chromosomes $2n = 34$.

Culture: *Cryptocoryne minima* is a rare plant about which little is known regarding its cultivation in aquariums. Jacobsen (1982) mentions a nutrient-rich substrate, a not too intense lighting as well as a water temperature

of 22–28 °C as important conditions for keeping.

Ecology: Jacobsen and Bogner report on several native habitats of *Cryptocoryne minima* on the Malay Peninsula. According to their observations, populations grow in or around the edges of slow-flowing streams or rivers, as well as occasionally in rain forest pools in sandy-boggy soils. The biotopes were situated within rubber plantations or in forests. Depending upon individual living environments, the plants displayed strong differences with regard to size, shape and color of the leaves.

Other: Studies in native habitats, as well as the cultivation of collected specimens, show that *C. minima* is a polymorph species which reacts to different living environments by being very changeable in its appearance. The plants described by de Wit as *Cryptocoryne zewaldiae* are, therefore, also considered as a large-leaved form of *C. minima*.

Inflorescences of *Cryptocoryne minima* with brownish and yellow limb.



Cryptocoryne moehlmannii

de Wit (1982)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *moehlmannii*: after F. Möhlmann (1920–1991) who has earned a lot of credit with his involvement in the cultivation of *Cryptocorynes*.

Distribution: Central western Sumatra.

Description: Marsh plant with a creeping rhizome, 10–30 cm tall. Leaves 5–15(–20) cm long petiolate. Blade lanceolate to narrow ovoid, 10–15 cm long and 3.5–7 cm wide, smooth or slightly bullate. Apex acute and base slightly to distinctly cordate. Margin entire. Light to olive green coloration, not brownish.

Spathe 4–6 cm long. Tube 0.5–1 cm long. Limb 3–3.5 cm long, cuspidate, more or less erect (form from Tapaktuan) or 1–2 times obliquely twisted (form from Sasok), mammillate, interior dark purple-red. Collar narrow. Throat and collar colored similarly to the limb. Female flowers 5. Male flowers 25–30. Number of chromosomes $2n = 30$.

Culture: *Cryptocoryne moehlmannii* is a

decorative, undemanding, very recommended *Cryptocoryne*. In the aquarium, the species is similarly unproblematic to keep in the form of the hardly distinguishable *C. pontederiifolia*. For details on cultivation refer to *C. pontederiifolia*.

Ecology: *Cryptocoryne moehlmannii* populates similar habitats to *C. pontederiifolia*. The species grows in slow-moving water in rivers and streams in lowland forests. The waters are influenced in their lower reaches by high and low tides.

Other: *Cryptocoryne moehlmannii* was imported from western Sumatra only in recent years. Due to the similar appearance, the species was at first considered to be *C. pontederiifolia*. Only by the inflorescences, which develop on emerged plants, was it realized that they were, in fact, two species. Another not always safe differentiating feature are the purely green leaves in *C. moehlmannii* as opposed to the occasionally brownish or slightly violet ones in *C. pontederiifolia*.

Further reading: Jacobsen (1988).

Cryptocoryne moehlmannii.



Cryptocoryne nevillei

Hooker f. (1898)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *nevillei*: after the discoverer of the plant, H. Nevill.

Distribution: Central and eastern Sri Lanka.

Description: Strong rhizome. No development of runners has so far been observed in *C. nevillei*. Leaf blade narrow elliptical to narrow ovoid, rounded, 2–8 cm long and 1–2 cm wide, medium green in color.

Spathe 10–20 cm, tube 8–15 cm, limb 2–3 cm long, erect, twisted by about 180°, interior smooth, purple-red in the lower part, brownish in the upper part. Collar bulgy, black purple-red. Throat zone wide, with conspicuous black purple-red spots. Female flowers 4–6. Male flowers 60–80. Number of chromosomes $2n = 28$.

Culture: *Cryptocoryne nevillei* is not suited for cultivation in the aquarium. In emersed culture, the relatively rare plants will regularly have rest periods during which they completely retract.

Ecology: In contrast to other *Cryptocorynes*,

C. nevillei does not exist in flowing waters but in muddy locations instead, which are periodically flooded. These locations will dry out during the dry seasons, the foliage will dry out, and only the strong rhizomes will remain in the sandy soil. The species populates habitats with full sun exposure. The rest period lasts about 6 months. With the onset of the wet season the plant will flower.

Other: Studies undertaken by Jacobsen showed that the plant described in aquaristics for a long time as *C. nevillei* should really be correctly called *Cryptocoryne × willisii* Reitz. The “real” *C. nevillei* has been cultivated only since 1979.

Further reading: Jacobsen (1981, 1987a).

Limb of *C. nevillei*.



Opened kettle of *C. nevillei*.



Cryptocoryne nurii

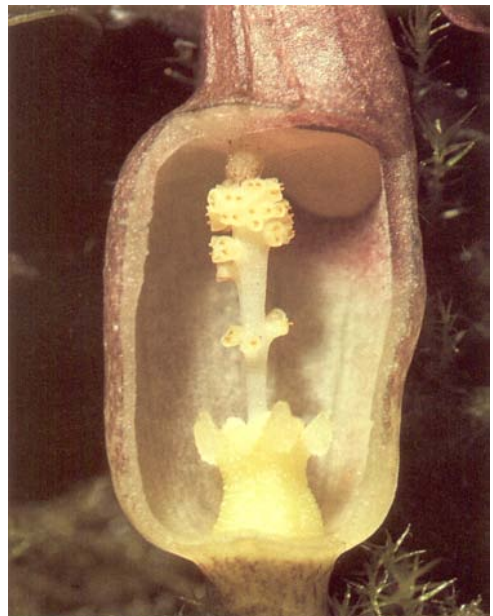
Furtado (1935)

Family: Araceae.**Synonyms:** *Cryptocoryne* "serrulata."**Etymology:** *Cryptocoryne*: see *C. affinis*; *nurii*: after the plant collector Nur.**Distribution:** Malay Peninsula.**Description:** Petiole 3–10(–20) cm long. Leaf blade lanceolate to narrow ovoid, 5–18 cm long, 1.5–3 cm wide, dark green to red-brown marmorate, often with short red lines. Apex acute; base round or slightly cordate. Margin more or less crispate.

Spathe about 5 cm long. Tube 1.5 cm, kettle 1 cm long. Limb about 2.5 cm long, wide cordate, recurved, short caudate, not twisted, interior featuring large irregular protuberances, dark purple-red. Throat very small. Collar swollen. Female flowers 5–7. Male flowers 25–30. Number of chromosomes $2n = 34$. (The data figures on size are based on inflorescences of cultivated plants. Lengths of the tube and limb mentioned by de Wit (1990) probably refer to specimens from native habitats.)

Culture: The culture of this rare *Cryptocoryne* is exceptionally difficult in the aquar-

ium. This species probably requires the very soft, acid water from their native habitats. Maintaining the plant above water is not easy, but can, however, be satisfactorily achieved if the plants are cultivated in a substrate with an acid reaction (e.g., beech leaf mold). In well-growing specimens, the small but conspicuously decorative inflorescences can occasionally be made out.

Ecology: *Cryptocoryne nurii* populates shady and sunny places in fast-flowing streams and rivers which feature a gravelly-sandy substrate. Previous water analyses in natural locations show that the plants can be found in very acid waters with a pH-value around 5.**Other:** Even though *Cryptocoryne nurii* has occasionally been imported in the last couple of years, the species is rarely being cultivated, even by *Cryptocoryne* lovers, due to its problematic maintenance.**Spathe of *Cryptocoryne nurii*.****Opened kettle of *C. nurii*.**

Cryptocoryne pallidinervia

Engler (1879)

Family: Araceae.

Synonyms: *C. venemae* de Wit, *C. pallidinervia* Engler subsp. *venemae* (de Wit) de Wit.

Etymology: *Cryptocoryne*: see *C. affinis*; *pallidinervia*: with pale venation; refers to the type-species; mostly not distinct in cultivated plants.

Distribution: Borneo (Sarawak, Kalimantan).

Description: Marsh plant, up to 15 cm tall. Leaves 5–10 cm petiolate. Blade ovoid, 3–7 cm long, 2–4.5 cm wide, usually highly bul-late, rarely smooth. Apex acute; base cordate. Margin sometimes fine undulate. Upperside medium green coloring, at locations mild purple-red underside.

Spathe 5–12 cm (up to 20 cm in imported plants) long. Tube 3–10 cm long. Limb about 1 cm long, aciculate, erect or the upper part curled outside, interior wrinkly, purple-red in color. Collar and limb margin warty, purple-red, collar smooth, bright yellow and dotted red toward the throat. Sterile part of the spadix conspicuously short. Female flowers

4–7. Male flowers 30–50. Number of chromosomes $2n = 34$.

Culture: An aquarium cultivation of *C. pallidinervia* has so far not succeeded. The aquarium water's pH-value probably has to be very low. Bastmeijer and Kettner (1991) report on a successful emerged culture in pots with a mixture of sand and peat.

Ecology: *Cryptocoryne pallidinervia* occurs in slow-moving water in marsh forests. The small communities grow in an acid environment in shallow depth between fallen tree foliage. According to observations from collectors, the species is supposedly not uncommon.

Other: De Wit (1990) doubts that the *C. pallidinervia*, as described by Engler with bul-late leaf blades, is identical to the plant that is cultivated today under this name. According to the studies done by Jacobsen (1985a), *C. venemae* as described by de Wit, which supposedly differs from *C. pallidinervia* in its smooth leaf blades and a two-lobed stigma, cannot be distinguished from *C. pallidinervia* Engler.

Spathe of *Cryptocoryne pallidinervia*.



Opened kettle of *C. pallidinervia*.



Cryptocoryne parva

de Wit (1970)

Family: Araceae.**Synonyms:** *C. nevillii* sensu auct., non Hook. f.**Etymology:** *Cryptocoryne*: see *C. affinis*; *parva*: small.**Distribution:** Central Sri Lanka.**Description:** Marsh plant, up to 10 cm tall. Leaves 1–6 (–10) cm petiolate. Blade narrow elliptical to lanceolate, entire, emersed 1.5–2.5 cm long, 0.4–0.8 cm wide, submersed up to 2 cm long, 0.2–0.3 cm wide, smooth, medium to dark green. Apex acute; base cuneate. Indistinct venation.Spathe 1.5–2.5 (–3.5) cm long. Tube 0.7–1.5 cm long. Limb 0.4–1.2 cm long, not caudate, obliquely twisted, interior rough to mammillate, purple-red in color. Collar and throat dark purple-red. Female flowers 4–6. Male flowers 30–50. Number of chromosomes $2n = 28$.**Culture:** *Cryptocoryne parva* is the smallest *Cryptocoryne*. The species features a good adaptability to cultivation conditions. Even though it counts among the rather slow-growing plants, it has enjoyed great popu-larity for many years because of its unproblematic cultivation. Soft water, as found in the natural locations, is not necessary for cultivation because *C. parva* also tolerates hard tap water with pH-values within the alkaline range. Washed sand is adequate as substrate. In a bright place within the aquarium, the leaves will spread horizontally, in shady places they will, in turn, develop more upright. Vegetative propagation proceeds fairly slowly. Optimum temperature range is 23–28 °C. An emersed cultivation, during which inflorescences will occasionally develop, is also unproblematic.**Ecology:** The species grows as a marsh plant in dense communities on the banks of fast-moving rivers. Even though *C. parva* has often been collected, only Horst (1986), who located the species together with *C. × willisii* in Mahaweli-Ganga, has published a water analysis: temperature 26 °C, GH/KH 0.7 °dH, pH 6.8, 36 µS/cm, Fe 0.1 mg/L as well as many other trace elements. The substrate was loamy, the location sunny and only occasionally slightly shaded.**Spathe of *Cryptocoryne parva*.*****Cryptocoryne parva* with infructescence.**

Cryptocoryne pontederiifolia

Schott (1863)

Family: Araceae.

Synonyms: *C. sulphurea* de Wit

Etymology: *Cryptocoryne*: see *C. affinis*; *pontederiifolia*: refers to the similarity of the leaves of the genus *Pontederia*.

Distribution: Sumatra (Padang Province).

Description: Marsh plant, 10–40 cm tall. Blade lanceolate to narrow ovoid, 9–14 cm long, 3–8 cm wide, smooth or slightly bullate, light to olive green, occasionally brownish or mild violet. Apex acute; base usually cordate.

Spathe 4–7 cm long. Tube up to 0.5 cm long. Limb 1.5–5 cm, cuspidate, erect or recurved, little twisted, rough to slightly wrinkly, interior yellow or reddish. Collar wide, smooth to a little rough, coloring like the limb. Female flowers 5–6. Male flowers 20–35. Number of chromosomes $2n = 30$.

Culture: Due to unproblematic maintenance, *C. pontederiifolia* counts among the most often kept *Cryptocorynes*. A shady place is adequate. Slightly illuminated specimens, however, will attain a greater growth height compared to plants cultivated under intensive

light. The species feels most comfortable in soft to medium-hard, weak acid to neutral water. Depending on the nutrient supply, the habitus will develop more or less strong. *Cryptocoryne pontederiifolia* prospers in temperatures between 18 and 28 °C, with the optimum range between 22 and 25 °C. After an initial period of several weeks, when the plants take root, they will develop rapidly and propagate easily by forming runners. Plants more often than not react to interference with the so-called *Cryptocoryne* rot. *Cryptocoryne pontederiifolia* belongs to the medium-sized *Cryptocorynes* and should be planted as a group. Its appearance is similar to *C. moehlmannii* (see photo p. 206)

Ecology: The species grows in the freshwater tidal zone together with *Nypa fruticans* (Nipa palm). Refer also to *C. moehlmannii*.

Other: Bogner and Jacobsen imported *C. pontederiifolia* in 1985 from western Sumatra. In cultivation the plants, collected from a single location, developed both yellow as well as reddish colored limbs.

Inflorescences of *Cryptocoryne pontederiifolia* with yellow and reddish limb.



Cryptocoryne purpurea

Ridley (1902)

Family: Araceae.**Synonyms:** *Cryptocoryne griffithii* sensu Hooker, non Schott, *C. aquatica* J.J. Hoedeman, *C. purpurea* Ridley f. *concolor* de Wit, *C. hejnyi* Rataj, *C. purpurea* Ridley f. *nana* de Wit.**Etymology:** *Cryptocoryne*: see *C. affinis*; *purpurea*: purple-red (color of the limb).**Distribution:** Malay Peninsula.**Description:** Marsh plant. Leaves 5–25 cm petiolate. Blade ovoid to elliptical, obtuse to slightly cordate at the base, 5–12 cm long, 2–4 cm wide, submersed upperside dark green, underside light green, with irregular purple-red venation and lines; emerged blade smaller than submersed, upperside dark green to purple red-brown, underside reddish.Spathe 7–20 cm, tube 3–13 cm, limb 3.5–5 cm long, short caudate, more or less erect, not or hardly twisted, rough to wrinkly (not mammillate, as in *C. griffithii*), purple-red to purple-red-brown. A collar is missing. Throat zone wide, colored like the limb or orange. Female flowers 5–8. Male flowers 40–60. Number of chromosomes $2n = 34$.**Culture:** *Cryptocoryne purpurea* has previously only occasionally been cultivated in the aquarium. Jacobsen (1987b) recommends a temperature of 22–26 °C, a medium light intensity, and soft, acid water with a pH-value of 5–6. At the same time, though, he points out that the plants are adaptable. A not too nutrient-rich substrate, consisting, for instance, of sand or beech leaf mold mixed with peat and clay is suitable for emersed cultivation.**Ecology:** Jacobsen (1986) reports on what must be the largest community of *C. purpurea*: the enormous lowland marsh area Tasek Bera on the Malay Peninsula. Refer to the detailed biotope description No. 12 on p. 43.**Other:** *Cryptocoryne purpurea* was, until now, thought to have originated exclusively from Kota Tinggii (around 1900) and the habitat described above. The species used to be imported under the name of *C. griffithii* and not recognized as *C. purpurea*. The plant displays sterile pollen, which points to hybrid origins.**Limb of *Cryptocoryne purpurea*.****Opened kettle of *C. purpurea*.**

Cryptocoryne retrospiralis

(Roxburgh) Kunth (1841)

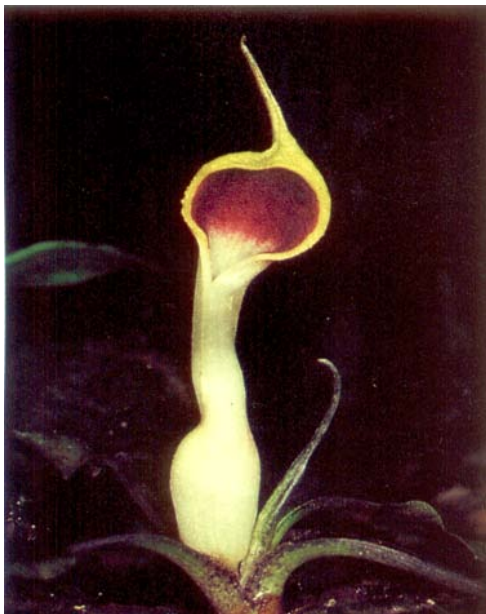
Family: Araceae.**Synonyms:** *Ambrosina retrospiralis* Roxb. (1814), *A. unilocularis* Roxb., *Cryptocoryne unilocularis* (Roxb.) Kunth, *C. roxburghii* Schott, *C. roxburghii* Dalzell, *C. dalzellii* Schott, *Lagenandra dalzellii* (Schott) Rataj.**Etymology:** *Cryptocoryne*: see *C. affinis*; *retrospiralis*: spirally reflexed, refers to the limb.**Distribution:** India.**Description:** Marsh plant. Long-day leaves, linear to strap-shaped, 15–40 cm long, 0.1–1.0 (–1.5) cm wide, flat or slightly undulate. Apex acute; narrowed base. Margin entire, occasionally denticulate. Emerged short-day leaves subulate, round, 10–15 cm long. Light green color.Spathe 10–30 cm long. Tube 5–20 cm long, slightly twisted. Limb (1–)3–8 cm long, erect, spirally twisted, with only one open stoma, smooth inside, yellowish to greenish, also featuring rather large reddish spots. No collar. Female flowers 4–7. Male flowers 100–140. Number of chromosomes $2n = 36, 72$.**Culture:** Information on cultivation found earlier—and sometimes even today—under the name of *C. retrospiralis* usually refers to different forms of *C. crispatula*. The “genuine” *C. retrospiralis* was seldom imported and is very rare. According to previous experience, this species is hardly suited to continuous maintenance within an aquarium. Emerged cultivation, however, is quite possible, with especially good growth results being achieved on a pure loam soil. Typical for *C. retrospiralis* is the formation of short subulate “winter leaves” which develop in the course of short-days. Vegetative propagation is relatively slow. Inflorescences form only during summer.**Ecology:** According to Jacobsen, the species grows in its native habitats in a sandy, rocky substrate in and at the edges of rivers. During the flowering stage (October to February), the plants grow more or less emerged.**Further reading:** Jacobsen (1991).*Cryptocoryne retrospiralis* (far right in the photo).

Cryptocoryne schulzei

de Wit (1971)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *schulzei*: after the plant's discoverer J. Schulze, Berlin.**Distribution:** Malay Peninsula.**Description:** Leaf blade lanceolate, 4–6 cm long, 1.5–4 cm wide, round or slightly cordate base, green or brownish, marmorate.Spathe 3.5–11.5 cm long. Tube 1–6 cm long. Limb 1.0–3.5 cm long, erect or recurved, cuspidate, not or hardly twisted, yellow or dark red with a yellow margin. Distinct collar. Wide throat, light or dark purple-red coloration. Number of chromosomes $2n = 34$.**Culture:** This rare *Cryptocoryne* has, until now, rarely been cultivated within aquariums. The plant can best be kept in soft, acid water, emersed in beech leaf mold.**Ecology:** *Cryptocoryne schulzei* grows in slow-moving acid rainforest streams in boggy soil, often together with *Barclaya motleyi*.***Cryptocoryne scurrisilis***

de Wit (1962)

Family: Araceae.**Synonyms:** *C. bullosa* Engler var. *scurrisilis* (de Wit) Rataj.**Etymology:** *Cryptocoryne*: see *C. affinis*; *scurrisilis*: funny, teasing, refers to the limb's appearance.**Distribution:** Sumatra.**Description:** Petiole up to 11 cm. Blade lanceolate, often with a cordate base, up to 11×4 cm in size, flat or slightly bullate, upperside green or brownish, the underside is often purple-red.Spathe 5–11 cm, tube 2.5–6 cm, limb 2–2.5 cm long, aciculate, obliquely reflexed, interior very mammillate, torose margin, light to dark brown. Fleshy collar, narrow. Very small throat, yellowish. Female flowers 5–8. Male flowers 30–50. Number of chromosomes $2n = 68$ (Bastmeijer 1989).**Culture:** Aquarium cultivation of this rare *Cryptocoryne* has been unsuccessful so far. Emersed keeping of this plant, however, is relatively easy in beech leaf mold or a mixture of sand and peat.**Spathe of *Cryptocoryne schulzei*.****Limb of *Cryptocoryne scurrisilis*.**

Cryptocoryne spiralis

(Retzius) Wydler (1830)

Family: Araceae.

Synonyms: *Arum spirale* Retzius (1779), *C. huegelii* Schott, *C. tortuosa* Blatter and McCann; for *C. spiralis* var. *cognatoides*: *C. cognatoides* Blatter and McCann.

Etymology: *Cryptocoryne*: see *C. affinis*; *spiralis*: spirally twisted, refers to the limb.

Distribution: Southern India, Bangladesh.

Description: Very variable marsh plant. Leaves 1–37 cm petiolate. Blade emersed lanceolate to narrow lanceolate or very narrow elliptic, submersed linear or strap-shaped, 10–70 cm long and 1–5 cm wide. Apex acute; base more or less cuneate to acute. Margin entire or slightly undulate. Grass green coloration emersed, submersed light green, in some forms also brownish.

Spathe without tube. Limb cuspidate, erect, little to spirally twisted 5 times. Margin features toothed protuberances. No collar. Female flowers 4–6. Male flowers about 50–65. Number of chromosomes $2n = 33, 66, 88, 110, 132$. Variety *spiralis*: spathe 6.5–12 cm long, kettle 1–1.5 cm, limb 5–10 cm long, distinctly transversely wrinkled inside, purple-red in

color, rarely yellow. Number of chromosomes $2n = 33, 66/72, 88, 110, 132$. Variety *cognatoides*: spathe 15–35 cm, kettle 3–7 cm, limb 11–32 cm long, transversely wrinkled inside up to a length of 3–4 cm, becoming smooth towards the top, purple-colored below, top yellow or entirely purple-red. Number of chromosomes $2n = 66, 72$.

Culture: *Cryptocoryne spiralis* is not only a polymorph species but the individual types are also very different in their cultivation requirements. Previously, only those forms displaying a limited capacity for submersed cultivation and which hardly multiplied under water were kept. Several years ago, Prof. Cook imported a new growth form from India which, in contrast, is extremely suited to aquarium cultivation and also easily reproduces. Even though this plant is still very rare, it is expected that it will eventually find a wide distribution within aquaristics. According to previous experience, they grow without any problems in medium-hard tap water, within a weak acid to slightly alkaline environment at a temperature of 23–27 °C. A nutrient-rich substrate (added loam and peat), as well as a medium-bright location are rec-

***Cryptocoryne spiralis* var. *cognatoides* with yellow limbs in its habitat (Western Ghats, India).**



ommended. The specimens develop a strong root network with long runners so that the substrate should be at least 5–7 cm thick. *Cryptocoryne* rot, occasionally found in other *Cryptocorynes*, is unknown to *C. spiralis*. Due to a growth height of 40–50 cm, an entire group of this new form should be used for planting only in the middle or rear sections of an aquarium. Emerged cultivation within a loamy substrate with a bit of sand and peat being added, is unproblematic. Inflorescences are produced quite often in strong plants. Little data is available so far on the cultivation of var. *cognatoides*. It is interesting to note that this variety, in contrast to var. *spiralis*, puts in a rest period under cultivation conditions and totally retracts (see Yadav, Patil and Bogner 1993).

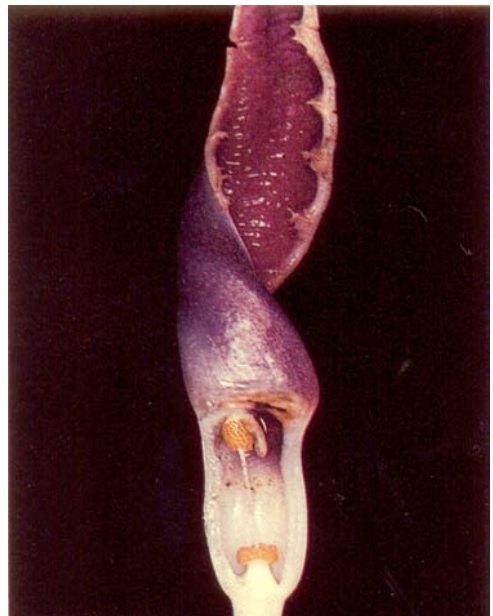
Ecology: *Cryptocoryne spiralis* var. *spiralis* populates riverbanks as well as moist locations which are temporarily flooded during the wet season. Bogner even located magnificent groups of plants growing as weeds in rice paddies. Whereas var. *spiralis* is only found in low-lying areas, var. *cognatoides* grows along streams and rivers in wooded areas in higher altitudes between 650 and 900

m, with high rainfall and a humid climate from June to September. Yadav, Patil and Bogner (1993) give an impressive report on the phenology of *Cryptocoryne spiralis* var. *cognatoides*. According to them, the petiole will extend after the first monsoon showers in early June, thereby elevating the infructescence above the ground, so that following the opening of the fruit, the released seeds are distributed over large distances by means of the flowing water. The plants display their vegetative growth from June to September. They flower from September to November. The authors also report on a location near Amboli which features a mixed population of both var. *spiralis* and var. *cognatoides*, which crossbreed and display all intermediate forms. **Further reading:** Bastmeijer (1992); Yadav, Patil and Bogner (1993).

Cryptocoryne spiralis.



Spathe of *C. spiralis* with open kettle.



Cryptocoryne striolata

Engler (1879)

Family: Araceae.

Synonyms: *Cryptocoryne gracilis* de Wit, *Cryptocoryne gracilis* var. *gracilis* (de Wit) de Wit, *C. striolata* Engler var. *ongii* de Wit, *Cryptocoryne* "ongii."

Etymology: *Cryptocoryne*: see *C. affinis*; *striolata*: finely striped, refers to the coloration of the leaf's upperside.

Distribution: Borneo.

Description: Petiole up to 10(–18) cm long. Leaf blade lanceolate to narrow elliptic, with a round to slightly cordate base, 2–12 cm long and 1–4 cm wide, flat to slightly bullate, very changeable in color, upperside ranging from dark green to bronze, often striped or marmorate, underside more or less purple-red or brownish.

Spathe 5–10(–20) cm long. Tube 2–7(–14) cm long. Limb 2–3(–5) cm long, more or less erect, cuspidate or caudate, from little to multiple twisted, cream-colored to purple-red. No collar. Collar zone distinct, purple-red to reddish brown in color, sometimes spotted. Female flowers 4–6. Male flowers 30–50. Number of chromosomes $2n = 20$.

Culture: The maintenance of this rare *Cryptocoryne* is extremely difficult within an aquarium. Corresponding to the natural habitat, the water probably has to be very acid and soft as well as measuring a temperature of about 25–28 °C. Compared to submersed cultivation, *C. striolata* will remain smaller when cultivated in emersed conditions. Good results with cultivation have been achieved by using beech leaf mold as a substrate. Well-growing specimens occasionally produce inflorescences.

Ecology: *Cryptocoryne striolata*, in its native habitat, grows mostly submersed in shaded locations in more or less fast-flowing waters in a rocky, sandy-gravelly substrate or one rich in humus. The most magnificent populations were found in fast-moving water.

Further reading: Jacobsen (1985a).

Emersed plant of *C. striolata* with spathe.



Limb of *C. striolata*.



Cryptocoryne thwaitesii

Schott (1857)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *thwaitesii*: after G.H.K. Thwaites (1812–1882).

Distribution: Southwestern Sri Lanka.

Description: Marsh plant, emerged 5–10 cm, submersed up to 20 cm tall. Emerged blade 1–5 cm petiolate, ovoid, $3.5\text{--}12 \times 1.5\text{--}4.5$ cm in size, crispate margin, rough upper side, olive green to brownish, underside paler. Submersed up to 15 cm petiolate, lanceolate, $5\text{--}8 \times 2\text{--}3$ cm in size, entire to slightly toothed, flat upper side, bronze-colored, red-brown underside. Apex acute to obtuse; round or slightly cordate base.

Spathe 6–12 cm long. Tube 2–4 cm long; kettle and tube red-spotted on the inside. Limb 3.5–7 cm long, caudate, erect or curved to the front, smooth inside, pure white or more or less red-spotted. No collar. Female flowers 4–6. Male flowers 20–30. Number of chromosomes $2n = 36$.

Culture: *Cryptocoryne thwaitesii* was occasionally imported in the late 1950s. It has,

however, become very rare since then. Successful submersed cultivation was occasionally reported, but the cultivation of this decorative species in an aquarium is problematic. Soft water, a nutrient-rich substrate as well as a not too bright location are the prerequisites for satisfactory growth. Emerged cultivation, in contrast, is achieved without significant problems in conditions of high humidity within a shaded location. A mixture of sand, loam, gravel and soil may be used as a substrate.

Ecology: *Cryptocoryne thwaitesii* populates small flowing waters. The author located solitary submersed communities with magnificent, bronze-colored leaves in shallow water in a sunny-shady stream in the Kottawa forest (Sri Lanka). Individual emerged specimens grew alongside the edges of the stream in a moist substrate and heavily shaded. The water analysis of this location (1/1985): temperature 24°C , pH 6.92, GH/KH $< 1^{\circ}\text{dH}$, $43 \mu\text{S/cm}$, rH 263 mV. Also compare the substrate analysis of this location (Jacobsen 1984) as well as a water analysis (Horst 1986).

Submersed populations of *C. thwaitesii* in a stream in Kottawa forest (Sri Lanka).





Native habitat of *Cryptocoryne thwaitesii* in Kottawa forest (Sri Lanka).

Cryptocoryne undulata

Wendt (1955)

Family: Araceae.**Synonyms:** *Cryptocoryne willisii* Baum, *C. axelrodii* Rataj.**Etymology:** *Cryptocoryne*: see *C. affinis*; *undulata*: undulate, refers to the structure of the leaf blade.**Distribution:** Central Sri Lanka.**Description:** Marsh plant, 10–25 cm tall. Leaves 7–15 cm petiolate. Blade lanceolate to narrow lanceolate, 4–11(–15) cm long, 1–3 cm wide, slightly undulate. Apex acute; base narrow, acute, truncate or slightly cordate. Margin entire or undulate. Upperside medium green to dark brown coloring, occasionally marmorate, underside green or brown, often featuring reddish venation.Spathe 4–10 cm long. Tube 2–6 cm long. Limb 1.5–4 cm long, more or less aciculate to twisted spirally, also slightly obliquely twisted, slightly rough in the inside, limb and collar cream-colored to yellowish or brownish. Throat white in color. Female flowers 4–7. Male flowers 30–70. Number of chromosomes $2n = 28, 42$.**Culture:** *Cryptocoryne undulata* (previously*C. willisii* Baum) has, for many years, been considered a popular and unproblematic aquarium plant. Both diploid ($2n = 28$) and triploid plants ($2n = 42$) prosper well and multiply rapidly; the triploid form will grow larger under submersed conditions and will also produce decorative dark brown marmorate leaves. Both forms are adaptable to water values and lighting. A sandy substrate with loam added is best. Optimum temperature range is 22–26 °C. Emerged cultivation, also, is not difficult.**Ecology:** *Cryptocoryne undulata* grows in streams and rivers, both submersed as well as emerged. No water analyses have been published so far.**Other:** In the aquarium, and with the plant's increasing age, *C. undulata* sometimes differs from the *C. wendtii* growth forms in that the rhizomes will grow vertically out of the substrate due to large internodes. Jacobsen (1981) commented extensively on the complex problem of the usage of the different names *undulata*, *willisii* and *nevillei*.**Diploid plants of *Cryptocoryne undulata*.**

Cryptocoryne usteriana

Engler (1905)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *usteriana*: after A. Usteri (1869–1948).

Distribution: Philippines (Guimaras Island).

Description: Aquatic plant, up to 70 cm tall. Leaves up to 30 cm petiolate. Blade lanceolate to narrow elliptic, up to 40 cm long, 2–6 cm wide, bullate. Apex acute; base round or acute. Undulate margin. Medium green coloration, often pale to deep purple-red on the underside. Strong midrib.

Spathe 5–14 cm long. Tube 3.5–9 cm long. Limb 1.8–3.5 cm, cuspidate or short caudate, hardly twisted, slightly mammillate inside, bright yellow, margin narrow and purple-red. No collar. Throat and throat zone smooth, bright yellow. Female flowers 5–6. Male flowers 20–50. Number of chromosomes $2n = 34$.

Culture: Even though *C. usteriana* is presently quite rare, it will certainly gain wider popularity in the next few years because of its simplicity in the aquarium. The species displays excellent growth in hard water, requires

a medium light intensity as well as a loose, preferably nutrient-rich substrate. After a short period of adaptation runners will easily develop. Depending on the size of the aquarium, the species is suited for planting in the central and rear zones of the aquarium. Optimum temperature range is 22–26 °C.

Ecology: A. Usteri first collected these *Cryptocorynes* near Buenavista, a location that no longer exists today. During the summer of 1983, J. Bogner again discovered the species on the Island of Guimaras in the Bigo River near the village of Concepcion. The small populations grew in a shaded location in shallow water within a gravelly-sandy soil. The pH-value measured around 6. The plants represented a state of starvation.

Other: The different types of *C. usteriana* display a high degree of variability in their habitat, which accounts for the opinion held over many years that *C. aponogetifolia* and *C. usteriana* are one and the same species. Clarification was only achieved after Bogner's research (1984) within their natural habitat.

Cryptocoryne usteriana.



Limb of *C. usteriana*.



Cryptocoryne walkeri

Schott (1857)

Family: Araceae.**Synonyms:** *C. lutea* Alston, *C. lutea* Alston var. *minor* Alston; *C. legroi* de Wit, *C. walkeri* Schott var. *lutea* (Alston) Rataj, *C. walkeri* Schott var. *legroi* (de Wit) Rataj.**Etymology:** *Cryptocoryne*: see *C. affinis*; *walkeri*: after A.W. Walker.**Distribution:** Central Sri Lanka.**Description:** Marsh plant, 10–25 cm tall. Leaves 5–16 cm petiolate. Leaf blade lanceolate, ovoid to narrow ovoid, 3–9(–15) cm long, 1.5–3.5(–6) cm wide, flat. Apex acute; base cuneate, round to slightly cordate. Margin entire, sometimes fine undulate. Grass green or brownish coloration. Distinct venation, often red in color.Spathe 5–15(–28) cm long. Tube 3–10(–20) cm long. Limb very variable, 1.5–5(–6) cm, more or less cuspidate, slightly recurved, more or less twisted, almost smooth or slightly rough, greenish or light yellow, changing to brownish. Collar colored like the limb. Throat greenish, yellowish or pale purple-red. Female flowers 4–7. Male flowers 40–90. Number of chromosomes $2n = 28, 42$.**Culture:** Green and brown forms are commercially available, all of which are suitable for submersed cultivation. They can be easily differentiated from *C. wendtii* and *C. beckettii* by their slightly stiff and upright growth. Multiplication, however, is slower compared to the latter two species. Refer to *C. wendtii* and *C. beckettii* for further information on cultivation.**Ecology:** Horst (1986) located the species on the banks of the Deduru Oya River on a boggy loam soil. He recorded the following water values which are, however, untypical for Sri Lanka: temperature 29°C, GH 13.5°dH, KH 8.7°dH, pH 7.8, 760 µS/cm.**Other:** According to Jacobsen's research (1987a), it is impossible because of intermediate forms to clearly differentiate between forms with a distinct collar and forms featuring a wide collar zone (initially the main differentiating feature) so that *C. lutea*—classified by de Wit as a separate species—has to be considered as *C. walkeri*. The earlier *C. legroi* constitutes a triploid form ($2n = 42$) of *C. walkeri*. Habitats of the triploid form are not known.Opened fruit of *Cryptocoryne walkeri*.*Cryptocoryne walkeri*.

Cryptocoryne walkeri × *nevillii*

Family: Araceae.

Etymology: *Cryptocoryne*: see *C. affinis*; *walkeri*: after A.W. Walker; *nevillii*: after H. Nevill.

Distribution: No natural distribution (artificial hybrid).

Description: Marsh plant, emersed 5–15 cm, submersed 2–7 cm tall. Leaves up to 12 cm petiolate, sometimes slightly fleshy and stiff. Leaf blade lanceolate, up to 5.5 cm long, 1.8 cm wide, flat. Apex acute; base round. Light to medium green coloration.

Spathe up to 17 cm long. Tube up to 10 cm long. Limb about 5 cm in length, erect, cuspidate, slightly twisted, rough, dirty yellow in color. Distinct collar. Throat and collar zone dark purple-red. Female flowers 4. Male flowers about 60.

Culture: *Cryptocoryne walkeri* × *nevillii* is a small-growing hybrid which grows slowly but is very undemanding. In emersed culture, in the course of several months, thick populations will develop displaying a conspicuously dense root network. Depending on the conditions of cultivation (humidity, lighting), specimens with more or less long petiolate leaves

will develop which will be either soft or rather stiff and slightly fleshy. The substrate should be rich in nutrients and can, for example, consist of a loam-sand mixture. Inflorescences will develop very often throughout the entire year. According to the experience of the author, cultivation within the aquarium is quite unproblematic in medium-hard, low acid to slightly alkaline water at temperatures of 25–28 °C and a medium light intensity. Under submersed conditions, too, the small plants develop surprisingly long and strong roots. The plant will multiply only very slowly. *Cryptocoryne walkeri* × *nevillii* is evergreen. It may, however, for a short time retreat in growth.

Other: This hybrid was the result of cross-breeding experiments conducted by N. Jacobsen in the winter of 1977–1978 in the context of trying to prove the hybrid origin of *C. × willisii*. This hybrid complex can be traced back to the parent plants *C. parva* and *C. walkeri* or *C. beckettii* (Jacobsen 1981).

Cryptocoryne walkeri × *nevillii*.



Limb of *C. walkeri* × *nevillii*.



Cryptocoryne wendtii

de Wit (1958)

Family: Araceae.**Synonyms:** *Cryptocoryne wendtii* de Wit var. *wendtii*, var. *jahnelli* Rataj, var. *krauteri* Rataj, var. *nana* Rataj, var. *rubella* Rataj.**Etymology:** *Cryptocoryne*: see *C. affinis*; *wendtii*: after Albert Wendt (1887–1958), author of the comprehensive work *Die Aquarienpflanzen in Wort und Bild*.**Distribution:** Central, western to north-western Sri Lanka.**Description:** Marsh plant, 10–30 cm tall. Leaves 5–20(–25) cm petiolate. Leaf blade elliptic to very narrow elliptic or narrow lanceolate to narrow ovoid, 5–15(–23) cm long, 1.0–4.5 cm wide, flat or slightly undulate. Apex acute; base cuneate, obtuse or slightly cordate. Margin entire or undulate. Differing coloration, ranging from different shades of green to dark brown, occasionally slightly marmorate.

Spathe 5–12(–17) cm long. Tube 3–8(–12) cm long. Limb (1–)1.5–3(–5) cm long, more or less cuspidate, hardly twisted, smooth to slightly rough on the inside, collar and limb dark brown to purple-red in color. Throat

white. Female flowers 4–7. Male flowers 35–80. Number of chromosomes $2n = 28, 42$.**Culture:** *Cryptocoryne wendtii* must be undisputedly the most recommendable *Cryptocoryne* for aquarium cultivation. It ideally combines a decorative appearance with optimal growth. Several growth forms are commercially available which, without exception, are suitable for emersed cultivation. A shaded location is adequate for ensuring good growth. The plants are adaptable to water values and will prosper in soft and hard, as well as weak acid or alkaline water. Multiplication occurs rapidly through runners so that dense communities will develop after a couple of weeks. The optimum temperature range lies between 22 and 26 °C, but both higher and lower temperatures can be tolerated over short periods.The emersed cultivation of *C. wendtii*, too, is unproblematic, if conditions of high humidity and a nutrient-rich substrate are provided. The latter, for example, may consist of a loam-sand mixture. The inconspicuous inflorescences develop quite often.**Ecology:** Even though *C. wendtii* has often been collected in its native habitats, hardly**Green color form of *Cryptocoryne wendtii*.**

any detailed information on these locations has been published. This *Cryptocoryne* apparently usually grows in or on the banks of streams and rivers. Horst (1986) discovered *Cryptocoryne wendtii* at a very untypical *Cryptocoryne* location in a stream between rice paddies in intense sunlight, where the plants developed conspicuously bullate leaves resting on the ground. The following data was recorded: water temperature 26 °C, GH 4.5 °dH, KH 5.2 °dH, pH 7.8, 148 µS/cm, Fe 0.27 mg/L. Horst (1983) also mentions another location, namely a stream accommodating a brown as well as a green color form of *Cryptocoryne wendtii*. He recorded the following values during the dry season: water temperature 27.5 °C, pH 6.4, hardness 0.5 °dH, Fe 0.112 mg/L.

Other: Numerous natural local variations are known of *Cryptocoryne wendtii* which all differ in size, leaf shape, and coloration. These specific features are, however, in no way consistent all the way through: for example, the leaf color of some forms may strongly vary under different conditions of cultivation.

This differing appearance of the plants led Rataj to describe five different varieties (var.

wendtii, var. *jahnelli*, var. *krauteri*, var. *nana*, var. *rubella*), the arbitrary separation of which, however, seemed questionable. Since it is not proven that the differences in appearance are due to a different genetic makeup, the different growth forms should be classified only as color and shape modifications and therefore as synonyms to *C. wendtii*.

The Tropica company distributes a brown, well-growing color form under the brand name of *C. wendtii* 'Mi Oya'.

Brown form of *C. wendtii*.



Limb of *C. wendtii*.



Cryptocoryne* × *willisii

Reitz (1908)

Family: Araceae.**Synonyms:** *Cryptocoryne nevillei* sensu auct., non Hook. f., *C. lucens* de Wit.**Etymology:** *Cryptocoryne*: see *C. affinis*; *willisii*: named after J.C. Willis.**Distribution:** Central Sri Lanka.**Description:** Marsh plant, emerged up to 25 cm, submersed 5–15 cm tall. Leaves 2–12 (–20) cm petiolate. Blade narrow ovoid to lanceolate, 1.5–12 cm long, 0.6–2.5 cm wide, flat, medium green in color. Apex usually acute; base acute or slightly cordate. Margin entire. Indistinct venation.Spathe 4–8 cm long. Tube 2–5 cm long. Limb 0.8–3 cm long, not caudate, erect and hardly twisted, distinctly rough to mammillate, usually brownish to dark purple-red. Collar a deep purple-red (occasionally yellowish). Throat colored like the limb or reddish. Female flowers 4–7. Male flowers 40–60. Sterile pollen. Number of chromosomes $2n = 28$.**Culture:** A recommended, popular aquarium plant, the cultivation is similar to that of *C. parva* (refer to *C. parva* for details). *Cryp-**tocoryne* × *willisii* is, however, more fast-growing.**Ecology:** *Cryptocoryne* × *willisii* grows submersed and emerged on the bank area of rivers. For other ecological data refer to *C. parva*.**Other:** Jacobsen proved by means of cross-breeding experiments that *C. × willisii* is a hybrid going back to a cross of *C. parva* with *C. walkeri* or *C. beckettii*. Crossings of all three species mentioned constitute an extremely variable hybrid complex to which Jacobsen also counts *C. lucens*, described by de Wit. De Wit, however, though not disputing the opinion that *C. lucens* is a cross, does not use the spelling *Cryptocoryne* × *lucens* which classifies the plant as a hybrid. For further information on this problem, refer to Jacobsen (1981, 1982, 1987a) and de Wit (1990).*Cryptocoryne* × *willisii* was, for many years, incorrectly cultivated under the name of *C. nevillei*; the genuine *C. nevillei*, however, was only introduced in the mid-1970s by D.H. Nicholson and is not suitable for aquarium culture.**Limb of *Cryptocoryne* × *willisii*.*****Cryptocoryne* × *willisii*.**

Cyperus helferi

Boeckeler (1874)

Family: Cyperaceae.

Synonyms: None.

Etymology: *Cyperus*: from *kypeiros* = Greek plant name; *helferi*: after the collector Johann Wilhelm Helfer (1810–1840).

Distribution: India, Burma, Thailand, Cambodia, western Malaysia.

Description: Marsh plant, up to 60 cm tall. Creeping rhizome, up to 5 cm long, 7 mm thick, very branchy. Leaves basilar, bushy growth, 10–60 cm long, 2–9 mm wide, strap-shaped, cuspidate, gramineous, flaccid, flat, with a deep, angular furrow in the center of the blade, green, the margin featuring minute denticles, therefore slightly rough. Leaf base sheathed; sheaths closed and include the younger leaf bases; sheath reddish and with narrow transparent scale.

Peduncle triangular, up to 45 cm in length. Inflorescence apical, in compound umbels, consisting of 5–9 rays unequal in and up to 14 cm in length, with adventitious plants. Bracts spread out. Partial inflorescences with 2–7 rays. Every spike petiolate, 8–12-flowered, distichous, 5–10 mm long, 1.5–2 mm wide.

Glumes ovoid, aciculate, slightly compressed, 3 mm long, green with a colorless margin; 2 stamens. Style 3-parted. No perigone bristles. Nut trigonous, oblong, 1.2–1.4 mm long, 0.8 mm wide, light brown.

Culture: This *Cyperus*, introduced in only 1991 by the Tropica company (Denmark), is well-suited to aquarium culture in both soft and hard water. A good lighting setup as well as a nutrient-rich substrate are prerequisites. The optimum temperature range lies around 22–26 °C. In order to give a decorative effect to the grass-like habitus, a free-standing location is recommended. Vegetative propagation occurs through rhizome division as well as adventitious plants on the emerged inflorescences. Cultivation in a paludarium is easily achieved under conditions of humid air and a loamy substrate.

Ecology: H. Windeløv discovered the plant in a river in southern Thailand, 20 km from Ranong.

Cyperus helferi (center).



Didiplis diandra

(De Candolle) Wood (1855)

Family: Lythraceae.

Synonyms: *Peplis diandra* De Candolle (1828) and others.

Etymology: *Didiplis*: *dis* = twice, *diploos* = double, twofold; *diandra*: refers to an untypical plant having 2 stamens.

Distribution: Eastern North America.

Description: Delicate marsh plant, emerged 5–10 cm, submersed 10–40 cm tall. Stem 1–1.5 mm thick, glabrous. Leaves sessile, decussate, amplexicauline. Leaf blade entire, emerged cuneate to lanceolate, 7–25 mm long, 2–4.5 mm wide, light green, submersed narrow linear, 2.2–2.6 cm long, 1.5–3 mm wide, light green to bright red.

Flowers axial, solitary, cleistogamous or chasmogamous. Flower 2 mm in size, with 4 trigonal green to red sepals. Without calyx attachment or petals; 4 stamens. Style very short or absent. Ovary globular. Capsule with seeds about 0.7 mm in size.

Culture: *Didiplis diandra* is a demanding, sensitive, light-requiring aquarium plant. The aquarium's light intensity will only be high enough once the leaves on the shoot apex are

reddish in color and the minute flowers start developing. Soft to medium-hard water with additional CO₂ fertilization is recommended to ensure healthy growth. Optimum temperature range is 22–26 °C, but may be temporarily higher. To ensure rapid root formation, a fine substrate rich in nutrients is suitable. The dainty habitus will have an effect only if the plant is arranged in groups. Every shoot, however, has to be individually planted since they break easily and will also rot at the lower stem under insufficient lighting. It is a magnificent contrast plant for the aquarium's foreground or middle area. Multiplication is through lateral shoots. The plant will react very sensitively to algae infestation and chemical additives.

Ecology: *Didiplis diandra* will grow submersed in shallow, stagnant waters as well as emerged on banks of rivers and lakes.

Other: *Peplis diandra* is a synonym. The distinction of different species is based on missing calyx attachments as well as 6-merous flowers in *Peplis* and 4-merous in *Didiplis*.

Didiplis diandra.



The *Echinodorus* Genus

ALISMATACEAE FAMILY

Nomenclature

The *Echinodorus* genus was first extensively dealt with by Micheli (1881), further work followed by Buchenau (1903) and Fassett (1955). Rataj (1975a) then published a revision of the genus. Since this was the only new publication for a long time, it represented, for many years, an important basis for aquarists for the identification of the species. From the beginning, though, there were critical voices who accused Rataj of describing too many species and varieties in a careless fashion. Over the last couple of years, two botanists, R.R. Haynes (University of Alabama) and L.B. Holm-Nielsen (University of Aarhus), studied this genus and initially published work preparatory to a more fundamental monograph (1984, 1986). These publications illustrate how inadequate Rataj's revision is in many parts, and how it has to be considered as hasty as far as the many new identifications are concerned. Many of the descriptions were completed with an uncritical approach and the species concerned have, in the meantime, again been retracted as synonyms. Name changes, especially for aquarists, always constitute an irritation if they concern species to which they have become accustomed over many years and without which species aquaristics is hardly imaginable.

In the monograph covering the *Echinodorus* genus by Haynes and Holm-Nielsen (1994) only 26 species—plus several subspecies—of the original 47 species and numerous varieties as described by Rataj (1975a) remain accepted and recognized. In the *Flora Neotropica*, however, this modifying work excludes a few species which display a distribution not corresponding to this flora.

This revision has undoubtedly to be considered as thorough and conscientious. Never-

theless it, too, cannot be considered satisfactory in all aspects. In this scientific piece, the leaf shape modified under submersed conditions, which can only be adequately studied during cultivation in the aquarium, has, above all, been neglected. Therefore, closely related species, which can be clearly distinguished in the aquarium through their submersed habitus, are combined in several instances to a single polymorphic species. This in-part, hardly practice-orientated and subjective approach does not correspond to aquarists' requirements.

Practically all cultivated species known to aquaristics are described extensively in this book. In doing so, the author essentially follows the results of Haynes and Holm-Nielsen, but does retain previous names of species in doubtful cases until final clarification, simply in order to avoid contributing further to any confusion over names.

In most instances, the descriptions were compiled according to herbarium specimens as well as cultured plants, which were collected by the author from their native habitats and identified by Haynes and Holm-Nielsen. Furthermore, some cultivars and crosses were included which are relevant in aquaristics and which are commercially available. Only those species which have not been previously cultivated and were unknown to the author have not been included in this book. In these cases the reader is referred to the scientific publications listed in the bibliography.

Use of English Names

The English trivial name of Amazon sword plant is being applied incorrectly to *Echinodorus* species because it creates the impression that they all originate from the Amazon area or its immediate surroundings, which is extremely misleading. The author has therefore chosen the English name sword plant for the genus *Echinodorus* since this name has been well established over time.



New cultivars: *Echinodorus* 'Oriental' (above) and *Echinodorus* 'Kleiner Bär' (below).





New cultivars: *Echinodorus* 'Apart' (above) and *Echinodorus* 'Ozelot' (below).



Defining Features of the Genus

All *Echinodorus* species are annual or perennial water or marsh plants. Whereas the medium-sized and larger sword plants display more or less large rhizomes through which they also vegetatively multiply, the smaller species are stoloniferous. Some species form swollen roots. This feature, which is apparently highly dependent on the surrounding environmental conditions, has been previously neglected in research and therefore deserves closer attention.

The leaves are arranged in the form of a rosette and are, corresponding to the living conditions, very variable. The leaf form will thus frequently change under water and will develop an entirely different habitus compared to emersed plants. The petiole, in most instances, is triangular, it can occasionally also be round. A species-specific feature is the absence or presence of pellucid lines in

the leaf blade which consist of more or less long lines and/or dots (see p. 278). These lines are milk-tubes which can be made out best in emersed leaves as well as herbarium plants using a pocket lens against the back light. In some species these pellucid lines are also visible in submersed leaves. Almost all previously studied *Echinodorus* species show a chromosome count of $2n = 22$. A triploid set of chromosomes was found in only a very few (*E. angustifolius*, *E. opacus*, *E. osiris*, *E. quadricostatus*) and tetraploid set of chromosomes in *E. portoalegrensis*. The reason for the triploid and a tetraploid condition could be a hybrid origin or mutation. It is difficult to determine which hypothesis is correct.

Depending on the species, inflorescences are formed in either submersed cultured plants and/or in terrestrial plants. The inflorescence can be simple or branched, erect, dependent or creeping, with or without ad-

New cultivar: *Echinodorus* 'Green Panda'.



ventitious plants (proliferation). It is distinctly petiolate and the peduncle is round or angular.

The inflorescence consists of a differing number of flower whorls which, in turn, display a more or less large number of flowers. At the base of the flower whorl are three bracts whose shape and length are taken into consideration to differentiate the species from one another. The length of the pedicel, as well as the size, shape and structure of the three green sepals and the three white petals, are also essential distinguishing characteristics. The flowers are always bisexual (in contrast to the related *Sagittaria* genus). Each flower displays a more or less constant number of stamens as well a larger number of carpels which are arranged in spirals. The fructescences usually consist of numerous seeds. The surface structure of the seeds is a specifically typical feature in the *Echino-*

dorus species. The nutlets are ribbed on their sides and have a more or less large number of glands which can sometimes be entirely absent. A species-specific beak is found on the tip of the seed.

Depending on the surrounding environment, some of the mentioned features can vary considerably. Plants in drier locations, for example, produce small rosettes, leathery blades, shorter inflorescences and pedicels as well as smaller flowers, compared to plants in wet or moist habitats. Only the overall consideration of all important characteristics will enable a safe identification of *Echinodorus* species.

Although this book lists all essential features of the species in its descriptions of the plants, thereby enabling the reader to identify his or her plants, it must be emphasized that the *Echinodorus* genus is extremely difficult in this regard because there are so many hy-

Echinodorus grandiflorus subsp. *aureus* in its native location in Mexico.



brids being cultured. Furthermore, the identification of many species requires special botanical expertise and knowledge.

Distribution of *Echinodorus* Species

The distribution of the *Echinodorus* genus is limited to the American continent. Its northern limits lie in the U.S., the southern border in Argentina. Rataj described two species (*E. africanus* and *E. veronikae*) from Africa (Cameroon), but in doing so obviously started out on the basis of erroneous assumptions. With regard to the first species, this author was able to clarify on the spot in its native habitat that the plants which supposedly originated from Cameroon were, in fact, confused with *Limnophyton fluitans*, and that *E. africanus* most definitely does not come from Africa (see also p. 278). The origin details for the second species, i.e., the type-locality, which Rataj also recklessly lists as Cameroon, also lacks any credibility.

Native Habitats of *Echinodorus* Species

Surprisingly little has been published about the ecology of the *Echinodorus* genus, a genus that is very important in aquaristics. In scientific publications, too, hardly any details are found on native habitats. Among aquaristic publications the works of Schulze (1968) deserve to be specifically mentioned here for their informative content. Other publications (de Graaf 1988), in contrast, contain rather weird details on the native habitats. *Echinodorus* species are, for example, supposed to be exclusively rheophytes, i.e., plants resident in waters with a strong current, and principally located in only sunny places. Such generalizations are, of course, absurd.

During several trips to Central and South America, this author had the opportunity to make observations and conduct tests at numerous native locations of many *Echinodorus* species. It is, therefore, a special con-

Echinodorus grisebachii on a riverbank in Venezuela.



cern of the author to summarize the results obtained as follows, in order to contribute to a better understanding of the living conditions of these plants. The description of individual locations is given in the portraits of the different species.

General Habitat Description

The majority of *Echinodorus* species grows either in boggy flood areas or in the immediate embankment of stagnant or flowing waters. Some species even exist in temporary waters which dry out completely and in which soil the plants survive and endure with their hardy rhizomes. (These species display a more or less identical life cycle to *Aponogeton* species.) Only a few sword plants are known to probably exist submersed in water all year round, even though their rhizome would enable them to endure a short dry period. There are only a few species, as an exception, within this group that are found—at least for limited periods—in stronger flowing waters.

Echinodorus species populate both sunny as well as shaded locations.

Environmental Factors

1. Variations in Water Levels in Areas with Distinct Seasonal Climates—Those *Echinodorus* species existing in tropical or subtropical areas have adapted their living requirements to periodic dry and wet seasons and associated variations in water levels. However, only few *Echinodorus* species are able to survive variations in water levels of more than 1–1.5 m over a longer period of time. Most species, as soon as their leaves die off due to lack of light, could endure only a short spell with the aid of their rhizomes. This easily explains why sword plants cannot exist in the area immediately surrounding the Amazon, with variations in water levels of 6–8 m, but only in its more distant catchment areas instead.

During the dry season, many species from subtropical regions grow more or less close to the edges of waterways completely emerged or stand only a few centimeters in water. During high-water periods (rainy, warm season), they lead a partial or completely submersed lifestyle. Those plants resident in such habitats are thus able to adapt to an emerged and submersed existence over the course of annual seasons.

It is not rare to find several *Echinodorus* species at the same location. There, compared to larger sword plants, small and medium-sized species populate different ecological niches. The smaller species grow several meters from the riverbank during the dry season and can thus endure a very dry location for some time, whereas the larger species, which tolerate a higher water level during the wet season, exist closer to the river's edge.

It is interesting with regard to possible native hybrids that several species can also lead an intermingled existence in the same area. It is not known which species are thus associated with each other, but it is most important for conclusions regarding species definition, variability of the plants, mutations and natural hybrids.

With regard to ecological observations, the year-long cultivation experiences of aquarists, too, are of interest, which are at one with observations in native habitats. It is known from cultivation that larger species, for example *E. grandiflorus* subsp. *grandiflorus*, *E. macrophyllus* and *E. paniculatus*, have a strong desire to protrude from the water and to form only very few submersed leaves. The growth process of these plants should be similar during high-water periods: the plants are able to adapt to the higher water level and the associated reduction in light by developing longer petioles. Furthermore, it is known from practical experience in cultivation that small-remaining sword plants, for example *E. tenellus* and *E. bolivianus*, are more light-demanding. In nature therefore, they grow

only in habitats which supply sufficient light even during high-water periods to enable adequate growth, i.e., in a zone which is only just touched by the river at its maximum high tide.

2. Climate Rhythm—The climatic changes in the rainy (warm) and dry (cold) seasons, too, have a decisive influence on the lifestyle of the *Echinodorus* species in subtropical regions. Plants within these zones are in a position to endure extreme variations in temperature. For example, temperatures in subtropical regions of the Southern Hemisphere (southern Brazil to northern Argentina), in which a large number of *Echinodorus* species exist, can occasionally drop to frost level. On the other hand, air temperatures can reach figures above 30 °C during the warm season in the same places.

So far, no research is available on the influence of the changes in relative humidity on the growth of emersed *Echinodorus* species.

3. Other Ecological Factors—Apart from the individual factors such as water level and temperature, other essential environmental factors—such as light intensity and length of day, composition and water content of the substrate, as well as water chemistry—have to be mentioned as well, all of which have already been discussed in the introductory chapters.

The Vegetative Rhythm of the *Echinodorus* Species

On the basis of the author's observations during different seasons of different *Echinodorus* species, she would like to attempt a portrayal of the lifestyle of *Echinodorus* species. It must be specifically emphasized, though, that it is a model that is simplified and requires modification and amendment since there is no or little data available on the native habitats of many species. The specific ecology of individual species should therefore be studied in a more targeted and focused way in

Adventitious plants on *Echinodorus uruguayensis*.



order to better comprehend the life of this interesting plant genus.

a) Amphibious *Echinodorus* Species—Amphibious-growing *Echinodorus* species, especially, have adapted to the periodic change of seasons of high and low rainfall, which are defined by variations in water levels, temperature and light. With the onset of the wet season, many species find themselves under water and initially develop (dependent on the water level) submersed leaves. Once the water levels eventually begin to gradually drop again, the plants will increasingly move their leaves above the water surface and will proceed to grow to their full size. Only at low water levels will flowers and fruit develop. Once the habitats begin to dry out, the plants will produce ever smaller leaf rosettes and shorter inflorescences, until the foliage will—depending on the degree of moisture in the soil—entirely dry out. Sometimes only the rhizome will survive in the dry substrate. The

mature seeds will initially remain either in the fructescence or drop on the soil, where they will remain in a restive phase until the onset of the next wet season when they will be stimulated to germinate under advantageous environmental conditions.

b) *Echinodorus* Species Existing Under Water—Those *Echinodorus* species existing in rivers and other bodies of water carrying water all year, are primarily adapted to the changing light intensity in water resulting from the seasonal variation in water levels. During the wet season the water level will be high, and the resulting reduced light volume impacts on the plants' photosynthesis and reduces its assimilatory activity. If water levels drop, plants will again receive more light, grow stronger and form inflorescences. A temporary drying out of the waterway due to extreme climatic conditions can be survived by the plants in the short term through the help of their rhizomes.

Echinodorus paniculatus in its habitat in Mexico.



Within this life cycle, it is interesting to note the relationship between the water level and the temperature conditions in the sub-tropical regions of the Southern Hemisphere: during the lowest water levels, when the plants are strongest in their assimilatory activity and when they also flower, the water temperatures will be at their lowest; during high-water levels and limited plant growth, the water temperatures will, in contrast, reach their peak! The following *Echinodorus* species would display such a vegetative rhythm: *E. osiris*, *E. opacus*, *E. portoalegrensis* and *E. uruguayensis*.

General Recommendations for Cultivation

Echinodorus species are popular and normally undemanding plants, which are recommended for use in tropical aquariums. Many species, however, are suitable only for spa-

cious aquariums from about 100 L upwards because, under optimum growth conditions, they would simply appear too dominant in small aquariums. The leaves of larger specimens, however, may also be truncated which will not impact much on growth. Adult leaves, though, will subsequently initially remain smaller in size.

Specimens which have become too large can easily be relocated; a trimming of roots in this context will lead to slowed growth for only a short time.

Almost all *Echinodorus* species can be kept in soft or hard water, with a preferred pH-value around the 6.5–7.5 mark. Even though many species can make do with only a moderate light intensity, a higher light intensity will undoubtedly enhance better growth. The substrate should be nutrient-rich. In fast-growing species, a deficiency in iron may often occur which is indicated by the yellow

Echinodorus tenellus in its habitat in Bolivia.



coloring of the leaves (chlorophyll deficiency). This necessitates fertilization.

Generally speaking, the *Echinodorus* species can be optimally cultivated within a temperature range between 23–26 °C, while some species from temperate or subtropical regions can also cope with much lower values up to about 12 °C, temporarily also down to the frost limit. Other species from tropical regions can still be well maintained in aquariums in temperatures around 30 °C.

Induction of Flowering in *Echinodorus* Species

Vegetative propagation in small species usually occurs through cuttings on runners; in larger species juvenile plants occasionally develop on rhizomes. Most productive, though, is reproduction through adventitious plants which, in many *Echinodorus*, are formed on the whorls of the inflorescences. These will

also appear occasionally in aquariums, which is always an indication of good growth. If the inflorescence strives to protrude from the water, it should be pressed back under water to enable better development of adventitious plants. As soon as the adventitious plants are strong enough and have formed roots, they can be removed by slightly twisting them and subsequently be planted. The flowers will not normally open under water. The study of the flowers thus necessitates the protrusion of the inflorescence from the water.

Triggering factors for the formation of flowers can be temperature and the length of the lighting period. During cultivation it was found that some *Echinodorus* species, independent from the light situation, will only flower in summer, others only in winter, and others during the entire year, thereby developing their individual and specific growth formations. Accordingly, one distinguishes between short-day plants (plants which flower

The flowers of *Echinodorus* are often visited by butterflies.



during a lighting period of less than 12 hours), long-day plants (flower formation occurring during a daylight period of more than 12 hours), and day-neutral plants (daylight period has no influence on the formation of flowers). This photoperiodic behavior can, for example, be utilized in plant nurseries in order to increase reproductive productivity. In some species, inflorescences with adventitious plants may be induced early on in very small plants with the aid of the lighting period, while other species require a cold period prior to flowering.

Published observations and opinions on the flower induction of individual species will not always tally. The credibility of the authors, however, is not in question. Rather, variations in flowering behavior can be explained by the geographic origin of the plants. It might well be that populations from countries with a large geographic distance in their

north–south direction have adapted to the different native conditions in their habitats and thus react differently to the length of the lighting period. For example, *Echinodorus berteroi* is considered to be a long-day plant, van der Vlugt (1993b), however, reports—entirely credibly—that his specimens imported from Curaçao have proven to be day-neutral.

Previous observations on the induction of flowering in *Echinodorus* species are in no way complete. They are rather fragmentary, but could be further expanded in cooperation with aquatic plant nurseries as well as studies in native habitats. There exists a wide scope for experimentation for those interested in this topic!

Insofar as the flowering behavior of individual *Echinodorus* species is well known and can be confirmed by the author, it has been included in the plant catalogue.

Infructescence of *Echinodorus schlueteri*.



Artificial Hybrids

It has been known for a couple of years that some *Echinodorus* species can be easily crossed. The first targeted experiments in this regard by aquatic plant nurseries commenced in the early 1980s. The purpose of these experiments was to obtain new plants for use in aquaristics which differed decidedly from the previous species in their coloration and in their habitus. They should also be fast-growing and undemanding.

During these crossbreeding experiments, very decorative hybrids were indeed obtained, some of which are regularly commercially available. All crosses and hybrids, for which a cultivar name has been published have been considered for this book.

Since the commencement of crossbreeding experimentation, it could be observed that the breeding of new *Echinodorus* hybrids and cultivars has increasingly replaced the original species in aquariums. Simultaneously, plants were offered that were, in fact, hybrids, but not clearly marked as such.

Such practice deserves to be condemned because it leads to total confusion. Basically nothing can be said against the commercial marketing of hybrids, practiced for a long



Nutlets of *Echinodorus schlueteri*.

time in ornamental plant cultivation, if such crossings are adequately marked as such, for example, with a multiplication symbol (×). There is also the option of using a cultivar name.

Echinodorus amazonicus

Rataj (1970)

Family: Alismataceae.**Synonyms:** *Echinodorus brevipedicellatus* auct. non (O. Kuntze) Buchenau.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *amazonicus*: originating from the Amazon.**Distribution:** Two habitats in the Brazilian Amazon region: Rio Jamari (Rondonia), Belém (Pará).**Description:** Medium-sized sword plant, submersed 30–50 cm tall. Petiole up to 10 cm long. Leaf blade narrow lanceolate, often slightly recurved sideways, up to 40 cm in length, 1.5–3 cm wide, medium green with dark horizontal veinlets. Apex and base acute; 5 leaf veins. Pellucid lines.

Inflorescences in submersed plants in both long-day and short-day, reaching far beyond the plants, simple or paniculate, with adventitious plants. Inflorescence with 4–6 whorls. Each whorl has 3–6(–12) flowers (which do not open under water). Bracts exceed the pedicels in length. Flowers up to 1 cm petiolate, about 1–1.5 cm in diameter; (6)9(12) stamens. Nutlet 2 × 1 mm in size, with 3–4 ribs on each side and 2–5 or more glands. Beak 0.5–0.75 mm long (partly according to Rataj 1975a).

***Echinodorus amazonicus*.**

Culture: *Echinodorus amazonicus* belongs to the group of medium-sized and especially recommended sword plants. For many years this species, for a long time incorrectly described as *E. brevipedicellatus*, was part of the standard collection of aquarium plants which proves its simplicity. Depending upon the substrate's nutrient supply, stronger specimens will develop. In smaller aquariums up to a volume of 100 L, the substrate should consist only of sand so that the plants do not grow too big. In medium-sized aquariums with a nutrient-rich substrate, use as a solitary plant is recommended. In very spacious tanks a group, too, can appear very decorative. Even though the light requirement is only moderate, one should take care that *E. amazonicus* has a free and bright location within the aquarium. The optimum temperature range lies between 22–26 °C. Vegetative propagation does not pose a problem with this species since sturdy specimens will often produce inflorescences with numerous adventitious plants within the aquarium. These may be severed from the parent plant after reaching a size of several centimeters and replanted.

Ecology: The plants grow in slow-moving as well as stagnant water in a depth of 50–100 cm.

Other: Haynes and Holms-Nielsen (1994) consider *E. amazonicus*, *E. bleheri* and *E. parviflorus* as synonyms of the polymorphic species *E. grisebachii*. This opinion, however, does not sufficiently take into account the different habitus of the plants in submersed conditions. In the aquarium, easily identifiable plants which differ in appearance will develop without intermediate forms. Research in the hardly known native habitats, as well as a comparative cultivation of different populations of this species, therefore seems necessary in order to arrive at satisfactory results. Even though the close relationship of these species seems obvious, the author nevertheless considers it more important at this stage to retain the present names since they

Echinodorus angustifolius

Rataj (1975)

Family: Alismataceae.

Synonyms: None.

Etymology: *Echinodorus*: see *E. aschersonianus*; *angustifolius*: narrow-leaved.

Distribution: Brazil (Mato Grosso).

Description: Delicate marsh plant, stoloniferous. Emerged leaves linear, 6–15 cm long, 0.6–1 cm wide. Submersed leaves short petiolate, strap-shaped, up to 60 cm in length, 3–4 mm wide, light green. Leaf apex cuspidate; base decurrent.

Inflorescences erect, together with the peduncle 15–25 cm long. Inflorescence with 2–3 whorls. Pedicel 1–3 cm long. Flower 1.2–1.5 cm in diameter. Nutlets 1.2–1.6 mm long, 3 ribs on each side (description of emerged plants and flowers according to Rataj 1975a).

Culture: Even though *Echinodorus angustifolius* belongs to the most recommendable and undemanding sword plants, it is, surprisingly, hardly made available for use in aquarium culture. The plant is conspicuous by its especially long, ribbon-like leaf blades, which is why it is easily confused with angustifoliate *Vallisneria*. Cultivation of *E. an-*

gustifolius is not difficult: both soft and hard water is suitable. A weak acid environment is advantageous. Temperature range is about 20–28 °C.

Echinodorus angustifolius easily produces runners so that vegetative propagation poses no problem at all. A group planted in an open location or application on the side and rear panels appears decorative. The plants will grow best under intense lighting conditions.

Ecology: There is no detailed information available.

Other: The systematic status of *E. angustifolius* is unclear. The plant is closely related to *E. bolivianus* from which it can be distinguished by the longer submersed leaves. *E. angustifolius* is supposed to be triploid (de Wit 1990); in this case it could be a form (hybrid or mutation) of *E. bolivianus*. Until the issue is finally clarified, the author considers it appropriate to retain the previous name of *E. angustifolius*.

***Echinodorus angustifolius*.**



Echinodorus aschersonianus

Graebner (1911)

Family: Alismataceae.

Synonyms: *E. aschersonianus* var. *nulliglandulosus* Rataj.

Etymology: *Echinodorus*: (Gr.) *echinos* = hedgehog, *doros* = pipe, hose, hedgehog hose, refers to the spiny fruit; *aschersonianus*: after the German botanist P. Ascherson (1834–1913).

Distribution: Southern Brazil to Argentina.

Description: Small to medium-sized marsh plant. Emerged plants: petiole usually up to 10 cm long, half-round. Blade narrow ovoid, 6–14 cm long, 3.5–6 cm wide, medium green. Leaf apex round or acuminate; base slightly cordate, with minuscule teeth. Submersed leaves mostly short petiolate, with narrow lanceolate up to 10 × 3-cm sized blades. A change in the leaf blades depending on lighting duration was not noted; 3–7 veins. No pellucid markings.

Inflorescences both emerged and submersed, initially hanging dependent, subsequently creeping, not branched, with few adventitious plants. Peduncles 1–1.5 mm thick, round, soft, glabrous. Inflorescence usually

with 1–2 whorls, rachis round. Each whorl with about 4 flowers. Bracts up to 1 cm long. Flowers up to 8 cm petiolate, about 3–3.5 cm in size. About 18 stamens. Nutlets about 2 mm long, 3–4 ribs on each side and 0–1 gland.

Culture: A recommended, light-demanding sword plant for the aquarium's foreground or center area. Cultivation problems are usually due to nutrient deficiency in the substrate. The species displays healthy growth in both hard and soft water. Optimum temperature range is 22–26 °C. *Echinodorus aschersonianus* can be used as both a solitary and a group plant. Multiplication through adventitious plants of inflorescences formed during short- and long-days.

Ecology: No detailed information is available.

Other: Emerged plants of *E. aschersonianus* can be easily differentiated from other species of the genus by their cordate, small leaf blades devoid of pellucid markings, as well as the decumbent peduncles.

***Echinodorus aschersonianus*.**



Echinodorus* × *barthii

Mühlberg (1986)

Family: Alismataceae.

Commercial name: *Echinodorus* “osiris double red.”

Etymology: *Echinodorus*: see *E. aschersonianus*; *barthii*: after the breeder H. Barth.

Distribution: No natural distribution.

Description: Medium-sized hybrid, 10–20 cm tall and 20–40 cm wide in the aquarium. Emerged blade up to 50 cm petiolate, elliptic, narrow ovoid or narrow obovoid, up to 17 cm long, 10 cm wide. Apex acute; base round or slightly cordate. Submersed blade up to 10 cm petiolate, narrow elliptic, up to 12 cm long, 2–4(–6) cm wide, dark brown-red in color. Apex acute or obtuse acuminate; base acute or obtuse. Leaf margins slightly undulate and curled up towards the outside. Submersed 3–5, emerged 5–7 leaf veins. Pellucid lines long and medium-long.

Inflorescences in short-day emerged plants together with peduncle up to 1 m long with adventitious plants; 5–6 whorls. Flowers about 3.5 cm in size; 18–22 stamens. Nutlets fertile.

Culture: Due to the dark brown-red leaf col-

oration, it is a very decorative hybrid which is used in the front or central planting zone. Only the leaf margins, curled to the outside, appear obtrusive. Cultivation poses no problem in either soft or hard water. A bright location is essential. A nutrient-rich substrate is recommended. Temperature range is about 18–26 °C. Multiplication is only through adventitious plants, since different phenotypes will develop from any sowing of seeds originating from self-pollination.

Other: The hybrid was introduced to aquaristics under the commercial name of *E. “osiris double red”* and erroneously described as *E. barthii* by Mühlberg in 1986 under the assumption that it is a good species. It is, however, undoubtedly a hybrid which possibly originated with an Australian plant breeder. According to the latter, *E. uruguayensis* is one of the two parent plant species. The author had the opportunity of viewing the F1-generation of *E. × barthii* in the aqua plant nursery J. Hoechstetter, Trostberg, Germany, where a distinct segregation was noticeable.

Further reading: Mühlberg (1986).

***Echinodorus* × *barthii*.**



Echinodorus berteroi
(Sprengel) Fassett (1955)

Family: Alismataceae.

Synonyms: *Alisma berteroi* Sprengel (1825), *A. rostratum* Nuttall, *E. rostratus* (Nutt.) Engelm., *E. patagonicus* Spegazzini, and others.

Etymology: *Echinodorus*: see *E. aschersonianus*; *berteroi*: after J. Bertero (1789–1831).

Distribution: U.S. and Central America (widespread); isolated in Venezuela, Guyana, Ecuador, Peru.

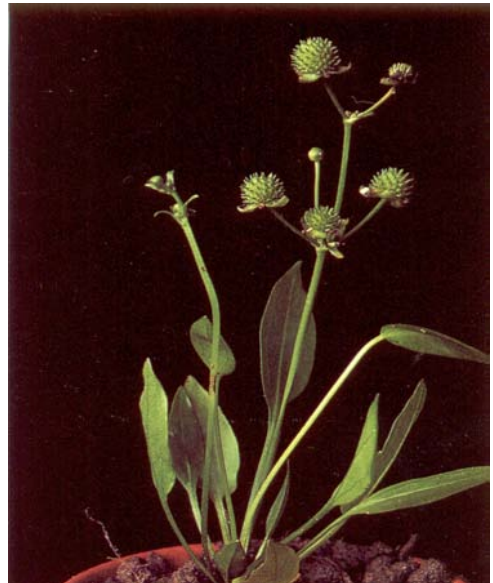
Description: Strong marsh plant, up to 70 cm tall in the aquarium. Petiole up to 50 cm long (rarely longer), triangular. Emerged leaf blade wide ovate with an obtuse round apex, cordate base and round base lobes, 8–20 cm long, 5–14 cm wide, medium green. Submersed blade very variable: juveniles strap-shaped, indistinctly petiolate, up to 40 cm long, 1.5 cm wide, thin; mature leaves ranging from narrow lanceolate to narrow elliptic with an undulate margin and aliferous petiole, up to 40 cm petiolate, 20–30 cm in length, 3–4 cm wide, thin, fragile, transparent, light green with a dark venation, forming a network. Long petiolate floating and emerged leaves

follow, featuring cordate blades; 3–13 veins. Pellucid lines distinct.

Inflorescences usually in the long-day, overtopping the plants, paniculate, erect, without adventitious plants. Peduncle up to 60 cm long, triangular or almost round. Inflorescence up to 30 cm long, with 2–9 whorls with 3–7 flowers each. Rachis triangular. Bracts lanceolate, 3–10 mm long, 1–3 mm wide. Flowers 1–2 cm petiolate, about 1 cm in size. Sepals 0.9–3.4 mm long, 1.3–2.9 mm wide. Petals 2.5–4 mm long, about 3.5 mm wide; 12(–15?) stamens. Numerous carpels. Nutlets 2–3 mm long, 1–1.5 mm wide, aliferous, with 3–4 ribs and 1 gland on each side; beak 1 mm long.

Culture: Even though *E. berteroi*, through its slightly transparent conspicuous leaf blades, is an unusually decorative sword plant for the aquarium culture, it is no longer that regularly commercially available. Many aquarists are unaware that the species develops a strong desire to produce floating and emerged leaves under lighting periods of more than 12 hours (long-day) and to subsequently flower. This photoperiodic behavior can already be observed in very small (up to a height of 5 cm)

E. berteroi submersed under short-day conditions, and with long-day-induced inflorescences.



emersed growing specimens in which inflorescences can be induced early on through long-day illumination. Since *E. berteroi* does not form any adventitious plants on its inflorescences, this behavior can be utilized by the well-germinating seeds. This conspicuous solitary plant can be easily kept in the aquarium under medium to high light intensity, in either soft or hard water, a nutrient-rich substrate and optimum temperatures between 20 and 27 °C.

Ecology: *Echinodorus berteroi* populates riverbanks as well as temporary pools. Depending on the season water, floating and emersed leaves as well as inflorescences and infructescences will form. The lower the humidity of the substrate, the smaller the plants will grow until they eventually die off altogether and regrow from seeds during the following wet season. In August 1984 the author discovered dense communities of *E. berteroi* in pools running dry in Mexico (between Tuxpan and Valles), and growing under intense sunlight in a boggy soil. Whereas many plants could be found in shallow water with only submersed or floating leaves, some specimens on the banks already featured

emersed leaves and inflorescences. Van der Vlugt (1993b) reports on native habitats on the island of Curaçao. These *E. berteroi* specimens proved not to be influenced by the length of daylight. A water analysis after strong rainfall reveals a very hard, alkaline water rich in salt.

Other: Rataj (1975a) differentiates between var. *berteroi* (North and Central America) and var. *patagonicus* (Argentina), the description of which he bases exclusively on geographical origin. He simultaneously assumes that *E. berteroi* var. *patagonicus* could have been introduced by birds. Meanwhile, however, *E. berteroi* was also located in one habitat each in both Ecuador and Peru, contradicting this hypothesis. During their research Holm-Nielsen and Haynes (1986) found no typical differentiating features, which is why no varieties of *E. berteroi* have been recognized.

Echinodorus berteroi in its native location in Mexico.



Echinodorus bleheri

Rataj (1970)

Family: Alismataceae.

Synonyms: *Echinodorus paniculatus* auct. non Micheli, *E. "rangeri," E. "platyphylla."*

Etymology: *Echinodorus*: see *E. aschersonianus*; *bleheri*: after A. Bleher (?).

Distribution: Unknown.

Description: Medium-sized sword plant, emerged up to 40 cm, submersed up to 60 cm tall. Petiole 10–20 cm long, angular. Emerged blade narrow elliptic, 10–20 cm long, 2.5–6.0 cm wide, medium green. Apex acute or acuminate; base acute and slightly decurrent; 5 veins, the inner ones initially running concurrent with the midrib. Submersed blade very narrow elliptic, up to 40 cm long, 4–8 cm wide, medium to dark green, slightly undulate at the margin. Pellucid lines more or less long.

Inflorescences in both short- and long-day, rarely submersed, frequently emerged, long overtopping the plant, dependent, paniculate, with adventitious plants. Flowers about 0.8 cm in size; 9 stamens. Nutlets not seen.

Culture: *Echinodorus bleheri* combines a decorative appearance with optimum growth

qualities. The species has been regularly commercially available over many years. Within a few months, a comprehensive, dense bush with numerous leaves will develop in the aquarium. The leaves will grow to a height of 40–60 cm under good conditions. Due to the rapid growth, the substrate must occasionally be fertilized; the timing of this can easily be concluded from the growth behavior: if shorter, light green leaves suddenly develop and additional fertilization becomes necessary. A medium light intensity is sufficient. Recommended temperature range is 22–28 °C. In contrast to the similar *E. amazonicus*, *E. bleheri* rarely produces inflorescences with adventitious plants within the aquarium. In aquatic nurseries the plants are cultivated under conditions of high humidity and will thus form inflorescences more readily. **Ecology:** No detailed information is available.

Other: For the systematic classification of *E. bleheri* refer to *Echinodorus amazonicus*.

Echinodorus bleheri.



Echinodorus bolivianus

(Rusby) Holm-Nielsen (1979)

Family: Alismataceae.

Synonyms: *Alisma bolivianum* Rusby (1927), *Echinodorus austroamericanus* Rataj, and others.

Etymology: *Echinodorus*: see *E. aschersonianus*; *bolivianus*: originating from Bolivia.

Distribution: South America: Ecuador, Brazil, Bolivia, Peru, Argentina, Paraguay.

Description: Small marsh plant, stoloniferous, emerged up to 25 cm, submersed up to 10 cm tall. Emerged blade up to 20 cm petiolate, linear, 2–8 cm long, 3–10 mm wide, with an acute apex and decurrent base, medium green. Submersed blade 1–2 cm petiolate, up to 10 cm long, 5–7 mm wide, light green; 3(–5) veins. Long pellucid lines.

Inflorescences emerged, equal in height or overtopping the plant, up to 13 cm petiolate, without adventitious plants. Inflorescence erect, simple, up to 6 cm long, with 1–4 whorls. Peduncle and rachis round, soft. Each whorl with 6–14 flowers. Flowers 2–6 cm petiolate, about 1.3 cm in size. Bracts about 5 × 2 mm, sepals up to 6 × 2 mm, petals 6 × 3 mm in size; 9 stamens; filament up to 3 mm in

length. Nutlets 0.8–1.5 mm long, 0.5–1 mm wide, 3 ribs on each side, without glands; tiny beak.

Culture: This small-growing sword plant with its light green leaves is a very decorative and recommended plant for the aquarium's foreground. Its cultivation essentially corresponds to that of *E. quadricostatus*. According to the author's experience, however, *E. bolivianus* requires a longer initial start-up phase and seems to be slightly more light-demanding. Optimum temperature range is 20–26 °C. Strong specimens develop many runners.

Ecology: At times of low water, the author observed individual specimens of *E. bolivianus* on the Rio Guaporé (southwestern Brazil), about 5 m from the riverbank, in shaded locations. One can assume that the plants will be found in shallow water during high-water periods. Due to the low moisture content of the soil, they achieved a growth height of only 10–15 cm.

Other: For a differentiation to *E. quadricostatus* refer to the latter.

Echinodorus bolivianus.



Echinodorus cordifolius

(Linné) Grisebach (1857)

Family: Alismataceae.**Synonyms:** *Alisma cordifolia* L. (1753), *E. ovalis* Wright, *E. fluitans* Fassett, *E. radicans* Engelmänn, and others.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *cordifolius*: cordate leaves.**Distribution:** subsp. *cordifolius*: Venezuela, Caribbean islands, Mexico; subsp. *fluitans*: eastern U.S., Mexico, Colombia, Venezuela.**Description:** Sturdy marsh plant. Petiole up to 120 cm long, triangular, glabrous. Blade wide ovoid, up to 40 × 24 cm, with an acute, occasionally round apex as well as a round, truncate or slightly cordate base with round base lobes, medium green, submersed frequently with red spots; (5)7–9 veins. Pellucid lines short and distinct (subsp. *cordifolius*) or absent (subsp. *fluitans*).

Inflorescences emerged or submersed during the long-day, initially erect, subsequently dependent and creeping, with adventitious plants. Peduncle up to 110 cm. Inflorescence with 7–12 whorls, rachis triangular. Each whorl with 5–12(–15) flowers. Bracts 1.5–2.5 cm long, acuminate. Flowers 1–7 cm petio-

late, about 2.5–3 cm in size. Sepals about 5 × 6 mm. Petals 1.2–1.7 cm in size, almost round. About 17–22 stamens; filament up to 2 mm. Numerous carpels. Nutlets about 2.5 mm long, 0.8–1.2 mm wide, 3–4 ribs on each side and 1–5 glands; beak up to 1 mm.

Culture: *Echinodorus cordifolius* belongs to the medium-sized to large sword plants requiring large aquariums for cultivation. Unfortunately, most of the cultivated populations with increasing size and in the long-day (a lighting period exceeding 12 hours) tend to protrude from the water with their cordate leaf blades. To suppress this undesired quality in aquarium cultivation it is advisable to limit the lighting period to 11 hours. If *E. cordifolius* is still being cultivated under long-day conditions, a nutrient-rich substrate as well as a not too powerful lighting setup should be used. Plants that have grown too large can be kept to a smaller size for a considerable period of time by radically removing leaves. Adventitious plants are best suited for the purpose of aquarium planting because these require many months until they need trimming. Those not inclined to go to these efforts, or who have aquariums with a height of less than 50 cm, should preferably utilize one of the smaller *Echinodorus* species. Cultivation of *E. cordifolius* is also possible in unheated room aquariums and outdoors during the summer months. Optimum temperature range is 20–28 °C.**Ecology:** *Echinodorus cordifolius* populates boggy locations. The author discovered subsp. *fluitans* in Mexico (8/1985) in (probably) temporary waters in shallow depths.**Other:** According to Haynes and Holm-Nielsen (1986, 1994), *E. cordifolius*, *E. ovalis* Wright and *E. fluitans* Fassett constitute a polymorphic species. The authors differentiate between the subspecies *cordifolius* and *fluitans* (Fassett) Haynes and Holm-Nielsen which differ through their habitats as well as the presence or absence of pellucid lines in the leaf blades.***Echinodorus cordifolius*.**

Echinodorus cordifolius**'Tropica Marble Queen'****Family:** Alismataceae.**Etymology:** 'Tropica Marble Queen' = cultivar description, refers to the highly spotted leaves, especially on emerged plants. This pattern occurs through a differing quantitative distribution of chlorophyll within the leaf cells, resulting in a color pattern consisting of light and dark green and brown color tones.**Description:** Sturdy marsh plant, up to 50 cm tall. Leaves long petiolate, emerged narrow ovoid with a cordate base, acute, 15–20 cm long and 6–9 cm wide. Submersed blade initially lanceolate, 10–20 cm long and 2.5–5 cm wide, with increasing maturity shaped as in the emerged specimen. Inflorescence with adventitious plants.**Culture:** *Echinodorus cordifolius* 'Tropica Marble Queen' is a decorative and unproblematic cultivar. Commercially available specimens originating from emerged cultivation completed by dealers appear specifically decorative and conspicuous through their chlorophyll layer, as was described above. Plants cultured in a hothouse will continue to grow well under water and are fast-growing.

The degree of impression of the spots will, however, decrease under conditions of submersed growth, so that the design pattern will eventually become less distinctly identifiable. Under weak lighting, the intensity of the spots appears to be stronger than under high light intensity. More light, however, will enhance the formation of anthocyanins so that juveniles depict a strong red-brown touch.

Washed sand is sufficient for the purpose of cultivation. The plants tolerate medium-hard and hard water as well as pH-values within the slightly alkaline range. The tendency to form emerged leaves is very strong, which is why specimens that have matured too strongly have to be substituted with smaller ones after a couple of months.

Other: This cultivar is not—as initially assumed—a cross, but quite clearly a virus-infested plant. The virus quickly transmits itself from emerged plants to the floating leaves of waterlilies so care has to be taken! A cultivar patent was not issued.

Leaf blade of *Echinodorus cordifolius* 'Tropica Marble Queen'.



Echinodorus grandiflorus

(Chamisso and Schlechtendal) Micheli
(1881)

Family: Alismataceae.

Synonyms: For subsp. *grandiflorus*: *Alisma grandiflorum* Cham. and Schlecht. (1827), *E. argentinensis* Rataj, and others. For subsp. *aureus* (Fassett) Haynes and Holm-Nielsen: *E. grandiflorus* var. *aureus* Fassett, *E. muricatus* Grisebach, and others.

Etymology: *Echinodorus*: see *E. aschersonianus*; *grandiflorus*: featuring large flowers.

Distribution: Subspecies *grandiflorus* from central Brazil to Argentina, subsp. *aureus* from Cuba, Mexico to Argentina.

Description: Strong marsh plant. Petiole up to 100 cm long, round. Subspecies *aureus*: leaf blade up to 40 × 35 cm in size, ovoid to very wide ovate with obtuse, round apex and cordate base with round base lobes. Petiole and leaf blade underside with warts and stellate hairs along the veins, (9–)17–21 veins. Leaf blade with pellucid dots. Subspecies *grandiflorus*: emerged blade lanceolate to narrow ovoid, usually up to 20 × 9 cm, with an acute apex and round (not cordate) base, medium green in color, under intense sunlight

also depicting red venation, juveniles dark red, 5–7(–11) veins. Pellucid lines distinct, rarely absent. Submersed leaf blade more or less petiolate, very narrow elliptic, up to 25 cm long, 1.5–4 cm wide, acute, base decurrent, light green.

Inflorescences paniculate, overtopping the plant, without adventitious plants. Peduncle up to 60 cm, round. Inflorescence up to 50 cm in length, with 5–10 whorls, rachis triangular, mammillate and pubescent. Whorl with 3–9 flowers. Flowers from almost sessile, up to 1 cm or up to 4 cm petiolate, 1–3.5 cm in diameter. Bracts 0.8–3 cm long, aciculate. Sepals 5–8 mm long, 4–5 mm wide. Petals 0.6–2 cm long, 0.5–1.8 cm wide; 21–30 stamens; filament 2–3 mm. Numerous carpels. Nutlets 2–3 mm long, 0.5–1.5 mm wide, 2–3 ribs on each side and several glands; beak from almost absent to about 1 mm long.

Culture: *Echinodorus grandiflorus* subsp. *aureus* is little suited to submersed cultivation. Within the aquarium, with increasing size the specimens display a quick desire to raise their leaf blades out of the water. In contrast, subsp. *grandiflorus* is an undemanding plant and well suited for aquarium pur-

Echinodorus grandiflorus subsp. *grandiflorus* on the banks of the Rio Guaporé (Brazil).



poses. Occasionally long petiolate leaves will suddenly develop in this regularly commercially available subspecies (often sold as *E. argentinensis*) which should be removed immediately; mature leaves will subsequently again remain shorter petiolate. Cultivation is possible in both soft or hard water with optimum temperatures between 20 and 28 °C. The utilization of a nutrient-rich substrate is recommended.

Ecology: Subspecies *grandiflorus* is characterized by a surprising degree of variability. In August 1987, the author conducted research in natural habitats on the Rio Guaporé (Southwestern Brazil) where the plants grew together with *E. paniculatus*. On dry soil they reached only a reduced height, and thus developed small blades and short inflorescences. Plants from dry locations produced leathery leaf blades, whereas those located near the water showed soft, dependent, long petiolate leaf blades. Plants under intense sunlight had not only pure green but also green blades with red veins and dark red leaves. At another location in Brazil, subsp. *grandiflorus* grew together with *E. subalatus*. In contrast to the habitat described above the

author observed subsp. *aureus* in Mexico, not on riverbanks but in small, temporary waters. In July 1993, in Argentina (between La Cruz and Mercedes) the author studied submersed and emersed specimens of *E. grandiflorus* which featured pellucid lines and spots. Water values of one location read as follows: temperature 9.5 °C (air temperature 18 °C at 14:30 h), pH 7, GH < 1 °dH, KH 3 °dH, 150 µS/cm, O₂ 11.5 mg/L.

Other: According to Haynes and Holm-Nielsen (1986), the *E. argentinensis* species, described only later by Rataj, is identical to the holotype of *E. grandiflorus* and is, therefore, to be interpreted as a synonym of *E. grandiflorus*.

The main differentiating feature between the two subspecies of *grandiflorus* and *aureus* is the occurrence of pellucid spots or lines in the leaves. Intermediate forms appear in the overlapping habitats which display the pellucid spots and lines.

E. grandiflorus submersed in its native habitat in Argentina.



Echinodorus grisebachii

Small (1909)

Family: Alismataceae.

Synonyms: *Echinodorus gracilis* Rataj.

Etymology: *Echinodorus*: see *E. aschersonianus*; *grisebachii*: after the German botanist H.R.A. Grisebach (1814–1879).

Distribution: Central and South America.

Description: Small to medium-sized, variable marsh plant with a short, thin rhizome. Petiole 2–23 cm long, triangular. Emerged leaf blade very narrow elliptic to elliptic or narrow ovoid, 5–12 cm long and 1.5–6 cm wide, with an acute apex and acute or round base, entire, light to medium green in color, 3–7 veins. Pellucid lines present. Submersed blade up to 20 cm long, petiolate, strap-shaped to linear, pellucid, up to 40 cm long and 0.5–3(–4) cm wide, acute, and with a decurrent base, medium to dark green in color.

Inflorescences emerged, erect, simple, overtopping the plant, with or without adventitious plants. Peduncle and inflorescence together up to 35(–50) cm long. Rachis triangular. Inflorescence with 4–8 whorls, each whorl with 3(–6) flowers. Flowers from very short to 1.5 cm petiolate, about 1 cm diameter.

Bracts up to 1 cm long. Sepals about 3 mm long, 2–3 mm wide. Petals about 5 mm long, 4 mm wide; 9 stamens; filament up to 1 mm in length. Numerous carpels. Nutlets up to 2 × 0.5 mm in size, aliferous, with 3–4 ribs and 2–8 glands; beak up to 0.3 mm long.

Culture: This species, often confused in the aquarium literature with other species of the genus, has so far only occasionally been collected and cultivated. It is currently not being commercially distributed.

According to the author's own experience, *E. grisebachii* does not have any special requirements with regard to maintenance in the aquarium. It is, however, more light-demanding than the closely related species *E. amazonicus*, *E. bleheri* and *E. parviflorus*. In a bright location, as well as in a nutrient-rich substrate, strong plants will develop up to a height of 60 cm. Inflorescences have so far not been observed on magnificently growing specimens of *E. grisebachii*, which have been kept in aquariums for many years. In contrast, inflorescences with adventitious plants will very frequently develop on *Echinodorus amazonicus*, *E. bleheri* and *E. parviflorus* in submersed cultivation.

***Echinodorus grisebachii*.**

Ecology: In August 1987, the author researched native habitats of *E. grisebachii* on the Rio Guaporé (southwestern Brazil) during low-water periods. Dependent on the degree of humidity of the soil, very different plants developed. On relatively dry ground, about 5 m from the riverbank, only about 7 cm tall, flowering and fruiting compact rosettes developed under intense sunlight. The uppermost layer of the substrate consisted of soil, the next of sand. Populations of *E. grisebachii*, growing on the riverbank in shallow water and shaded, showed both emerged as well as submersed leaves which were much larger and longer petiolate. The inflorescences as well as the pedicels were significantly longer. The author could not find the formation of any adventitious plants within the populations of *Echinodorus grisebachii* located on the Rio Guaporé.

In August 1989, W. Staeck located populations of *E. grisebachii* on the riverbank of the Rio Tiquire (Venezuela, Estado Bolivar), a contributory of the Rio Caura which flows into the mid-Orinoco. The plants grew in such deep water that they could hardly be

made out from the bank. Water values: temperature 25.3 °C (air temperature 29 °C at 17:00 h), pH 5.8, GH and KH < 1 °dH, 35 µS/cm.

During the low-water period of April 1992, the plants grew entirely emerged at the same location and also displayed inflorescences and fructescences with isolated adventitious plants. Water values: temperature 28.5 °C (air temperature 36 °C at 16:30 h), pH 6.6, GH and KH < 1 °dH, 10 µS/cm.

Other: In aquarium literature, several plants are mentioned under the name of *E. grisebachii*. The collections described above—determined by the *Echinodorus* expert Holm-Nielsen—develop only narrow submersed leaves. Haynes and Holm-Nielsen (1994) consider *Echinodorus grisebachii* as identical to *Echinodorus amazonicus*, *E. bleheri* and *E. parviflorus*, an opinion which the author does not share (see *Echinodorus amazonicus*).

Echinodorus grisebachii flowering on dry soil on the banks of the Rio Guaporé (Brazil).



Echinodorus horizontalis

Rataj (1969)

Family: Alismataceae.

Synonyms: None.

Etymology: *Echinodorus*: see *E. aschersonianus*; *horizontalis*: horizontal, refers to the position of the leaf blade.

Distribution: South America: eastern Venezuela, Colombia, Ecuador, Peru, Brazil, in the Amazon's wider and more outlying catchment basin.

Description: Medium-sized marsh plant, emersed 20–50 cm, submersed up to 35 cm tall, 35–50 cm wide. Rhizome up to 7 × 2 cm in size. Petiole up to 20(–60) cm long. Leaf blade 10–20(–25) cm long, 5–10(–15) cm wide, ovoid, acute, base cordate round, light green, juveniles light brown in color; 7–11 veins. The pellucid lines form a network independent of the veins.

The relatively rare inflorescences develop on emersed plants during the short-day, but can, however, also occasionally be found on submersed specimens. Peduncle 15–20(–50) cm long, round, glabrous, 4–5 mm thick. Inflorescence 30–40(–100) cm long, overtopping the plant, declinate. Inflorescence not

paniculate, with 3–4 whorls. Whorl with 3–4(–6) flowers and few adventitious plants. Flower up to 2 cm long petiolate, opened only a little and only briefly, up to 1.5 cm in diameter; (2)3 bracts, about 2–3(–7.5) cm long, about 7 mm wide, cuspidate. Sepals up to 10 mm in width, 9 mm long, clinging closely. Petals up to 5 × 4 mm in size; 20–22 (according to Rataj 24–30) stamens; filaments and anthers each up to 1.5 mm long. Numerous carpels. Fructescence 1 cm in diameter. Nutlets club-shaped, 3-ribbed on each side, not aliferous, with 6–9 glands, 2.5–3.1 mm long, 0.2–1.1 mm wide; beak 0.4–0.8 mm long.

Culture: *Echinodorus horizontalis* is a recommended medium-sized sword plant which has, for many years, been part of aquatic plant nurseries' assortments but is only rarely commercially available because, compared to other *Echinodorus* species, it displays a considerably lower degree of vegetative multiplication through adventitious plants. In the aquarium, growth is relatively slow so that even under optimum conditions many months will pass before a sturdy specimen will have developed. After a long initial start-up phase, a wide horizontal rosette will form which has

***Echinodorus horizontalis*.**

to be considered during the planting process. Solitary plants require a free, bright location. To ensure healthy growth, however, a medium-level light intensity is sufficient. Washed sand or gravel will usually do as substrate, but a nutrient-rich substrate will certainly enhance growth towards strong specimens. The species grows best in soft, weak acid water, but medium-hard water is still adequate for successful cultivation. The pH-value should lie in the weak acid to neutral range. In soft water, iron chlorosis can occasionally occur so that when deficiency symptoms appear, extra fertilization should occasionally be provided. The optimum temperature range lies between 25–29 °C.

Ecology: The author was able to research several habitats in the vicinity of the town of Coca (Ecuador) where *E. horizontalis* constitutes a frequent species which, however, only occurs in low individual numbers. Native living environments include streams and small rivers with a moderate current strength as well as flood areas. During low-water levels (beginning of February 1990), all specimens grew at the edge of the biotope in shallow water which was murky or clear and often

displayed brownish coloring due to humus matter. With their strong root network, the plants were firmly anchored in soft, boggy, sandy soil, the top layer of which consisted of foliage. The locations which were studied were both fully sunlit as well as partially shaded by surrounding trees. Inflorescences and individual adventitious plants were found on several specimens existing in shallow water. The inflorescences were declinate so that the adventitious plants were rooted in the water and the bog. Locally conducted water analyses at several locations always revealed a very soft, acid environment. The following water values were recorded at one native habitat which featured the largest specimens of *Echinodorus horizontalis* living in small populations: water temperature 26 °C (air temperature 29 °C at 12:45 h), pH-value 6.5, GH < 1 °dH, KH 3 °dH, 95 µS/cm.

Echinodorus horizontalis in its natural location near the town of Coca (Ecuador).



Echinodorus macrophyllus

(Kunth) Micheli (1881)

Family: Alismataceae.**Synonyms:** For subsp. *macrophyllus*: *Alisma macrophyllum* Kunth (1841); for subsp. *scaber* (Rataj) Haynes and Holm-Nielsen: *Echinodorus scaber* Rataj, *E. scaber* var. *prolifera*-*tus* Rataj.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *macrophyllus*: large-leaved.**Distribution:** Southern Nicaragua, Venezuela to Argentina.**Description:** Sturdy marsh plant. Petiole up to 1 m long, round, glabrous (subsp. *macrophyllus*) or mammillate with stellate hair (subsp. *scaber*). Emerged blade 15–40 cm long, 8–25 cm wide, ovoid to wide ovoid, with obtuse, round or emarginate apex as well as cordate rounded base; (7–9)11–13 veins. Leaf underside with pubescent warts. Submersed leaves are smaller, with brownish spots, mostly with 7–9 veins. Pellucid lines absent.

Inflorescences emerged, paniculate, with or without adventitious plants. Peduncle up to 120 cm, round, mammillate and pubescent. Inflorescence up to 50 cm long, with 4–13

whorls, rachis triangular. Each whorl with 6–9(–20) flowers. Bracts about 0.5–1.3 cm long. Flowers 0.5–2 cm petiolate, about 2.3–2.7 cm in size. Sepals about 5 × 7 mm. Petals 1.5 × 1.7 cm in size; 20–25 stamens; filament up to 3 mm. Numerous carpels. Nutlets 1–3 mm long, 0.8–1.2 mm wide, with 2–4 lateral ribs on each side, with or without 1–5 glands; beak 0.3–1.2 mm.

Culture: As detailed in *E. cordifolius*.**Ecology:** The author discovered two locations: 1) Southwestern Brazil (3/1986), large, flowering populations in the shallow water of a flood area of the Rio Cuiabá, together with *E. paniculatus*. Water analysis: temperature 28 °C (air 27 °C at 10:00 h), pH 5.5, GH/KH < 1 °dH, 18 µS/cm; and 2) Peru (8/1992), Laguna Cocococha, Reserva Natural de Tambopata: small, flowering populations, unshaded at the edge of a lake in a loamy soil.**Other:** Rataj described *E. scaber* which is supposed to differ from *E. macrophyllus* in producing different looking fruit. According to Haynes and Holm-Nielsen (1986), Rataj used the immature fruit of *E. macrophyllus* for his identification.**Plant and flower of *E. macrophyllus* subsp. *scaber* on the Laguna Cocococha (Peru).**

Echinodorus martii

Micheli (1881)

Family: Alismataceae.

Synonyms: *E. martii* Micheli β *major* Micheli, *E. major* (Micheli) Rataj, *E. "leopoldina."*

Etymology: *Echinodorus*: see *E. aschersonianus*; *martii*: after the German botanist K.F.P. von Martius (1794–1868).

Distribution: Eastern Brazil.

Description: Medium-sized sword plant, emerged up to 25 cm, submersed up to 60 cm tall. Emerged: stem up to 5 cm, half-round. Blade oblanceolate, up to 20 × 5 cm in size, light green. Apex acute; base usually truncate. Margin undulate; 3–7 veins. Submersed plants considerably larger. Petiole 5–20 cm long. Blade narrow oblanceolate, up to 40 cm in length, 3–5(–10) cm wide, light green. Pellucid lines are usually absent.

Inflorescences emerged and submersed, overtopping the plant, not paniculate, with adventitious plants. Peduncle almost round, with up to 10 whorls; rachis slightly angular. Whorl with 6–15 flowers. Bracts 1.7–2.5 cm long, adnate, conspicuously wide (1 cm), cuspidate. Flowers 0.5–1.5 cm petiolate, 1.5–2

cm in diameter. Petals 7–9 mm wide, 1.1–1.3 cm long; 9–12 stamens. Nutlets featuring 4 ribs and many glands on each side.

Culture: This plant with its undulate light green leaves, also well-known to aquarists under the name of *E. major*, must be considered one of the most magnificent sword plants overall. In contrast to other large-growing species of this genus, it does not form floating or emerged leaves in submersed cultivation. This positive characteristic, together with its generally unproblematic maintenance, make it an ideal aquarium plant. Difficulties with cultivation can usually be resolved through intensive fertilization of the substrate as well as more powerful lighting. Maintenance is successful in both soft as well as hard, weak acid or slightly alkaline water. Recommended temperature range 24–26 °C.

Sometimes the plant will die off after inflorescence and fructescence (annual populations?).

Ecology: Detailed data is unavailable.

***Echinodorus martii*.**



Echinodorus opacus

Rataj (1970)

Family: Alismataceae.**Synonyms:** None.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *opacus*: shaded, dark.**Distribution:** Southern Brazil: Paraná (Ponta Grossa) and Santa Catarina (Tangara).**Description:** Medium-sized aquatic plant with a short rhizome, up to 30 cm tall. Petiole up to 20 cm long, almost round, hard. Blade narrow ovoid to ovoid, up to 13 cm long, 8 cm wide, conspicuously stiff, leathery, medium to dark olive green. Apex acute, mucrous or obtuse rounded; base cordate on strong specimens. Leaf margin flat; 5–7 veins. Pellucid markings absent. Number of chromosomes $2n = 33$.

Inflorescences very rare in submersed specimens, simple, overtopping the plant, with adventitious plants. Flowers become stunted during the budding stage. Nutlets unknown.

Culture: *Echinodorus opacus* is an undemanding and very rare sword plant. The leathery stiff leaves, which are initially decumbent and grow erect in more mature plants, are very conspicuous. Root growth is exceptionally slow which is why a targetedsubstrate fertilization with loam in the root zone of the plant is recommended. Since newly planted specimens require a long initial growing phase, they should be moved as little as possible. Even under good conditions *E. opacus* will display very slow growth. Even though the light requirement is only moderate, care should be taken that the plants have a free-standing and bright location. Maintenance is best possibly in soft, weak acid water. Optimum temperature range is 18–24 °C. Vegetative propagation is only very limited and is achieved through rhizome partitioning and adventitious plants on the rare inflorescences. Emerged cultivation is difficult but possible in conditions of high humidity.**Ecology:** Wanke and Wanke (1994) describe the discovery of *E. opacus* in the Rio Chopim. Upstream from a natural weir, the water was dammed up to a length of several hundred meters. Large populations of *E. opacus* with cordate emerged leaves grew on sandbanks in the middle of the river. Six larger populations, each with several hundred specimens, were discovered. No *Echinodorus* could be located outside this dammed section. Other aquatic plants included *Isoetes* spp., *Mayaca* and *Eichhornia*. The water measured a conductivity of 42 $\mu\text{S}/\text{cm}$ and a pH-value of 6.5 at a temperature of around 23 °C. A joint occurrence of *E. opacus* with *E. portoalegrensis* and *E. uruguayensis* in the Rio Peixe at Videira, reported by de Graaf (1992), could not be confirmed by Wanke and Wanke.**Other:** The systematic position of *E. opacus* and *E. portoalegrensis*, as described by Rataj in 1970 on the basis of sterile specimens, is unclear. In the meantime, isolated cases of inflorescences with adventitious plants (the flower of which did not open) have appeared in cultivation. Nothing is known about the appearance of mature nutlets. As in the case of *E. osiris*, it might be a case of natural hybrids or mutations in both species.***Echinodorus opacus*.**

Echinodorus osiris

Rataj (1970)

Family: Alismataceae.

Commercial name: *E. osiris rubra*, *E. aureobrunneus*.

Etymology: *Echinodorus*: see *E. aschersonianus*; *osiris*: refers to the Brazilian aquatic plant nursery Lotus Osiris.

Distribution: Southern Brazil (few habitats).

Description: It is distinguished from *E. uruguayensis* by the following features: *E. osiris* easily forms emersed leaves. Petiole 40–70 cm long. Blade elliptic or narrow ovoid, 15–25 cm long, 7–15 cm wide. Submersed blade 10–40 cm petiolate, very narrow elliptic, narrow lanceolate or oblanceolate, 10–30 cm long, 3–9 cm wide, olive green or brown-red. Leaf margin more or less undulate; (3)5(7) veins. Pellucid dots and markings are distinct.

Peduncle with inflorescence exceeds 1 m in length, with adventitious plants; 6–10 whorls. Often flowers do not open; 18(–24) stamens. Sterile. Number of chromosomes $2n = 33$.

Culture: *Echinodorus osiris* is one of the most recommendable sword plants for the purposes of aquarium cultivation. Its red-brown leaves, which develop under intense lighting, give the solitary plant a specifically decorative appearance. The species can be kept in soft and hard water without encountering problems. A substrate rich in nutrients will enhance strong growth. Optimum temperature range is 18–26 °C. The triploid plant does not produce any seeds, so multiplication relies on adventitious plants on the inflorescences as well as on the rhizome.

Ecology: In August 1967 (winter), Schulze (1968) discovered large populations of *E. uruguayensis* (syn. *E. horemanii*) and *E. osiris* as well as several plants of *E. opacus* and *E. grisebachii* (described as *E. intermedius* Grisebach) in a rapid-flowing river west of Curitiba and Ponta Grossa. The water, deficient in nutrients, did not register any hardness, and a pH value of 6.2 and a temperature range of 12–15 °C were recorded. *Echinodorus osiris* grew unshaded in water up to 50

cm deep in very solid, rocky-gravelly-loamy substrate. In March 1994, Wanke and Wanke researched two rivers near Guarapuava containing *E. osiris* and other species. Under temperatures of 21 °C and below 20 °C, pH-values of 6.3 and 6.5 and a conductivity measuring below 20 $\mu\text{S}/\text{cm}$ were recorded.

Other: Haynes and Holm-Nielsen (1994) record this triploid *Echinodorus* as a synonym for *E. uruguayensis*. There are, however, several reasons which support the notion that we are concerned here with a natural hybrid. The habitat description above, for example, shows that at least four *Echinodorus* species exist together in the immediate vicinity of each other. Crossbreeding experiments with these species could bring proof of a hybrid origin. Even though, so far, only *Echinodorus* species with a chromosome count of $2n = 22$ (with the exception of the triploids) are known, it cannot be excluded that a species with a count of $2n = 44$ have been discovered, which would easily explain the existence of triploid hybrids. Furthermore, the sterility as well as the presence of both pellucid dots and lines of differing length in the leaf blades of *E. osiris* could point to a hybrid (almost exclusively long lines in *E. uruguayensis*).

Echinodorus osiris.



Echinodorus palaefolius

(Nees and Martius) MacBride (1931)

Family: Alismataceae**Synonyms:** *Sagittaria palaefolia* Nees and Martius (1823), *Alisma palaefolium* (Nees and Martius) Kunth, *A. ellipticum* Martius, *E. palaefolius* var. *latifolius* (Micheli) Rataj, *E. palaefolius* var. *minus* (Seubert) Rataj, and others.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *palaefolius*: with primeval, primitive leaves.**Distribution:** Eastern Brazil.**Description:** Sturdy marsh plant. Petiole up to 75 cm long, almost round, grooved, glabrous. Emerged blade ovoid, not cordate, up to 30 cm long, 23 cm wide, leathery, dark green. Apex obtuse rounded or slightly acute; base truncate or obtuse and short decurrent. Submersed blade more or less petiolate, very narrow elliptic, up to 30 cm long, 2–4 cm wide, light green; 5–11 veins. Pellucid markings absent.

Inflorescences in both short- and long-day, simple or panicate, initially erect, then dependent and creeping, with adventitious plants. Peduncle up to 70 cm long, triangular.

Inflorescence over 1 m long, with 7–11 whorls, each with 6–14 flowers; rachis triangular. Bracts 1.5–5 cm long, very narrow, cuspidate. Flowers up to 7 cm petiolate, 2–2.5 cm in size. Sepals 5 × 3 mm in size. Petals 1.2 cm long, 1 cm wide. Usually 12 stamens. Filaments about 1.5 mm. Nutlets 2–3 mm long, 1 mm wide, with 3–5 ribs and 1 gland on each side; beak about half the length of the nutlet.

Culture: *Echinodorus palaefolius* has been cultivated by aquarists since the early 1970s. The undemanding species can be easily kept in an aquarium, although it tends to protrude from the aquarium under optimum living conditions. If leaves that push out of the water are removed immediately, adults will initially remain shorter petiolate. The author achieved good cultivation results in medium-hard water with a weak acid pH-value, intense lighting and a temperature range of 23–28 °C. Adventitious plants are best suited for aquarium planting since they root quickly and develop a medium-sized rosette consisting of elliptic leaf blades.**Ecology:** No detailed data is available.***Echinodorus palaefolius*.**

Echinodorus paniculatus

Micheli (1881)

Family: Alismataceae.

Synonyms: *Echinodorus cylindricus* Rataj, *E. macrocarpus* Rataj.

Etymology: *Echinodorus*: see *E. aschersonianus*; *paniculatus*: paniculate, refers to the inflorescence.

Distribution: Central and South America (from southern Mexico to Argentina), frequent.

Description: Strong marsh plant, more than 1 m tall, with a thick, short rhizome. Petiole triangular, more than twice the length of the blade. Leaf blade from linear, lanceolate to narrow ovoid, up to 25 cm long, 1–8 cm wide, aciculate, acute or obtuse at the base, medium green in color, occasionally spotted deep red. Submersed leaves with a long, triangular petiole. Leaf blade linear to strap-shaped, 10–20 cm long, 0.5–1.5 cm wide, light green, occasionally slightly brownish; 3–7 veins. Pelucid markings absent.

Inflorescences in emerged plants, simple or paniculate, mostly shorter, rarely longer than the leaves, sometimes with adventitious plants. Peduncle erect, with adventitious

plants dependent, up to 1 m in length, triangular, glabrous. Inflorescence up to 30 cm long, with 4–9(–14) whorls, rachis triangular. Each whorl with 6–45(!) flowers. Bracts 1–2(–5) cm long. Flowers 1–5.5 cm petiolate, diameter about 3–4 cm. Sepals about 6 mm long, 5 mm wide. Petals up to 2.5 cm wide, 2.1 cm long, almost round. About 17–22 stamens; filament up to 1.5 mm long. Numerous carpels. Nutlets 1.7–3 mm long, 0.7–1.5 mm wide, aliferous, 4–5(–7) ribs on each side, no glands; beak up to 0.7 mm long.

Culture: *Echinodorus paniculatus* has only a limited suitability for submersed cultivation. In the aquarium the species will develop long petioles with very narrow and short blades, which is hardly decorative. Also, under acceptable growth conditions emerged leaves will develop quickly. Juveniles are mainly suited for the purposes of temporary submersed maintenance. By utilizing a nutrient-deficient substrate and not too powerful lighting (a little experimentation is necessary at this stage), the process of protruding growth can be slightly delayed. Furthermore, leaves protruding from the water should be severed, resulting in adult leaves remaining mostly

***Echinodorus paniculatus*.**



smaller petiolate. Otherwise, the species has no special requirements as to maintenance. Multiplication occurs through seeds. Optimum temperature range is 20–28 °C.

Ecology: *Echinodorus paniculatus* populates the banks of pools and rivers as well as flood areas. During the low-water period in August 1987, the author discovered expansive populations on the riverbank of the Rio Guaporé (southwestern Brazil) in semishaded and fully sunlit locations, together with other *Echinodorus* species (among others *E. grandiflorus*). Surprisingly, no adventitious plants were found on the numerous inflorescences (for a detailed water analysis of the Rio Guaporé see p. 40).

In August 1985, small populations of *E. paniculatus* were found in three other native habitats in Mexico, with the plants growing in shallow water on a loamy substrate. Water values of one location: temperature 27 °C, pH 7.5, GH 4 °dH, KH 5 °dH, NH_4^+ 0.5 mg/L, NO_2^- , 0.05 mg/L, Fe not found. The plants in Mexico had numerous adventitious plants on their inflorescences.

Other: *Echinodorus paniculatus* can be well distinguished from other species by the usu-

ally lanceolate (unlobed) leaf blades, with an acute apex, as well as the erect, many-flowered inflorescence which mostly does not overtop the plant.

It is unclear if *E. glaucus* Rataj represents a good species or can be classified together with *E. paniculatus*, because the species displays only minor differences to *E. paniculatus*. *Echinodorus glaucus* is covered with a layer of wax, a blue-green (= *glaucus*) leaf upperside, round petioles, 24–28 stamens, as well as nutlets with three glands on each side. Haynes and Holm-Nielsen (1994) consider *E. glaucus* as a synonym to *E. paniculatus*.

The plant named by Wendt (1952–1955) as *Echinodorus paniculatus* was subsequently described by Rataj 1975 as *Echinodorus bleheri*.

Echinodorus paniculatus var. *dubius* Fassett is a synonym to *Echinodorus grandiflorus* subsp. *aureus*.

Echinodorus paniculatus near Teresina in eastern Brazil.



Flowers of *E. paniculatus*.



Echinodorus parviflorus

Rataj (1970)

Family: Alismataceae.

Commercial name: *Echinodorus peruensis*, *E. tocatins*.

Etymology: *Echinodorus*: see *E. aschersonianus*; *parviflorus*: small-flowered.

Distribution: Not definitely known; mass exports in the 1970s arrived supposedly from Peru and Bolivia.

Description: Medium-sized marsh plant. Leaves up to 15 cm petiolate. Blade narrow lanceolate in the short-day, lanceolate in the long-day, up to 27 cm long, 4–6.5 cm wide, medium green, frequently with dark cross-venation, juveniles also brownish. Apex and base acute. Leaf surface often slightly bullate; 5 veins. Pellucid markings more or less long.

Inflorescences in emerged plants in the long-day, simple, with adventitious plants. Peduncle and rachis triangular. Inflorescence with 4–6 whorls. Each flower whorl with 5–6 flowers. Pedicel up to 1 cm long. Bracts cuspidate, shorter than the pedicels. Flower diameter about 0.8 cm. About 9 stamens. Nutlets 1.5–1.7 mm long, 1 mm wide, with 3–4

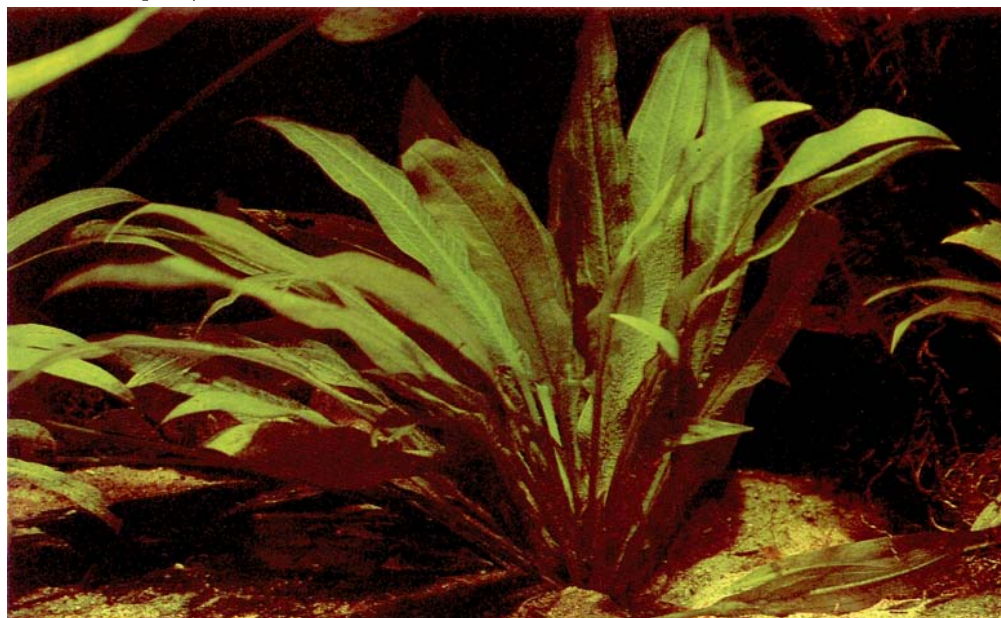
ribs on each side and many irregularly spread small glands; beak about 0.5 mm long.

Culture: An undemanding and rapidly growing species, *E. parviflorus* has been well-known to aquarists for many years under the name of black sword plant. A 20–40-cm tall compact rosette, consisting of numerous leaves, will develop in the aquarium, depending on the living conditions. Use in the middle or rear planting zone is therefore recommended. Moderate lighting as well as a sand substrate are adequate. Cultivation is equally possible in both soft and hard water. Temperature range is about 20–26 °C. Shorter leaf blades, as well as inflorescences with adventitious plants, will develop in the aquarium under lighting periods of less than 12 hours (short-day).

Ecology: No reliable information on the native habitats is available.

Other: Refer to *E. amazonicus* for the systematic status.

Echinodorus parviflorus.



Echinodorus parviflorus 'Tropica'

Etymology: Cultivar name 'Tropica' after the aquatic plant nursery of the same name in Hjortshøj, Denmark.

Distribution: Unknown.

Description: Small to medium-sized marsh plant. Petiole up to 5 cm long. Blade narrow obovoid, up to 12 cm long, 5 cm wide, coarse, a little bullate, medium to dark green in color, without dark cross-venation. Apex obtuse rounded, with an up to 7-mm long tip. Leaf margin slightly undulate. Number of chromosomes $2n = 22$. Description otherwise as in *E. parviflorus*.

Culture: At the beginning of the 1980s, the aquatic plant nursery Tropica received a shipment of aquarium plants that included a deviate form of *Echinodorus parviflorus*, which was cultivated in Singapore and Sri Lanka. In 1985, this plant was described as the cultivar *Echinodorus parviflorus* Rataj 'Tropica' [Aqua-Planta 10 (3/1985): 15] and has since found widespread acceptance in aquaristics.

In contrast to *E. parviflorus*, the 'Tropica' cultivar forms a compact rosette in the aquarium with a growth height of 5–10 cm, making it ideal for planting in the foreground. This

species, however, is not only more light-requiring compared to the wild form, but also more demanding. Even under good cultivation conditions growth will be relatively slow. A free-standing location as well as a nutrient-rich substrate are essential to ensure optimum development. Temperature range is about 22–24 °C. In contrast to submersed cultivation, the maintenance of the terrestrial form is not difficult under good lighting conditions. The specimens grow rapidly and will frequently produce inflorescences with adventitious plants, so that vegetative multiplication is exceptionally quick and productive. Even though mature nutlets are formed simultaneously, the propagation of *Echinodorus parviflorus* 'Tropica' in the nurseries proceeds by means of adventitious plants. The formation of flowers in the aquarium is very rare.

Other: If one considers *E. parviflorus* and *E. bleheri* as synonyms to *E. grisebachii* (Haynes and Holm-Nielsen 1994), then the cultivar 'Tropica' would also have to be considered as belonging to *E. grisebachii*. The author, however, does not follow this line of argument at this stage (see also *E. amazonicus*).

Echinodorus parviflorus 'Tropica'.



Echinodorus portoaalegrensis

Rataj (1970)

Family: Alismataceae.

Synonyms: None.

Etymology: *Echinodorus*: see *E. aschersonianus*; *portoaalegrensis*: after Porto Alegre.

Distribution: Southern Brazil: Rio Grande do Sul, Porto Alegre (habitat description doubtful) and Santa Catarina, Tangara.

Description: Medium-sized aquatic plant with a long, thin rhizome. Petiole up to 15 cm long, almost round, hard. Blade narrow elliptic to elliptic or narrow lanceolate to oblanceolate, 5–16 cm long, 2–7 cm wide, conspicuously stiff, leathery, medium to black olive green coloration. Apex obtuse acuminate to mucronate; base acute. Margin moderately undulate, blade slightly twisted; 3–5 veins. Pellucid markings absent. Number of chromosomes $2n = 44$.

Inflorescences rare in submersed specimens, overtopping the plant, with adventitious plants. Inflorescence with about 6 whorls carrying only a few flowers. Nutlets unknown.

Culture: *Echinodorus portoaalegrensis* belongs to medium-sized, demanding, very rare

sword plants. The cultivation essentially corresponds to that of *E. opacus*. The stiff leaves of *E. portoaalegrensis*, however, do not grow erect but are rather slightly bent downwards. Depending on the substrate's nutrient supply an up to 30-cm wide rosette with 10–20 leaves reaching a growth height of 5–15 cm, will form in the aquarium. *Echinodorus portoaalegrensis* is, therefore, recommended only for the greening of the foreground.

Ecology: Wanke and Wanke (1994) report enthusiastically about large populations of *E. portoaalegrensis* in the Rio Peixe, right in the middle of the town of Videira in Santa Catarina state. Even though large volumes of effluent are channelled into the river, the populations still looked good. The specimens also featured spoon-like emerged leaves as well as inflorescences with adventitious plants. A water analysis revealed temperatures between 21 and 24 °C, a pH-value of 7.4 and a conductivity of 64.5 $\mu\text{S}/\text{cm}$. These data contradict the water values registered by de Graaf (1992).

Other: Refer to *E. opacus*.

***Echinodorus portoaalegrensis*.**



Echinodorus quadricostatus

Fassett (1955)

Family: Alismataceae.

Synonyms: *Echinodorus magdalenensis* Fassett, *E. quadricostatus* Fassett var. *xinguensis* Rataj, var. *magdalenensis* (Fassett) Rataj, *E. isthmicus* Fassett? *E. latifolius* (Seubert) Rataj?

Etymology: *Echinodorus*: see *E. aschersonianus*; *quadricostatus*: four-ribbed (fruit).

Distribution: Central and South America.

Description: As indicated for *E. bolivianus*, different in the following features: emerged rosette small, about 5 cm tall, 10 cm wide, with about 20–25 leaves. Petiole to about 1 cm length. Leaf blade 2.5–5 cm long, 0.6–1 cm wide, slightly pellucid, light green. Submersed sometimes indistinguishable from *E. bolivianus*. Nutlets usually with 4 ribs.

Culture: *Echinodorus quadricostatus* belongs to the especially recommendable (although a little light-demanding) foreground plants. Growth is equally good in soft and hard water, although soft water will often lead to an iron deficiency (chlorosis?), so that fertilization is necessary now and again. Fine sand or gravel is best suited as substrate. Un-

der conditions of good growth, the formation of cuttings from runners is so rapid that a dense “carpet” will develop within only a few weeks, which has to be regularly thinned or cleaned out. In doing so, the runners are separated from one another and only sturdy specimens are used for further planting. These are inserted slightly spaced out and at least 3 cm from the front glass panel. After only a short time, the specimens will be so strong that they will develop new runners.

Other: According to research completed by the Laboratory for Plant Taxonomy of the Agricultural University of Wageningen (Netherlands), *E. quadricostatus* is a triploid plant ($2n = 33$). It can be clearly distinguished from the closely related *E. bolivianus* by the emerged growth formation. Until final clarification of it as either a hybrid or a mutation, the author will retain the previous name of *E. quadricostatus*.

***Echinodorus quadricostatus*.**

Echinodorus **'Rosé'**

Family: Alismataceae.

Etymology: *Echinodorus*; see *E. aschersonianus*; 'Rosé': cultivar name, refers to the leaf coloration.

Distribution: No native distribution.

Description: Medium-sized hybrid, about 10–25 cm tall, 20–40 cm wide in the aquarium. Emerged plants: leaf blade up to 45 cm petiolate, ovoid, up to 25 × 15 cm in size, dark olive green, juveniles reddish, occasionally with reddish spots. Apex obtuse aciculate; base round and short decurrent. Margin slightly undulate or flat. Submersed plants: petiole 5–20 cm long. Blade very narrow elliptic, 10–25 cm long, 2–8 cm wide, light to dark olive green in color, juveniles rosé-colored, with or without red spots; 5–7 veins. Pellucid lines mostly very long.

Inflorescences overtopping the plants, decinate, paniculate, with numerous flower whorls and many adventitious plants. Whorl with 12–16 about 3-cm large flowers. Pedicel 1.5–7 cm long. Bracts 1–2 cm long, aciculate. Sepals 8–10 mm long, 4–6 mm wide. Petals

1.8–2.0 cm wide, 1.5 cm long; 19–24 stamens. Nutlets fertile.

Culture: *Echinodorus* 'Rosé' is a decorative hybrid of which two color forms are kept. These are distinguishable by the presence or absence of conspicuous dark red spots which are spread over the entire submersed leaf blade. Strong specimens of *E. 'Rosé'* develop a loose spread out rosette. A medium to intense lighting, a free-standing location and a nutrient-rich substrate are recommended. Temperature range is 22–30 °C. Use—depending on the aquarium size—either in the middle or background. Multiplication should only be done through adventitious plants since sowing would lead to a division into different phenotypes.

Other: According to Hans Barth (1988), the breeder of this cultivar, *E. 'Rosé'* is a cross between *E. horizontalis* and *E. horemanii* "red" (color form of *E. uruguayensis*). A similar looking, but different plant is the cultivar *Echinodorus* 'Oriental' which is a mutation that appeared during tissue cultivation of *Echinodorus* 'Rosé'.

Two color forms of *Echinodorus* 'Rosé'.



Echinodorus 'Rubin'

Family: Alismataceae

Etymology: *Echinodorus*: see *E. aschersonianus*; 'Rubin': cultivar name refers to the leaf coloration.

Distribution: No native habitat.

Description: Large-growing hybrid, up to 60 cm tall in the aquarium. Submersed leaves 5–25 cm petiolate. Blade very narrow elliptic, 15–35 cm long, 3–5 cm wide, leathery. Juveniles more or less deep brown-red in color, later dark olive green. Apex acute or obtuse aciculate; base acute. Margin slightly undulate; 5 light green-colored veins, the inner ones initially run together with the midrib.

Inflorescences overtopping the plants, with several flower whorls and numerous adventitious plants.

Culture: In its habitus and coloring, this new cultivar, commercially available only since 1993, is very reminiscent of *E. osiris*, but is a deeper brown-red, with a high content of red turning even more deep red under good lighting; the lighter veins contributing to its conspicuous appearance. *Echinodorus* 'Rubin' is a large-growing solitary plant for spacious

aquariums and is easy to keep. Cultivation is not difficult in soft or hard, weak acid to moderately alkaline water. A medium light intensity and unwashed sand are adequate for optimum keeping. The author achieved good growth results, both at low temperatures (around 22 °C) as well as continuously high temperatures (26–30 °C). Juvenile adventitious plants are initially suitable for planting in the foreground where they will be decorative for a couple of months; once they have reached a certain size they have to be moved to the background.

Reproduction can occur through adventitious plants on the inflorescences as well as through rhizome partition. In some aquatic plant nurseries, *Echinodorus* 'Rubin' is propagated by tissue culture.

Other: According to information from the breeder, Hans Barth, this cultivar was selected from a population resulting from cross-breeding between *Echinodorus horemanii* "red" (color form of *E. uruguayensis*) and *E. × barthii*.

Echinodorus 'Rubin'.



Echinodorus schlueteri

Rataj (1981)

Family: Alismataceae.

Synonyms: None.

Etymology: *Echinodorus*: see *E. aschersonianus*; *schlueteri*: dedicated name (not explained when first used).

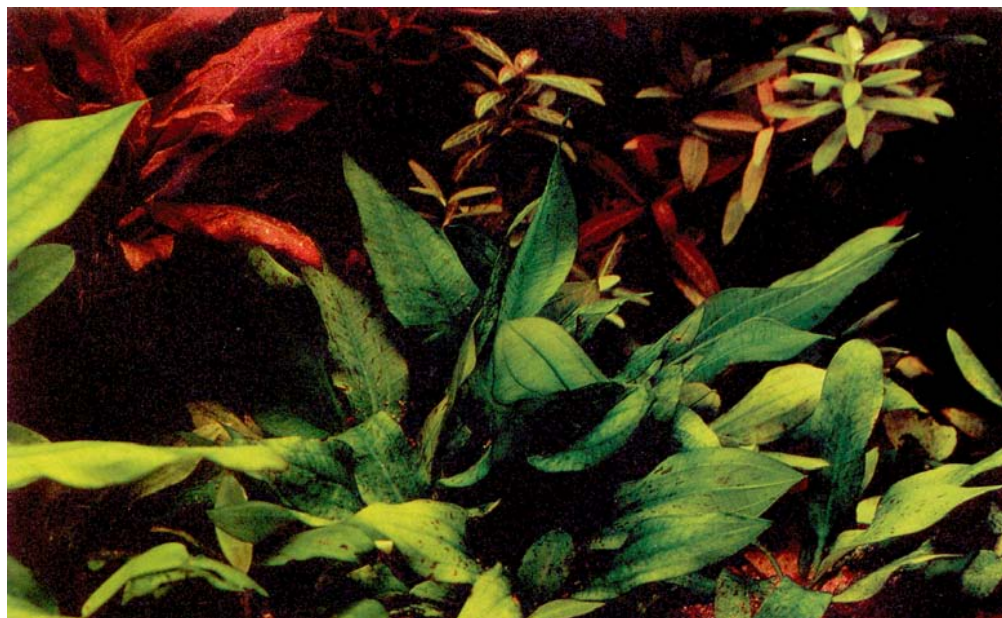
Distribution: Unknown.

Description: Small to medium-sized marsh plant, 5–25 cm tall. Leaves up to 20(–40) cm petiolate. Blade narrow ovoid to ovoid, up to 16(–23) cm long, 10(–16) cm wide, with acute or fine acuminate apex and more or less cordate rounded base. Margin flat or slightly undulate. Coloration is light to medium green, submersed also moderately brownish red with more or less intense light brown spots; 5–9 veins. Pellucid lines and dots distinct.

Inflorescences are formed submersed and emerged, overtopping far over the plants. Peduncle dependent, paniculate, triangular, frequently with stellate hair; peduncle and inflorescence up to about 70 cm in length, with 2–3(–7) whorls. Rachis triangular. Each whorl with 3–9(–11) flowers. Bracts 10–25 mm long. Flowers up to 8 cm petiolate, 2.5–3.5 cm in diameter. Sepals 6 mm long, 5

mm wide. Petals 2 × 2 cm in size; 20–24 stamens; filament about 2–3 mm. Nutlets about 2.4 mm long, 1.2–1.5 mm wide, not curved, aliferous, 3(4) ribs on each side and a total of 3–6 glands; beak about 0.5 mm long.

Culture: Even though *E. schlueteri* has been in culture for only a couple of years the plant has achieved a surprising distribution among aquarists. It must be one of the most suitable and recommendable sword plants for aquaristics, combining in an optimum way a decorative appearance, unproblematic cultivation as well a rapid multiplication. It is definitely adaptable to different living conditions. Good growth results have been achieved in both soft as well as medium-hard water, with pH-values ranging between 7 and 8. A nutrient-rich substrate enhances the formation of strong roots and, thereby, nutrient absorption, but the specimens also grow well in gravel soil. If nutrient deficiencies become visible (glassy leaf blades or bad growth in general), fertilization above water may also be conducted. The plants obviously seem to prosper better at low temperatures (22–25 °C) compared to high temperatures (up to 30 °C) which can also still be tolerated.

***Echinodorus schlueteri*.**

Echinodorus schlueteri is possibly an especially nitrogen-appreciating plant, because the best growth results were achieved in one of the author's aquariums densely populated with fish, in which feeding took place quite often and where a lot of rot and decay had accrued. Even though the species cannot be characterized as specifically demanding on lighting, one should nevertheless provide the plant with a free-standing location within the aquarium. *Echinodorus schlueteri* multiplies a lot through adventitious plants on inflorescences which regularly form under water as well.

Ecology: Nothing is known about native habitats.

Other: *Echinodorus schlueteri* is supposed to have been imported by the Brazilian nursery Lotus Osiris.

***Echinodorus schlueteri* 'Leopard'**

This decorative cultivar originated in the aquatic plant nursery of Hans Barth, Dessau. According to information supplied by the

breeder (Barth 1988), it is a mutated plant of *E. schlueteri* which was discovered after sowing among a population of juveniles and was subsequently propagated. This cultivar differs from the normal plant through the intensely brown-spotted leaves, whereby, in contrast to the original, the spotting is mostly retained even in adult leaves. The plant is fertile and the seedlings, which occur through self-pollination, corresponded 100% to the new type. This plant was given the cultivar name of *Echinodorus schlueteri* 'Leopard', the cultivar name referring to the strong spotting of the leaves.

Echinodorus schlueteri 'Leopard', like *E. schlueteri*, is a recommended and magnificent plant, but is not as readily commercially available. It seems that this cultivar grows a bit slower and also multiplies at a slower rate. Cultivation corresponds to that of *E. schlueteri*.

Echinodorus schlueteri 'Leopard'.



Echinodorus subalatus

(Martius) Grisebach (1866)

Family: Alismataceae.**Synonyms:** *Alisma subalatum* Martius (1830), for subsp. *subalatus*: *E. longistylis* Buchenau, *E. andrieuxii* (Hooker and Arnott) Small var. *longistylis* (Buchenau) Rataj, *E. intermedius* (Martius) Grisebach; for subsp. *andrieuxii* (Hooker & Arnott) Haynes and Holm-Nielsen: *Alisma andrieuxii* Hooker and Arnott (1838), *E. andrieuxii* (Hooker and Arnott) Small, *E. ellipticus* (Martius) Micheli γ *ovata* Micheli.**Etymology:** *Echinodorus*: see *E. aschersonianus*; *subalatus*: slightly aliferous (petiole); *andrieuxii*: after Andrieux (dedicated name).**Distribution:** Widespread in Central and South America.**Description:** Variable marsh plant. Rhizome up to 5 cm long. Petiole much longer than the blade, angular, slightly aliferous. Emerged blade narrow elliptic to narrow ovoid, 7–20(–40) cm long, 2.5–9(–21) cm wide, with a round or acute apex and obtuse to truncate base, medium green. Margin entire or slightly undulate. Submersed leaves up to 20 cm petiolate. Linear to ribbon-shaped blade, up to about 20 cm long, 1–2 cm wide, light green incolor; 5–11 veins. Subspecies *subalatus*: distinct pellucid lines, subsp. *andrieuxii*: pellucid markings absent.Inflorescences emerged, erect, overtopping the plant, simple or paniculate in subsp. *subalatus*, simple in subsp. *andrieuxii*. Peduncle and inflorescence up to 70(–100) cm long. Triangular to aliferous rachis. Inflorescence up to 40(–80) cm long, with 3–13 whorls, with or without adventitious plants, each whorl holding 3–9 flowers. Bracts conspicuously narrow and cuspidate, 1.5–6 cm long, longer than the pedicels. Flowers 2–10(–15) mm petiolate, about 1.5 cm in size. Sepals 3–4 mm long, 2–3 mm wide. Petals about 1 cm long, 8 mm wide; 12 stamens (according to Haynes and Holm-Nielsen [1994] 15–20 stamens); filament up to 1.5 mm long. Numerous carpels. Aliferous nutlets, 3–5 ribs, 1 large gland on each side, 1.4–2.2 mm long, 0.8–1.1 mm wide; beak 0.3–0.7 mm long in subsp. *subalatus*, less than one-third of the length of the nutlet, beak conspicuously long in subsp. *andrieuxii* (0.8–1.4 mm), measuring more than half the length of the nutlet.**Culture:** In the aquarium, both subspecies of *E. subalatus* form a 30–50-cm tall rosette***E. subalatus* subsp. *andrieuxii* in Mexico.**

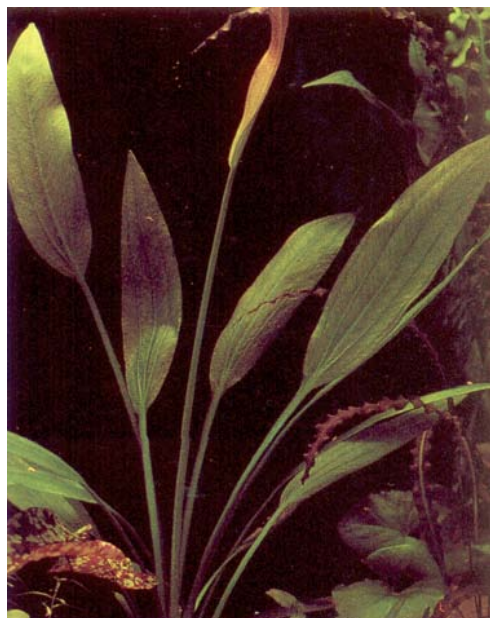
consisting of petiolate, relatively narrow blades. Through this unusual submersed growth, they deviate conspicuously from other sword plants. To achieve a decorative effect, one or several plants require a free-standing location in which they are well illuminated. The subspecies can be satisfactorily maintained in soft and medium-hard water. In general, though, they are very demanding. Flowering plants of *E. subalatus* are easily identifiable by their conspicuously long and narrow bracts.

Ecology: *Echinodorus subalatus* grows in boggy locations, on the edges of pools and lakes, as well as in flood areas. The author studied a habitat of *E. subalatus* subsp. *subalatus* in southwestern Brazil. In August 1987 (low-rainfall season), dense populations were found in a flooded area of a small river, growing largely emerged in shallow water in a boggy-loamy soil rich in laterite. The plants were flowering and fructifying abundantly, but did not produce any adventitious plants. Water values were as follows: temperature 22 °C (air temperature 27 °C around 10:00 h), pH 6.8, GH/KH < 1 °dH, 10 µS/cm. *Echinodorus grandiflorus* was also found in this

habitat. *Echinodorus subalatus* subsp. *andrieuxii* also populates marshy locations. The author found this subspecies in Mexico (8/1984), also growing almost emerged in shallow water. Here, too, the numerous inflorescences and infructescences did not display any adventitious plants which occasionally do occur in greenhouse cultivation.

Other: Haynes and Holm-Nielsen (1986, 1994) consider *E. subalatus* subsp. *subalatus* and *E. subalatus* subsp. *andrieuxii* as being subspecies of a widespread species. Both can be easily distinguished by the length of their beak (style foot of the nutlet). Rataj (1975a) described several intermediate forms between *E. subalatus* and *E. andrieuxii* which, according to him, were possibly hybrids, as *E. andrieuxii* var. *longistylis*. With the description of both subspecies by Haynes and Holm-Nielsen, this variety was withdrawn. In aquaristic literature *E. subalatus* is often confused with other species.

Echinodorus subalatus.



E. subalatus subsp. *subalatus* (Caceres/Brazil).



Echinodorus tenellus
(Martius) Buchenau (1868)

Family: Alismataceae.

Synonyms: *Alisma tenellum* Martius (1830), *E. tenellus* var. *ecostatus* Fassett, *E. parvulus* Engelm., *E. parvulus* Engelm. f. *randi* Fassett, *E. tenellus* (Martius) Buchenau var. *parvulus* (Engelm.) Fassett.

Etymology: *Echinodorus*: see *E. aschersonianus*; *tenellus*: very delicate.

Distribution: Widespread in North, Central and South America.

Description: Stoloniferous delicate marsh plant, without rhizome, emerged up to 6 cm, submersed up to 5 cm tall. Emerged leaves 0.5–4 cm petiolate; blade narrow lanceolate, entire, glabrous, 1.5–2.5 cm long, 2–4 mm wide, acute apex and decurrent base, with 1–3 veins, light green. Submersed leaves narrow linear, 5–10 cm long, 1–3 mm wide, light to dark green, also colored brownish. Pellucid markings absent.

Inflorescences only on emerged rosettes, usually widely overtopping the plants. Peduncle up to 13 cm long, thin, soft, round, glabrous. Inflorescence erect, simple, with 1–2 whorls, without adventitious plants. Each

whorl with 4–16, about 0.5–3-cm long petiolate flowers. Flower diameter 6–10 mm. Bracts up to 5 × 2 mm in size. Sepals about 2.5 mm long and 2 mm wide. Petals about 4 × 2.5 mm in size; 9 stamens; filament 0.5 mm long; 15–20 carpels. Nutlets obovate, 1.0–1.5 mm long and 0.8–1 mm wide, aliferous, up to 3 ribs on each side, without glands; the beak is tiny.

Culture: The smallest sword plant is one of the most popular and most decorative plants for the foreground. Under the right conditions, especially intense lighting, a dense and low “cushion” made of runners will form after only a short time. In aquariums over 50 cm in height, care has to be taken to ensure adequate lighting of the foreground because the delicate plants will otherwise quickly perish.

Because of the delicate roots, a fine gravel or sand substrate is best. *Echinodorus tenellus* will prosper better in soft to medium-hard, weak acid water compared to a hard, alkaline environment. The temperature tolerance of between 18 and 28 °C (temporarily even higher or lower) is very high.

Ecology: *Echinodorus tenellus* usually populates the banks of more or less large rivers. In

Growth form of *Echinodorus tenellus* with light green short leaves.



August 1987, during low water levels on the Rio Guaporé in southwestern Brazil, *E. tenellus*, on the one hand, grew in between the embankment vegetation about 5 m from the river in very dry soil; on the other hand, it grew frequently on the moist sand zones of the riverbanks. In very dry locations, the small populations produced compact, only about 3-cm high rosettes with numerous inflorescences and infructescences, due to the limited moisture content of the substrate. The plants populated shaded, though preferably sunny places. *Echinodorus tenellus* didn't grow far from *E. bolivianus* and *E. grisebachii*. Submersed populations were not found at that time of year so that *E. tenellus* is probably only found on the Guaporé during high-water periods in shallow water.

Similar observations were also made by W. Staeck in the following two native habitats: 1) Bolivia (border area between Brazil and Bolivia), Canal de Mandioré: in August 1991, the dense, flowering and emerged populations of *Echinodorus tenellus* grew in shallow water in a dry, collapsed riverbank, unshaded, in moist soil. Water values in the river: temperature 25 °C (14:00 h), pH 7.6, GH 1 °dH, KH

4 °dH, 60 µS/cm; and 2) Northeastern Venezuela, Barrancas—Tucupita road (4/1992): dense flowering “meadows” of *E. tenellus* were found in full sunlight, emerged and submersed, on the banks of larger lakes. Water values: temperature range 32–33 °C (air 34 °C at noon), pH 6.1, GH/KH < 1 °dH, 20–30 µS/cm.

Other: Two kinds of *Echinodorus tenellus* are cultivated in aquariums. They differ in coloring, leaf length, and growth height. Whereas one form displays light green, short blades, as well as low growth in the aquarium, the other form develops medium to dark green, often brownish, considerably longer leaf blades, and a growth height of up to 5 cm.

The “False Tenellus,” occasionally commercially available, is in fact *Lilaeopsis brasiliensis*.

Growth form of *E. tenellus* with long medium to dark green leaves.



Echinodorus uruguayensis

Arechavaleta (1903)

Family: Alismataceae.

Synonyms: *E. horemanii* Rataj, *E. subulatus* Niederlein, *E. martii* Micheli var. *uruguayensis* (Arechavaleta) Hauman, *E. africanus* Rataj.

Etymology: *Echinodorus*: see *E. aschersonianus*; *uruguayensis*: originating from Uruguay.

Distribution: Southern Brazil, Uruguay, Chile, northern Argentina.

Description: Medium-sized to large polymorph sword plant, with a long, thin rhizome, living predominantly in the water, up to 70 cm tall in the aquarium. Emerged plants: petiole 15–35 cm long, round. Blade elliptic, lanceolate, oblanceolate or narrow ovoid, 9–23 cm long, 3–8.5 cm wide, medium green. Apex acute; decurrent or acute base. Submersed plants: petiole 10–30 cm long. Leaf blade very narrow elliptic or narrow oblanceolate, strap-shaped, 30–45 cm long, 1–4 cm wide, coriaceous, light to dark olive green or black-red in color. Apex acute or obtuse aciculate; base decurrent. Margin flat or undulate; 3–5 veins, lateral veins submersed

initially concurrent with the midrib. Pellucid markings (individual dots) conspicuously long and distinct (easily identifiable also in submersed blades using a magnifying glass) or absent.

Inflorescences submersed and emerged, erect, overtopping the plants or curved downwards, in most cases simple, 2–3 adventitious plants on each whorl. Peduncle up to 25 cm long, more or less thick, almost round. Inflorescence 15–25 cm long, rachis triangular, with 2–4(–6) whorls. Each whorl with 8–12 flowers. Bracts 1.2–1.7 cm long. Flowers 1.5–6.5 cm petiolate, 3 cm in diameter. Sepals 5 × 5 mm in size. Petals 1.8 cm long, 2 cm wide. 17–22 stamens; filament 1–1.5 mm; anthers 1.5 mm. Numerous carpels. Nutlets 1.8–2.3 mm long; 0.8–1.1 mm wide, aliferous, (2–3)4(5) ribs and (2)3 glands on each side, arranged fairly regularly, diagonally in one row and individually between the ribs in the nutlet's upper half; very short beak, up to 0.3 mm long.

Culture: The cultivation of this decorative solitary plant, variable in coloration and shape, requires spacious aquariums from 300 L upwards. Under optimum growth condi-

Latifoliate growth form of *Echinodorus uruguayensis*.



tions, several magnificent specimens will develop over several months which can display up to 100 leaves. In contrast to many large-growing sword plants, *E. uruguayensis* does not develop any floating or emersed leaves. The plants will prosper best in soft to medium-hard, weak acid water, in a nutrient-rich substrate (loam), under medium to intense lighting and a not too high temperature (the optimum is around 18–24 °C). Multiplication can be achieved through rhizome partition, adventitious plants and seeds. Inflorescences will form relatively rarely, usually in the short-day; certain factors, such as low temperatures and high light intensity, however, may also trigger flower formation during the long-day. In the Hoechstetter nursery, Trostberg (Germany), for example, strong plants flower in loam soil during all four seasons.

Ecology: Wanke and Wanke (1994) report on several native habitats of *E. uruguayensis* in southern Brazil. Not only pure red and pure green but also mixed populations were found in a tributary of the Rio Peixe. Habitats in the Rio Peixe contained small-leaved or wide-bladed forms of this species. Water analyses revealed temperatures between 22.5–23 °C, pH-values between 6.6–7.11 and a conductivity of 68–82 µS/cm. Schulze (1968), too, reports extensively about a native habitat (see ecology section on *E. osiris*).

Pellucid markings in *E. uruguayensis*.



Other: Several color and growth forms are being cultured, all belonging to the species of *E. uruguayensis*. *Echinodorus horemanii*, described by Rataj and characterized by missing pellucid markings in the leaf blades, belongs to this collection of *E. uruguayensis* formations. Color formations with dark olive green and black-red leaf blades are maintained under the synonym of *E. horemanii*. The last mentioned color form, occasionally mentioned as *E. horemanii* “red” or “black-red” in aquarium literature, is undoubtedly a hybrid, which was proven in the aquatic plant nursery Julius Hochstetter, Trostberg, through self-pollination and sowing. This hybrid often served as the base material for other crossings (for example *Echinodorus* ‘Rubin’).

Echinodorus africanus, described by Rataj in 1981, also differs only marginally from *E. uruguayensis* and is also to be considered as belonging to this very variable species. The author searched for the supposed habitat in Cameroon and proved (Kasselmann 1984a, 1985a) not only the nonexistence there of any *Echinodorus* species, but also the occurrence of only the very similar *Limnophyton fluitans* which belongs to the same family. Therefore the *L. fluitans* plants collected from this location must have been confused later during cultivation with an ecological race of *E. uruguayensis*. Rataj described these plants as a new species (*E. africanus*) in the mistaken belief that they originated from Cameroon.

Echinodorus osiris Rataj is considered by Haynes and Holm-Nielsen (1994) as a synonym of *E. uruguayensis*. However, as long as it has not been established that the triploid *E. osiris* is, in fact, a mutated form of *E. uruguayensis* or a hybrid, supported by several indicators, the author considers it more correct to retain the previous name of *E. osiris*.



Narrow-leaved growth form of *E. uruguayensis* from Argentina.

Egeria densa

Planchon (1849)

Family: Hydrocharitaceae.**Synonyms:** *Elodea densa* (Planch.) Casp., and others.**Etymology:** *Egeria*: after the nymph Egeria; *densa*: dense, refers to the foliage.**Distribution:** Southeastern Brazil, Uruguay, Argentina, introduced in Chile, Mexico, North America, East Africa, Australia, New Zealand, Japan and Europe.**Description:** Perennial floating or aquatic plant with 2–3-mm thick, hard, fragile, densely leaved stem. Internodes 0.3–1 cm. Leaves sessile. Prophylls scaleous, opposite, upper leaves usually in 4-merous whorls. When branched, 2 leaf whorls are arranged above each other on the node (genus *Elodea* with a simple leaf whorl). Narrow oblong blade, 2–3 cm long, 3–4 mm wide, slightly recurved, transparent, pale dark green, with a single vein, occasionally with a reddish midrib. Scales on the leaf base. Margin fine serrate. Apex with minute denticles (*Lagarosiphon* genus with 2 denticles).

Plants dioecious. Flowers with nectaries. Male spathe with 2–4(–5) flowers, female

with 1(2) flowers; 3 green sepals; 3 white petals, more than twice the size of the sepals. Male flower usually with 9 stamens; filaments 0.8–4.5 mm long, swollen club-like, strongly mammillate. Female flower similar in appearance to the male flower, but a little smaller, with 3 yellow to orange-colored staminodes, 0.9–2.4 mm long; 3 styles; stigma usually trifid.

Culture: A popular and undemanding cold-water plant for many years, with only limited hardiness, *E. densa* grows free-floating or implanted, but can usually be kept at higher temperatures for only short periods. It adapts to soft, acid water, but will prosper especially well in water rich in lime with higher pH-values. In comfortable conditions, the species is a good oxygen provider because of its rapid growth.**Ecology:** In stagnant or slow-moving, usually deeper waters, in an acid, humus-rich environment, as well as in (up to pH 9.2, Japan) eutrophic water rich in lime. Endures winter without special survival organs. In some regions a pest due to its rapid growth. Two water analyses from Sri Lanka (1/1985) follow: 1) Small river with slow-moving water, pH 5.78, GH 3 °dH, KH 2 °dH, 91 µS/cm, rH 240 mV; and 2) Pond: temperature 30 °C(!), pH 6.04, GH/KH < 1 °dH, 85 µS/cm, rH 201 mV. Water analysis Argentina (7/1993): Big river, slow-moving, loamy clouded water, temperature 12 °C (air temperature 13.5 ° at 15:00 h), pH 7, GH and KH 2 °dH, 50 µS/cm.**Other:** Easy to distinguish from *Lagarosiphon major* by the whorled, soft leaves. Essential, but difficult to observe features for differentiation from other genera of the family (*Elodea*, *Hydrilla*, *Lagarosiphon*) are, among others, leaf structure, flowers and nectaries. Leaf arrangement, leaf size and color can be additional distinguishing criteria for aquarists.**Further reading:** Cook and Urmi-König (1984a).*Egeria densa*.

Egeria najas

Planchon (1849)

Family: Hydrocharitaceae.

Synonyms: *Elodea najas* (Planchon) Caspary, and others.

Etymology: *Egeria*: see *E. densa*; *najas*: similar to the *Najas* genus.

Distribution: Brazil, Uruguay, Paraguay, Argentina.

Description: Perennial, flooding, very variable aquatic plant with a roughly 1-mm thick, soft, slightly brittle stem. Internodes usually 0.1–1 cm long. Sessile leaves. Prophylls scaleous, opposite, the upper leaves usually arranged in 5-merous whorls. When branching, 2 whorls are arranged above each other at the node (*Elodea* genus with simple leaf whorls). Linear blades, acute, usually 2–3 cm long and 1–2 mm wide, more or less strongly recurved, with a single vein, light to dark green in color. Scales on the leaf base. Margin denticulate. Apex with tiny pointed denticles (*Lagarosiphon* genus with 2 denticles).

Plants are dioecious. No nectaries. Male spathe with 2–3 flowers, female spathe with 1(2) flowers, 3 green sepals, 3 white conspicuous petals more than twice the size of the sepals. Male flower usually with 9 stamens; filaments 0.6–1.3 mm long, not swollen club-like, hardly mammillate. Female flowers similar to the males in appearance, but slightly smaller, with 3 yellow to orange-colored staminodes, 0.4–1.3 mm long; 3 styles; stigmas usually trifold.

Culture: Even though *Egeria najas* is a very adaptable aquatic plant and does not cause any major problems when kept in an aquarium, this species is very rarely cultivated. It is a gracile stem plant which, in contrast to *Egeria densa*, is suited to permanent culture in a tropical aquarium and which will also prosper in high temperatures (optimum range is 15–26 °C). Soft and medium-hard water is recommended for cultivation purposes. To ensure a successful keeping, a high light in-

tensity is essential. In the aquarium, the plants can be best kept and cultivated when free-floating or also implanted, the latter being most effective as a group arrangement. *Egeria najas* can easily be propagated through lateral shoots.

Ecology: In August 1987, the author located *Egeria najas* in the Rio Guaporé, Mato Grosso (Brazil). Massive populations grew in calm side arms or bays unaffected by currents on the water surface, under intense sunlight. A detailed water analysis of the Rio Guaporé can be found on p. 40. Several water analyses were conducted in native habitats during July 1993 in the northeast of Argentina as well, summarily reported as follows: water stagnant or slow-flowing, cola-colored or clear, biotopes were unshaded, boggy-sandy or loamy substrate, water temperature 10.5–16 °C, GH < 1–7 °dH, KH < 1–7 °dH, pH 5.2–7.6, 10–240 µS/cm, Fe 0.05–0.1 mg/L. The plants grew in a water depth of up to 1 m. Refer also to a water analysis of a location in Argentina on p. 40, biotope No. 5.

Other: For differentiations to similar genera see *Egeria densa*.

Further reading: Cook and Urmi-König (1984a).

Egeria najas.



Eichhornia azurea

(Swartz) Kunth (1843)

Family: Pontederiaceae.**Synonyms:** *Pontederia azurea* Swartz (1788), *Piaropus azureus* (Sw.) Britton.**Etymology:** *Eichhornia*: after the Prussian Minister A. J. Fr. Eichhorn (1779–1856); *azurea*: sky blue, refers to the color of the flower.**Distribution:** Widespread in the tropical and subtropical regions of the Americas.**Description:** Submersed or floating plant, featuring a branched and very long caulome rooted in the substrate or the water. Emerged alternate and long petiolate leaves, petioles not swollen. Blade ovate to orbicular, up to 16 cm in size, medium green in color. Submersed plants erect. Leaves distichous alternate, linear, 10–25 cm long and 10 mm wide, light green color.

Inflorescence spike-like, up to 15 cm long, with 50 flowers (cultured plants with only a few flowers). Color and morphology of the flower varies greatly. Perigone with 6 lobes, in 2 circles, white, azure blue to strong violet coloration; inner tepals frayed, the upper leaf featuring a bright yellow spot; 6 stamens dif-

ferent in length; 1 style. Capsule many-seeded. The mature infructescence will disappear into the water.

Culture: A demanding, decorative, solitary plant, only the submersed growth form—reminiscent of a palm leaf—is relevant for cultivation in aquariums. The species will develop best in soft, very acid to neutral, nutrient-rich water. Experience with cultivation has shown, however, that *E. azurea* is a very adaptable species which also grows well in medium-hard water. Water movement as well as a nutritious substrate (loam addition) will have an advantageous effect. Optimum temperature range is 15–24 °C. Light intensity can not be high enough. Under conditions of light deficiency the plants will remain frail, with the lower leaves turning black and starting to rot. Emerged shoots, developing under good lighting and with strong-growing shoots on the water surface are, however, undesirable, which is why the shoots have to be trimmed early on. If the lower part of the stem is left in the substrate, it will develop new lateral shoots so that vegetative propagation does not pose a problem. A specifically effective decoration of the aquarium can be achieved by planting two to three shoots in a benched setting and with parallel arrangement of the leaves. During summer, the species can also be kept emerged in garden ponds, with decorative inflorescences forming in bright locations (see photo on p. 2).**Ecology:** In natural habitats, *E. azurea* will form a dense carpet of floating plants; submersed populations are rare. The author located the species in very different biotopes, in stagnant, pond-like waters and in marshy areas without any visible water movement, as well as in strong-flowing water, always under intense sunlight. A summary of numerous water analyses is given as follows (at air temperatures of 7–34 °C): water temperature 9–33 °C, pH 5.4–7.6, GH and KH < 1–8 dH, 10–360 µS/cm. See also the detailed water analyses No. 1 and No. 5 on p. 40.**Further reading:** Kasselmann and Staeck (1990).**Inflorescence of *E. azurea* (Venezuela).**



Eichhornia azurea.

Eichhornia crassipes

(Martius) Solms (1883)

Family: Pontederiaceae.**Synonyms:** *Pontederia crassipes* Martius (1823), and others.**Etymology:** *Eichhornia*: see *Eichhornia azurea*; *crassipes*: thick-stemmed.**Distribution:** Worldwide (originally Brazil).**Description:** Usually free-floating, up to about 50-cm tall plant with abundantly branched, bluish black roots. Internodes strongly compressed, so that the emerged leaves form a rosette. Petioles up to 40 cm long, spongy swollen. Sheath up to 15 cm long. Blade roundish to rhombic, sized up to 25 cm, apex obtuse, base cuneate to narrow cordate.

Inflorescence spike-like, with 20–35 flowers. Perigone with 6 lobes, in 2 circles, light violet, the inner upper lobes with a yellow spot; 6 stamens, in 2 levels; 1 style. Capsule 1.5 cm long, many-seeded.

Culture: This floating plant is only suitable for cultivation in aquariums if it is subjected to intense lighting and sufficient high space with humid, slightly circulated air between the water surface and cover are provided. The

species requires nutritious water. Cultivation in open aquariums is recommended, where care should be taken that the leaves are not burnt by lamps. If *E. crassipes* is placed in a garden pond during summer, magnificent inflorescences with numerous bright violet flowers will develop under conditions of warmth and light. Winter survival is best achieved in a bright and cool location. Even under good cultivation conditions, this species will usually reach only a fraction of the size attained by plants resident in native habitats.

Ecology: In natural waters, this species will often develop such large populations that they pose a problem for ship navigation. Numerous water analyses were conducted and are summarized here as follows: water temperature (20)27–33 °C, pH 6.5–7.5, GH < 1–12.5 °dH, KH < 1–6 °dH, 20–785 µS/cm. Also in brackish water (4900 µS/cm). Refer also to the water analyses of the Rio Guaporé and Rio Yanayacu p. 40.

Flowering *E. crassipes* in its habitat in Venezuela.



Eichhornia diversifolia

(Vahl) Urban (1903)

Family: Pontederiaceae.**Synonyms:** *Heteranthera diversifolia* Vahl (1805), and others.**Etymology:** *Eichhornia*: see *E. azurea*; *diversifolia*: with leaves of different shapes.**Distribution:** Central America (Antilles), South America (Guyana, Venezuela, Brazil).**Description:** Herbaceous aquatic plant, very similar to *Eichhornia natans* in its habitus (often confused with it, compare both descriptions). Submersed leaves up to 9 cm long, 2–5 mm wide. Floating leaves 2–6 cm petiolate; blade up to 2.3 cm × 1.6(–2.8) cm in size.

Inflorescence up to 5 mm petiolate, with 2–3(4) light blue or more or less blue violet flowers, 1–2 cm in size. Inner tepals up to 1.5 cm in length, 0.6 cm wide, one with a yellow spot, outer tepals slightly smaller. Seed capsule about 1 cm long and 2 mm thick.

Culture: *Eichhornia diversifolia*, like *E. natans*, is a demanding but better suited culture plant. It is also very light-hungry, but the leaves on the lower shoot segments will not blacken as quickly as is the case in *E. natans*.

For an optimum growth, soft, slightly acid to neutral water seems to be important. Optimum temperature range is 20–28 °C.

Ecology: In March 1986 and August 1987, the author researched three locations in the northern Pantanal (Brazil): 1) Marsh area, with stagnant water. The plants are rooted in boggy substrate in a depth of up to 1 m. Water temperature 28 °C, air temperature 27 °C at 10:00 h, pH 5.5, GH/KH < 1 °dH, 18 µS/cm; and 2) Pool with standing water. Substrate slightly loamy-boggy. Water temperature 35 °C on the surface, 25 °C in 50 cm depth, air temperature 28 °C at 11:00 h, pH 7.2–7.3, GH/KH < 1 °dH, 25 µS/cm. 3) Lake. Water temperature 24 °C, air temperature 25 °C at 16:00 h, pH 6, GH/KH < 1 °dH, 30 µS/cm. Refer also to the detailed water analyses of the Rio Guaporé (Brazil) and Venezuela No. 2, p. 40.**Other:** Inflorescences are essential for definite identification. Frail shoots of *E. diversifolia* cannot be differentiated from the smaller African *E. natans* on the basis of their habit alone.***Eichhornia diversifolia* (center).**

Eichhornia heterosperma

Alexander (1929)

Family: Pontederiaceae.**Synonyms:** *Eichhornia venezuelensis* Velasquez.**Etymology:** *Eichhornia*: see *E. azurea*; *heterosperma*: with different seeds.**Distribution:** Central and South America (up to northern Brazil).**Description:** Marsh plant with floating (in shallow water) or creeping (in boggy environments) nonpubescent shoots. Stem, petiole and sheaths conspicuously wine red in color. Emerged leaves up to 15 cm petiolate; petiole not inflated. Emerged leaf blades oblanceolate to wide obovoid, 3–10 cm long, 1.2–6.2 cm wide, glabrous. Sheath 1.5–6 cm long. Submersed leaves alternate, linear, 6–11 cm long.

Inflorescence spike-like, 5–6 cm long, with 4–8(–14) flowers. The petiole of the inflorescence is 1–5 cm long. Spathe 1.8–4 cm long. Flower about 1.5–4 cm in size. Perigone with 6 lobes. Perigone tube 10–20 mm long, pubescent. Tepals entire, pale blue to blue-violet in color, no yellow spot; 6 stamens different in length; glabrous filaments;

blue-violet anthers. Capsule 1.5–3 cm long; seeds ribbed, different in size.

Culture: *Eichhornia heterosperma* has previously not been introduced to aquaristics. A comparison regarding cultivation with *E. azurea* would be interesting, the latter obviously being indistinguishable in its submersed habit.**Ecology:** Grows in stagnant water in ponds and lakes, on the banks of which loose, herbaceous populations are formed at low water. In a native location in Venezuela, the substrate was sandy to loamy. Water analysis of this habitat by W. Staeck (4/1992): temperature 32 °C (air temperature 34 °C at noon), pH 6.1, GH/KH < 1 °dH, 20 µS/cm.**Other:** Essential distinguishing features to *E. azurea* are the strong wine red-colored stems and petioles found in *E. heterosperma*, also the inflorescences with only a few flowers, the unfrayed tepals, as well as the absent yellow spot on the mid-upper tepals, otherwise a distinctive feature of the species.**Further reading:** Kasselman and Staeck (1993a).

***Eichhornia heterosperma* in its native habitat in Venezuela.**



Eichhornia natans

(P. Beauvois) Solms-Laubach (1882)

Family: Pontederiaceae.

Synonyms: *Pontederia natans* P. Beauvois (1810), *Monochoria natans* Thomson, *Eichhornia diversifolia* Troupin (non Urban).

Etymology: *Eichhornia*: see *E. azurea*; *natans*: swimming.

Distribution: West Africa, individually also in East Africa (Tanzania, Madagascar).

Description: Sturdy aquatic plant. Submersed leaves alternate, spirally arranged or distichous, sessile, linear, acute, 3–8 cm long, 2–4 mm wide, light green on the apex of the shoot. Floating leaves 4–10 cm petiolate, with a sheath. Blade cordate, slightly overlapping at the base, 2 × 1.5 cm in size, dark green.

Flowers solitary, short petiolate, about 1 cm in size. Perigone in 2 circles, more or less blue-violet (no yellow spot, compare *E. diversifolia*), fused to form a tube at the base. Tepals sized up to 5.5 × 3 mm, obovate; 6 erect stamens differing in length. Fruit is a trilocular capsule with about 20–60 ribbed seeds, about 1 mm in length.

Culture: *Eichhornia natans* is a rare, de-

manding and very light-requiring species. Even though the plants normally grow in full sunlight in their native habitats, the lower shoot segments are usually blackish, a negative characteristic, which is why the species also seems less suited to cultivation. Even under high light intensity the leaves will remain green only at the shoot apexes. In the aquarium, *E. natans* will grow in soft to medium-hard and nutrient-rich water. The substrate should also be nutritious. Sturdy plants will also develop floating leaves and inflorescences within the aquarium. The seeds will best germinate under good lighting and high temperatures (30–35 °C).

Ecology: The author located *E. natans* in West Africa in very shallow water or depths of up to 1 m in pools and slow-flowing streams, always in intense sunlight. The substrate was, in most cases, boggy and often strongly interspersed with humus.

Other: *Eichhornia natans* is easily confused with *E. diversifolia* and *Heteranthera zosterifolia* (compare the flower descriptions).

Inflorescence of *Eichhornia diversifolia*.



Flower of *Eichhornia natans*.



Eleocharis acicularis

(Linné) Roemer and Schultes (1817)

Family: Cyperaceae.

Synonyms: *Scirpus acicularis* L. (1753), and others.

Etymology: *Eleocharis*: helos = marsh, charis = joy; *acicularis*: needle-pointed (leaves).

Distribution: Europe, North Africa, Asia, Sumatra, Australia, North and South America.

Description: Runner-producing, delicate marsh plant. Buried rhizome, filiform, strongly branched. Culms solitary or rosette-like, 5–20 cm (submersed rarely to 50 cm) tall, filiform, flat and angular, with a sheath at the base, light to medium green coloration.

Inflorescence a terminal 3–8(–15)-flowered, 2–5-mm long small spikelets. Flowers bisexual, spirally arranged. Ovoid glumes, obtuse, keeled. Perigone bristles 2–4(–6), narrow, equal or longer than the nutlets, often absent; 3 stamens; 3 adnate carpels; style caducous, style base remaining on the apex of the nutlet, small, about half as wide as the nutlet, constricted. Nutlets 0.7–1.2 mm long, oblanceolate to obovate, with 10 fine longitudinal ribs.

Culture: *Eleocharis acicularis* is a delicate,

undemanding, carpet-forming plant for the aquarium's foreground. Populations commercially available can be moderately well maintained under not too high temperatures (up to 25 °C) and intense light in a tropical aquarium. A sandy substrate is best suited. Propagation is done through runners. This species is excellently suited for planting in aquariums utilized for breeding. It is a hardy plant which may also be used on the edges of ponds, flowering in such places from June to October in shallow water.

Ecology: Grows on the banks and edges of marshes, ponds and rivers, preferably in moderately nutritious, more or less boggy sand, gravel and clay soils deficient in lime. In Asia often found in rice paddies. Remains sterile in deep water.

Other: Svenson (1929) described 5 forms and 5 varieties of *E. acicularis*, which displayed differences in the culms, spikelets and perigone bristles. Alongside these features, the number of flowers, the shape of the glumes, the appearance and size of the style base as well as the nutlet all serve to distinguish the roughly 150 different *Eleocharis* species.

***Eleocharis acicularis*.**

Eleocharis vivipara

Link (1827)

Family: Cyperaceae.

Synonyms: *Eleocharis prolifera* Chapman, *Chlorocharis vivipara* Rikli.

Etymology: *Eleocharis*: see *E. acicularis*; *vivipara*: live-bearing.

Distribution: Southern and southeastern U.S.

Description: Runner-producing, live-bearing (viviparous) marsh plant. Creeping rhizome. Culms arranged in rosettes, submersed up to 100 cm, emersed up to 30 cm long, filiform, firm, light to medium green. Leaf sheaths acute, firm; 1–3 whorls above each other; each whorl again has 6–8 culms.

Inflorescence is a many-flowered, live-bearing 3–8-mm long small spikelets. Bisexual flowers, spirally arranged. Obtuse glumes, usually not keeled, 2 mm long; 6 perigon bristles, almost as long as the nutlet; 3 adnate carpels; style caducous, style base pyramid-shaped, more narrow than the triangular, obovate, 1-mm long nutlet.

Culture: Even though *E. vivipara* has been known to aquarists as an undemanding plant since 1912, it is rarely kept. This may be due to the fact that the species forms a dense thicket of culms in low-set aquariums, which

appears rather “untidy.” Because of this very feature, however, the species is especially suited for aquariums used for breeding purposes. If the umbrella-like habitus is to have a pronounced effect, the plants have to be cultivated in aquariums as high as possible. For optimum growth a medium intense lighting is sufficient. In the long run, the plants do not appreciate temperatures above 27 °C. Sand or fine gravel is best as substrate, providing the fine roots with a good anchor. For vegetative propagation the blades, on which roots may also form, are cut off and planted. Only emersed plants will develop inflorescences.

Ecology: The species lives amphibiously on the boggy edges of waters, often in sandy soil.

Other: Mature nutlets are rare in cultivation.

Submersed plants of *Eleocharis vivipara*.



Elodea canadensis

Michaux (1803)

Family: Hydrocharitaceae.

Synonyms: *Udora canadensis* (Mich.) Nutt., and others.

Etymology: *Elodea*: helodes = marshy; *canadensis*: originating from Canada.

Distribution: North America, introduced to Europe (female plants), Australia, New Zealand.

Description: Perennial aquatic plant. Creeping or erect stem, about 1 mm thick, densely leaved. Prophylls opposite, the upper leaves mostly in trimerous whorls. Lateral shoots form on the nodes with simple leaf whorls (in contrast to *Egeria* with double leaf whorls). Leaves sessile, lanceolate, usually up to 10 mm long, 3 mm wide, slightly recurved, transparent, dark green, single-veined. Scales on the leaf base. Margin toothed. Apex with 1(2) acute denticles (magnifying glass!).

Plants dioecious, rarely monoecious. Nectaries are absent. Spathe with 1(2) flowers, male spathe longer than 6 mm; 3 green sepals; 3 petals, much narrower but almost equal in length to the sepals, very thin, inconspicuous, white. Male flowers more than 15 cm petio-

late. Usually 9 stamens; filaments very short. Female sepals and petals similar to their male counterparts, but smaller; 3 staminodes; 3 styles, usually bifid, 2.6–4 mm long.

Culture: *Elodea canadensis* is a recommended cold-water plant which prospers optimally at temperatures of 15–20 °C (temporarily also above 28 °C). It will grow especially well in alkaline water rich in carbonate. It is a light-demanding plant and, due to its rapid growth, it is a very good oxygen producer.

Ecology: Grows in lakes and ponds as well as in slow-moving, mostly eutrophic, occasionally also in slightly brackish water. In southeastern Australia and New Zealand, the species is still considered a pest. Winter shoots and turions develop during autumn.

Other: The number of leaves per whorls can, to a limited extent, be used to distinguish the plant from the very similar species *Elodea nuttallii* and *Hydrilla verticillata*.

Further reading: Cook and Urmi-König (1985).

Elodea canadensis.



Elodea nuttallii

(J.E. Planchon) St. John (1920)

Family: Hydrocharitaceae.

Synonyms: *Anacharis nuttallii* J. E. Planchon (1848), and others.

Etymology: *Elodea*: see *E. canadensis*; *nuttallii*: after the English botanist Thomas Nuttall (1786–1859).

Distribution: North America, introduced to Europe and Japan.

Description: Perennial aquatic plant. Creeping or erect stem, about 1 mm thick, loosely leaved, soft. Prophylls opposite, the upper whorls usually 4–5-merous. Lateral shoots on nodes with simple leaf whorls (in contrast to *Egeria* with double leaf whorls). Sessile leaves, lanceolate, usually up to 8 mm long, 2 mm wide, strongly recurved, on the shoot apex not tile-shaped (as in *E. canadensis*), transparent, pale dark green, single-veined. Scales on the leaf base. Toothed margin. Leaf apex with one acute denticle (magnifying glass!).

Plants dioecious, rarely monoecious. Nectaries are absent. Spathe with 1(–2) flowers, male spathe not longer than 4 mm; 3 sepals, green; 3 petals, much narrower and smaller

than the sepals, very thin, inconspicuous, white. Male flowers almost sessile. Usually 9 stamens; filaments very short. Female sepals and petals similar to their male counterparts; 3 staminodes; 3 styles, usually bifid, shorter than 2 mm.

Culture: *Elodea nuttallii* is a cold-water plant, cultivated as in *Elodea canadensis*, but it grows more slowly.

Ecology: Grows in stagnant or slow-moving water rich in lime, occasionally also in slightly brackish water. Survives winter with low-lying winter sapling turions on the floor. These will form new shoots in spring which will branch strongly on the water surface. In North America often sympatric with *E. canadensis*.

Other: In its vegetative state *E. nuttallii* is difficult to distinguish from *E. canadensis*. For differentiation to similar genera (*Egeria*, *Hydrilla*, *Lagarosiphon*) compare the descriptions for the individual species.

Further reading: Cook and Urmi-König (1985).

Elodea nuttallii.



Female flowers of *E. nuttallii*.



Eusteralis stellata

(Loureiro) Panigrahi (1976)

Family: Lamiaceae.**Synonyms:** *Mentha stellata* Loureiro (1790), *Dysophylla verticillata* Benth (nom. nud.), *Mentha verticillata* Roxburgh (nom. nud.), *Dysophylla stellata* Benth, *Dysophylla benthamiana* Hance, *Dysophylla ramoissima* Benth (nom. nud.).**Etymology:** *Eusteralis*: the derivation is unknown; *stellata*: star-shaped, refers to the leaf arrangement.**Distribution:** Japan, China, Taiwan, Malaysia, and Australia.**Description:** Marsh plant with erect or ascendent up to 50-cm long shoot. Glabrous stem or hardly pubescent, more or less furrowed. Internodes 3–5(–7)mm thick, few millimeters to 5.5 cm long. Leaves verticillate, emerged 3–6, submersed 3–10(–14) sessile or almost sessile leaves in 1 whorl. Leaf blade narrow lanceolate to linear, 4–9 cm long and 3–6 mm wide; margin toothed to serrate, more distinctly pronounced in terrestrial shoots. Emerged leaf surfaces green to dark green on the upperside, green to reddish in color on the underside; submersed green,

reddish or red-violet, leaf underside pale reddish, distinctly purple on the node.

Inflorescence is a 1–3(–6)-cm long spike, covered densely with almost sessile, about 2 mm-sized flowers. Bracts 1–2 mm long and 0.5–1 mm wide; 4 sepals, 1–1.2 cm long, plummy pubescence on the outside. Corolla pale pink or purple-red; 4 pubescent stamens. Nutlets about 7 mm long, elliptic, pale brown.

Culture: A decorative, fast-growing plant which, for healthy growth, requires a very high light intensity and a nutrient-rich substrate. Even under optimum growth conditions, the cultivated specimens will not reach the size of imported ones. Soft to medium-hard water with a temperature of 22–28 °C is advantageous. Propagation is through cuttings. After separation of the shoot apex, numerous lateral shoots will develop on the one remaining in the substrate. These have to be reduced because the leaf whorls will otherwise progressively become smaller in size. The thick and fleshy stem will break off easily during the planting procedure, so care is required. In order to prevent the shoots from impeding each other's growth, they should be planted individually and spaced out in the substrate. Strong specimens are also very suitable as solitary plants (photo cover page).If one lets *Eusteralis stellata* protrude right up to the water surface, it will continue to grow under the water surface. Transformation into the terrestrial form and emerged cultivation are difficult, and can only be done under conditions of high humidity and light intensity. In emerged cultivation, inflorescences with numerous small individual flowers are comparatively rare.**Ecology:** The plant exists in marshes, moors, ponds and rice paddies, in Sulawesi and New Guinea up to altitudes of 2500 m.**Other:** *Eusteralis stellata* displays a peculiar behavior, for which the author has, so far, failed to find an explanation: even under optimum growth, the shoot apex will die off after achieving about 10–20 cm of growth length. Simultaneously, however, new and strong lateral shoots will develop immediately.**Inflorescence of *Eusteralis stellata*.**

Glossostigma elatinoides

Bentham (1854)

Family: Scrophulariaceae.

Synonyms: *Tricholoma elatinoides* Bentham (1846).

Etymology: *Glossostigma*: glossoides = tongue-shaped; stigma = stigma, part of the flower; *elatinoides*: similar to the *Elatine* genus.

Distribution: Australia, New Zealand, Tasmania.

Description: Delicate marsh plant with creeping, often branchy shoots rooted on all nodes. Leaves opposite, up to 2.0 cm petiolate. Blade entire, glabrous, narrow spatulate, 0.3–1.2 cm long, up to 6 mm wide, colored light green. Apex obtuse or sinuate.

Flowers axial, solitary, about 10 mm petiolate. Calyx with 4 lobes, green, about 2 mm long. Corolla white, about 5 mm in size, with a trilobular upper and a lower lip with 2 lobes, slightly pubescent and fimbriate along the margin; 4 stamens (2 long and 2 short) within the crown. Style with a large, ligular stigma, only slightly protruding from the crown. Capsule with about 20 seeds.

Culture: *Glossostigma elatinoides* is a gra-

cile, well-growing, carpet-forming plant with high light requirements. Under high light intensity, the shoots will grow creeping; under light deficiency they will, however, strive to grow upright towards the light. Recommended for cultivation is, therefore, a low, well-illuminated aquarium. Soft, weak acid water with a temperature range between 22 and 26 °C is optimal for growth. The implanting of the delicate stems into a preferably coarse-grained substrate requires a little patience and should be done in a very careful manner. Propagation is through lateral shoots. During summer, this hardy species can be kept on the edges of ponds where flowers will regularly develop.

Ecology: Populates marshy regions, in rivers and lakes, often being completely submersed.

Other: The process of pollination is interesting: if the stigma is touched, it will lift up through a sensor mechanism and will expose the anther. Before an insect reaches an anther, carried pollen will be shed onto the stigma which is pubescent on the outside, thus resulting in cross-pollination.

***Glossostigma elatinoides* in the foreground.**



Gymnocoronis spilanthoides

(Hooker and Arnott) De Candolle (1838)

Family: Asteraceae.

Synonyms: *Alomia spilanthoides* D. Don (1835), *Gymnocoronis attenuata* DC., *G. subcordata* DC., *Adenostemma gymnocoronis* Schultz-Bip.

Etymology: *Gymnocoronis*: *gymnos* = naked, *corona* = crown; relating to the absent pappus of the calyx; *spilanthoides*: similar to a *Spilanthes*.

Distribution: Western Brazil, Bolivia, Chile, Uruguay, Argentina.

Description: Up to 2 m high, upright marsh plant. Stem more or less angular, hollow, to thumb-thick, green or wine red. Leaf blade up to 9 cm petiolate, lanceolate to ovoid, glabrous, up to 23.5 cm long, olive green, acute and with a round or cordate up to 12.5-cm wide base. Margin toothed. Submersed blade up to 1 cm petiolate, lanceolate, up to 12 × 4.5 cm in size, light green. The juice is very scented.

Flowerheads 6 mm in diameter, a terminal cyme with 80–150 tubiform florets. Marginal flowers are absent. Involucre with 25–35 acute, green bracts, each 4 × 0.7 mm in size.

Calyx without a pappus. Corolla 5-lobed, about 3.55 mm long. Style dichotomous, about 1 cm long; stigmas club-shaped enlarged, about 1.5 mm. Cypsela 2.0–2.3 mm long, 0.8–1 mm wide, ribbed, light green.

Culture: *Gymnocoronis spilanthoides* is a strong marsh plant with good adaptive capabilities to submersed cultivation. Hardness and pH-values are of subordinate importance for optimum maintenance. However, good lighting is important because otherwise not only will the lower leaves rot but the internodes will also stretch too far. Unwashed sand is adequate because a nutrient-rich substrate will result in unwanted strong growth. The optimum temperature range lies between 15 and 28 °C. Arrangement in a terraced group is recommended, with the thick-fleshed stems being planted individually. Reproduction occurs without problems through lateral shoots or through individual leaves drifting on the water surface.

Emersed cultivation is recommended only in very high and, spacious paludariums because the shoots grow very quickly. During emersed cultivation, high humidity and a saturated substrate are necessary. Strong speci-

Inflorescences of *Gymnocoronis spilanthoides*.





Gymnocoronis spilanthoides: on the left the cultivar 'Red-stemmed'.

mens often develop inflorescences during summer. The formation of seeds is rare.

Ecology: *Gymnocoronis spilanthoides* populates the edges of stagnant or slow-moving, temporary or permanent bodies of water. Water analyses, which were conducted by the author and W. Staeck in Bolivia and Argentina, resulted in soft to medium-hard water (GH < 1–4 °dH, KH < 1–12 °dH, 10–410 µS/cm), which usually displays an alkaline reaction (pH values usually between 7.5 and 8). In the months of July and August, i.e., during the colder time of year, readings of water temperatures between 6.5 and 24 °C were registered, with air temperatures between 0 °C (at night) and 34 °C. The substrate was sandy, loamy or muddy, the locations subjected to full sunlight.

***Gymnocoronis spilanthoides* 'Red-stemmed'**

This deviating form of *Gymnocoronis spilanthoides* was imported by the author and W.

Staeck from Bolivia in 1991 and Argentina in 1993. It is distinguishable by a distinctly slower growth and thus better suitability as an aquarium plant (see Kasselmann & Staeck 1993b). In contrast to the wild form, this cultivar has a more or less deep wine red-colored stem. During simultaneous cultivation of both forms, this feature is always distinctly pronounced so that the shoots can easily be distinguished and identified.

White-green specimens of *Gymnocoronis spilanthoides*

Since about 1992, a white-green plant of *G. spilanthoides* has become commercially available. It displays both a partial absence of chlorophyll as well as stunting in the leaf blades. This appearance is typical of viral infections. Whereas these white-green specimens grow well in emersed cultivation, their adaptive capabilities to submersed living conditions are only limited and their growth is only very moderate.

Virosistic plants of *G. spilanthoides*.



Hemianthus micranthemoides

Nuttall (1817)

Family: Scrophulariaceae.

Synonyms: *Micranthemum nuttallii* A. Gray, *M. micranthemoides* Wettstein.

Etymology: *Hemianthus*: from hemi = half, and anthos = flower, refers to the insignificant upper lip; *micranthemoides*: similar to a small *Anthemis*.

Distribution: East coast of North America.

Description: Delicate marsh plant with creeping or erect, glabrous, multibranched shoots. Leaves decussate or in 3–4-merous whorls, sessile, entire, lanceolate to elliptic, 3–9 mm long, 2–4 mm wide, light green.

Flowers axial, solitary, very small, up to 1.5 mm petiolate. Calyx green, about 1.5 mm long, glabrous, with 4 obtuse denticles. Corolla white, about 1.5 mm wide, 2 mm long, with an insignificant upper lip and a trilobular lower lip, the central lobule of which is the largest; 2 stamens, protruding from the crown. Style short; stigma with 2 lobes. Capsule globular, 1.5 mm in size.

Culture: A light-requiring, but undemanding, recommendable, gracile plant for the aquarium foreground, the shoots of *H. mi-*

cranthemoides will grow equally well in soft and very hard water. Acid to neutral water is essential for good growth because, with alkaline pH-values, a thin layer of lime will form easily on the leaf surfaces, to which the plants will react with reduced growth. A fine-grained substrate is recommended for the planting of the delicate shoots. The composition of the substrate is of only limited relevance; even shoots that have been placed onto the water surface will continue to grow well, and will rapidly develop a dense plant cushion. Optimum temperature range is 24–26 °C. Propagation is through lateral shoots. During trimming, the shoots can be easily cut with scissors to form a terraced arrangement. It is also suited for planting in the foreground in paludariums and flowers will form under conditions of good light and warmth.

Ecology: *Hemianthus micranthemoides* grows in gravelly or muddy soils on riverbanks.

Other: Similar to *Micranthemum* (see there).

***Hemianthus micranthemoides*.**



Heteranthera reniformis

Ruiz López and Pavón (1798)

Family: Pontederiaceae.

Synonyms: *Heteranthera reniformis* Beauvois (1799), *H. acuta* Willdenow, *Leptanthus reniformis* Michaux, *L. virginicus* Persoon, *L. peruvianus* Persoon, *Heteranthera acuta* Vahl, *Buchosia aquatica* Vellozo, *Heteranthera virginica* Steudel, *Schollera reniformis* Kuntze, *Phrynium reniforme* Kuntze.

Etymology: *Heteranthera*: *heteros* = different, *anthera* = stamen, refers to the differently upright stamens; *reniformis*: reniform, kidney-shaped, refers to the leaf blade.

Distribution: North and South America.

Description: Caulome creeping or floating, root-sprouting on all nodes, branched. Submersed leaves linear to oblanceolate, floating or emersed leaves up to 20 cm long, with a sheath. Blade reniform, greasy shiny, up to 5 cm long and 6 cm wide, medium green in color.

Inflorescence is an up to 5-cm long petiole spike with (2–)5–8 flowers. Spathe about 15 mm long. Solitary flower with 6 pale blue tepals which are set in 2 circles. Perigone up to 10 mm long, the center upper tepal with a

yellow spot on the apex; 3 stamens, 1 longer than the other 2; 1 style. Capsule with many seeds.

Culture: *Heteranthera reniformis* is often kept in botanical gardens, but can also be well cultivated in the marsh section of a paludarium. A purely submersed culture is, however, not possible. High light intensity and humidity are necessary to ensure good growth. In summer, many inflorescences are often formed under a lot of light and warmth. In greenhouse cultivation, the plants will strongly recede during winter due to a lack of light. Since the species readily multiplies through seeds, the plants may be revived again every spring.

Ecology: *Heteranthera reniformis* populates its native habitats with floating leaves in shallow water or creeping in boggy surrounds.

Other: The species is rarely being cultured by aquarists.

Floating and emersed shoots of *Heteranthera reniformis*.



Heteranthera zosterifolia

Martius (1823)

Family: Pontederiaceae.

Synonyms: *Schollera zosterifolia* (Martius) Kuntze, *Heteranthera osteniana* Herter.

Etymology: *Heteranthera*: see *Heteranthera reniformis*; *zosterifolia*: with leaves similar to the *Zostera* genus.

Distribution: Brazil, Bolivia, Paraguay, Uruguay, Argentina.

Description: Submersed rising or erect, often branched shoots, strongly root-developing on the lower nodes. Emerged leaves only in high humidity, very similar to the submersed ones, slightly more sturdy and shorter. Submersed leaves alternate, sessile, glabrous, linear or spatulate, up to 5 cm long, 3–7 mm wide, light green in color. Floating leaves up to 2 cm petiolate, lanceolate, up to 2.5 cm long, 10 mm wide.

Flower formation after the development of floating leaves. Inflorescence axial, about 2 cm petiolate, surrounded at the base by a 15-mm long spathe, with 2 about 10-mm sized flowers, 1 flower sessile, the other short petiolate. Perigone tube up to 12 mm long; perigone 6-lobed, in 2 circles; outer tepals hardly

larger than the inner ones, colored blue-violet; throat dark blue, no yellow spot; 3 stamens, one longer than the other two; 1 style. Fruit is a trilocular capsule.

Culture: A decorative, easy to keep, but light-demanding stem plant, *H. zosterifolia* grows well in both soft and hard water. Sand is adequate as a substrate. Optimum temperature range is 23–27 °C. Depending on the aquarium's size, the shoots are planted in the front or middle zone. A well-prospering group must be replanted in a benched setting every 2–3 weeks. Beautiful contrasts can be created through a combination with numerous red-leaved species. Due to the abundant production of lateral shoots, reproduction does not pose a problem. If one wants to observe the small blue-violet flowers, the shoots will have to float to the water surface.

Ecology: Populates stagnant or slow-moving waters with submersed or floating shoots, or emerged in moist locations.

Inflorescence of *H. zosterifolia*.



***Heteranthera zosterifolia* (center).**



Hottonia palustris

Linné (1753)

Family: Primulaceae.

Synonyms: *Hottonia millefolium* Gilibert.

Etymology: *Hottonia*: after the botanist P. Hotton from Leiden (1648–1709); *palustris*: inhabiting marsh areas.

Distribution: Europe, North Asia.

Description: Perennial marsh plant. Rhizome rooted in the substrate. Submersed stem erect, over a meter in length and, prior to the formation of inflorescences, branched several times at its base; shoots also emerged if water levels drop. Leaves alternate or whorl-like, 1- or 2-pinnate, 3–6 cm long, 1–3 cm wide, light green in color.

Inflorescence above the water surface, an erect raceme with 2–11 flower whorls; each whorl with 2–6 flowers. Bracts linear, about 5 mm long. Flowers petiolate, 5-merous, heterostylous. Sepals about 5 mm long, green. Petals tubular below, 15–25 mm in diameter, white to pale violet with a light yellow throat; 5 stamens, adnate with the petals.

Culture: *Hottonia palustris* is part of the regular aquarium plant stock commercially available. It is an unproblematic, especially deco-

orative plant for cultivation at the edges of garden ponds or in cold-water aquariums, demanding a light location in garden ponds. There, too, the conspicuous inflorescences can be observed during May and June. Under the false assumption that it is the North American *H. inflata* species, it is not uncommon for the shoots to be used for cultivation in tropical aquariums where its maintenance, however, rarely proves to be satisfactory. A temperature of 25 °C in the aquarium should not be exceeded for lengthy periods. Also, both intensive illumination as well as a free-standing location in the aquarium's foreground are recommended. Propagation is through lateral shoots.

Ecology: The species grows in shallow, small bodies of water, such as gullies, pools, etc., featuring stagnant or very slow-moving water. It prefers mesotrophic locations with a muddy or sandy substrate. It develops winter buds. The species is protected in Germany.

***Hottonia palustris*.**



Houttuynia cordata

Thunberg (1748)

Family: Saururaceae.**Synonyms:** *Polypara cochinchinensis* Loureiro, *P. cordata* O. Kuntze.**Etymology:** *Houttuynia*: after the Dutch doctor M. Houttuyn (1720–1798); *cordata*: heart-shaped.**Distribution:** East Asia, from India to Japan and Taiwan.**Description:** Marsh plant growing up to a height of 80 cm, with a creeping, strongly branched rhizome. Stem erect, hard, glabrous, up to 3 mm thick, green to reddish. Leaves alternate, 2–4 cm petiolate. Petiole up to 2 cm long, curled up at the base, unfolded about 1 cm. Above the leaf base is a stipule, about 1 cm long and 1–2 mm wide. Blade entire, wide ovate, 4–8 cm long, 3–6 cm wide, medium green with a wine red margin, plumy pubescence. Cordate base; apex cuspidate.

Spike up to 3 cm petiolate, densely flowered, about 1.3 cm long; 4 petaloid bracts, white and 1.8 × 1.2 cm in size. Sepals and petals are absent; 3 stamens; 3 carpels, equal

in length to the stamens. Fruit globular, 1-seeded.

Culture: A species hardly suitable for submersed cultivation in aquariums, *Houttuynia* can, however, be used quite well under intense lighting in paludariums, or on the edge of ponds with a sunny and moist location. Under these conditions, growth will be just as quick and unproblematic as in *Saururus cernuus*. Propagation is easily accomplished through rhizome partition. The species displays only limited hardiness. If the leaf is crumbled between the fingers, an intense scent will develop, and it is probably due to the plant's juice that the shoots do not suffer from plant lice infestation.**Ecology:** Populating marshy locations, in its native habitats it is sometimes so frequent that *H. cordata* has long become to be considered a weed. In China, the shoots are used as a vegetable and for medicinal purposes.**Other:** Also in cultivation are cultivars with colored leaves as well as double-flowered plants.**Double-flowered cultivar of *H. cordata*.****Flowering plant of *Houttuynia cordata*.**

Hydrilla verticillata

(Linné fil.) Royle (1839)

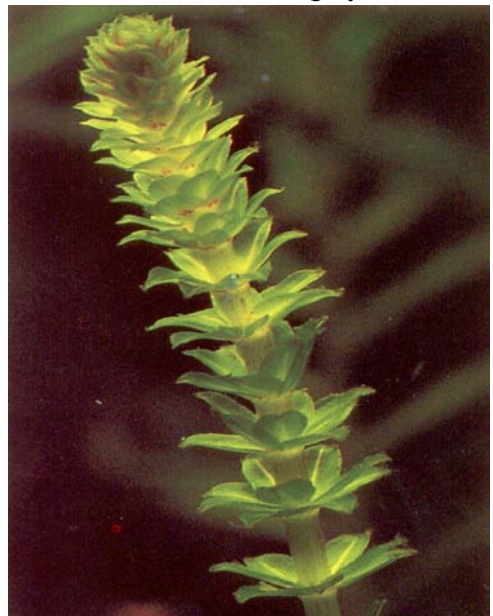
Family: Hydrocharitaceae.**Synonyms:** *Serpicula verticillata* Linné fil. (1781), and others.**Etymology:** *Hydrilla*: *hydor* = water, *illein* = to turn, revolve; *verticillata*: whorled, refers to the whorled arrangement of the leaves.**Distribution:** Widely spread in Asia, Australia, East Africa, Europe, North America, absent from South America.**Description:** Polymorphic aquatic plant with 1–2-mm thick, soft, more than 2-cm long stem. Internodes usually 0.5–2 cm long. Leaves sessile, prophylls opposite, the upper leaves set in 3–6(–12)-merous whorls. Blade linear to narrow lanceolate, usually 1–2 cm long, 1–3 mm wide, transparent, soft, light to medium green, sometimes with a red midrib. Scales on the leaf base. Margin toothed. Apex with one acute denticle (magnifying glass!).

A deviating, genetically fixed growth form in East Africa: stem and leaves stiff. Leaf blade narrow ovoid to ovate, 5×3 mm in size; irregular double leaf whorls; margin with a larger number of denticles.

Plants monoecious, occasionally dioecious.

Flowers unisexual, inconspicuous, rare. Male spathe with a short petiolate flower, solitary, globular, about 1.5 mm in size, with 8–22 appendages on the tip. To mature, the spathe will burst open and release the male flower to the water surface on which it will float. Female spathe with 1 flower, solitary or rarely 2 in the leaf axils; female flower floating on the water surface on an up to 10-cm long hypanthium.

Culture: *Hydrilla verticillata* is an undemanding and recommendable aquatic plant which, due to its inconspicuous appearance, is only rarely commercially available. The species will adapt magnificently to aquarium conditions, so that it can be accommodated both in soft or hard, weak acid or alkaline water. To obtain thickset shoots, good lighting is recommended even though the species can also make do with very little light. If the shoots are planted into the substrate, they have to be trimmed regularly because of the unusually rapid growth. Because of their herbaceous growth, *H. verticillata* is especially recommended for smaller breeding aquariums in which the plants are simply placed onto the water surface. Propagation is pro-

***Hydrilla verticillata*.****Growth form from Lake Tanganyika.**

ductive through lateral shoots. Optimum temperature range is 20–27 °C. The species can also be cultivated over the entire year in garden ponds. Winter buds will form in autumn, they will drop to the bottom, survive the winter there and will sprout again in spring.

The author collected a deviate growth form of *H. verticillata* in the southern part of Lake Tanganyika. This species will—in line with the ecological conditions there—prosper well in medium-hard and hard, alkaline water. The form grows decidedly slower than the form cultivated in most cases. Also, its shoots can only be used if planted and not floating. Due to its relatively consistent habitus a decorative arrangement is rather difficult.

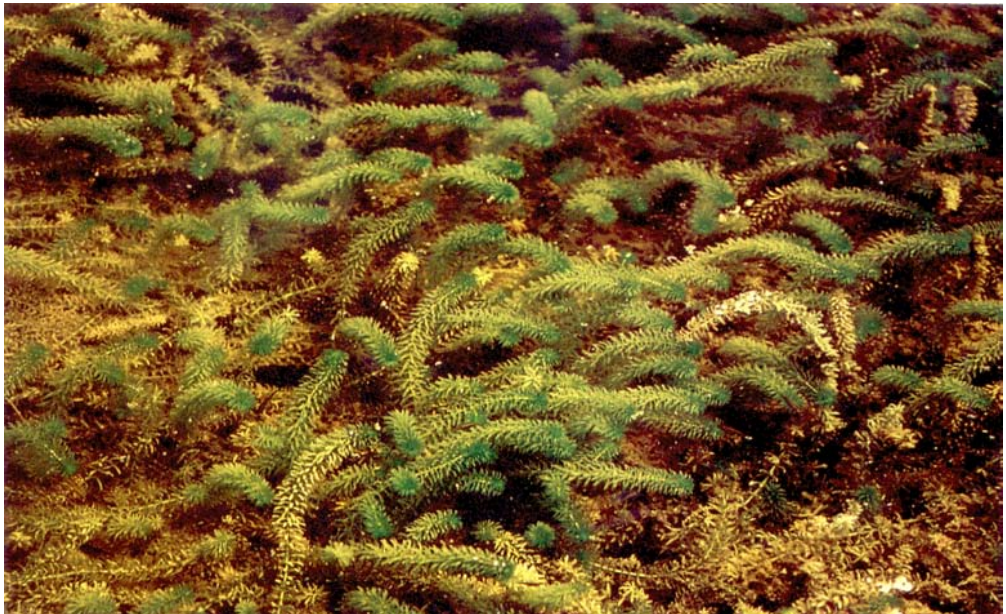
Ecology: Usually the species grows in stagnant or moderately moving water, in a depth of up to 1 m; it was, however, also occasionally found in depths of up to 7 m. It prospers both in alkaline, oligotrophic to eutrophic water, as well as brackish water. In Asia, the author often located the species in drainage gullies. The species loves sunny locations. At Ndole Bay in southern Lake Tanganyika, *H. verticillata* forms herbaceous populations in the sandy zone of the lake,

rooted in the soil in about 1 m depth. Water values of Lake Tanganyika, see p. 41. Water analyses of two tropical habitats follows: 1) Bali (7/1981): small river, water temperature 27 °C, pH 6.5–7, GH 3 °dH, 450 µS/cm; and 2) Papua New Guinea (7/1988): river, about 10 m wide, water temperature 27 °C (air temperature 28 °C at 09:30 h), pH 7.4, GH 15 °dH, KH 15 °dH, 1050 µS/cm.

Other: *Hydrilla verticillata* can easily be confused with other species from the genera *Egeria*, *Elodea* and *Lagarosiphon*. In its vegetative state, the leaf arrangement, the number of leaves per whorl, the length of internodes as well as the margin can be helpful indicators in distinguishing the species.

Further reading: Cook and Lüönd (1982).

***Hydrilla verticillata* in its native location in Papua New Guinea.**



Hydrocleys martii

Seubert (1847)

Family: Limncharitaceae.

Synonyms: *Ostenia uruguayensis* Buchenau, *Hydrocleys uruguayensis* (Buchenau) Peder-
sen.

Etymology: *Hydrocleys*: *hydor* (Gr.) = water;
kleis = key; *martii*: after the German botanist
K. F. P. von Martius (1794–1868).

Distribution: Brazil, Argentina, Uruguay.

Description: Aquatic plant with runners up
to 50 cm long. Juveniles submersed, sessile,
linear. Mature leaves floating or emersed, up
to 40 cm petiolate, on the base with an up to
8-cm sheath. Leaf blade wide ovate to orbicu-
lar, up to 12 × 10 cm in size, deep green. Apex
obtuse to mucronate; base cordate; 5–7 veins.

Inflorescence with 1–6 flowers. Peduncle
up to 30 cm in length. Leaves and runners
will often form on the inflorescence (prolif-
eration). Elliptic bracts, up to 4.5 × 1 cm in
size. Pedicel up to 17.5 cm long. Flowers
about 5 cm in size. Green sepals, with a dis-
tinct midrib. Petals a strong yellow, gold-
yellow at the base, longer than sepals; 12–18
stamens, in 2 or more circles; staminodes
numerous; 5–8 carpels. Fruit 10–15 mm long,

2–3 mm thick. Seeds about 1 mm long, dense
glandular pubescence.

Culture: *Hydrocleys martii* is a marvelous
plant which can often be seen in botanical
gardens, but is seldom available commer-
cially. Though the species is hardly suited for
aquarium cultivation because it develops
rather large floating leaves, it can, however,
be well maintained in both a paludarium and
in flat bowl with a low water level or merely a
moist substrate at a light, warm location.
There, not only will floating leaves develop
but often emersed leaf blades as well. Even in
winter brightly colored flowers will form.

Ecology: *Hydrocleys martii* is found in shal-
low water in stagnant waters, where it will
flower and fructify over the entire year.

Other: Occasionally the incorrect spelling of
Hydrocleis is used.

Further reading: Haynes and Holm-Nielsen
(1992).

***Hydrocleys martii* in its native habitat in eastern Brazil.**



Hydrocleys nymphoides

(Willdenow) Buchenau (1871)

Family: Limncharitaceae.**Synonyms:** *Stratiotes nymphoides* Willdenow (1805), and others.**Etymology:** *Hydrocleys*: see *H. martii*; *nymphoides*: *Nymphaea*-like.**Distribution:** North, Central and South America.**Description:** As indicated for *Hydrocleys martii*. Differentiating features: floating leaf blade with 5–9 veins. No emerged blades. Sepals without any distinct midrib. Petals light yellow to white with a yellow base; 20–25 stamens. Few seeds, glandular pubescence.**Culture:** In the 1950s, *Hydrocleys nymphoides* counted among the most popular aquatic plants with floating leaves. Today, the species is seen only in botanical gardens where they are conspicuous by their large, decorative flowers. The plants are hardly suitable for tropical aquariums since the floating leaves produce too much shade. However, maintenance in a paludarium in shallow water and a light location is recommended. A nutrient-rich substrate and soft water are important.**Ecology:** The author located *H. nymphoides* in a strongly shaded marsh zone of the Rio Guaporé (Southwestern Brazil) in boggy soil, associated with *Hydrocleys* sp., *Echinodorus paniculatus*, *Ludwigia sedoides*, *Utricularia breviscapa* and *U. hydrocarpa*. Water analyses (8/1987): temperature 24 °C (air 25 °C at 16:00 h), pH 6.0, GH/KH < 1 °dH, 30 µS/cm. Three habitats in Argentina produced the following data (7/1993, summarized): water temperature 6–12 °C (air 12–20 °C), pH 5.5–7, GH < 1 °dH, KH 1–2 °dH, < 10–45 µS/cm. Dense populations grew in standing to slow-moving water, in a depth of up to 1 m. The substrate was sandy-gravelly or loamy, the locations sunny.**Other:** Apart from the two species described here, other known species are *Hydrocleys modesta* Pedersen from South America, *H. parviflora* Seubert from Central and South America, and *H. mattogrossensis* (Kuntze) Holm-Nielsen and Haynes from western Brazil and Bolivia.

Hydrocleys nymphoides in its native habitat in Argentina.



Hydrocotyle leucocephala

Chamisso and Schlechtendal (1826)

Family: Apiaceae.

Synonyms: *Hydrocotyle leucocephala* var. *truncatiloba* Urban, and others.

Etymology: *Hydrocotyle*: *hydor* = water, *kotyle* = Nabel; *leucocephala*: white-headed, refers to the inflorescences.

Distribution: Southern Mexico to northern Argentina.

Description: Amphibious plant with creeping, submersed upright or floating shoots, producing roots on all nodes. Leaves alternate. Petiole glabrous or only pubescent on the upper part, up to 15 cm in length, features 5-mm sized stipules at the base. Leaf blade roundish to reniform, rarely overlobed, 2–5(–10) cm in diameter, with 9(–11) veins and a deep incision to the middle of the blade. Margin irregularly crenate. Juveniles flat, older leaves bullate, upperside light green, underside whitish green.

Inflorescence is a 15–30-flowered umbel. Peduncle up to 12 cm long, strong pubescent. Solitary flower 1–2 mm petiolate, white. Flowers 5-merous; 2 carpels, fruit 1 × 1.5 mm in size.

Culture: A recommended, undemanding, resistant and fast-growing plant, the species displays excellent adaptation to bad lighting conditions, which also makes it suitable for less well-illuminated aquariums. Optimum temperature range is 20–28 °C. Healthy growth is mostly independent from water hardness and pH-value. The plant will prosper optimally in nutrient-rich and highly “polluted” water (nitrogen-loving?). Planted as a stem plant in the substrate, the shoots will have already reached the water surface within a few days, where they will continue to grow floating, will branch out strongly and develop a dense blanket of floating plants. Creeping emersed shoots are well suited for use in paludariums under high humidity conditions and it will flower often.

Ecology: Populates both moderately moist as well as wet locations, e.g., rivers with slow-moving water, or flooded areas, up to altitudes of 1700 m.

***Hydrocotyle leucocephala*.**



Hydrocotyle ranunculoides

Linné fil. (1781)

Family: Apiaceae.

Synonyms: *Hydrocotyle americana* Walter, and others.

Etymology: *Hydrocotyle*: see *H. leucocephala*; *ranunculoides* similar to the *Ranunculus* genus.

Distribution: North, Central and South America; introduced to several countries.

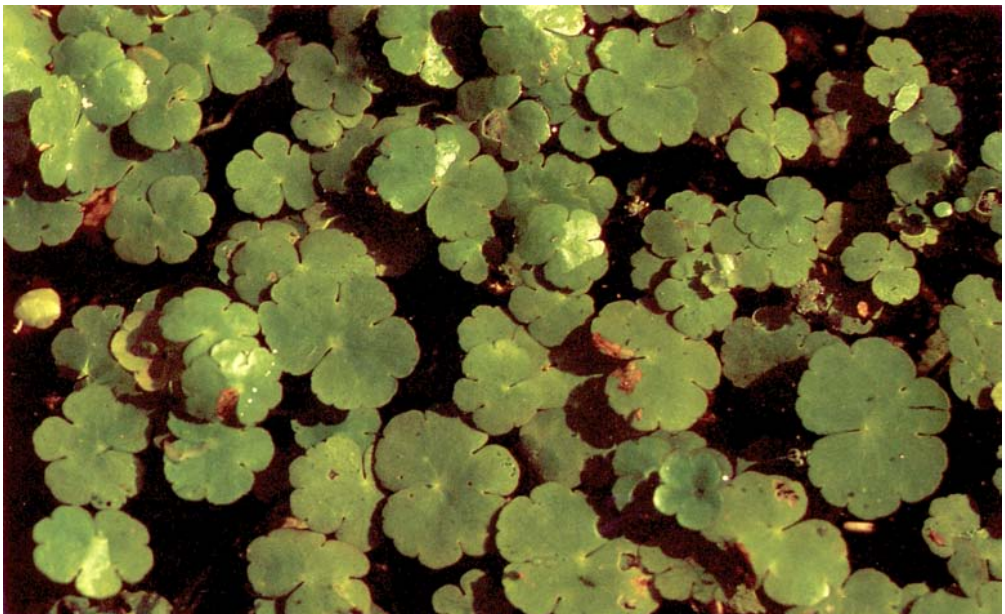
Description: Marsh plant with emerged creeping shoots which float in water and produce roots on all nodes. Leaves alternate, glabrous. Petiole 2–10(–34) cm long. Leaf blade reniform, smaller blades also almost orbicular, 0.7–4(–8) cm wide, 0.5–3 cm long, medium green. Margin lobed, lobes irregularly crenate.

Inflorescence is a 2–5(–10)-flowered umbel. Peduncle shorter than the leaves, glabrous, 0.5–6 cm long. Flowers 1–3 mm petiolate, 5-merous, about 2 mm in size. Fruit 1.5–3.2 mm wide, 1–2.3 mm long, ribs not protruding.

Culture: *Hydrocotyle ranunculoides* is a fast-growing, undemanding plant which can be used as both a plant for paludariums as well as for edges of garden ponds. In the

paludarium, the creeping shoots will form a dense greenery within a short time. On the edges of garden ponds the shoots will also grow into the water where they will float above or below the water surface. The species is very temperature-tolerant, temperatures from near 0 °C to about 30 °C can be handled. Leaf blades of varying size will grow depending on the degree of moisture and nutrient supply within the substrate. This *Hydrocotyle* is only moderately suitable as an aquarium plant.

Ecology: The species populates moist and wet habitats as well as the edges of stagnant and fast-flowing waters. Numerous water analyses, conducted in many biotopes in north-eastern Argentina in July 1993, showed up both very soft, acid as well as hard, alkaline water. During the cold time of year the plants grew at temperatures of 10–19 °C. The substrate was muddy, sandy or loamy. The locations were shady-sunny or exposed to full sunlight. Conspicuously often *H. ranunculoides* was located in drainage water. For water analyses see p. 40, biotope No. 4.

***Hydrocotyle ranunculoides* in its natural habitat in Argentina.**

Hydrocotyle sibthorpioides

Lamarck (1789)

Family: Apiaceae.

Synonyms: *Hydrocotyle rotundifolia* Roxburgh, *H. japonica* Makino, *H. yabei* Makino, *H. rotundifolia* var. *pauciflora* Yabe.

Etymology: *Hydrocotyle*: see *H. leucocephala*; *sibthorpioides*: similar to the *Sibthorpia* genus.

Distribution: Widely spread in tropical Asia, introduced to the New World.

Description: Small marsh plant with emerged creeping, thin glabrous shoots, also being erect in the water and producing roots on the nodes. Leaves alternate. Petiole 0.5–11 cm long. Leaf blade almost orbicular, with an incision to the middle of the blade, 0.5–2 cm in diameter, indistinctly lobular, lobes crenate.

Inflorescence is a 2–10-flowered umbel. Peduncle shorter than the leaves, 0.5–2 cm long, glabrous. Flowers almost sessile, 5-merous, very small. Fruit almost globular, 0.8–1.5 mm in diameter, occasionally wider than long.

Culture: Even though this umbelliferous plant is occasionally found entirely sub-

mersed in its native habitat, the author was unable to achieve any satisfactory cultivation results. *Hydrocotyle sibthorpioides* obviously seems to be little suited to aquarium cultivation. Growth in paludariums and in open areas is, in contrast, much improved in only moderately moist soil, so that inflorescences are regularly formed. The plants love a sunny location as well as a nutrient-rich substrate.

Ecology: *Hydrocotyle sibthorpioides* grows in both very dry as well as moist and wet locations and is also occasionally found entirely submerged. In July 1981, the author researched the plants on Bali, which were growing exclusively submerged in the springs at Ubud. *Hydrocotyle sibthorpioides* was associated with *Ceratophyllum demersum* and *Hydrilla verticillata*. A water analysis provided the following results: water temperature 27 °C, pH 6.5–7, GH 3.0 °dH, 450 µS/cm.

Other: *Hydrocotyle sibthorpioides* is also occasionally commercially available under the name of *Hydrocotyle* sp. “Bali” or “Java.”

Emerald plants of *Hydrocotyle sibthorpioides*.



Hydrocotyle verticillata

Thunberg (1798)

Family: Apiaceae.

Synonyms: *Hydrocotyle vulgaris* var. *verticillata* Richard, *H. volckmannii* Philippi, *H. verticillata* Thunb. var. *pluriradiata* Urban.

Etymology: *Hydrocotyle*: see *H. leucocephala*, *verticillata*: whorled, refers to the whorled inflorescences.

Distribution: Temperate and subtropical regions of North and South America (possibly in other countries).

Description: The species is distinguishable from *Hydrocotyle vulgaris* in only a few, not clearly differentiating vegetative features: the internodes are mostly up to only 10 cm long. The petiole usually remains shorter with only 5–20 cm length. The leaf blade measures a diameter of 3.5(–6) cm emerged and up to 2.5 cm submersed, and usually has 9–12 veins. Further details see *H. vulgaris*. Both species, however, cannot be certainly and definitely distinguished by their vegetative characteristics. Essential differentiating features are the 1–2 times whorled (*H. vulgaris*) and usually multiple-whorled (*H. verticillata*) inflorescences.

Inflorescence in *H. verticillata* is up to 12 cm long petiolate, with 3–5-flowered umbels, which are arranged above each other in up to 7 whorls. Petals white. Fruit almost sessile or up to 20 mm long petiolate, with a little projection on the base, rarely flat.

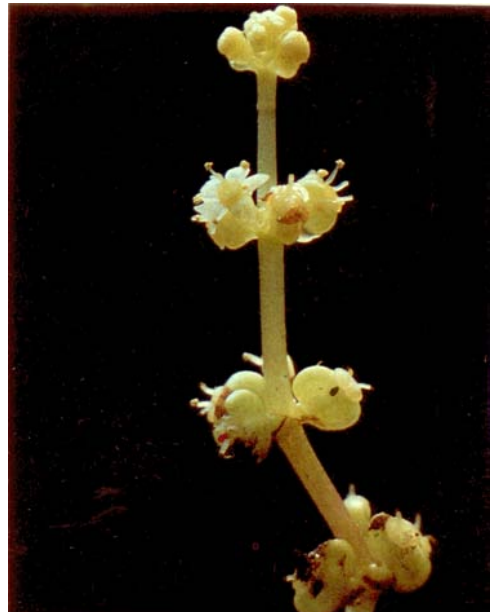
Culture: With umbrella-like leaf blades and only a limited height of 5–10 cm, *H. verticillata* is an unusual and decorative plant for the aquarium foreground. It is, however, only limitedly suitable for tropical aquariums because it prefers cool water up to 25 °C. Even then it will grow only slowly. Optimum growth necessitates high light intensity. Fine-grained sand-gravel-loam is recommended as a substrate in which the delicate roots can easily take hold. Water hardness is of limited importance. Propagation is through partition-

ing of the creeping caulome into segments with at least two nodes. Contrary to the relatively slow and not always satisfactory submersed growth, emerged cultivation is unproblematic. It can also occur in unheated and covered glass containers on window ledges where, in only a short time, the substrate will be crisscrossed by creeping shoots. Low temperatures, too, of 10–15 °C can be temporarily handled quite well. During summer the numerous, usually whorled inflorescence will appear regularly. Sexual reproduction through seeds is difficult.

Ecology: The species populates moist and wet locations; it is especially found in flood areas and on wet meadows, but will also grow on the edges and banks of pools, lakes, streams and rivers. Only occasionally will the plants grow entirely submersed in their native habitats.

Other: Four varieties of *Hydrocotyle verticillata* have been described, which are supposed to differ in the length of their petioles and the degree of pubescence of their peduncles: *Hydrocotyle verticillata* var. *verticillata*, var. *racemosa*, var. *cubensis* and var. *featherstoniana*. The validity of these varieties is disputed.

Inflorescence of *Hydrocotyle verticillata*.



Hydrocotyle vulgaris

Linné (1753)

Family: Apiaceae.**Synonyms:** None.**Etymology:** *Hydrocotyle*: see *Hydrocotyle leucocephala*; *vulgaris*: common.**Distribution:** Europe, isolated in north-western Africa, in the Caucasus and Iran, doubtful in New Guinea and Australia.**Description:** Stem creeping, root-producing on all nodes. Leaves emerged alternate, up to 15 cm long petiolate, submersed up to 70 cm long petiolate. Internodes up to 15 cm. Leaf blade almost orbicular, peltate, umbilically indented in the middle, emerged up to 5.5 cm, submersed up to 3.5 cm in diameter, occasionally slightly arched, with 7–12(–15) veins; margin irregularly crenate in juveniles, only faintly recognizable in mature leaves.

Inflorescence an umbel, terminal or arranged in 2 whorls above each other (rarely up to 5 whorls), axial, short petiolate, 3–5-flowered. Petals white or reddish. Fruit almost sessile, smooth or slightly crenate at the base.

Culture: The species can be utilized for cold-water aquariums and for planting on the edges

of garden ponds, and constitutes a fast-growing plant for submersed cultivation in tropical aquariums. However, it will remain only low-growing initially because, under good growth conditions, the petioles and internodes will grow much longer compared to *Hydrocotyle verticillata*, resulting in the shoots crisscrossing the entire aquarium within only a few weeks. Therefore, this species is more suited to location in the aquarium's middle section where individual "umbrellas" can appear very decorative. If the petioles are not to protrude the water surface, longer petiolate leaves must be trimmed now and again. You won't be able, though, to permanently keep the plant below 10 cm.

The species loves a bright location in the aquarium. A nutrient-rich sand is suggested as a substrate. Water values appear to play only an irrelevant role for healthy growth. Soft to medium-hard, slightly acid water is suited well. Consistent maintenance is possible under temperatures up to 28 °C. In warm water, growth will be far more rapid compared to a cold-water aquarium. The planting of the stem can sometimes cause problems because the plants have a strong upward lift. Plastic pins may find good use here. Propagation is through division of the caulome.

It is interesting to observe the ability of juvenile blades to turn vertically towards the light a few minutes prior to switching off the lighting or also under influx of daylight. Mature blades have lost this ability. During summer, numerous, mostly terminal, inflorescences will form on the emerged plants.

Ecology: The species will usually grow in marshy locations on moderately acid moor and peat soils, on the edges of nutrient- and lime-deficient waters. However, the author also found it relatively dry in sandy soils in the Lüneburger Heath (Germany) region in both shady and sunny locations. In shallow water, the leaf blades will float on the water surface.

Emerged plants of *Hydrocotyle vulgaris*.

Hydrothrix gardneri

Hooker fil. (1887)

Family: Pontederiaceae.

Synonyms: None.

Etymology: *Hydrothrix*: water hair, refers to the hair-like leaves; *gardneri*: after George Gardner who discovered the species.

Distribution: Eastern Brazil (Bahia, Ceará, Goiás, Piauí).

Description: Annual, delicate, herbaceous aquatic plant with upright or drifting shoots. Stem often branched, root-forming on the nodes, glabrous, 20–55 cm long. “Leaf whorl” (lateral short shoots) with 7–30 filiform, in transversal section ovoid leaves, sheathed. Blade 2–4 cm long, slightly curved downwards on the apex, light to dark green.

Inflorescence axial. Flowers always paired, surrounded by a spathe, opened 6–8 mm in size. The flowers will open above the water surface (chasmogamous), under water they remain closed (cleistogamous). Perianth gamophyllous, with 6 unequal, quickly caducous yellow petals; 3 stamens, only 1 of them fertile. Style 0.5 cm long. Fruit a transparent, up to 3.5 mm-sized capsule with 18–40 seeds. Seeds 0.5 mm long, twice as long as wide, brownish in their mature state.

Culture: *Hydrothrix gardneri* prefers soft, slightly alkaline water, but will also still prosper under medium-hard conditions. Optimum temperatures lie between 23 and 25 °C, but values up to 28 °C can be handled temporarily. Decisive for healthy, rapid growth is high light intensity. Under light-deficient conditions, the internodes will stretch, the leaves will turn brown, and the plants will die. Under intense light, thickset shoots with strong “leaf whorls” will form. Due to the numerous delicate roots, a fine-grained substrate is recommended; it does, however, have only a limited role in the plant’s nutrition intake. The graceful habitus of *Hydrothrix* will come to good effect if a group of 5–20 cuttings are planted between big-leaved,

light green and reddish species. The water should be clear because *H. gardneri* is very sensitive to algae and general pollution. Despite the rich reproduction through lateral shoots, one is reliant on sexual propagation because the species is annual in the aquarium as well. Seeds will be formed even if the flowers have not opened. In the greenhouse, they will drop to the ground where they will survive during the cool seasons, only to germinate again in spring. To avoid the seeds being lost in the aquarium, they may be collected in autumn and stored in a moist substrate in dark and warm conditions. In autumn, they are left to germinate in temperate water. Under the preconditions mentioned above, *H. gardneri* is a worthwhile aquarium plant.

Ecology: The species populates lakes, ponds and slow-moving waters. Bogner found *H. gardneri* in 1976 in fish ponds near Icó in Ceará State (Brazil), which have to be continuously removed from these ponds, and subsequently imported it for aquaristic purposes.

Other: Unfortunately, this very decorative aquarium plant will remain a rarity due to its short lifespan.

Further reading: Rutishauer (1983).

***Hydrothrix gardneri*.**



Hydrotriche hottoniiflora

Zuccarini (1832)

Family: Scrophulariaceae.**Synonyms:** None.**Etymology:** *Hydrotriche*: *hydro* = water, *thrix* = hair, refers to the hair-shaped aquatic leaves; *hottoniiflora*: with flowers as in the *Hottonia* genus.**Distribution:** Madagascar.**Description:** Delicate aquatic plant with up to 70 cm long shoots. Leaves in 10–20-merous whorls, sessile, aciculiform, 3–5 cm long, 0.5–2 mm thick, light green in color. Margin with acute denticles on the apex.

Inflorescence is a 5–25-cm tall raceme with few petiolate solitary flowers. Flowers cleistogamous and chasmogamous; 2 bracts, 1–3 mm long. Calyx about 3 mm long, 5-lobed. Corolla 2-lipped, 5(–6)-lobed, about 2 cm in diameter, white in var. *hottoniiflora*, more or less intensely pink or mauve or light blue in color with a yellow throat, var. *flava* with a pure yellow corolla. Plants in cultivation usually flower white with a yellow throat; 2 fertile stamens; 2 staminodes. Style 5–7 mm long; stigma bifid. Fruit (rare) is a 4–8-mm sized 2-valved capsule.

***Hydrotriche hottoniiflora*.**

Culture: *Hydrotriche hottoniiflora* is a rare plant which is conspicuously distinguishable from most other aquarium plants by its unusual habit. It grows best in well-illuminated aquariums with soft, acid water and low temperatures between 21–24 °C, even though it is adaptable within limits. Good growth could still be achieved under higher hardness levels, a pH-value within the slightly alkaline range and temperatures of about 25 °C. The substrate should be nutrient-rich (e.g., loam addition). It is best to plant a small group of at least three shoots in the middle zone of the aquarium. The plant reacts very sensitively to algae infestation. Propagation is through lateral shoots. Inflorescences will occasionally develop on drifting shoots in the aquarium as well.

Ecology: During the wet season (January 1987) on Madagascar, the author located thick colonies in very fast-flowing, clear waters, at a depth of 40–80 cm. An analysis revealed the following data: water temperature at 11:30 h 21.5 °C, air temperature 25.5 °C, GH and KH < 1 °dH, pH 5.6, conductivity 30 µS/cm. The substrate consisted of yellow, compact loam, mixed with a bit of sand and small individual stones and rocks. The species is also found in stagnant waters with a boggy substrate (Bogner and Heine 1968).

Other: For many years, the *Hydrotriche* genus was considered to be monotypical. In 1979, Raynal-Roques identified three other species, *H. galiifolia*, *H. mayacoides* and *H. bryoides*, which are, like *H. hottoniiflora*, all endemic to Madagascar, are also very rare and have, so far, not been collected for aquarium purposes. Two *H. hottoniiflora* varieties have been described, var. *hottoniiflora* and var. *flava*, which differ only in their flower color. Both varieties are also sympatric and have identical ecological requirements. The type-variety has a far greater distribution than var. *flava*. The species was introduced to Europe in 1968 by J. Bogner.

Hygrophila balsamica

(Linné fil.) Rafinesque (1838)

Family: Acanthaceae.

Synonyms: *Ruellia balsamica* Linné fil. (1781), *Synnema balsamicum* Alston, and others.

Etymology: *Hygrophila*: *hygros* = moist, *philein* = to love, refers to the habitats; *balsamica*: balsam (thick-fluidous, strong smelling mixture of resins and oils).

Distribution: India, Sri Lanka.

Description: Differently shaped plant with an up to 40-cm long, erect or creeping 3–7-mm thick stem. Emerged leaves decussate, up to 1.5 cm petiolate. Leaf blade oblong, slightly sticky, toothed-serrate, 7×1.5 cm in size, olive green. Apex obtuse; base narrowed. Stem dense and short, blade hardly pubescent. If the stem is broken or the leaf crumpled, an intense scent of balsamica occurs. Underwater comb-like, pinnatisected light green leaf blades up to 10×7 cm will form.

Inflorescence axial, up to 0.7 cm petiolate, with 1–5 flowers, with 2 bracts 1.0×0.25 cm at the base. Solitary flower about 1 mm petiolate and with 2.5×1 mm bracts. Calyx with 5

lobes, about 8 mm long, green, one sepal slightly longer. Corolla 2-lipped, pale violet-white in color. Two of the 4 stamens are 5 mm, 2 are 3.5 mm long. Style about 6.5 mm. Ovary oblong, 2.5 mm long.

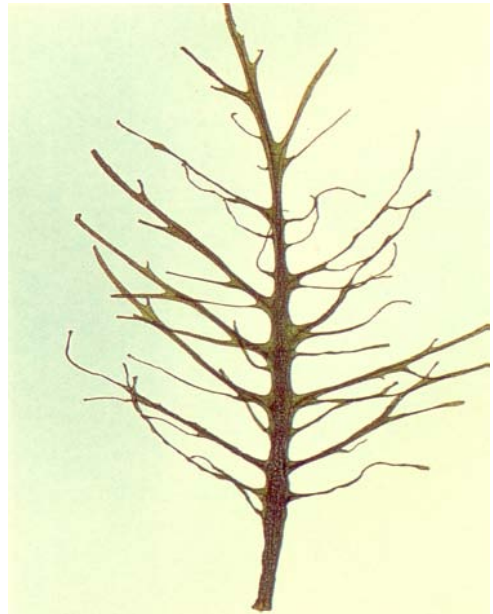
Culture: This species looks very similar to *H. difformis*, but is less suitable for aquarium cultivation. Furthermore, emerged shoots have to be soaked for 3 days prior to introduction into the aquarium because *H. balsamica* contains a very dangerous, concentrated substance toxic to the fish, as the author's research experiments have shown. Even though submersed cultivated shoots may be used without hesitation, an urgent warning not to cultivate this plant must be issued! If this rare species is nevertheless cultivated, soft to medium-hard water, a high light intensity and temperatures above 25°C are recommended. In its emerged state the plant will flower often.

Other: The species was briefly commercially available in about 1980, but was not distributed further due to loss of fish stock.

Flowering, emerged shoot of *H. balsamica*.



Submersed leaf of *H. balsamica*.



Hygrophila corymbosa

(Blume) Lindau (1895)

Family: Acanthaceae.**Synonyms:** *Nomaphila corymbosa* Blume (1826), *Justicia stricta* Vahl, *Nomaphila stricta* (Vahl) Nees, *Hygrophila stricta* (Vahl) Lindau, and others.**Commercial name:** *Hygrophila* "lacustris," *H.* "siamensis," *H.* "longifolius," and others.**Etymology:** *Hygrophila*: see *H. balsamica*; *corymbosa*: corymbous, refers to the inflorescences.**Distribution:** Widely spread in Southeast Asia.**Description:** Marsh plant, with erect, branched, up to 5-mm thick stems. Plant glabrous (with the exception of one growth form). Leaves decussate, 1–5 cm petiolate. Several genetically fixed, partially obviously sterile growth forms are being cultivated, the leaf blades of which are very different in shape and size.

Broad wide-leaved form: Leaf blade narrow ovoid or elliptic, emerged 6–8 cm long, 2.5–3 cm wide, submersed 10–20 cm long, 3–7 cm wide. Purely olive green and reddish brown color forms exist.

Thai form: Emerged leaf blade narrow elliptic, 7–10 cm long, 1.5–2.5 cm wide, submersed blade narrow lanceolate, 10–20 cm long, 1.5–2 cm wide; one color form with light green and one with reddish brown leaves.*Pubescent form:* Emerged plant (leaf underside as well) softly pubescent (almost glabrous in high humidity), strongly aromatic. Emerged leaf blade narrow elliptic, 4–7 cm long, 1–1.5 cm wide; submerged blade linear, 10–30 cm long, 0.5–1.5 cm wide, light green in color.

Inflorescence is a 0.5–2 cm pedicellate dichasium with 3 to numerous flowers. Bracts 2–2.5 mm long, 0.5 mm wide. Solitary flower light blue to strongly blue-violet; 5 sepals, pubescent, 4–8 mm long, one 1–3 mm longer than the others. Flower adnate to form a tube in the lower section; corolla 10–15 mm long, 2-lipped; upper lip 2-lobed, lower lip 3-lobed, wrinkled arched, and with a white-blue striped pattern; 4 stamens, 2 of which almost reach the edge of the upper lip, as well as 2 shorter ones with a length of 3 mm. Style up to 1.3 cm long. Ovary cylindric, 3.5 × 1.5 mm in size. Seed capsule 1–1.3 cm long, with about 20 flat, almost round seeds.

Culture: All growth forms of *H. corymbosa***Different growth forms of *Hygrophila corymbosa*.**

are very recommendable and fast-growing stem plants. Basically, their light requirements are only moderate, but the shoots will become stronger and more thickset if the plant is illuminated intensely. The reddish color forms especially will develop their beauty only if they are located at a light and free-standing place. Gravel or washed sand are sufficient as substrate, but the shoots will grow stronger in a nutrient-rich substrate or by using relevant fertilizer additives. *Hygrophila corymbosa* prospers excellently in medium-hard to hard, slightly alkaline water, with optimum temperatures ranging between 24 and 28 °C. Conspicuously good growth can be observed in fast-flowing water, e.g., in the vicinity of a filter outlet. This *Hygrophila* appears best in a small, terraced group in the middle to back section of the aquarium. In the course of time lateral shoots will develop under good conditions, which provide the plant group with a bush-like appearance. These lateral shoots can be cut off at a size of about 10 cm.

Hygrophila corymbosa is usually available from emerged cultivation and will, in most

cases, lose the emerged leaves during transfer into the aquarium.

A marsh cultivation, as well as maintenance in moist substrates on window ledges or in hydro containers, is simple and the plants will continue to grow well under water, will soon form new leaves and will flower easily.

Ecology: *Hygrophila corymbosa* populates marshy locations. The author observed two very different habitats in Sulawesi. Near Bantimurung (Maros, photo p. 26) a narrow-leaved, few-flowered form grew in a small river with fast-flowing water both submersed and emerged. Water analysis (7/1981): temperature 28 °C, pH 7.5, GH 7.8 °dH, KH 6 °dH, 300 µS/cm. At another location, near Angkona, a broad-leaved, many-flowered form was found entirely emerged only in wet soil.

Pubescent *Hygrophila*.



Flower of *Hygrophila corymbosa*.



Hygrophila difformis

(Linné fil.) Blume (1826)

Family: Acanthaceae.**Synonyms:** *Ruellia difformis* Linné fil. (1781), *Ruellia triflora* Roxburgh, *Synnema triflorum* O. Kuntze, and others.**Etymology:** *Hygrophila*: see *Hygrophila balsamica*; *difformis*: refers to the differently structured leaves.**Distribution:** India, Burma, Thailand, Malaysian Peninsula.**Description:** Perennial, very changeable marsh plant with decumbent or upright shoots, 30–80 cm long. Stem pubescent, up to 5 mm thick, green or reddish. Emerged leaves short petiolate, decussate, pubescent and sticky. Leaf blade lanceolate-elliptic to elliptic, up to 6.5×4.0 cm in size, with a serrate margin, medium to dark green in color. Submersed blade initially shaped as in emerged state, blades formed after are pinnatifid to pinnatisected, up to 15 cm long, light green in color.Inflorescence up to 1.4 cm petiolate, with 1–3 axial flowers; 2 bracts, pubescent, about 9×4 mm; 5 sepals, pubescent, about 10 mm long. Corolla 10–16 mm long, about 7 mm

wide, colored pale violet. Upper lip bilobular, lower lip trilobular. Throat dark violet in color, pubescent and arched in a wrinkled way; 4 stamens, 2 of which reach the edge of the upper lip, 2 remain slightly shorter; anther deep violet; pollen yellow in color. Style finely pubescent, reaching the edge of the upper lip; tiny stigma. Ovary narrow and acute stretched. Capsule without a petiole, about 8 mm long, slightly plummy pubescent; seeds are rarely developed in cultivation.

Culture: *Hygrophila difformis* is undoubtedly one of the most beautiful and recommendable aquarium plants, and is part of a regularly commercially available plant product range. The plants are undemanding and will prosper well in both very soft and hard water (above 30°dGH). While a medium-strength lighting is adequate for optimum growth, stronger specimens will develop under intense light. Unwashed or loam-containing coarse sand is recommended as substrate. The optimum water temperature ranges between 24 and 28°C , temperatures below and higher are also tolerated for a limited period.

Often lateral shoots will develop close above the substrate which will initially dis-

Hygrophila difformis*.**H. difformis* 'White-Green'.**

play entire leaves and creeping growth, but which will later develop the typical pinnatisected leaf blades.

To achieve quick reproduction, it is best to sever and replant lateral shoots, with shoot cuttings being equally suitable. Adventitious plants will also form on floating leaves. Flower formation can be expected only in strong emersed specimens and with a lot of light available.

Ecology: *Hygrophila difformis* grows in marshy habitats. Water analyses are not available.

Other: In the course of describing a new species, *Hygrophila mediatrix*, which occupies an intermediate position between the genera of *Hygrophila* and *Synnema*, Dr. H. Heine, Paris, withdrew the more recent genus *Synnema* in 1971, so that only the name *Hygrophila difformis* remains valid.

***Hygrophila difformis* 'White-Green'**

In contrast to the wild form, this plant depicts a more or less strongly pronounced white marking which refers mainly to the venation, but also to other parts of the leaf

blade. So far, it has not been determined if this is a mutation or a virus infection, the latter, however, being very likely. Because the consistency of the white marking is not settled, it seems more appropriate to classify the plant not as a separate variety or form, but as a cultivar 'White-Green' (Kasselmann 1981b, 1983a).

Hygrophila difformis 'White-Green' can also retain the white marking in submersed cultivation, thereby aiding decorative effects in the planting of the aquarium. The development of this feature is obviously neither light-dependent, nor is it significantly influenced by the growth speed, because slow- as well as fast-growing shoots may display chlorophyll deficiencies. The cultivar can, under optimum cultivation conditions, grow just as well as the wild form. It has been commercially available since about 1976.

Flowers of *Hygrophila difformis*.



Hygrophila guianensis

Nees (1845)

Family: Acanthaceae.**Synonyms:** *Hygrophila conferta* Nees.**Etymology:** *Hygrophila*: see *H. balsamica*; *guianensis*: originating from Guyana.**Distribution:** Guyana, Venezuela, Bolivia.**Description:** Marsh plant, up to 50 cm tall. Stem round or angular, (almost) glabrous, 1.5–5 mm thick, little-branched. Leaves 1–2 cm petiolate, decussate. Leaf blade very narrow elliptic to narrow elliptic, with an acute apex and decurrent base, 6–15 cm long, 0.8–2.3 cm wide, entire, upperside short pubescence, medium green coloration.

Flowers short petiolate, several in each leaf axil of the emerged, glabrous or pubescent shoots. Bracts 1.5 mm wide. Corolla 2-lipped, 7 mm long, 4–5 mm wide, white. Upper lip bilobular, lower lip trilobular; 4 stamens. Style and stamens shorter than the corolla. Capsule 0.8–1.5 cm long; seeds 0.5–0.8 mm in size, flat.

Culture: Several plants are commercially available under the name of *H. guianensis* which are, however, in most cases not part of this species. The genuine *H. guianensis* has

only limited suitability for aquarium cultivation. Even under optimum conditions it will grow exceptionally slowly. Especially important are high light intensity, a nutritious substrate and soft water with an optimum temperature range of 20–26 °C. In unproblematic emersed cultivation, flowers and fruit are often formed.

Ecology: In a flood area of a river in Venezuela, the author found *H. guianensis* in dense, semi-aquatic populations. The shoots grew in a depth of 50 cm in standing water within a loamy soil under intense sunlight. Water values (8/1989): temperature 26.5 °C (air temperature 27 °C at 10:30 h), pH 7.6, GH/KH < 1 °dH, 35 µS/cm. W. Staeck collected submersed plants in Bolivia on the bank of a small stream containing almost stagnant water. The substrate was sandy-boggy, the habitat was unshaded. Water values (8/1991) at noon: temperature 17 °C (air temperature 18 °C), pH 6.5, GH 4 °dH, KH 11 °dH, 125 µS/cm.

***Hygrophila guianensis* in its natural habitat in Venezuela.**



Hygrophila polysperma

(Roxburgh) T. Anderson (1867)

Family: Acanthaceae.

Synonyms: *Justicia polysperma* Roxburgh (1832), *Ruellia polysperma* Wallich, *Heliadelphis polysperma* Nees.

Etymology: *Hygrophila*: see *H. balsamica*; *polysperma*: multiseeded.

Distribution: India, Bhutan, introduced to Mexico.

Description: Perennial marsh plant with decumbent or erect shoots, submersed 15–50 cm tall. Stem glabrous, 1–2 mm thick. Leaves decussate, sessile or short petiolate. Leaf blade very narrow elliptic, entire, up to 7 cm in length and 1.5 cm wide, submersed soft and light green, yellowish green to brownish, emerged more sturdy and medium green in color. Apex usually round, narrowing base.

Flowering shoots with short internodes, lower leaves about 1 cm long and 0.5 cm wide, pubescent, becoming smaller towards the top. Inflorescence 5–10 cm long, with solitary axial very small flowers; 2 bracts, about 5 × 1 mm in size, pubescent; 5 sepals, pubescent, 5–6 mm long and less than 0.5 mm wide. Corolla a little more oblong than

the calyx, 2-lipped, white or pale blue-violet in color; upper lip bilobular, lower lip trilobular; 2 stamens, reaching the edge of the corolla; 1 style. Seeds not seen.

Culture: *Hygrophila polysperma* is an extremely modest and recommendable aquarium plant, which will tolerate conditions under which many other aquarium plants will succumb. It grows well in soft water with temperatures between 22 to 28 °C. Under intensive lighting, conspicuously strong shoot apices will form. In poorly illuminated aquariums, it can be clearly noticed that the plants will still grow normally, but that growth is slower, the shoots remain smaller and are therefore less decorative in appearance. The substrate quite obviously plays only a subordinate role in the plants' nutrition. Washed sand is entirely adequate. An additional CO₂ fertilization will generally support growth in aquariums, but is not required for this species.

The species is used as a group in the aquarium's foreground or in the middle zone. The shoots have to be trimmed every 2–4 weeks due to their rapid growth. Reproduction occurs through lateral shoots. *Hygrophila poly-*

Angustifoliate growth form of *Hygrophila polysperma*.



sperma is especially suitable for the first-time planting of new aquariums. Flower formation only occurs very rarely in emerged shoots.

Ecology: Unfortunately, there is hardly any data available on the ecology of the species, and water analyses from India have so far not been published. To her surprise, the author found *H. polysperma* in northern Mexico in a canal in the Laguna Media Luna, a place which has often been mentioned in aquaristic literature because of its interesting cichlids. The species was probably introduced there by the local population. The plants obviously prosper especially well in the canals, even though the water, as shown by the analysis (August 1984), is extremely hard: water temperature 29 °C, pH 7.9, GH 55 °dH, KH 12 °dH. The plants grew semiaquatic and were flowering, enabling identification of the species.

Other: The main differentiating feature of the *Hygrophila* and *Justicia* genera is the

number of stamens, usually four (occasionally two as staminodes) in *Hygrophila* and two fertile stamens in *Justicia*.

Hygrophila polysperma 'Rosanervig'

A variegate, white-green variant of *Hygrophila polysperma* is commercially available, described as a cultivar under the name of *H. polysperma* 'Rosanervig'. The cultivar name of 'Marmor', introduced later, should not be used for the sake of uniformity. The white pattern on the plant leaves—due to a lack of chlorophyll—is almost certainly caused by virus infection. This feature, however, is not consistent (refer also to *H. difformis* "White-Green"). The cultivar 'Rosanervig' is expressedly fast-growing and is highly recommended.

Flowering, emerged shoot of *H. polysperma*.





Hygrophila polysperma 'Rosanervig'.

Isoetes velata

A. Braun var. *sicula* (Gennari) (1861)

Family: Isoetaceae.

Synonyms: [Not *Isoetes sicula* Todaro (1866)].

Etymology: *Isoetes*: *isos* = equal, similar, *etos* = year, displaying the same growth over the entire year; *velata*: masked; *sicula*: originating from Sicily.

Distribution: Sicily, Sardinia.

Description: Tuberous rhizome, up to 2 cm long. Up to 220 leaves in 1 rosette, 10–30 cm long, rising, subulate, slightly turned, reducing towards the apex, 1–3 mm wide at the base, with a distinct margin, otherwise grass green.

Sporangiums with macro- and microspores separated from each other at the leaf bases. They are narrow-oblong, 1–4 mm wide, 1.5–10 mm long, totally covered by the velum (refers to name). Macrospores globular, 450–500 μm in size, microspores ellipsoid, 31 $\times$ 21 μm in size.

Culture: There are no major problems with the cultivation of this unusual plant. It will grow in both soft as well as hard water, with the pH-value being in either the acid or alka-

line range. Medium to intense lighting is recommended. A mixture of sand and fine gravel is suggested as a substrate, with a little loam possibly being added. Optimum temperature range is 22–26 °C. On the swollen leaf bases, sporangiums with macro- and microspores will develop after a couple of months on fully grown plants. The spores are mature once the leaves can be easily detached from the plant. The macrospores are still recognizable by the naked eye as small “balls” whereas the microspores are only identifiable as “brown powder.” The author was most successful with the following method of sowing: first, the spores are mixed in a small container and then sown in moist soil. Once the little plants have achieved a size of several centimeters, they can be transplanted (see photo p. 70). They can also be left to “germinate” in the water and be transplanted after. Regular sowing might be time-consuming, but necessary, because fully matured specimens will often die off after the formation of spores.

Further reading: Kasselmann (1986).

Isoetes velata var. *sicula*.



Sporangia with macro- (left) and microspores.



Lagarosiphon cordofanus

Caspary (1858)

Family: Hydrocharitaceae.

Synonyms: *Udora cordofana* Hochstetter, and others.

Etymology: *Lagarosiphon*: *lagaros* = schlaff, *siphon* = tube (refers to the female flower); *cordofanus*: from Kordofan (a landscape in central Africa).

Distribution: Eastern and South Africa, Cameroon.

Description: Aquatic plant with soft, 0.5–1-mm thick stem. Leaves alternate, occasionally whorled, linear, slightly curved downwards, 1–3 cm long, 0.5–1.5 mm wide, soft, transparent, light green. Margin with 12–66 denticles on triangular protrusions on each side. Leaf base with ovate or narrow ovate scales. Leaf apex with two acute, minute denticles (magnifying glass!).

Plants dioecious; flowers unisexual. Male inflorescence with 7–14 flowers; male flowers float on the water surface to mature, with 3 white reflexed sepals and petals each, 3 fertile stamens, 3 longer staminodes which form a “sail.” Female spathe with 1 flower which floats on the water surface attached to a long

pedicel; perianth white, forming a “bowl”; 3 staminodes; 3 styles. Ovary with more than 20 ovules. Ovoid capsule, many-seeded.

Culture: A gracile, recommendable but light-demanding species, its shoots will prosper best in soft water with an acid to neutral pH-value. An essential prerequisite is a high light intensity. Often an additional CO₂ supply will also have a positive effect. The substrate plays only a limited role in the supply of nutrients because the few roots primarily serve to anchor the plant. Temperature range is 22–34 °C with the optimum range between 25 and 28 °C. Arrange as a group. Propagation is through lateral shoots.

Ecology: The author found the species in its native habitats in Tanzania and Zambia, drifting below the water surface in temporary waters under intense sunlight. The stagnant water was loamy-clouded or clear and up to 1 m deep, often shallower, however. R. Wildenkamp recorded the following water values: 22–32 °C, pH 5.9–7.5, GH < 1–8 °dH, KH 2–8 °dH, 80 µS/cm, O₂ 3.2–4.5 mg/L.

Lagarosiphon cordofanus (center).



Lagarosiphon madagascariensis

Caspary (1881)

Family: Hydrocharitaceae.

Synonyms: *Lagarosiphon densus* Ridley.

Etymology: *Lagarosiphon*: see *L. cordofanus*; *madagascariensis*: originating from Madagascar.

Distribution: Madagascar.

Description: Delicate aquatic plant with a soft, 0.5–1-mm thick stem. Leaves alternate, almost opposite, rarely in trimerous whorls. Blade linear, slightly curved downwards, usually 10–15 mm long, 0.5–1 mm wide (in western Madagascar a population with 1–2.2-mm wide leaves), soft, transparent, light green. 28–80 (–150) denticles (not on protrusions as in *L. cordofanus*) on each side of the margin. Ovate or narrow ovate scales on the leaf base. Leaf apex with 2 pointed minute denticles (magnifying glass!).

Male inflorescence with few flowers. Ovary with 8–14 ovules. Otherwise as described in *L. cordofanus*.

Culture: A delicate, decorative and recommendable plant for the foreground, it used to be commercially available but is hardly so these days. The plant requires a lot of light and loves soft, acid water, but will also still

prosper satisfactorily in medium-hard water. Free-floating shoots will also continue to grow well. Recommended for every aquarium size, even for smaller, well-illuminated breeding tanks, *L. madagascariensis* is propagated through lateral shoots. The optimum temperature range is 24–28 °C.

Ecology: Grows in its native habitat in standing waters drifting below the water surface. In Madagascar, the author often found the species in rice paddies. Water analysis of one location (12/1986 at 14:00 h): temperature 27.5 °C (air temperature 28 °C), pH 6.5, GH 3 °dH, KH 2 °dH, Fe²⁺ 0.2 mg/L. The substrate was boggy-loamy as well as iron-holding.

Other: Clear distinguishing features of sterile *Lagarosiphon* species are, among others, the denticles on the leaf margin as well as the leaf structure (see Symoens & Triest 1983). Species of the genera *Egeria*, *Elodea* and *Hydrilla*, all similar in appearance, have, in contrast to *Lagarosiphon*, a whorled leaf arrangement. The flower biology of these genera is especially interesting (see Cook 1982).

***Lagarosiphon madagascariensis*.**

Lagarosiphon major

(Ridley) Moss (1928)

Family: Hydrocharitaceae.

Synonyms: *Lagarosiphon muscoides* Harvey var. *major* Ridley (1886), *Elodea crispa*, nom. nud.

Etymology: *Lagarosiphon*: see *L. cordofanus*; *major*: larger.

Distribution: Zimbabwe, South Africa, introduced to western Europe and New Zealand.

Description: Aquatic plant with a stiff, 1.5–3-mm thick stem, up to 40 cm tall in the aquarium. Leaves alternate, rarely verticillate. Blade linear, strongly curved downwards, usually up to 15 mm long, 1.5–2 mm wide, thin, hard, transparent, medium to dark green; 50–100 obtuse denticles on each side of the margin (not on protrusions as in *L. cordofanus*). No scales on the leaf base. Leaf apex with 2 obtuse minute denticles (magnifying glass!).

Male inflorescence with over 50 flowers. Sepals and petals of both male and female flowers colored a pale pink. Ovary with 10–12 ovules. Description of the flower otherwise as in *L. cordofanus*.

Culture: This cold-water plant, popular in

aquarium cultivation since 1906, has a very decorative appearance through its conspicuously downward-curved leaf blades. The shoots can be used either floating or implanted. Some populations are even hardy. For use in tropical aquariums, the species is only suitable for temperatures up to 25 °C; the plants will dissolve after only a couple of weeks in too warm water. *Lagarosiphon major* is very light-demanding; under light deficiency the internodes will stretch. Propagation is through lateral shoots.

Ecology: Populates stagnant waters by drifting below the water surface and being anchored to the soil only by its roots. Loves waters deficient in lime. Under agreeable living conditions in its habitats, it is often considered a bothersome weed.

Other: For many years, *L. major* was cultivated in aquaristics under the names of *L. muscoides* var. *major* (*L. muscoides* Harvey is a different species) and *Elodea crispa*. The species is similar to *Egeria densa*, but is much “harder” in its habit and usually forms alternate leaves.

Further reading: Symoens and Triest (1983).

***Lagarosiphon major*.**



The *Lagenandra* Genus

ARACEAE FAMILY

The *Lagenandra* genus is closely related to the *Cryptocoryne* genus, well-known in aquaristics, which is why species of both genera are confused with each other. However, both can be easily distinguished by the following features:

1) *Lagenandra* species do not develop runners as the *Cryptocorynes* do, but develop juveniles directly on the rhizome. (One exception is *Lagenandra nairii*).

2) In the *Lagenandra* genus the leaf blade is curled up from both leaf margins (involute vernation); in *Cryptocoryne* species it is curled up from only one side (convolute vernation).

3) Female flowers in *Lagenandra* are arranged in several circles, whereas they are arranged in only one circle in the *Cryptocorynes*. (Exceptions are *Lagenandra gomezii* [female flowers in one circle] and *L. nairii* [female flowers in a pseudo-whorl].)

Other typical features of the *Lagenandra* genus are: shape and structure of the spathe,

free female flowers and therefore free berries, opening of the fruit on the base and the curling back of the pericarp.

Other *Lagenandra* Species

Apart from those four *Lagenandra* species described in the following, there are a further 10 species known: *L. meeboldii* (Engler) C. Fischer and *L. toxicaria* Dalzell are found in southeastern India, *L. undulata* Sastry and *L. gomezii* (Schott) Bogner and Jacobsen are widespread in northeastern India, *L. bogneri* de Wit, *L. dewitii* Crusio and de Graaf, *L. erosa* de Wit, *L. koenigii* (Schott) Thwaites, *L. lancifolia* (Schott) Thwaites and *L. thwaitesii* Engler originate from southwestern India and Sri Lanka. These species are either little suited for submersed cultivation or have, so far, not been tested; usually, however, they are plants well suited to paludariums.

Further reading: Detailed information on the genus can be found with Bogner and Jacobsen (1987), Dassanayake (1988), de Wit (1978, 1990).

Dissected spathe of *L. dewitii*.



Seeds and fruits of *Lagenandra*.



Lagenandra jacobsenii

de Wit (1983)

Family: Araceae.

Synonyms: *Lagenandra insignis* sensu auct., non Trimen.

Etymology: *Lagenandra*: from *lagenos* (Gr.) = bottle, *andros* = man; refers to the bottle-shaped stamens; *jacobsenii*: after the Danish botanist Niels Jacobsen (1941–).

Distribution: Southwestern Sri Lanka.

Description: Medium-sized plant found in moist locations. Rhizome creeping, up to 4 cm thick. Petiole 10–20(–30) cm long, sheathy. Leaf blade lanceolate to narrow ovoid, 13–25(–30) cm long, 4–10 cm wide, more or less horizontally growing (not vertically as *L. ovata* and *L. praetermissa*), medium green. Apex acute to aciculate; base usually round. Margin entire. Midrib distinctive on the underside.

Inflorescence petiolate. Spathe 13–25 cm long. Limb 4–8 cm long, 4 cm wide, opened wide, sharply reflexed at 90° to the side above the kettle, long caudate, fine mammillate on the outside, white-reddish in color, inside black-purple-red, irregularly transversally ribbed and with branched extensions.

Tail 5–9 cm long, bent sideways during flowering, occasionally curved to the rear. Distinct collar. About 70–80 female flowers, arranged in 5–6 spiral circles; mammillate ovary; round stigma, slightly indented in the center. Male flowers about 80–100. Number of chromosomes $2n = 36$.

Culture: A rare decorative plant which, due to its height of about 20–30 cm, is more suited for paludarium cultivation than the large-growing *L. ovata* and *L. praetermissa* which are kept more regularly. *Lagenandra jacobsenii* loves a shaded, moist location as well as a lot of warmth. Especially conspicuous are the inflorescences with wide open limbs. The plant is not recommended for submersed cultivation in the aquarium.

Ecology: The species is found in small populations in shady, moist places in tropical rainforests.

Other: *L. jacobsenii* was incorrectly classified as *L. insignis* Trimen for a long time. This name constitutes a synonym for *L. ovata*.

***Lagenandra jacobsenii* in its native habitat in Kottawa forest (Sri Lanka).**



Lagenandra nairii

Ramamurthy and Rajan (1984)

Family: Araceae.

Synonyms: None.

Etymology: *Lagenandra*: see *L. jacobsenii*; *nairii*: after the botanist C. Nair, India.

Distribution: India (Kerala State).

Description: Medium-sized marsh plant. Rhizome creeping, 1.5–2 cm thick. Petiole 3–28 cm long, dense and short pubescence; sheath 1–6 cm long. Leaf blade elliptic-oblong to ovoid, 8–17 cm long, 5–9 cm wide, medium green and glabrous on the upper side, light green and slightly pubescent on the underside, especially on the veins. Apex acute; base slightly cordate or round. Margin entire or slightly undulate.

Inflorescence 2–5 cm petiolate. Spathe 4–5 cm long. Limb 2.5–3.5 cm petiolate, ovoid to cuspidate, bent far sideways, mammillate and pubescent on the outside, slightly transversally ribbed on the inside, entire on the margin or slightly irregularly gnawed, inside and outside red-brown. Distinct collar, greenish yellow. Female flowers 10–15, arranged in a pseudowhorl next to each other in a plane; style 1.5–2 mm long; ovary hardly mammil-

late, slight pubescence. Male flowers 45–55. Number of chromosomes $2n$ = about 72.

Culture: This species, only discovered in 1981, is excellently suited for marsh cultivation in paludariums. There, the plants will attain a height of about 10–20 cm. Vegetative propagation is very productive through runners. Inflorescences are often formed. According to the author's own experience, the species also seems to be suited for use in aquariums. Details on cultivation, however, can not be provided as yet.

Ecology: *Lagenandra nairii* is so far known only from the type locality—the Athirappally Falls in Trichur District (Kerala State). There, it leads an amphibious existence on the shady banks of the Chalakkudi River. During the wet season the plants are totally submersed in the water.

Other: *Lagenandra nairii* is the only species of the genus which produces runners. In all other species the juveniles develop on the rhizome.

Further reading: Sivadasan (1986).

Spathe of *Lagenandra nairii*.



Lagenandra ovata

(Linné) Thwaites (1864)

Family: Araceae.**Synonyms:** *Arum ovatum* Linné (1753), *Caladium ovatum* (L.) Ventenat, *Cryptocoryne ovata* (L.) Schott, *Lagenandra insignis* Tri-men.**Etymology:** *Lagenandra*: see *L. jacobsenii*; *ovata*: egg-shaped.**Distribution:** Southwestern Sri Lanka, India.**Description:** Strong marsh plant, over 1 m tall. Rhizome long, creeping, up to 8 cm thick. Petiole up to 50 cm long, fleshy, thick. Blade narrow elliptic to lanceolate, 25–60 cm long and 7–15(–20) cm wide, vertical standing, light to medium green in color. Apex acute to acuminate; base acute or obtuse.

Inflorescence up to 20 cm petiolate. Spathe 5–25 cm long. Limb long caudate, twisted once, globularly inflated above the kettle, outside with more or less large warts or very wrinkled, purple-red, inside in the lower part very wrinkled, in the upper part mammillate to transversally ribbed, dark purple-red. Tail up to 8 cm long. Collar wide. Female flowers 20–110, in 4–8 spiral circles; ovary mammillate; ovary more or less round, indented in the

center. Male flowers 90–100. Number of chromosomes $2n = 36$.**Culture:** *Lagenandra ovata* can be cultivated in the aquarium but, due to its size and the strong desire to protrude from the water, has only limited suitability for submersed cultivation. Best are small specimens which will grow fairly slowly in a nutrient-poor substrate. Strong plants require very high aquariums. More recommended than submersed maintenance is the keeping in spacious paludariums, where growth poses no problems in shallow water or moist soil. The specimens require a high degree of humidity and warmth. They have only limited light requirements, but grow better under intense light. Vegetative propagation is possible through partitioning of the strong rhizomes.**Ecology:** The species grows in dense communities in shady and sunny locations, alongside the banks of fast-flowing streams and rivers in a gravelly-loamy substrate. Occasionally, juveniles are found entirely submersed in the current.**In comparison: spathes of *Lagenandra ovata* (left) and *L. praetermissa*.**

Lagenandra praetermissa

de Wit (1983)

Family: Araceae.**Synonyms:** none.**Etymology:** *Lagenandra*: see *L. jacobsenii*; *praetermissa*: omitted, overlooked (reference, see Other.)**Distribution:** Southwestern Sri Lanka.**Description:** Strong marsh plant, up to 1 m tall. Rhizome creeping, 3–5 cm thick. Petiole 30–60 cm long, sheathed. Blade narrow elliptic, 30–45 cm long, (6–)9–12 cm wide, growing vertically, medium green. Apex acute; base acute to almost obtuse. Margin partially fine undulate and colored brownish. Midrib distinct.

Inflorescence 7–30 cm long petiolate. Spathe 8–20 cm long. Limb long caudate and twisted once, slim, not globularly inflated as in *L. ovata*, opened by a narrow gap, with warts on the outside and wrinkled, longitudinal stripes, green to light purple-red color, inside slightly mammillate and transversally ribbed, light purple-red. Tail 1–8 cm long and erect. Collar distinct, thick. Female flowers about 60–70, in 4–6 spiral circles; ovary mammillate; stigmas round, indented in the

center. Male flowers about 50. Number of chromosomes $2n = 36$.

Culture: As described in *L. ovata*.**Ecology:** *Lagenandra praetermissa* populates the same habitats as *L. ovata*.**Other:** Even though *L. praetermissa* was already collected by Thwaites in 1853, it received its present name only in 1983. It was for a long time confused with *L. toxicaria* Dalzell from western India as well as *L. ovata* (L.) Thwaites. The spathe from *L. praetermissa* is, in contrast to *L. toxicaria*, mammillate on the outside. In comparison to *L. ovata*, *L. praetermissa*'s outer spathe features only very small warts. Furthermore, the leaf blade of *L. praetermissa* is distinctly more narrow than that of *L. ovata*.

Lagenandra praetermissa and *L. ovata* are easily confused with *Cryptocoryne ciliata*. Both species can be most easily distinguished from one another by their juvenile blades: the margins in *Lagenandra* are curled up from both sides, in *Cryptocoryne* from only one side.

***Lagenandra praetermissa* on the banks of a stream in Sri Lanka.**

Lemna gibba

Linné (1753)

Family: Lemnaceae.

Synonyms: *Lenticula gibba* Moench, and others.

Etymology: *Lemna*: Greek plant name; *gibba*: gibbous, refers to the inflated underside of the frond.

Distribution: In regions with a mild climate: America, Europe, Africa, southwest Asia; not in Australia.

Description: Small plant, floating on the water surface. Fronds leaf-like, ovoid, entire, solitary or remaining in groups, 1–8 mm long and 0.8–6 mm wide, flat on the top side, underside gibbous, up to 4 mm thick, green-colored, occasionally red-spotted, underside occasionally red. Numerous stomata. Veins (3)4–5(7). Each frond with a root; this with a tubular sheath and root-cap. Daughter fronds borne from the 2 lateral pouches of the parent frond.

One flower per frond, in the same lateral pouch as the daughter frond. Flower structure as in *L. trisulca*. Ovary with 1–7 ovules. Fruit symmetric, aliferous. Seeds with 8–16 distinct ribs.

Culture: *Lemna gibba* and *L. minor* are generally unwanted cultivated plants because they will display mass reproduction under conditions of good nutrition supply. One can easily unwantingly introduce these *Lemna* when purchasing aquarium plants or when catching water fleas. They can, however, nevertheless be useful as a nutrient indicator: bad growth by *Lemna* will point to a generally insufficient nutrient supply and indicates the necessity for fertilization. *Lemna gibba* develops flowers and fruit often and can then be an interesting object for study. *Lemna gibba* and *L. minor* develop winter fronds (no turions) which will not drop to the bottom.

Ecology: *Lemna gibba* populates tranquil, permanent and temporary waters. In temporary waters, the fruit will survive during the dry period in the bog. The species will not tolerate pH-values below 4 and will grow only in waters with a high conductivity (between 100 and 3370 $\mu\text{S}/\text{cm}$).

Further reading: Landolt (1986).

Lemna gibba is gibbous and curved on the underside (highly enlarged).



Lemna minor

Linné (1753)

Family: Lemnaceae.

Synonyms: Numerous (see Landolt 1987).

Etymology: *Lemna*: see *Lemna gibba*; *minor*: smaller (smaller than *Spirodela polyrhiza*).

Distribution: Worldwide in regions with a temperate climate, except eastern Asia, Australia (introduced near Melbourne).

Description: Fronds 1–8(–10) mm long, 0.6–5.0(–7) mm wide, with 3(4–5) veins, never gibbous on the underside as in *L. gibba* (not thicker than 1 mm), upperside green, occasionally reddish (especially in the cold seasons), underside rarely reddish.

Ovary with 1 ovule. Seeds with 10–16 distinct ribs. Description otherwise as for *L. gibba* (according to Landolt 1986).

Culture: The occurrence of this *Lemna* is rarely wanted due to the mass reproduction under agreeable conditions. Only a regular skimming will do to decimate plant numbers (see also *L. gibba*).

Lemna minor flowers occasionally, fruit is, however, very rare. The winter fronds (no turions) contain more starch than normal fronds,

enabling their survival for lengthy periods under disadvantageous living conditions.

Ecology: *Lemna minor* populates standing and slow-moving waters, but can also exist in waterfalls (known to occur in the Caucasus). *Lemna minor* is able to populate these special environments due to its especially long roots. The roots serve as an important stabilizing aid during strong winds. The fronds will still tolerate even low pH values below 4. In native habitats, plants were found in water with a conductivity of 52–435 $\mu\text{S}/\text{cm}$. In Europe, in contrast to other *Lemna*, *L. minor* prefers waters without an optimal nutrient supply in areas with high precipitation and cold summers. Minimum temperature is 15 °C, maximum temperature is 32.5 °C.

Other: *Lemna gibba* and *L. minor* are difficult to distinguish in their vegetative states, compare the descriptions. Natural hybrids are also supposed to occur.

Lemna minor.



Lemna trisulca

Linné (1753)

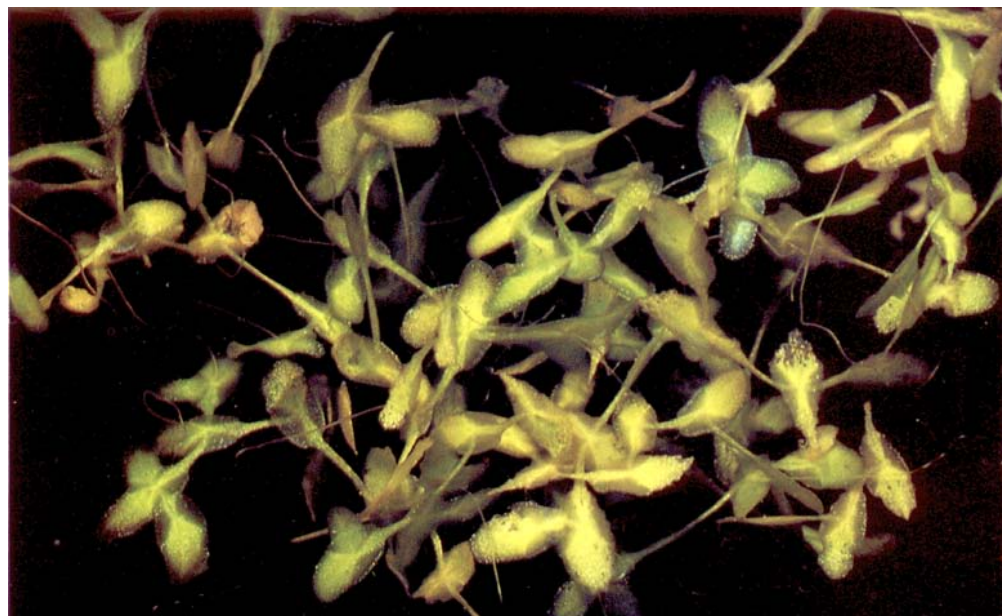
Family: Lemnaceae.**Synonyms:** Numerous (see Landolt 1987).**Etymology:** *Lemna*: see *Lemna gibba*; *trisulca*: refers to the 3 veins of the fronds.**Distribution:** Worldwide in areas featuring a temperate climate, not in South America.**Description:** Polymorphic aquatic plant. The plants hover below the water surface, fronds leaf-like, narrow ovoid, toothed at the front, 3–15 mm long, 1–5 mm wide, flat, transparent, light green or reddish. Base narrowed to a 2–20-mm long style. No stomata; (1)3 veins. Each frond with an up to 2.5-cm long root.

Sexual (flowering) plants float on the water surface, are ovoid, much shorter and less toothed than the vegetative plants, with numerous stomata; 1(2) flowers, in the same lateral pouch as the daughter frond. Every flower has a membranous leaflet, 2 stamens, which will develop after each other, and 1 pistil. Ovary with 1 ovule. Fruit symmetric, laterally winged towards the top. Seeds with 12–18 distinct ribs (Landolt 1986).

Culture: Good for only limited use in tropical aquariums in not too high temperatures.

Lemna trisulca is the recommended aquatic plant for cultivation in cold-water aquariums or garden ponds. In contrast to most “unpopular”, *Lemna* species, it does not reproduce on a massive scale. Fronds (being together) appear very decorative and are preferred by fish as a spawning site and cover. Shorter and wider fronds develop during winter which will drop to the substrate bottom and continue to grow there very slowly (no turions). The plant flowers occasionally and fruit formation is rare.

Ecology: Populates stagnant waters with a low phosphate concentration and usually a conductivity above 100 $\mu\text{S}/\text{cm}$. Cannot tolerate pH-values below 4. Temperature range from -40°C to 22°C (temporarily up to 30°C). Water values of a shallow lake in Greece (6/1980): temperature 25°C (air 26°C at 13:00 h), pH 7.2, GH 5.8°dH , KH $< 1^{\circ}\text{dH}$, 81 $\mu\text{S}/\text{cm}$.

Lemna trisulca.

Lilaeopsis brasiliensis

(Glaziou) Affolter (1985)

Family: Apiaceae.

Synonyms: *Crantzia brasiliensis* Glaziou (1909), *Lilaeopsis carolinensis* var. *minor* Hill, *Lilaeopsis minor* (Hill) Pérez-Moreau.

Etymology: *Lilaeopsis*: similar to the genus *Lilaea*; *brasiliensis*: from Brazil.

Distribution: Southeastern Brazil, Paraguay, Argentina (Buenos Aires).

Description: Gramineous marsh plant with a creeping, branched 0.2–1.7-mm thick rhizome. Each node with 1 or more leaves. Leaves erect, entire, glabrous, hollow in the lower section and elliptic in a sectional view, towards the top too narrow spatulate and flattened, usually up to 6 cm long, 2–3 mm wide and featuring 6–10 transversal veins.

Inflorescence an axial 2–15(–25)mm long petiolate umbel with 2–8 small flowers. Pedicel 2–10 mm long. Bracts 0.5–1.5 mm. Flowers bisexual, 5-merous. Petals white; 2 carpels. Fruit wide globular to wide obovate; mericarp with 5 ribs.

Culture: *Lilaeopsis brasiliensis* is a grass-like and small-remaining plant which is well suited for the foreground decoration. Sub-

mersed cultivation is unproblematic; the plants, however, grow only slowly. They can be accommodated equally in both hard or soft, acid or slightly alkaline water. Light requirement is only moderate, but high light intensity is clearly growth-enhancing. A fine-grained substrate is recommended into which the delicate shoots can be easily implanted. Optimum temperature range is 22–26 °C. The species is especially suited for the planting of paludariums where a dense carpet will be established after only a few weeks. During summer, *L. brasiliensis* can also be cultivated on the edges of garden ponds. Inflorescences and fruit occur only in emersed cultivation. **Ecology:** On banks of slow-flowing rivers, in marshes, ponds, up to an altitude of 1200 m. **Other:** In the aquarium literature, *L. brasiliensis* was incorrectly listed under the names of *L. novae-zelandiae*, *L. attenuata* and *L. polyantha* (Petersen 1986).

***Lilaeopsis brasiliensis*.**



Lilaeopsis carolinensis

Coulter and Rose (1897)

Family: Apiaceae.

Synonyms: *Crantziola carolinensis* (Coulter and Rose) Koso-Poliansky, *Crantzia carolinensis* (Coulter and Rose) Chodat.

Etymology: *Lilaeopsis*: see *L. brasiliensis*; *carolinensis*: originating from Carolina (North America).

Distribution: Eastern North America in the coastal regions, southern South America in Argentina, Paraguay, Brazil, in Europe on the coasts of Portugal and northwestern Spain.

Description: Gramineous marsh plant with creeping, branched, about 2(–5.5)-mm thick rhizome which is root-forming on all nodes. Each node with 1(2–3) leaves. Leaves erect, entire, glabrous, hollow in the lower part and almost round in a sectional view, narrow spatulate towards the top, flattened, usually 4–20 cm long, 3–4 mm wide, with 10–20 transversal veins.

Emerald shoots in the leaf axils, with 2–3 umbels which are 1–5(–9) cm petiolate. Umbel with 3–14 solitary flowers. Pedicel 1–10(–30) mm long. Bracts 0.5–1.5 mm long. Flowers bisexual, 5-merous. Petals white or

pale dark red; 2 carpels. Fruit wide obovate to wide ovoid; mericarp with 5 ribs.

Culture: *Lilaeopsis carolinensis* is rarely commercially available. In cultivation, the species has to be treated similarly to *L. brasiliensis*. Due to the leaves being twice as long, both species can be well distinguished in their vegetative state, even during comparative emersed cultivation. Definite differentiating features are inflorescences and fruit which occur often in marsh cultivation. *Lilaeopsis carolinensis* develops far shorter leaves under water than emersed, so that the plant is easily confused there with *L. brasiliensis*. During autumn, shorter leaves with reddish flowers and infructescences will form.

Ecology: In marshy and wet locations, often in brackish waters.

Other: Occasionally *L. macloviana* (Gandoger) Hill is being cultivated, which displays leaf lengths of more than 30 cm.

Further reading: Affolter (1985).

Lilaeopsis carolinensis in marsh cultivation.



Limnobium laevigatum

(Wildenow) Heine (1968)

Family: Hydrocharitaceae.**Synonyms:** *Salvinia laevigata* Willdenow (1810), *Hydromystris laevigata* (Willdenow) A. T. Hunziker, *Limnobium stoloniferum* (G. F. W. Meyer) Grisebach, and others.**Etymology:** *Limnobium*: from *limne* = marsh, *bios* = life; *laevigatum*: smooth, possibly refers to the leaf upper side.**Distribution:** Central and South America.**Description:** Perennial aquatic plant. Leaves structured into sheath, petiole and blade; 2 scale-like leaves on the base of each rosette. Sheath up to about 2 cm long. Emerged leaves up to 27 cm petiolate, petiole not swollen, floating leaves usually 0.5–1 cm petiolate, petiole and blade often spongy swollen. Margin entire, wide elliptic to roundish, about 2–4 cm long, 1–3.5 cm wide, medium green. Base truncate, apex rounded.

Flowers unisexual, monoecious; 1–2 bracts. Male spathe with up to 11 petiolate flowers; 3 sepals, recurved when maturing; 3 petals; 6(–9) stamens in 2(3) circles. Female spathe with up to 3 petiolate flowers; 3 sepals. Petals usually absent; 2–6 staminodes; 3–6

styles, each bifid, mammillate. Fruit containing numerous seeds.

Culture: Culture is as described for *Limnobium spongia*, but *L. laevigatum* can handle higher temperatures up to 35 °C.**Ecology:** The species populates stagnant and slow-moving waters. Temperature tolerance is exceptionally high (right down to the frost limits). Several biotopes were researched: 1) Brazil (7/1987): Guaporé river, detailed water analysis see p. 40; 2) Peru (7/1990): Rio Yanayacu, slow-moving water, see detailed water analysis biotope No. 6 on p. 40; 3) Venezuela (8/1989): pond, stagnant water, temperature 33 °C (air temperature 34 °C at 10:30 h), GH 3 °dH, KH 5 °dH, pH 7.3, 250 µS/cm; 4) Argentina (7/1993): biotope with stagnant water, substrate consisting of loam, temperature 16.5–17.6 °C, air 25–27 °C, GH < 1–6 °dH, KH < 1–10 °dH, pH 5.5–7.6, 200 µS/cm, Fe < 0.05 mg/L; and 5) Detailed water analysis biotope No. 4, p. 40.**Further reading:** Cook and Urmi-König (1983a).***Limnobium laevigatum* in its natural habitat in Argentina.**

Limnobium spongia

(Bosc) Steudel (1841)

Family: Hydrocharitaceae.

Synonyms: *Hydrocharis spongia* Bosc (1807), *Limnobium bosci* L. C. Richard, *Hydrocharis cordifolia* Nuttall.

Etymology: *Limnobium*: see *L. laevigatum*; *spongia*: sponge, refers to the spongy swollen leaf blades.

Distribution: Southeastern U.S., Canada.

Description: Essentially as in *L. laevigatum*, *L. spongia* is distinguishable, however, by the following features: leaf blade usually acute, cordate on the base. Male spathe with about 25 flowers. Male flowers with (3–)9–12(–16) stamens in 3–5(–6) circles. Female spathe with up to 6 flowers. Female flowers with 6–9 styles.

Culture: *Limnobium spongia* is a floating plant that used to be used regularly but has since been replaced by other species, so that today it is only rarely cultivated by aquarists. The species is recommended for cold-water aquariums as well as low-temperate tropical aquariums (only temporarily above 25 °C). Due to its productive propagation through runners and the corresponding rapid develop-

ment of a dense layer of floating plants, the rosettes have to be trimmed regularly in order to prevent a too strong shading of species growing below it. The plants are most beautiful in soft to medium-hard water and high humidity. The light-demanding rosettes grow best in shallow water with little movement above a boggy substrate. During summer, the plants may be temporarily cultivated in a garden pond in a shaded-sunny location.

Ecology: The species populates wet habitats such as marshes, ponds, lakes and slow-moving rivers. Detailed information about its ecology have so far not been published. Cook and Urmi-König (1983a) mention that the largest specimens of *L. spongia* develop on a boggy substrate which, according to the author's experience, is also valid for *L. laevigatum*.

Other: *Limnobium* is pollinated through wind movement.

***Limnobium spongia*.**



Limnophila aquatica

(Roxburgh) Alston (1929)

Family: Scrophulariaceae.

Synonyms: *Cyrilla aquatica* Roxb. (1798), and others.

Etymology: *Limnophila*: *limne* = marsh, *philos* = friend; *aquatica*: existing in water.

Distribution: India, Sri Lanka, Sulawesi, possibly more widespread.

Description: Very changeable marsh plant. Emerged stem erect, up to 4 mm thick, round, glabrous or rough pubescent. Leaves entire, sessile, opposite or in 3(4)-merous whorls. Leaf blade linear-lanceolate to lanceolate-elliptic, 2.5–4.5(–8.0) cm long, 0.5–1.1 (–2.0) cm wide. Margin serrate to crenate. Submersed shoot up to 60 cm long, erect, 2.5–5 mm thick, plumy pubescence or smooth. Pinnate leaves in 17–22-merous whorls with a diameter of 5–12 cm; each leaf with about 10–50 hair-fine segments, light green, under intense light slightly reddish brown in color.

Flowers solitary or in many-flowered apical or axial racemes; 0 or 2 bracts. Pedicel 1–15 mm long. Calyx glabrous or glandular, 4–6 mm long. Corolla funnel-shaped, 8–13(–20)

mm long, white with purple-red or violet marking, outside glabrous, inside very pubescent; 4 stamens unequal in length. Style 6–7 mm long. Capsule 3.5–4 mm in size, globular.

Culture: Of all *Limnophila* species known to aquaristic cultivation, *L. aquatica* grows the largest. For optimum growth, *L. aquatica* requires soft to medium-hard water with a temperature range of 22–28 °C. Important for thickset and strong shoots is also a brighter and free-standing location. Nutrient-rich substrate enhances the development of magnificent leaf whorls. Propagation is through cuttings. Contrary to information found in literature, floating specimens grow out of the water, independent of the lighting period. Emerged culture is also possible on a heated window sill. The white-violet flowers generally appear in the short-day. Seeds germinate well in moist soil.

Ecology: Grows in wet, but also relatively dry locations in rice paddies, and, as an aquatic or marsh plant, in both fast- and slow-moving waters.

***Limnophila aquatica*.**

Limnophila aromatica

(Lamarck) Merrill (1917)

Family: Scrophulariaceae.

Synonyms: *Ambulia aromatica* Lam. (1783), and others.

Etymology: *Limnophila*: see *L. aquatica*; *aromatica*: spicy, aromatic scent.

Distribution: Widespread in Southeast Asia.

Description: 30–50 cm-tall marsh plant. Stem decumbent or erect, 2–5 mm thick, fleshy, slightly grooved, glabrous to a little glandular, light green to black-violet in color. Leaves opposite, almost enveloping the stem, or in trimerous whorls. Leaf blade sessile, emersed lanceolate-ovoid, submersed narrow lanceolate, acute or obtuse, 2.0–6.5 cm long, 1.0–2.5 cm wide, with distinctly serrate margin, upperside light to olive green, submersed also reddish, underside whitish green.

Flowers usually solitary, axial, up to 2 cm petiolate, rarely in many-flowered terminal or axial racemes. Bracts up to 3 mm long. Calyx 5–8 mm, glabrous or glandular. Corolla up to 14 mm long, pink to purple-red in color, inside rough pubescent; 4 stamens unequal in length. Style about 6 mm. Capsule 3–5 mm in size. Number of chromosomes $2n = 68$.

Culture: *Limnophila aromatica* is very variable in habitus and, depending on its country of origin, also different in suitability as to aquarium culture. Occasionally, commercially available specimens from Sri Lanka and Sulawesi can be utilized for a consistent submersed cultivation. High light intensity and soft to medium-hard water with a temperature range of about 22–27 °C are specifically recommended. Even under optimum cultivation conditions, the shoots will grow only relatively slowly. Propagation through cuttings and seeds is possible.

Ecology: Grows in boggy places, but also on the banks of flowing waters. On Sri Lanka, the author often found *L. aromatica* in rice paddies. At one specific location, dense populations on the banks of a river with the following water values were recorded: pH 5.8, GH 3 °dH, KH 2 °dH, 91 µS/cm, rH 240 mV.

Other: Submersed shoots of *L. aromatica* are easily confused with shoots from *Bacopa crenata*.

Emersed shoot of *Limnophila aromatica*.



Flower of *L. aromatica*.



Limnophila dasyantha

(Engler and Gilg) Skan (1906)

Family: Scrophulariaceae.**Synonyms:** *Ambulia dasyantha* Engler and Gilg (1903).**Etymology:** *Limnophila*: see *L. aquatica*; *dasyantha*: refers to the pubescence of the flower.**Distribution:** Africa (Mali, Guinea Bissau, Guinea, Sierra Leone, Gabon, Tanzania, Zambia, Angola).**Description:** Changeable marsh plant. Stem decumbent or erect, up to 70 cm long, fleshy, dense pubescence or glabrous, green to wine red. Submersed leaves pinnate, in 8–11-merous whorls; hair-fine segments, light green to strong red-brown. Emerged leaves after several whorly-arranged intermediate leaves decussate, sessile. Emerged leaf blade lanceolate to narrow ovoid, 1.0–1.5 cm long, 0.3–0.5 cm wide, slightly pubescent or glabrous, green. Margin crenate or indistinctly serrate, increasingly entire towards the shoot tip.

Flowers sessile, densely arranged in a short spike. Bracts absent. Calyx about 3.5 mm long, glabrous, green. Corolla about 14 mm long, bright yellow, with indistinct brownish

spots, outside short, inside densely pubescent. Upper lip trilobular, lower lip with 2 lobes; 4 stamens unequal in length; 1 style. Capsule 3×2 mm in size, compressed, wide elliptic.**Culture:** Nothing is known about a successful cultivation of this decorative *Limnophila* species. Shoots collected by the author in Tanzania could be maintained only in medium-hard water for a limited period. However, it might be possible that *L. dasyantha* will grow satisfactorily within the aquarium in soft, acid water under intense lighting and high temperatures.**Ecology:** Hardly anything is known about native habitats. Shoots from *L. dasyantha* grew at the above mentioned location under intense sunlight in shallow water in a iron-containing boggy substrate.**Other:** With its large yellow flowers and pinatisected leaves *L. dasyantha* is an especially decorative plant, the importation of which would certainly make for a rewarding effort.***Limnophila dasyantha*.****Inflorescence in its habitat in Tanzania.**

Limnophila heterophylla

(Roxburgh) Benthalm (1835)

Family: Scrophulariaceae.

Synonyms: *Columnnea heterophylla* Roxburgh (1832), *Limnophila heterophylla* (Roxb.) Benth. var. *reflexa* (Benth.) Hook. f., and others.

Etymology: *Limnophila*: see *L. aquatica*; *heterophylla*: different in leaf structure.

Distribution: Widespread in Asia (from Pakistan to China, Borneo).

Description: Small marsh plant with erect shoots. Emerged stem up to 20 cm tall, glandular to almost glabrous. Emerged leaves opposite or whorled, up to 20 mm long, sessile, oblong with serrate-crenate margin, 3–5-veined. Submersed shoot up to 70 cm long. Pinnate leaves in 8–14-merous whorls, up to 55 mm long, each leaf with numerous hair-fine medium green-colored segments.

The sessile, or up to 2-mm long petiolate flowers, are located solitary in the axils of the emerged shoots. Inflorescence occasionally forming a loose, terminal spike. No bracts. Calyx about 3 mm long, hardly glandular; calyx-lobes about 1.5 mm long. Corolla about

5 mm long, glabrous, white, pale violet in the throat in color; 4 stamens unequal in length.

Culture: As described for *L. indica*.

Ecology: Surprisingly there is no data available on the natural habitats of this species. The author often found *L. heterophylla* on Sri Lanka in rice paddies as well as in small, flowing waterways. The following water analyses were conducted at two habitats in January 1985: 1) Stream, with fast-flowing clear, water: pH 7.4, GH 21 °dH, KH 14 °dH, 1710 µS/cm, rH 179 mV; and 2) Pool, stagnant water, water temperature 30 °C, pH 6.0, GH < 1 °dH, KH < 1 °dH, 85 µS/cm, rH 201mV.

Other: *Limnophila heterophylla*, in its submersed habitus, is very similar to *L. indica* and *L. sessiliflora*. A definite identification can be made only on the basis of the emerged and flowering shoots (compare the descriptions of both species). The occasionally applied name of *L. heterophylla* var. *reflexa* (Bentham) Hooker fil. is a synonym.

Further reading: Philcox (1970).

Limnophila heterophylla.



Limnophila indica

(Linné) Druce (1914)

Family: Scrophulariaceae.**Synonyms:** *Hottonia indica* Linné (1762), and others.**Etymology:** *Limnophila*: see *Limnophila aquatica*; *indica*: originating from India.**Distribution:** Widespread in the tropical regions of Africa, Asia, and Australia, absent in North America, but introduced to south-western Brazil (Rio Guaporé).**Description:** Marsh plant with erect shoots. Emerged stem 5–15 cm tall, glabrous, glandular or hirsute pubescent. Emerged leaves usually arranged in 6–11-leaved whorls, from narrow-elliptic with crenate to serrate margin to pinnately parted, rarely opposite and unparted, 1–3-veined. Blade 3–20 mm long, 1–3 mm wide. Submersed shoot up to 80 cm long. Pinnate leaves in 6–20-merous whorls, leaf 10–40 mm long, each leaf with numerous hair-fine segments, light green, under intense light pale reddish brown in color.

The petiolate flowers are solitary in the axils of the emerged shoots. Pedicel (1–)3–10(–26) mm long, occasionally pubescent; 2 bracts, 1.5–4 mm long. Calyx 3–6 mm long, glandular or little pubescent; calyx-lobes short,

1–3 mm. Corolla 2-lipped, 4–12 mm long, white, often pale yellow or pink on the base, and pale violet stripes on the inside; 4 stamens unequal in length; 1 style, up to 4.5 mm long. Number of chromosomes $2n = 34, 68$.**Culture:** A very beautiful and recommended aquarium plant, *L. indica* is regularly commercially available. The plant requires a lot of light and a nutrient-rich substrate. Water movement is advantageous. It grows well in hard, alkaline water, with an optimum temperature range of 25–28 °C. The plant cannot cope with algae infestation.**Ecology:** *Limnophila indica* populates both flowing waters—where plants will usually grow submersed in the current in the vicinity of banks—as well as standing or hardly moving waters in which one will find the shoots often flowering semiaquatic or entirely emerged. The author conducted research in several very different habitats: 1) Papua New Guinea in July 1988: plants submersed in a river about 5 m wide with slow-moving, clear water. Substrate sandy-gravelly (volcanic rock), mixed with a bit of loam and bog (photo p. 7). Air temperature 28 °C at noon, water temperature 26 °C, pH 8.3, GH 7 °dH, KH 10 °dH, 310 $\mu\text{S}/\text{cm}$; and 2) Papua New Guinea in July 1988: submersed and semiaquatic-growing plants in standing, clear, sunny leftover water of a stream, about 20 × 3 m in size. Boggy substrate. Water temperature 29 °C at 11:00 h, pH 7.6, GH 19 °dH, KH 28 °dH, 730 $\mu\text{S}/\text{cm}$. Also see the detailed water analysis of the Rio Guaporé (Brazil) on p. 40.**Other:** *Limnophila indica* is a very variable species, which is very similar to *L. sessiliflora*. For differentiating features see there. Several varieties of *L. indica* have been described, the features of which have not been proven consistent in cultivation and therefore have no taxonomic position. In older aquaristic literature (Wendt) a toxicity of the juice is mentioned; this, however, is no longer valid for plants in cultivation today. *Limnophila indica* was previously cultured under the name of *L. gratioloides* R. Brown.***Limnophila indica* from Papua New Guinea.**

Limnophila sessiliflora

Blume (1826)

Family: Scrophulariaceae.

Synonyms: *Hottonia sessiliflora* Vahl (1791), and others.

Etymology: *Limnophila*: see *Limnophila aquatica*; *sessiliflora*: with sessile flowers.

Distribution: Widespread in Asia, from India to Japan.

Description: Marsh plant with erect shoots. Emerged stem up to 20 cm tall, hardly hirsute pubescent to almost glabrous. Emerged leaves in 3–8-merous whorls. Blade initially pinnate, then linear to elliptic with serrate to crenate or jagged margin, 5–20 mm long and 1–3 mm wide, glabrous. Submersed shoot up to 70 cm long. Pinnate leaves in 9–12-merous whorls, leaf 15–30 mm long, with numerous fine segments, light green in color.

Flowers sessile or rarely up to 1.5 mm long petiolate, solitary in the axils of the emerged shoots. Usually no bracts, if present never larger than 1.5 × 0.1 mm. Calyx 4–7 mm long, glandular or pubescent, calyx-lobes 2–4 mm long. Corolla 2-lipped, 5–12 mm long, white or pale blue-violet in color; 4 stamens un-

equal in length; 1 style, 3 mm long. Number of chromosomes $2n = 51, 68$.

Culture: Cultivation corresponds to that of *L. indica*, however, plants will display better growth at low temperatures of 20–26 °C.

Ecology: Hardly anything is known about the ecology of this plant. The author located *L. sessiliflora* once on Sulawesi in submersed populations in a small stream with fast-moving water and a sandy substrate.

Other: *Limnophila sessiliflora* is very similar to *L. indica*. According to Philcox (1970), *L. sessiliflora* can be distinguished from other *Limnophila* only by the absent pedicel, absent bracts, the pubescent calyx, the long calyx-lobes, the emerged pubescent stem as well as the number of chromosomes. The features are, however, variable to a certain degree depending on the plant's origin, and, according to this author, not always suited as distinguishing criteria (compare the description of *L. indica*). A wild hybrid of both species occurs in Louisiana.

Limnophila sessiliflora.



Flowering emerged shoot of *L. sessiliflora*.



Limnophyton fluitans

Graebner (1908)

Family: Alismataceae.**Synonyms:** None.**Etymology:** *Limnophyton*: *limne* = marsh, *phyton* = plant; *fluitans*: floating.**Distribution:** West Africa (Cameroon, Nigeria).**Description:** Perennial aquatic plant. Rhizome up to 7.5 cm and longer, up to 5 mm thick. Leaves 10–22 cm long petiolate, with a short sheath. Leaf blade linear-narrow lanceolate to strap-shaped, 30–66 cm long, 2.5–4.5 cm wide, green, slightly transparent. Base narrow cuneate; apex acute and terminating in a 2–5 mm long point. Margin slightly undulate. Distinct midrib, 1(–2) longitudinal veins on both sides.

Peduncle 25–40 cm long, up to 7 mm thick. Inflorescence 4–6 cm long, with (2–)3(–4) flower-carrying whorls, rarely branched on the lowest whorl; whorl with 3–12 flowers. Flowers polygamous (bisexual and male); bisexual flowers only on the lowest or on both lower whorls, male flowers above; 3 bracts, lanceolate to triangular, caudate, 1–2 cm long. Solitary flower petiolate,

with 3 green sepals and 3 white petals; sepal 4–5 mm long, 3–4 mm wide; petal about 7 mm long, 4 mm wide. Bisexual flower: stamens about 1 mm long; numerous carpels, bottle-shaped, 1.8–2 mm long, with a short style and capitate, papillose stigma. Male flower: 6 stamens, 2.5–3 mm long. Infructescence with 30–35 nutlets. Nutlets wide bottle-shaped, 4–5 mm long and 3–3.5 mm thick (see also Kasselmann 1984a, 1985a).

Culture: The culture of this rare plant is very difficult and has so far not been consistently successful in aquariums.**Ecology:** The author collected the species in its native habitat in Cameroon. The plants grew in a stream with fast-flowing, clear, up to 50-cm deep water. They formed dense populations with submersed, floating leaves; emerged leaves isolated only in shallow waters. The substrate consisted of rubble, sand, mud and a lot of dead foliage. Water values: temperature 29 °C, pH 5.9, GH < 1 °dH, KH < 0.1 °dH, 45 µS/cm.***Limnophyton fluitans* from Cameroon.****Inflorescence of *Limnophyton fluitans*.**

Lindernia parviflora

(Roxburgh) Haines (1922)

Family: Scrophulariaceae.

Synonyms: *Gratiola parviflora* Roxburgh (1819), *Ilysanthes parviflora* (Roxb.), Benth., *I. radicans* Pilger, *I. capensis* (Thunberg) Benth., *Lindernia capensis* Thunb.

Etymology: *Lindernia*: after the botanist Fr. Balth. v. Lindern (Strassbourg) (1682–1755); *parviflora*: small-flowered.

Distribution: Africa, Madagascar, Sri Lanka, India, Vietnam, introduced to Peru.

Description: Small marsh plant with decumbent or ascendent, often branched stem. Submersed shoots erect, up to 30 cm tall. Leaves decussate, sessile, entire, 0.7–1.2 cm long, 0.5–0.8 cm wide. Blade ovoid to roundish; apex round.

Flowers solitary, 0.7–1.5 cm petiolate; 5 sepals, green, pubescent, 3 mm long. Corolla tubular, gamophyllous, 0.5–1.2 cm long, upper lip with 2 lobes, lower lip trilobular. Petals round, up to 3 mm long, white with pale violet spots; throat slightly blue-violet; 4 stamens, the 2 rear ones 3–4 mm in length, the front ones reduced to staminodes and slightly protruding from the corolla. Anthers blue-

violet in color. Ovary 1 mm long. Style 5 mm long. Fruit is a 2–3-mm sized large capsule.

Culture: *Lindernia parviflora* is an undemanding and fast-growing aquarium plant for which water hardness, pH-value and substrate play only a nonessential role for growth. High light intensity is important for stronger specimens. Under bad lighting conditions, only frail and hardly decorative plants will develop. For a group arrangement 10–20 shoots are needed. These should consist of cuttings differing in length and planted in a terraced way in the foreground, thereby forming a contrast to large-leaved plants. Optimum temperature range is 22–26 °C. Emerged cultivation on the window sill in covered glass containers is also unproblematic. The small white-blue violet flowers develop on floating specimens and in emerged cultivation. Propagation through seeds is extremely productive, which is why *L. parviflora* has a reputation as a “weed” in aquatic plant nurseries and has therefore partially disappeared again.

Ecology: *Lindernia parviflora* populates entirely submersed or semiaquatic, mostly temporary waters. In Zanzibar (12/1980), the shoots grew under a pH-value of 6.8, GH 2°dH, KH 2°dH. Surprisingly, the author also found the species in Peru (Santa Ana), where it seems to occur wild.

Other: Fischer (1992) transferred the species of the *Ilysanthes* genus into the older *Lindernia* genus so that those species, classified under the name of *Ilysanthes parviflora*, must now be called *Lindernia parviflora*. Those plants of *Lindernia parviflora* currently in cultivation—which all go back to the author’s import from Zanzibar—lack the great variability of the leaves as described by Fischer. The very similar *Lindernia rotundifolia*, imported by Jacobsen from Sri Lanka, is also occasionally found in culture. It differs from *L. parviflora* essentially through the wide oval-shaped to orbicular leaves, which are also slightly crenate on the margin, as well as the shorter petiolate flowers.

Lindernia parviflora (green plants, center).



Lobelia cardinalis

Linné (1753)

Family: Lobeliaceae.

Synonyms: None.

Etymology: *Lobelia*: after the botanist M. de l'Obel (1538–1616); *cardinalis*: cardinal or bright red, refers to the color of the flower.

Distribution: Central and eastern North America.

Description: Marsh plant, more than 1 m tall. Stem erect, fleshy, 0.2–3 cm thick, olive green to wine red. Leaves alternate, 1–4 cm long petiolate. Emerged leaf blade very narrow elliptic, up to 18 cm long, 4 cm wide, with a decurrent base and acute apex. Margin crenate to serrate. Submersed blade oblong to narrow obovate, up to 11 cm long, 4.5 cm wide, but usually a little smaller, with a round apex, light green. Margin slightly crenate.

Inflorescence is an up to 20-cm long raceme with many unilateral bright red solitary flowers; 5 sepals, about 1 cm long. Corolla tube 2-lipped, up to 2 cm long; lower lip trilobular; upper lip with 2 lobes; 5 stamens, adnate to form a tube, protruding far from the corolla. No fruit detected.

Culture: Due to its unproblematic mainte-

nance, *L. cardinalis* is a recommended and popular aquarium plant. The slow-growing species is undemanding as to water values, substrate and temperature (optimum range is 22–26 °C). Depending on light intensity, more or less strong plants will develop. The species can be utilized in both the foreground or the central zone. In spacious aquariums, it will appear especially decorative if a larger number of cuttings is planted as a “row” diagonally from front to rear in a benched arrangement. It is also possible to use it on the edges of ponds, where decorative inflorescences will appear regularly (photo p. 61). It is not hardy.

Ecology: *Lobelia cardinalis* grows on the banks of rivers and lakes as well as in marshes. It flowers in its natural habitat from July to September.

Other: Easy pollination through birds is made possible by the retracted lower lip.

***Lobelia cardinalis* arranged in a “row.”**



Lobelia purpurascens

R. Brown (1810)

Family: Lobeliaceae.

Synonyms: *Rapuntium purpurascens* (R. Brown) C. Presl, *L. ilicifolia* Ker-Gawler, *L. purpurascens* var. *ilicifolia* A. de Candolle, *Pratia purpurascens* (R. Br.) E. Wimmer.

Etymology: *Lobelia*: see *Lobelia cardinalis*; *purpurascens*: becoming purple (color of the flower).

Distribution: Australia.

Description: Marsh plant. Emerged shoots creeping, 1–2 mm thick, glabrous, submersed erect or drifting at the surface. Leaves alternate, sessile. Leaf blade wide elliptic, 1–3 cm long and 0.7–2 cm wide, light to dark green, occasionally with a pale violet touch. Margin toothed, occasionally crenate, submersed almost entire.

Flowers solitary in the leaf axils. Pedicel 3–10 cm long, thin; 0 bracts. Calyx adnate, 5 mm long; 5 calyx-lobes, very small. Corolla 2-lipped, about 12 mm long, strong violet in color with white, partially slightly pubescent throat; lower lip trilobular; upper lip with 2 lobes; 5 stamens, adnate to form a tube, not protruding from the corolla. Capsule 2-valved,

about 9×4 mm in size. Numerous seeds, small, brown.

Culture: *Lobelia purpurascens* is a fast-growing, recommendable plant for culture in the paludarium or on the edge of a garden pond. Whereas the shoots will grow creeping in the paludarium and also be conspicuous by their beautiful light green foliage, shoots drifting on the water surface will also form in garden ponds. The plants are very tolerant of temperature variations and make do with a shaded location. Propagation through lateral shoots is possible. There is regular formation of flowers and fruit. The plants will display only limited growth in the aquarium.

Ecology: Clasen (1992) observed *L. purpurascens* in the Pilbara region (western Australia), both semiaquatic on the edge of a spring pool as well as in a small drain with trickling water from a steep rock cliff in the Dales Gorge. Van der Vlugt (1992) located the plant in the Millstream Oasis (also Pilbara semi-desert) mainly in shallow water and on wet banks under very high temperatures.

Flower of *Lobelia purpurascens*.



Ludwigia arcuata

Walter (1788)

Family: Onagraceae.**Synonyms:** *Ludwigia pedunculosa* Michaux, *Isnardia pedunculosa* de Candolle, *Isnardia arcuata* Kuntze, *Ludwigiantha arcuata* Small.**Etymology:** *Ludwigia*: after the botanist C.G. Ludwig (1709–1773); *arcuata*: curved.**Distribution:** Eastern U.S. (Carolina to Florida).**Description:** Marsh plant with an emersed creeping, submersed erect, branched, hardly pubescent stem, up to 50 cm long. Leaves opposite, short petiolate. Emerged leaf blade entire, lanceolate, 1.0–1.8 cm long, 3–5 mm wide, sometimes recurved downwards, green. Apex acute; base narrowing. Margin with tiny pointed denticles (magnifying glass!). Submersed leaves sessile, narrow linear, up to 4 cm long, 3 mm wide, green to red coloration.

Flowers axial, solitary, up to 3.5 cm petiolate. Bracts linear, about 3 mm long. Calyx 12 mm in length, light green, with 4 triangular, hardly pubescent calyx-lobes. Of all species of *Ludwigia* with opposite leaf arrangement, this species has the largest petals. They are up

to 11 mm long, 7 mm wide, curved to the inside, obovate and bright yellow; 4 stamens, not much longer than the style. Capsule 4-locular, about 10 × 3.5 mm in size. Number of chromosomes $n = 16$.

Culture: Light-requiring, a little demanding and decorative, *Ludwigia* grows best in soft to medium-hard water. Optimum temperature range is 24–26 °C. High light intensity enhances the intense red coloration of the shoots, which will turn green very rapidly under insufficient lighting. The species is suitable for planting in the foreground and middle zone in the aquarium. Propagation is through lateral shoots. It is also suited for inclusion in paludariums. During summer, *L. arcuata* can be cultured on the edges of ponds where it will easily develop flowers and fruit.

Ecology: The species populates moist and wet locations.

Other: Flowering shoots are required to identify the individual *Ludwigia* species (compare the descriptions). Submersed shoots of *L. arcuata* are similar to those of *Didiplis diandra*.

***Ludwigia arcuata*.****Flower of *L. arcuata*.**

Ludwigia brevipes

(Long) E.H. Eames (1933)

Family: Onagraceae.

Synonyms: *Ludwigiantha brevipes* Long (1913).

Etymology: *Ludwigia*: explanation as in *L. arcuata*; *brevipes*: short petiolate.

Distribution: Southeastern coast of the U.S. (Virginia, Carolina).

Description: Delicate marsh plant with an emersed creeping, submersed erect, often branched, glabrous stem. Blade sessile or up to 10 mm long petiolate, opposite, narrow elliptic to oblanceolate, glabrous, emersed 5–30 mm long, 2–10 mm wide, green, usually acute, with decurrent base, submersed up to 30 mm long and 4 mm wide, reddish.

Flowers solitary, axial, up to 1.8 cm long petiolate. Bracts up to 2 mm long; 4 petals, elliptic, 4–6 mm long, 2–3 mm wide, pale yellow. Calyx-lobes narrow triangular, about as long as the petals. 4 stamens, up to 3 mm long. Style 2 mm. Fruit 6–10 mm in length. Number of chromosomes $2n = 24$.

Culture: In the aquarium, *L. brevipes* is a demanding, delicate plant with high light requirements. A lot of light will enhance shoots

featuring an intense red coloration. The plant will grow most beautifully in soft to medium-hard water at temperatures in the range of 22–26 °C. *Ludwigia brevipes* is an inconspicuous plant with which good decorative effects can be achieved if planted—depending on the aquarium size—in the foreground or the middle zone in a group, and in a terraced arrangement. Propagation is easy through lateral shoots, but also possible with seeds. Short-lived flowers will appear during summer in the course of unproblematic, emersed cultivation.

Ecology: Populates marshy habitats in coastal proximity.

Other: A definite identification of *L. brevipes* and *L. arcuata* can be accomplished only with the aid of flowering shoots (compare the descriptions of the flowers). One aid to identification in emersed plants may also be the pubescence of the stem, which is glabrous in *L. brevipes* and hardly pubescent in *L. arcuata* (magnifying glass!).

Flower of *Ludwigia brevipes*.



Ludwigia brevipes.



Ludwigia glandulosa

Walter (1788)

Family: Onagraceae.

Synonyms: *Ludwigia cylindrica* Elliot, *L. heterophylla* Poiret, *Jussiaea brachycarpa* Lamarck.

Etymology: *Ludwigia*: see *Ludwigia arcuata*; *glandulosa*: glandular, reference unclear.

Distribution: North America.

Description: Marsh plant with decumbent or erect, glabrous shoots. Angular stem, wooden, often branched, 2–5 mm thick. Leaves alternate, 1–2 cm long petiolate. Blade entire, lanceolate, 3–11 cm long, 0.7–2 cm wide, upper-side olive green to wine red, underside wine red in color. Apex acute; base decurrent.

Fertile shoots up to 1 m tall. Flowers axial, small. Bracts linear; 4 calyx-lobes; 0 petals; 4 stamens; 1 style. Capsule 4-locular, sessile. Number of chromosomes $n = 16$.

Culture: *Ludwigia glandulosa* belongs to the category of problematic aquarium plants. If the shoots are kept in unsuitable cultivation conditions in the aquarium, i.e., under weak lighting, nutrient-deficient substrate and water, as well as high temperature, they will dissolve after a short time. A definite sign is

the initial shedding of the lower leaves. But even under advantageous growth conditions, i.e., under intense lighting, sufficiently free carbonic acid, nutritious substrate and water, as well as a temperature below 25 °C, the species will grow only slowly. For successful submersed cultivation, intensive lighting seems to be most important. A group planting of at least three terraced shoots in the middle zone of the aquarium has a decorative effect. *Ludwigia glandulosa* prospers best above water in a moist substrate. Flowering shoots are formed during summer; they will drop off after fruit maturity during autumn. The plants will, however, again sprout strongly from the base.

Ecology: Populates moist and wet habitats on boggy soil.

Other: It was introduced in 1988 under the name of *L. perennis*. Distinguishing features to other *Ludwigia* species: corolla absent, alternate leaf position.

Further reading: Kasselmann (1991b).

Flower of *L. glandulosa*.





Ludwigia glandulosa (center).

Ludwigia helminthorrhiza

(Martius) Hara (1953)

Family: Onagraceae.

Synonyms: *Jussiaea helminthorrhiza* Martius (1839), *J. natans* Humboldt and Bonpland (not *Ludwigia natans* Elliott), *Jussiaea natans* var. *emersa* Hassler.

Etymology: *Ludwigia*: see *L. arcuata*; *helminthorrhiza*: with a worm-like root.

Distribution: Southern Mexico to Paraguay.

Description: Floating or creeping plant in marsh, root-forming on all nodes and with numerous, fleshy 4–5-mm thick and 1–2-cm long pneumatophores. Stem over 1 m long, glabrous, often branched. Leaves 1–2 cm petiolate, alternate. Blade almost orbicular, entire, with an obtuse apex and obtuse base, 2–4 cm in size, light green, reddish or wine red in color.

Flowers solitary, 1–3.5 cm petiolate. Petals white, yellow at the base. Filaments unequal in length. Style 4–7 mm long. Capsule cylindrical, about 3 cm in length, 2–3 mm thick.

Culture: An especially decorative *Ludwigia*, the cultivation of which is recommended only for greenhouses or temporarily in the garden pond on warm summer days. This species

cannot be used for aquarium cultivation because it is extraordinarily light-demanding. It has limited use as a paludarium plant under conditions of a very illuminated location, and a lot of warmth in shallow water. During summer, when the shoots grow especially strong and the leaves develop an intense red color, conspicuous white pneumatophores will also form. They consist of an air-holding tissue (aerenchyma), which enables an exchange of gas with plant segments in the oxygen-deficient bog. *Ludwigia helminthorrhiza* can occasionally be admired in botanical gardens. In winter, the shoots will strongly recede due to the lack of light.

Ecology: The species takes root in bog in sunny and partially shaded areas on the banks of rivers. Some habitat data follow: Brazil (3/1986), 1) Amazon near Manaus, water temperature 27 °C, pH 6.7, GH/KH < 1 °dH, 100 µS/cm; and 2) 18 km south of Poconé, 20–30 m wide river with a strong current, water temperature 30 °C (air temperature 30 °C at noon), pH 6.2–6.8, GH/KH < 1 °dH, 18 µS/cm. Peru, Rio Yanayacu, see p. 40.

Ludwigia helminthorrhiza with pneumatophores.



Ludwigia inclinata

(Linné fil.) Raven (1963)

Family: Onagraceae.

Synonyms: *Jussiaea inclinata* (1781), and others.

Etymology: *Ludwigia*: see *Ludwigia arcuata*; *inclinata*: curved to the inside, reference unclear.

Distribution: Central and South America.

Description: Plant existing submerged in water or in marshes. Emerged shoots decumbent to ascendent, often branched, root-forming on the lower nodes. Shoots emerged slightly pubescent, submersed glabrous, up to 5 mm thick. Leaves alternate (in plants cultivated in aquaristics) or whorled (plants not in culture with aquarists). In alternate leaf arrangement: petiole 0.2–2 cm. Leaf blade oblong to narrow obovate, entire, glabrous, 1.0–5.5 cm long, 0.3–1.5 cm wide. Apex obtuse, base narrow cuneate. In whorled leaf arrangement: submersed stem 3–7 mm thick, fleshy. Strong shoots with 8–12 leaves in a whorl, blade linear, entire, 2–4 cm long, 1–2.5 mm wide. Apex acute, base narrowed. Emerged shoots light green, submersed ones olive

green to pink-red in color, depending on light intensity.

Flowers axial, solitary. Pedicel up to 4 cm long. Hypanthium 4–angular, up to 2 cm in length, with 2 minute bracts at the base; 4 sepals, 8–12 mm long, 3–5 mm wide; 4 yellow petals, larger than the sepals, wide ovate, cordate indented on the apex, caducous, about 15 mm long, 12 mm wide; 8 stamens about equal in length; filaments 1–3 mm. Style about 3 mm long; stigma capitate, 1.5 mm in diameter. Fruit is a capsule containing many small seeds.

Culture: *Ludwigia inclinata* is a typical soft water plant which is best maintained in acid water deficient in lime. Submersed, its delicate leaves will achieve a red coloring similar to those in its native habitat only under intense lighting. The plants, however, are able to grow in the aquarium under weak lighting conditions, but will lose their leaves on the lower shoot segments early on and will also turn green. The leaf color is thus a good indicator for the species' well-being. Also, once the shoots have reached the water surface, it becomes evident how light-hungry the plant

Flower of *Ludwigia inclinata*.



L. inclinata with alternate leaves.



is. The soil seems to have only a minor function in the plant's keeping, but a nutritious substrate will enhance growth. Water circulation, too, improves plant development.

Emersed cultivation of *Ludwigia inclinata* is possible under high humidity and intense light.

Ecology: The author found *L. inclinata* in the northern Pantanal in Mato Grosso State (Brazil), where it is a common species, dense populations of which are already recognizable from a distance by their shoots drifting below the surface. Countless bright yellow flowers transform these biotopes into a sea of flowers. The species prefers fast-moving waters. Only small populations were found in biotopes with standing waters, whereas, in contrast, populations were very dense in locations with fast-flowing water. Water analysis of a biotope with standing water follows (Mato Grosso State, Brazil, 3/1986): water temperature 28 °C (air temperature 27 °C at 10:00 h), pH 5.5, GH and KH < 1 °dH, 18 µS/cm. Water analysis of a 20–30-m wide river with a strong current follows: water temperature 30 °C (air temperature 30 °C at noon), pH 6.2–6.8, GH and KH < 1 °dH, 18

µS/cm. The plants grew in both intense sunlight and also in shade. At another biotope in Venezuela, *L. inclinata* was found in about 1-m deep fast-moving water. Water analysis of this habitat follows (8/1989): water temperature 27.5 °C (air temperature 32 °C), pH 7.3, GH and KH < 1 °dH, 40 µS/cm.

Other: *Ludwigia inclinata* is a very variable species. In August 1989 in Venezuela, between the towns of Bolivar and Maripa, the author collected plants where their submersed shoots were distinct in featuring a whorled leaf position with linear leaves (similar to *Eusteralis stellata*). The shoots grew in a flooded area in a depth of 30–50 cm of water. The substrate consisted of loam. A detailed water analysis of this location is found in biotope No. 3, p. 40. Also, the shoots from this population of *L. inclinata* proved to be extraordinarily difficult to maintain in culture, so that it could not be cultivated on a continuous basis. When this habitat was revisited a year later, the biotope had been completely destroyed by slash-and-burn clearing.

Ludwigia inclinata with verticillate leaves in its location in Venezuela.



Ludwigia palustris

(Linné) Elliott (1817)

Family: Onagraceae.

Synonyms: *Isnardia palustris* L. (1753), and others.

Etymology: *Ludwigia*: explanation as in *L. arcuata*; *palustris*: marsh-inhabiting.

Distribution: Eurasia, North, Central America, Colombia, Venezuela, North Africa, introduced to South Africa, Hawaii, New Zealand, Australia.

Description: Marsh plant with emerged creeping, submersed erect or floating shoots. Leaves opposite, glabrous, up to 1 cm long petiolate. Emerged leaf blade ovoid, up to 3.0 cm long, 2.2 cm wide, olive green to wine red, submersed up to 2.5 cm long, 1.0–1.5 cm wide, blood red to olive green in color. Apex acute or obtuse, base cuneate.

During summer, axial and inconspicuous, sessile 4-merous, about 2-mm sized flowers, a distinct feature of which is the absence of petals. *Ludwigia palustris* is thereby distinguishable from other *Ludwigia* species which have opposite leaves; 4 stamens. Fruit is a many-seeded capsule. Number of chromosomes $n = 8$.

Culture: In the aquarium, *L. palustris* is a moderately demanding, well-growing plant, whereby a high light intensity constitutes the most important factor for healthy growth. If the shoots are well illuminated, they will branch out and will turn an intense red color. If, however, the plants receive only poor light, growth will remain moderate, and the leaves will display a green coloration. A nutrient-rich substrate, as well as a regular additional iron supply, will enhance strong shoots. The species is very temperature-tolerant, with the best range in the aquarium being between 22–26 °C. *Ludwigia palustris* is best suited for positioning in the foreground and middle zone of the aquarium. To obtain emerged plants, shoots may, for example, simply be laid on the water surface from

where they will proceed to grow beyond the aquarium edge without any problems. Specimens obtained in this way can be quickly propagated in a moist substrate in containers placed on the window sill, also on the edges of ponds during summer where they will regularly develop small flowers. The adjustment of emerged shoots to submerged cultivation is not easy since the emerged leaves will often rot underwater.

Ecology: *Ludwigia palustris* inhabits flooded areas with varying water levels. One can find them in intense sunlight and in a nutrient-rich substrate. It is quite possibly a nitrogen-loving plant. In western Europe, the species obviously seems to have become quite rare. A few years ago, the author still managed to find it existing isolated in shallow ditches in the Netherlands.

In one habitat in Greece, where large populations grew on the edge and in shallow water of a lake, the following water values were read in June 1980 at 13:15 h: temperature 25 °C (air temperature 26 °C), pH 7.2, GH 5.8 °dH, KH < 1 °dH, 81 µS/cm.

Other: Four varieties of *Ludwigia palustris* have been described, the distinguishing features of which, however, are not consistent, so that the varieties have no taxonomic status.

***Ludwigia palustris* (center).**



Ludwigia palustris × *L. repens*

Family: Onagraceae.

Distribution: Hybrid resulting from cultivation. Natural hybrids (without petals) have, however, also been found in Chiapas (Mexico).

Description: Leaves decussate, 0.5–1 cm long petiolate. Blade elliptic to wide elliptic, 2–5 cm long and 1–3.5 cm wide, with an obtuse apex and decurrent base (description otherwise as in *Ludwigia repens*).

Flowers solitary in the axils, sessile or very short petiolate. Bracts up to 2 mm in length. Calyx-lobes about 2 mm long; 0–4 petals, equal in size or smaller than the calyx-lobes, rapidly caducous, yellow; 4 stamens. Style with stigma shorter than the stamens. Fruit will waste away, about 1 mm in size.

Culture: Among all the cultivated *Ludwigia* species, this one possesses the best growth ability. Furthermore, it appears especially decorative with its reddish foliage. It prospers in both soft as well as hard or alkaline water. One should not save on lighting, even though the shoots will grow even under moderate lighting. Especially strong and red-colored specimens, however, are formed only under

intense lighting. The optimum temperature range lies between 23 and 28 °C. Under good living conditions, growth will be so rapid that the shoots will have to be replanted every 2–3 weeks. About 3–5 stems are adequate for a decorative group arrangement in the middle zone or in the background of the aquarium. Propagation through lateral shoots is unproblematic and productive. As in all other cultured *Ludwigia* species, the emersed culture of *Ludwigia palustris* × *L. repens*—with which flowers may also be observed quite often—poses no problems. During summer, the shoots may also be temporarily kept on the edge of a garden pond.

Other: A chromosome count to check the identification of *Ludwigia palustris* × *L. repens* has so far not been conducted.

Further reading: Schmidt (1967).

Ludwigia palustris × *L. repens*.



Flower of *L. palustris* × *L. repens*.



Ludwigia repens

Forster (1771)

Family: Onagraceae.

Synonyms: *Ludwigia natans* Ell. (1821), and others.

Etymology: *Ludwigia*: see *Ludwigia arcuata*; *repens*: creeping.

Distribution: U.S., Mexico.

Description: Marsh plant with emerged creeping, submersed erect shoots, which produce roots on the nodes. Leaves opposite. Blade up to 1.2 cm petiolate, very variable, emerged usually wide elliptic, submersed from very narrow to wide elliptic, 2–3.5 cm long, 0.5–1.4 cm wide, upperside olive green or reddish, underside green or wine red.

Flowers solitary, axial, sessile or up to 5 mm petiolate. Bracts linear, 3–5 mm long. Calyx-lobes triangular, up to 4 mm. Petals smaller than or as long as the calyx-lobes, soon caducous, yellow; 4 stamens, about 1 mm long. Style with stigma about as long as the stamens. Fruit 5–8 mm in length, 2–3 mm thick; numerous seeds. Number of chromosomes $n = 24$.

Culture: Several growth forms of *L. repens* are presently in culture; they differ slightly in

their leaf shape and coloration, however, they do not have any taxonomic status. All growth forms can be cultivated in the aquarium without any problem. They will prosper in both soft and hard water, require a medium light intensity for optimum maintenance, and, if possible, a temperature below 26 °C. Higher temperatures can be tolerated for a short time. A substrate rich in nutrients enhances strong plants. Growth is very rapid so that the shoots have to be trimmed regularly. Recommended application is only as a group in the middle zone or background of the aquarium. Propagation occurs through lateral shoots which are produced in abundance. Flowers, which are often formed in emerged cultivation (sometimes also submerged), are required for any definite identification.

Ecology: *Ludwigia repens* populates marshy areas.

Other: Several varieties were described, which, however, all show intermediate forms (Munz 1965). In aquaristics, the species has, for a long time, been cultivated under the name of *Ludwigia* “mullertii.”

Flower of *Ludwigia repens*.



Ludwigia repens.



Ludwigia repens* × *L. arcuata

Family: Onagraceae.

Distribution: Cross-breed resulting from cultivation.

Description: Marsh plant with emerged creeping, submersed erect, hardly pubescent stem, up to 2.5 mm thick, dark red. Leaves opposite, up to 1 cm petiolate. Emerged blade 1.5–2.8 cm long, 1.0–1.5 cm wide, upperside dark green, underside slightly reddish; submersed blade 2–5 cm long, 0.5–1.5 cm wide, narrow elliptic to elliptic, apex acute, margin slightly undulate, upperside olive green to red. Stem and leaves slightly to deep red-purple on the underside.

Flowers axial, solitary, up to 1 cm long petiolate. Bracts linear, 2–5 mm long and 0.5–1 mm wide. Calyx gamophyllous; calyxlobes 4–5 mm long, triangular, 2.5 mm wide at the base, margin of the sepals with very fine denticles facing upwards. Always 4 petals, 2.3–2.4 × 1.1–1.2 mm in size; 4 stamens. Fruit 4-locular; many seeds, about 0.5 mm long. Number of chromosomes $2n = 40$.

Culture: If *Ludwigia repens* and *L. arcuata* are crossbred, the hybrid *Ludwigia repens* × *arcuata* is born. This cross will grow more

unproblematically and more rapidly than the parent plants, a phenomenon described in botany as heterosis. *Ludwigia repens* × *arcuata* is less demanding as to light intensity than *L. arcuata*, but its light requirement must not be underestimated. Under sufficient light the leaf surface will turn blood red. High temperatures will accelerate growth, with the advantageous temperature range lying between 24 and 28 °C. The hybrid is extraordinarily adaptive to water values. It grows in both soft and especially well in hard water with pH-values in the alkaline range. A nutritious substrate should be provided for the development of strong shoots. Under good living conditions, this crossbreeding is an excellent and very recommended plant which has to be replanted every fortnight. Group planting in the middle zone of the aquarium results in a decorative picture. The plant is also very suitable for paludariums where creeping shoots will develop.

The plants will easily protrude from the water and can also be kept on the window sill or on the edge of garden ponds during summer. A lot of light and high temperatures accelerate the formation of flowers, which will self-pollinate. The small brown seeds, however, are not able to germinate.

Other: This hybrid has been in culture for many years, but was not initially detected as such. A chromosome count, conducted by Arends (Wageningen) in 1982 in conserved root tips, resulted in a chromosome number of $2n = 40$ and the identification as *L. repens* × *L. arcuata* (see Kasselmann 1985b). The sex of the parents is important. In the hybrid *L. repens* × *L. arcuata*, a stigma of a flower of *L. repens* was pollinated with the pollen of *L. arcuata*. The reverse crossbreed (*L. arcuata* × *L. repens*) constitutes a different plant.

From all cultured *Ludwigia*, the two hybrids undoubtedly grow best in the aquarium.

***Ludwigia repens* × *L. arcuata*.**



Ludwigia sedoides

(Humboldt & Bonpland) Hara (1953)

Family: Onagraceae.

Synonyms: *Jussiaea sedoides* Humb. and Bonpl. (1805), *J. sedioides* H.B.K. (1823).

Etymology: *Ludwigia*: see *L. arcuata*; *sedoides*: similar to the *Sedum* genus.

Distribution: Central and South America.

Description: Aquatic plant usually floating on the water surface, with a thin reddish stem rooted on the nodes. Leaves arranged rosette-like, alternate, 1–5(–10) cm petiolate. Leaf blade rhombic, about 1 cm in size, upperside glabrous, underside pubescent, medium green to deep dark red. Margin serrate to crenate in the upper half, entire in the lower half.

Flowers solitary, about 2 cm in size, up to 3.5 cm petiolate; 4(5) calyx-lobes, 8 mm long; 4(5) petals, 1.4 cm long, 1.3 cm wide, bright yellow; 6–10 stamens, about 3 mm long, as long or slightly shorter than the style. Capsule 1 cm long. Number of chromosomes $n = 8$.

Culture: This decorative *Ludwigia* is reminiscent of *Trapa* (convergence). Due to its high maintenance needs, this species has, un-

fortunately, not succeeded as an aquarium plant because of its expressed demand for light and warmth. It is best utilized in shallow, tranquil water above a boggy substrate in a hothouse, or in intensely illuminated paludariums. Winter survival is very problematic due to the extreme light requirements.

Ecology: Grows in massive populations in ditches and ponds with stagnant water, but also inhabits free waters as well as areas near riverbanks lacking any current. Several water analyses of native habitats follow: 1) Mexico (8/1985), dense populations in ditches and pools, rooted in loamy soil, water temperature 29 °C (air 30 °C at 09:00 h), pH 6.3, GH/KH 2 °dH, O₂ 4 mg/L, Fe and NO₂⁻ not detectable, NH₄⁺ 0.5 mg/L; and 2) Mexico (8/1985), water temperature 34 °C (air 32 °C at 10:00 h), pH 6.9, GH 2.5 °dH, KH 2 °dH, NH₄⁺ 0.5 mg/L, Fe and NO₂⁻ not detectable, CO₂ 8 mg/L. See also detailed water analysis of the Rio Guaporé (p. 40, biotope No. 1).

Ludwigia sedoides in its native habitat in Venezuela.



Lysimachia nummularia

Linné (1753)

Family: Primulaceae.

Synonyms: *Nummularia repens* Gilibert, *Lysimachia rotundifolia* F.W. Schmidt, and others.

Etymology: *Lysimachia*: after King Lysimachos; *nummularia*: coin-like, refers to the leaf blade.

Distribution: Central Europe, introduced to the temperate regions of the entire world.

Description: Perennial marsh plant. Emerged shoots creeping, root-forming on the lower nodes, subramous, up to 60 cm long; submersed shoots erect, up to 40 cm tall. Leaves opposite, short petiolate. Emerged blade entire, wide ovate with round to slightly cordate base, up to 3.0 cm long and 2.7 cm wide, emerged green or yellowish green, submersed light green in color.

The 5-merous short petiolate, bright yellow flowers usually develop individually in the leaf axils of the emerged shoots. Fruit is rare.

Culture: The species belongs to the regularly commercially available cold-water plants. Several color formations exist. It is generally

considered to be an undemanding and adaptable species, which, however, will display optimum growth only under good lighting and water temperatures up to 20 °C. Under too high temperatures, the shoots will elongate whereby long internodes and very small blades will develop. Good lighting as well as a substrate rich in nutrients are prerequisites for maintenance in paludariums. However, it is best utilized for planting on the edges of garden ponds, where the creeping shoots will continue to grow even in relatively dry ground. Flowering period is May to August.

Ecology: The species inhabits moist and wet locations, but will also grow on relatively dry meadows, on the banks of streams, ponds and lakes.

Other: Only a few of the roughly 150 species of the *Lysimachia* genus inhabit moist and wet habitats. Apart from *L. nummularia*, the species *L. nemorum*, *L. punctata*, *L. thyrsiflora* and *L. vulgaris* are well-known pond plants which are all commercially available.

Submersed and flooding shoots of *Lysimachia nummularia*.



Mayaca fluviatilis

Aublet (1775)

Family: Mayacaceae.**Synonyms:** *Mayaca aubletii* Michaux, *M. vandellii* Schott and Endlicher, and others.**Etymology:** *Mayaca* (or Mahica): refers to a flood plain near Santarem (Brazil); *fluviatilis*: living in or alongside a river.**Distribution:** Southeastern U.S., Central and South America.**Description:** Perennial, delicate marsh plant. Emerged shoots creeping to ascendent, 5–20 cm long; submersed shoots erect, 20–40(–60) cm long. Leaves alternate, very dense arrangement in whorls, 1-veined. Blade sessile, linear, emerged 2–4 mm, submersed up to 8 mm long, less than 1 mm wide, light green. Apex entire or with 2 pointed denticles (magnifying glass!).

The flowers—1 cm in diameter, up to 12 mm long petiole—are solitary in the leaf axils of emerged shoots; 3 green sepals; 3 petals, white or pale violet with a white base; 3 stamens; anthers opening with 1 slit; 1 style. Fruit is a 3-valved capsule; numerous seeds.

Culture: Unfortunately this gracile, demanding, “moss-like” stem plant is rarely commercially available. Its cultivation will be most successful in well-illuminated aquariums with soft, acid water and a temperature range of 23–25 °C. CO₂ fertilization as well as medium water movement have a growth-enhancing effect. To enable an easy implanting of the delicate shoots, the use of a fine-grained substrate (e.g., sand) is recommended. More than other plants, *M. fluviatilis* tends to display chlorosis (lack of chlorophyll) which becomes obvious in a paling of the shoot tips. This can be remedied by adding a regular and commonly available iron fertilizer. Under optimum growth conditions, a small *Mayaca fluviatilis* bush looks quite appealing in the foreground or middle zone of an aquarium. Vegetative reproduction occurs through lateral shoots. Emerged cultivation of

the delicate plants will succeed only in a warm moist location under intense light, where they will occasionally also flower.

Ecology: *Mayaca fluviatilis* exists in and on the edges of small, more or less fast-moving waters. The numerous biotopes studied by the author in Venezuela are summarized as follows: temperature 23–30 °C, pH 5.0–6.7, GH < 1–2 °dH, KH < 1–5 °dH, 10–105 µS/cm. The plants often grew in black water. The soil was mostly sandy-gravelly. Water analysis of a habitat in Argentina follows (7/1993): temperature 11.5 °C (air temperature 12 °C at 11:30 h), pH 5.5, GH and KH < 1 °dH, < 10 µS/cm.

Other: Essential differentiating features of the *Mayaca* species are the flowers, as well as the shape and opening of the anthers. Next to the type species of *M. fluviatilis*, Lourteig (1971) mentions *kunthii* (Seubert) Lourteig, which, in contrast, has 1–2 lobes on the anther opening. *Mayaca fluviatilis* was, for many years, cultivated under the synonym of *M. vandellii*. *Mayaca fluviatilis* has a distinct similarity to *Rotala wallichii*, which has, however, a whorled leaf arrangement.

***Mayaca fluviatilis*.**

Micranthemum umbrosum

(Walter) Blake (1915)

Family: Scrophulariaceae.

Synonyms: *Anonymos umbrosus* Walter (1788), *Globifera umbrosa* Small, *Micranthemum orbiculatum* Michaux. (*Micranthemum* = nomen conservandum).

Etymology: *Micranthemum*: mikros = small, *anthemon* = flower; *umbrosum*: very shady.

Distribution: U.S. (from Virginia to Texas).

Description: Delicate marsh plant with creeping, branched, 10–20-cm long shoots which root on the nodes. Stem about 0.5 mm thick, glabrous. Leaves opposite, sessile. Blade roundish, about 4–7 mm in size, light green.

Flowers solitary, axial, small, short petiole. Calyx 4-lobular, 1.5–2 mm long, lower lip trilobular, with large middle lobe; 2 stamens; filaments short; 1 style; stigma bifid. Capsule globular, about 1 mm.

Culture: To grow well this gracile aquarium plant requires, above all, intense lighting, soft to medium-hard, slightly alkaline water, and a not too high temperature up to about 24 °C. Fertilization with CO₂ is recommended. Because the species is rather demanding, we see

it being cultivated only rarely. In the well-illuminated Dutch aquariums, however, it can often be admired as a foreground plant. Under optimum cultivation, *M. umbrosum* grows relatively rapidly and must be replanted regularly. Propagation occurs through lateral shoots. An emersed cultivation, during which the inconspicuous, minute flowers are occasionally formed, is easy under high humidity and good lighting.

Ecology: Populates marshy habitats.

Other: In contrast to *Hemianthus micranthemoides*, *M. umbrosum* has rounder and always opposite leaves, as well as a differently structured corolla. The separation of the two genera, *Micranthemum* and *Hemianthus*, is based on the different corollas, which are distinctly 2-lipped in the former, and usually single-lipped or only with an irrelevant upper lip in the latter. *Micranthemum orbiculatum* is a synonym.

***Micranthemum umbrosum* in the aquarium: oxygen bubbles caused by intensive assimilation.**



Microsorium pteropus

(Blume) Ching (1933)

Family: Polypodiaceae.

Synonyms: *Polypodium pteropus* Bl. (1829), *P. tridactylon* Wallich, *Pleopeltis pteropus* Moore, *Colysis pteropus* (Blume) Bosman.

Etymology: *Microsorium*: mikros = small, soros = heap, pile (small piles of spores); *pteropus*: aliferous (petiole).

Distribution: Widespread in tropical Asia.

Description: Amphibious, polymorph fern with a creeping, densely scaled rhizome. Petiole narrow aliferous roughly halfway, scaly. Leaves initially lanceolate, simple, short petiolate, or with 1–2(–5) lateral lobes, which are free almost to the base; central lobe longer than the lateral ones, up to 30 cm in length, 5.5 cm wide; lateral lobes up to 21 × 3.5 cm in size, acute or rounded, often with undulate margin, olive to dark green. Midrib more or less scaly.

Sori without indusia, isolated, sometimes adnate, irregular on the leaf undersides; mostly round, then about 2 mm in size, rarely oblong.

Culture: Slow-growing, but unproblematic and popular fern plant, *M. pteropus* prospers

in soft or hard water, in well- or moderately illuminated aquariums. Optimum growth occurs under medium light intensity, in soft to medium-hard water, in good water circulation and a pH-value within the weak acid range. Temperature should range between 20 and 28 °C. In the aquarium, the rhizomes are best attached to decorative material such as stones, cork bark, wood, etc., in such a way that the roots can grow and attach to them. This also enables good decoration of the side and rear panels. Planting in the aquarium substrate is not recommended because the rhizomes do not grow well under these conditions. In emersed cultivation, the rhizomes will, in contrast, grow well in a loose substrate. The plant is suitable for the planting of freshwater aquariums and paludariums, with limited use also in brackish water aquariums. Vegetative propagation is through rhizome partition and adventitious plants, which form on roots and leaves. Sexual reproduction through spores is also possible. Little spore piles are also found in emersed cultivation plants (rarely also on submersed ones) on the leaf undersides. Mature spores, appearing like brown powder, can be sown in moist soil.

Small-leaved growth form of *M. pteropus*.



Microsorium pteropus 'Windeløv'.



Rearing is not difficult, but requires time and patience.

Ecology: In native habitats, the species grows not only in mountains and forests in rivers and rocky streams where it is only partially flooded, but also in lowlands, often in rocky soil and on roots of trees standing in water. The author observed two very different habitats: 1) Shaded river in Sri Lanka with a rocky bed, plants positioned between rocks in a strong current; and 2) Papua New Guinea (small-leaved growth form), forest stream, small semiaquatic specimens rooted to stones or on the edge in boggy soil. Water temperature 23 °C (air 27 °C), pH 7.9, GH/KH < 1 °dH, 20 µS/cm.

Other: One large- and one small-leaved growth form as well as two introduced by Tropica (Denmark) cultivars are in culture. The large-leaved variant was introduced in 1957 under the name of *Gymnopteris*, later incorrectly interpreted as *Leptochilus decurrens*. Only in Kew, in 1961, was the plant correctly classified. The small-leaved form, which is rarely multilobed, has been in culture for many years and is increasingly displacing the larger plant. For the genus name

Colysis and the spelling of *Microsorium* see Kassermann 1994a.

'Windeløv' cultivar: a small-leaved cultivar with typical multidichotomous branching. Blade up to 15 cm long, 1.8 cm wide, dichotomously branched on the leaf apex, each branch is again multifurcate and forms numerous tips, arranged in different levels. Furbate apex 3–5 cm long, up to 8 cm wide, outline obtriangular. Cultivar name protected.

'Tropica' cultivar: a large-leaved cultivar. Petiole up to 2 cm wide aliferous. Blade up to 30 cm long, up to 15 cm wide, in contrast to the wild form, the outline is narrow triangular, pinnately parted, deep sinuate. Culture is as above.

Both cultivars supposedly originate from cultures the parent plants of which were collected from Java. The cultivar names refer to the names of the aquatic plant nursery Tropica and its owner H. Windeløv.

Microsorium pteropus 'Tropica'.



Myriophyllum aquaticum

(Vellozo) Verdcourt (1973)

Family: Haloragaceae.**Synonyms:** *Enydria aquatica* Vellozo (1825), *Myriophyllum brasiliense* Cambessedes, *M. proserpinacoides* Hooker and Arnott.**Etymology:** *Myriophyllum*: *myrios* = countless, *phyllon* = leaf, refers to the countless pinnate segments; *aquaticum*: existing in water.**Distribution:** South America; female plants introduced to many parts of the world.**Description:** Amphibious growing plant. Stem up to 2 m in length, 1–6 mm thick. Submersed whorls with 4–6 pinnate leaves, up to 5 cm long, with 16–40 hair-fine pinnate segments, these 3–7(–20) mm long, green. Emerged leaves in 5–7-merous whorls, pinnate, 1–4 cm long, light to blueish green in color, with 14–36 pinnate segments, these 4–6 mm long, wider than in submersed leaves.

Plants dioecious; flowers unisexual, axial, solitary. Bracts linear, 1–1.5 mm long. Male flowers 4-merous, white or reddish, initially sessile, 4 mm petiolate during flowering period; 4 sepals and 4 petals; 8 stamens; 0 style. Female flowers 4-merous, white or reddish,

very short petiolate, 1–2 mm in size; 4 sepals. No petals or stamens; 4 styles; pubescent stigma. Fruit very rare.

Culture: Female plants of *M. aquaticum* have been kept by aquarists for many years, and have retained their popularity even to this day. Male plants have been known since about 1989, they have been commercially marketed under the incorrect name of *M. elatinoides*. Female and male populations constitute demanding and especially light-requiring aquarium plants. Cultivation succeeds best in soft to medium-hard, slightly acid to neutral, not too warm water (10–25 °C). It is suitable for planting on the edges of ponds during summer.**Ecology:** Populates pools, rice paddies, edges of small flowing waters, up to an altitude of 1500 m. Some ecological data from Argentina (7/1993) is summarized as follows: water temperature 10.6–13 °C, pH 5.7–7.6, GH < 1–7 °dH, KH < 1–7 °dH, 5–240 µS/cm, Fe < 0.05–0.2 mg/L, biotopes were sunny, substrate was sandy-loamy, stony. Water analyses on p. 40, biotopes No. 4 and No. 5.**Submersed male shoots of *M. aquaticum*.****Male flowering shoot of *M. aquaticum*.**

Myriophyllum mattogrossense

Hoehne (1915)

Family: Haloragaceae.

Synonyms: None.

Etymology: *Myriophyllum*: see *M. aquaticum*; *mattogrossense*: originating from Mato Grosso (Brazil).

Distribution: Ecuador, Brazil, Peru (rare).

Description: Shoots 30–60 cm long, emerged leaves in 3–4-merous whorls, 10–13 mm long, 4–5 mm wide, pinnate, with about 7 filiform pinnate segments on each side. Submersed leaves light green, in 2(3)–4(5)-merous whorls, 20–50 mm long, 10–35 mm wide, pinnate, each with 7–10 pinnate segments.

Flowers bisexual, solitary in the axils. Bracts absent. Flowers 4-merous, 0.2–0.3 mm petiole; 0 sepals; 0 or 4 petals; 4 stamens; filaments up to 0.1 mm long or absent; anthers dark red; 4 styles, reddish. Ovary globular to dice-shaped, splitting into 4 mericarps.

Culture: The “real” *M. mattogrossense* was collected by the author in Ecuador and has been in culture only since 1990. It is a demanding and decorative plant which is, how-

ever, very suitable for cultivation if given good growth conditions. For healthy growth, the shoots require a nutrient-rich substrate as well as intense lighting. They grow in both soft as well as medium-hard water. Fertilization with CO₂ will have a positive effect. The nutrient requirements are unusually high, resulting in the necessity of regular fertilization. Optimum temperature range is 24–28 °C. The shoots will flower abundantly in the aquarium.

Ecology: *Myriophyllum mattogrossense* was found in the Rio Yanayacu (Ecuador, 1/1990) in fast-moving water. Temperature was 25 °C (air temperature 29 °C at 11:00 h), pH 6.8, GH < 1 °dH, KH 2–3 °dH, 50 µS/cm. The plants grew mostly submersed, in shallow places on sandbanks, but also emerged. The substrate was sandy-gravelly, partially boggy on the river's edge. The location was subject to full sunlight and semishaded.

Other: For over 20 years the name *M. mattogrossense* was incorrectly applied in aquaristics to *M. tuberculatum* (see that account).

Further reading: Orchard and Kasselmann (1992); Kasselmann (1992, 1994b, 1995).

***Myriophyllum mattogrossense*.**

Myriophyllum pinnatum

(Walter) Britton, Sterns and Poggenburg (1888)

Family: Haloragaceae.

Synonyms: *Potamogeton pinnatum* Walter (1788), *Myriophyllum scabratum* Michaux.

Etymology: *Myriophyllum*: explanation as in *M. aquaticum*; *pinnatum*: pinnate (leaf blade).

Distribution: Eastern North America.

Description: Submersed shoots up to 2 m long. Stem 2–4 mm thick, green to dark red in color. Emerged leaves linear, pinnate, alternate or usually with 5 leaves in pseudo-whorls, 1.0–1.7 cm long, about 1 mm wide, with 8–12 pinnate segments, segments much shorter than submersed, up to 3 mm long, olive green in color. Submersed leaves alternate or in pseudo-whorls with 3–5 pinnate leaves, up to 3 cm long, with 4–5 hair-fine segments on each side, these 1.0–2.5 cm long, light to olive green.

Plants monoecious. Inflorescence usually with unisexual (seldom bisexual) flowers. Triangular bracts, less than 1 mm in length; 4 sepals, very small, transparent; 4 petals, white to purple, 2 mm long; 4 stamens; anthers about 1.5 mm long; 4 stigmas, purple-red

with white, short pubescence. Fruit brown-red, tuberous, about 1.5–2 mm long, mericarps with flat sides and 2-ridged on the back.

Culture: In contrast to *M. tuberculatum*, *M. pinnatum* is identifiable in the aquarium by green foliage and a reddish stem. It is usually commercially available under the name of *M. hippuroides*. The plants are just as difficult to maintain in an aquarium as *M. tuberculatum*. *Myriophyllum pinnatum* can also be easily kept in garden ponds during summer where the shoots occasionally flower. Intense lighting as well as a not too high temperature (up to about 25 °C) are recommended.

Ecology: In its native habitats, *M. pinnatum* is found in marsh forests, lakes and pools on boggy banks, or in shallow water. There, the species will flower from March to June.

Other: Flowering shoots were identified by Susan Aiken (Canada), a researcher predominantly of the North American *Myriophyllum* species.

Female flowers of *M. pinnatum*.



Myriophyllum pinnatum.



Myriophyllum simulans

Orchard (1986)

Family: Haloragaceae.**Synonyms:** *Myriophyllum propinquum* auct. non A. Cunningham, *M. variifolium* auct. non J. Hooker.**Etymology:** *Myriophyllum*: see *M. aquaticum*; *simulans*: remarkable, refers to the similarity to *M. gracile* and *M. variifolium*.**Distribution:** Eastern Australia.**Description:** Amphibious growing plant. Stem 1–5 mm thick. Submersed shoots up to 40 cm long, light green. Submersed leaves in whorls numbering 4–5, 20–30 mm long, pinnate, with 1–6 filiform segments on each side. Emerged leaves in whorls numbering 3–5, entire, aciculiform to linear, stiff, up to 35 mm long, 1 mm wide.

Plants monoecious, flowers unisexual; male flowers in the upper axils of the inflorescence, females below them. Rarely also flowering shoots with only male or only female flowers. Bracts white to reddish, ovoid, in male flowers 0.8–1.2 mm long, smaller in female flowers. Male flowers 4-merous, sessile; 4 sepals; 4 petals, up to 3 mm long; 8 stamens; filaments about 1 mm; 0 styles. Female flowers 4-merous, sessile. Sepals ab-

Submersed shoot of *M. simulans*.

sent, petals or stamens. 4 styles. Fruit more or less dice-shaped; 4 mericarps, ovoid, about 1 mm long.

Culture: *Myriophyllum simulans* is a light-requiring aquarium plant that displays good growth. It can be kept in temperatures of 20–28 °C without any problems. Soft to medium-hard water is especially well suited for cultivation. The lower stems will rapidly lose their leaves under conditions of light deficiency. Under optimum conditions, the plants will have to be trimmed regularly due to rapid growth. As in all other *Myriophyllum* species, growth in *M. simulans* may be strongly impeded through algae infestation on the shoots. The plants appear best if arranged in a small group in the aquarium's foreground or middle zone, between large-leaved green or red species. In summer, *M. simulans* is also a great outdoor plant. The shoots will easily protrude from the water and are suitable for the planting of edges of garden ponds where they will also flower abundantly.**Ecology:** In its native habitats, *M. simulans* populates marsh areas, ponds and rivers featuring a slow current. The plants are often found emerged in boggy soil and are only rarely located existing in submersed conditions. Isolated also in brackish locations. *Myriophyllum simulans* was imported by P.J. van der Vlugt in 1983 from Australia, and was initially introduced in aquaristic literature as *M. propinquum*. He had found the plant in a stream near Walacia in New South Wales, where it grew in larger populations in shallow, slow-moving water on the riverbank area. All specimens grew emerged and flowered abundantly. Biotopes both shaded and exposed to full sunlight were found. Water temperature registered 17 °C in October, air temperature was 20 °C.**Other:** The species can be safely identified only by its inflorescences and fruit.**Further reading:** Orchard (1986), van der Vlugt (1987).

Myriophyllum tuberculatum

Roxburgh (1820)

Family: Haloragaceae.

Synonyms: *M. tetrandrum* Graham (non Roxburgh), *M. indicum* Griffith, *M. spathulatum* Blatt. and Hallbl.

Etymology: *Myriophyllum*: see *M. aquaticum*; *tuberculatum*: tuberous, refers to the fruit.

Distribution: India, Pakistan, Indonesia.

Description: Aquatic plant. Stem up to 2 m long, about 1 mm thick. Submersed whorls with 4–7 pinnate leaves; each leaf usually 2–2.5 cm long, with 14–27 filiform segments, these 5–10 mm long, brown-red in color.

Plants monoecious, flowers uni- and bisexual, sessile, 4-merous, in the axils of the emerged leaves. Emerged leaves initially whorled and pinnatisect, towards the tip of the inflorescence often alternate and with decreasing notches on the margin, 3–10 mm long, 1 mm wide. Lower whorls with 4–6 female flowers, followed by several whorls with female and bisexual flowers, above that whorls with irregularly arranged male flowers. Minute bracts. Calyx with very small calyxlobes; 4 petals, pale purple-red, recurved on maturity; 4 stamens; filaments and anthers each about 1 mm long; 4 stigmas, pale purple, white frayed, 1.5 mm in diameter. Fruit about 3 × 3 mm in size, tuberous, square in a cross-section view, curved.

Culture: This popular but very demanding aquarium plant distinguishes itself by its conspicuous brown-red coloration of the stem and leaves. It seems to be a typical soft-water plant which desperately needs carbon dioxide for proper growth. Best growth results are achieved in water deficient in calcium and salt, with a pH-value in the weak acid range. Furthermore, high light intensity is an important prerequisite for successful maintenance. Optimum temperature range is 22–28 °C. Cultivation is recommended only in almost algae-free aquariums with clear water, since both decaying rot as well as blue or filamen-

tous algae will suffocate the shoots within a short time. *Myriophyllum tuberculatum* is suitable for planting in the middle zone of the aquarium. Depending on the tank size, a small group comprising three to ten shoots is sufficient. They should be arranged in a terraced way. Loose sand is well suited as a substrate, posing no problem when inserting the plants. The delicate stems will break easily in coarse gravel, and they will also find insufficient support. Propagation through lateral shoots is unproblematic. Inflorescences will rise above the water surface on shoots which drift on the surface. Those who succeed in cultivating this demanding but beautiful *Myriophyllum* in the aquarium can utilize this plant to create beautiful decorations within the tank. The species can be temporarily kept in garden ponds during summer. They are sensitive to cold temperatures, not hardy.

Ecology: On the edges of waterways in shallow, stagnant water.

Other: For 20 years, this species was falsely listed under the names of *M. hippuroides* and *M. mattogrossense*. Only in 1994 did the *Myriophyllum* expert A.E. Orchard succeed in a definite identification (see Kasselman 1994b).

***Myriophyllum tuberculatum*.**



Najas conferta

(A. Braun) A. Braun (1868)

Family: Najadaceae.**Synonyms:** *Najas arguta* H.B.K. var. *conferta* A. Braun (1864), *N. hoehnei* Koch.**Etymology:** *Najas*: after Greek nymphs; *conferta*: densely arranged.**Distribution:** Southeastern U.S., Central America (Panama), South America (Bolivia, Brazil, Peru).**Description:** Perennial aquatic plant. Stem up to 60 cm long, glabrous, with few roots on the lower nodes, branched on every node. Leaves sessile, in trimerous pseudo-whorls, linear-lanceolate, 1.5–2.5 cm long, 0.5–1.3 mm wide, flat, recurved, more or less stiff, dark green. Margin with 10–11 distinctly visible denticles each. Denticulation many-celled. Leaf base sheathed, widened, about 3 × 2 mm in size, shoulders of the sheath round, 6–8 denticles on each side.

Plants dioecious; flowers unisexual, small, solitary in the leaf axils. Perianth absent. Male flower about 2 mm in size, with 1 stamen which is surrounded by a transparent spathe. On maturity, it will open and the pedicel will extend. Anther bilocular. Female

flower sessile, about 3 mm long, with 1-locular green ovary and bifid stigma. Ovary surrounded by a spathe on the tip of which are 2 spines. Fruit 1-seeded; seed straight or hardly curved, elliptic-spindle-shaped, 2.0–3.1 mm long, about 0.6 mm thick; testa with 20–36 rows of drawn-out cells 3 times as long as wide.

Culture: *Najas conferta* is a conspicuously decorative plant which has been kept in aquarium culture only since 1992. Its habitus is reminiscent of *N. indica* from which it is easily distinguishable by its stiff, dark green stems and leaves. *Najas conferta* is an undemanding plant which can grow well in both soft as well as medium-hard water. Slightly acid to neutral water is optimal. The temperature range of 20–28 °C speaks for a high degree of adaptability, even though lower temperatures are obviously preferred. Optimum growth is achieved under medium to intense lighting, which will lead to especially dense plant tufts on the water surface. With a good nutrient supply in place, the plants can make do with moderate lighting, but will then grow more slowly. The shoots tolerate only limited water movement. The inconspicuous flowers and fruits will also develop regularly in the aquarium.**Ecology:** The author was able to collect *N. conferta* in two habitats: 1) In the coves of the riverbanks of the slow-moving Rio Guaporé (Brazil), ecological data see p. 40; and 2) Laguna Cocococha, Reserva Natural de Tambopata (Peru, 8/1992): lake with moderately clear water and a sandy-loamy soil; isolated populations in water up to 1.20 m deep. Water and air temperature 24 °C at 09:30 h, GH/KH < 1 °dH, pH 7.0, 20 µS/cm.**Other:** Few of the roughly 40 known *Najas* species are in culture. They are commercially unimportant because they break easily during transportation. The most important distinguishing features are the denticulation of the leaf blade and sheath, as well as the surface structure (microscope!).***Najas conferta*.**

Najas guadalupensis
(Sprengel) Magnus (1870)

Family: Najadaceae.

Synonyms: *Caulinia guadalupensis* Sprengel (1825); *N. microdon* A. Braun, and others.

Etymology: *Najas*: see *N. conferta*; *guadalupensis*: after Guadeloupe ("Guadalupa").

Distribution: U.S., Central and South America.

Description: Perennial aquatic plant. Stem up to 1 m long, glabrous, soft, few roots on the lower nodes, often branched. Leaves sessile, linear-lanceolate, 1.5–3 cm long, 1–2 mm wide, flat, recurved, soft, olive green. Margin with up to 100 denticles on each side (microscope!). Denticulation 1-celled. Sheath at the leaf base up to 3.4 mm wide, round to slightly auriculate, with 4–10 minute denticles on each side. Midrib occasionally reddish.

Plant monoecious; flowers unisexual, 1–3 on the leaf axils. Male flowers with a spathe, anther 1- or 4-locular. Female flower also with 1 spathe, stigma with 4 lobes. Seeds 1.2–2.5 (–3.8) mm long, spindle-shaped; testa with 4–6 angular cells, width greater than length, arranged in 10–60 longitudinal rows.

Culture: *Najas guadalupensis* is an ex-

pressedly undemanding and rapid-growing plant, which will produce densely intertwined populations within only a short time making it especially useful in breeding aquariums. The shoots have the negative characteristic of breaking off easily at the nodes and then drifting on the water surface as fragments in large numbers where they continue to develop; probably for this reason the plants are not suitable for commercial sale. But because the species is undemanding as to substrate, light or water condition, it has nevertheless occasionally been cultivated for many years. Temperature range is 20–30 °C.

Ecology: *Najas guadalupensis* inhabits both stagnant waters, such as marshes and lakes, as well as streams and rivers featuring slow currents. Its habitational areas are widespread.

Other: Due to the intraspecific variability, Lowden (1986) described two forms and Haynes (1979) identified four geographic varieties.

Najas guadalupensis.



Najas indica

(Willdenow) Chamisso (1829)

Family: Najadaceae.

Synonyms: *Caulinia indica* Willdenow (1801), *Najas kingii* Rendle, and others.

Etymology: *Najas*: see *N. conferta*; *indica*: originating from India.

Distribution: Widespread in tropical Asia, Japan.

Description: Perennial aquatic plant. Stem up to 50 cm in length, glabrous, with few roots, often branched. Leaves sessile, alternate, linear, usually 2–3 cm long, up to 1 mm wide, flat, almost round or triangular in a sectional view, hardly recurved, slightly brittle, more or less stiff, light to dark green. Margin with 1–15(–40) distinctly visible denticles. Denticulation many-celled. Leaf base sheathed, widened; sheath mostly 2.5×3 mm in size, auricles absent or very short, entire, toothed or lobed, rarely torn.

Flowers usually solitary in the leaf axils. Male flowers surrounded by a spathe. Anther 4-locular. Female flower usually without a spathe. Stigma mostly bifid. Seeds about 2 mm in length; testa usually with 16–20 longitudinal rows consisting of almost square or

5–6 angular cells, mostly slightly wider than long.

Culture: This undemanding *Najas*, occasionally cultivated by aquarists a few years ago, is rarely kept today. Because the shoots tend to break off easily at the nodes, the species is hardly suited for commercial sale and can be acquired only by associated aquarists. Culture is not difficult and corresponds to that of *N. conferta*. However, *N. indica* grows decidedly slower, requires good lighting and a temperature over 22 °C.

Ecology: The species can be found in standing and low-current freshwater biotopes, occasionally also in brackish water, but will still grow in a depth of 5 m. The author found dense communities of *N. indica* together with *Ceratophyllum demersum*, *Potamogeton wrightii* and *Hydrilla verticillata* in a wide river in Sulawesi.

***Najas indica*.**

Najas marina

Linné (1753)

Family: Najadaceae.

Synonyms: Numerous (see Haynes 1979, Lowden 1986).

Etymology: *Najas*: see *Najas conferta*; *marina*: existing in the ocean.

Distribution: Cosmopolitan, isolated only in Central and South America.

Description: Polymorph, annual (perennial in the tropics?) aquatic plant. Stem up to 100 cm long, glabrous or with numerous acanthas, with few roots, subramous. Leaves sessile, seemingly opposite or whorled, linear-lanceolate, 1–4(–6) cm long, 0.5–2.5 mm wide (measured without denticles), stiff, fragile, medium to dark green. Midrib more or less acanthaceous. Margin with (0–)4–17 acanthas on triangular, many-celled protrusions. Sheath round, with 1–6 denticles each.

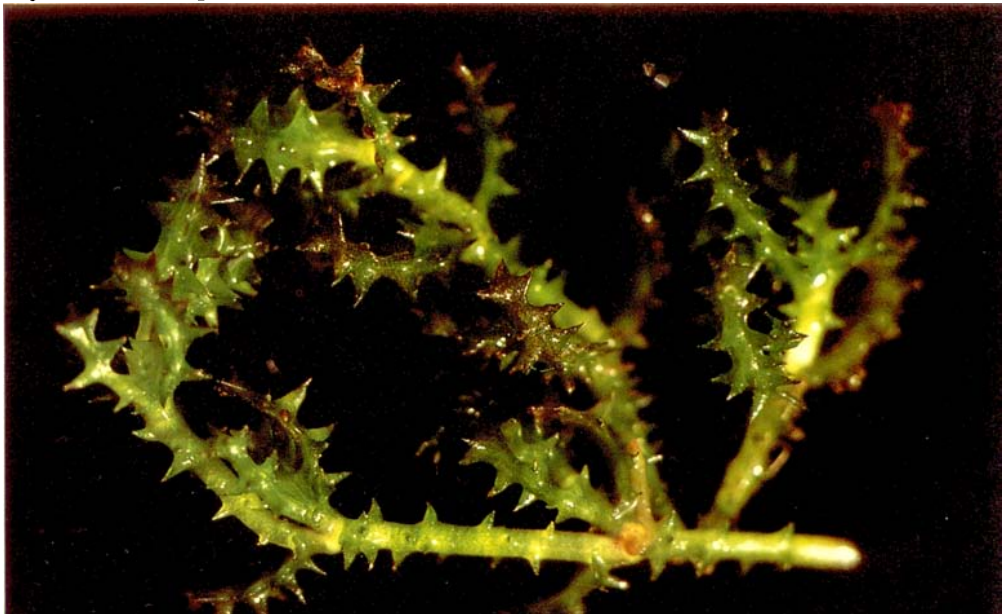
Plant dioecious; flowers unisexual, solitary. Male flowers with spathe. Stamen with 4-locular anther. Female flower naked (without spathe). Stigma with (2–)3(–4) lobes. Seeds elliptic or ovoid, 1.9–7.5 mm long; testa with many rows of irregularly shaped cells.

Culture: Occasionally plants of this polymorph and cosmopolitan species, originating from native waters (endangered in Germany), are kept in garden ponds. The author had the opportunity to cultivate specimens from populations coming from Mexico and Malawi; in both cases the experiments were unsuccessful. If it was possible to study the precise living conditions, *N. marina*, with its tropical origin, could constitute an unusual enrichment of the aquarium flora.

Ecology: *Najas marina* populates freshwater and brackish water biotopes, especially large lakes. The author located *N. marina* var. *mexicana* in Mexico in a canal of the Laguna Media Luna in very hard water (8/1984): temperature 29 °C, pH 7.9, GH 55 °dH, KH 12 °dH. *N. horrida* and *N. marina* subsp. *armata* inhabit both Lake Tanganyika and Lake Malawi (water analysis p. 41).

Other: Due to polymorphism of leaf size, covered with spines as well as seeds, numerous varieties have been described.

Najas marina subsp. *armata* from Lake Malawi.





Nesaea crassicaulis.

Nesaea crassicaulis

(Guillemin & Perrottet) Koehne (1882)

Family: Lythraceae.

Synonyms: *Ammannia crassicaulis* Guillemin and Perrottet (1833), *Nesaea polyantha* Tulasne.

Etymology: *Nesaea*: from *nesos* = island (*N. triflora* was first discovered on the island of Mauritius); *crassicaulis*: thick-stemmed.

Distribution: Tropical Africa, Madagascar.

Description: Marsh plant, up to 50 cm tall. Stem ascendent or erect, angular, thick-stemmed, fleshy, 3–5(–9) mm thick, green to brownish red. Leaves sessile or short petiolate. Emerged leaf blade obovate to oblanceolate, 4–8 cm long, 1.0–1.8(–2.5) cm wide, olive green. Apex obtuse or acute, base decurrent. Submersed blade lanceolate, 5–11 cm long (rarely longer), 1.0–1.6 cm wide, yellowish green to slightly reddish.

Inflorescence is an up to 12 mm petiolate dichasium with (1–)5–7(–12) flowers. Calyx with 4 short appendages; 3(4) petals, violet, 4 × 3 mm in size, rapidly caducous; (4–7)8 stamens (some staminodes), equal in length or a little longer than the calyx; 1 style, equal in length or shorter than the 1-mm globular

ovary. Seed capsule about 3.5 × 2 mm in size; numerous seeds.

Culture: *Nesaea crassicaulis* is a recommendable aquarium plant with high lighting requirements. It looks similar to *Ammannia gracilis*, but can be distinguished well in the aquarium by the yellowish green to slightly reddish colored shoots. Apart from high light intensity, a nutrient-rich, loose substrate as well as soft to medium-hard acid water will have a positive effect on growth. The leaves tend to quickly turn black, therefore a light, free-standing and unobstructed location is important. The shoots should be planted individually. The plant is also suited for culture in paludariums, but is more difficult to keep than *N. pedicellata*. Optimum temperature range is 22–28 °C.

Ecology: Grows in marshy areas, rice paddies and streams. The author discovered the species in December 1980 on Zanzibar, growing semiaquatic in a ditch with shallow water (pH 6.8–7, GH 2 °dH, KH 0.9–2 °dH).

Further reading: Kasselmann (1982b).

Flower of *Nesaea crassicaulis*.



Nesaea pedicellata

Hiern (1871)

Family: Lythraceae.

Synonyms: None.

Etymology: *Nesaea*: see *N. crassicaulis*; *pedicellata*: with short petiolate flowers.

Distribution: Tanzania (Mafia, Zanzibar), Mozambique.

Description: Marsh plant, up to 50 cm tall. Stem decumbent or ascendent, 2–8 mm thick, green to dark red in color. Emerged leaves sessile, opposite. Blade oblong, aciculate, base narrowed, 1.5–5 cm long, 0.5–1.0 cm wide, olive to dark green in color. Submersed leaves opposite, alternate or whorled, up to 9 × 1.5 cm in size.

Inflorescence is an up to 7 mm petiolate dichasium with 1–9 flowers. Calyx about 3.5 mm long with 4(5) appendages; (3)4(5) purple petals, 3–4 × 2.5–3 mm in size; 8(–10) stamens, of them 4(5) up to 7 mm long, the other 4(5) as long as the calyx. Style 5–8 mm long. Ovary elliptic. Seed capsule about 3 mm in diameter.

Culture: *Nesaea pedicellata* is a recommendable, decorative and readily growing aquarium and paludarium plant. Prerequisites for

strong shoots are medium to high light intensity as well as a nutritious substrate. If the plants are positioned in too dark a spot, they will remain small and the leaves on the lower stem segments will tend to blacken. The shoots should therefore be spaced out when planting so the lower stem segments, too, receive adequate light. An advantageous temperature range is 22–28 °C. The species can be well cultivated in both soft and hard water, though an acid environment is more advantageous. Propagation is through lateral shoots.

Ecology: *Nesaea pedicellata* grows in pools and on the edges of marshes. The author discovered the species in December 1980 on Mafia Island. Water values as follows: temperature 26–31 °C, pH 5.7, GH 5 °dH, KH 0.5 °dH.

Other: The author's collections of *N. pedicellata* (Mafia) and *N. crassicaulis* (Zanzibar) were identified by A. Fernandes (Coimbra/Portugal). Easily confused with *Ammannia* species (compare flower features).

Further reading: Kasselmann (1982a).

Flowers of *Nesaea pedicellata*.





Nesaea pedicellata (center).

***Nesaea* sp.**

Family: Lythraceae.

Synonyms: Unknown.

Etymology: *Nesaea*: see *Nesaea crassicaulis*.

Distribution: Unknown.

Description: Small marsh plant, 10–15 cm tall, glabrous. Stem erect, round, hard, 1–2 mm thick, dark red in color. Leaves sessile, opposite, entire. Leaf blade very narrow elliptic, 2–4.5 cm long, 3–7 mm wide, olive green to deep wine red in color. Apex acute; base decurrent. Margin often slightly undulate or crispate.

Inflorescence is an up to 1-mm long petiole dichasium with 3–4 very small flowers. Opened solitary flower rare, 5 mm in diameter, up to 2 mm petiole. Bracts about 1 mm long, linear. Calyx 2.2 mm long, 1.2 mm wide, with 4 triangular calyx-lobes and minute appendages as well as 8 reddish ribs. Usually 4 (rarely 5) petals, pale violet with dark violet midrib, 2 mm long, about 1.5 mm wide, very rapidly caducous; 8 stamens, as long as the calyx; short filament; red anthers, yellow pollen; 1 style, shorter than the stamens; stigma capitate. Ovary globular with numerous ovules.

Culture: This occasionally commercially available (sometimes under the incorrect name of *Nesaea crassicaulis*), delicate and very decorative stem plant is very difficult to keep in the aquarium. The species possibly requires very soft water and intense lighting. Plants in shops originate from export companies (e.g., Singapore) which seem to cultivate them in submersed conditions in nurseries. Despite a huge effort, the author was unable to achieve sustained cultivation in submersed maintenance. Keeping the species in paludariums is similarly problematic and possible only under intensive lighting.

Ecology: Nothing is known about native habitats.

Other: Even though this *Nesaea* species has been imported more or less regularly for several decades, the author was unable to research its scientific name. Identification is especially made difficult by the fact that the distribution area is unknown.

Nesaea sp.



Nesaea triflora

(Linné fil.) Kunth (1823)

Family: Lythraceae.

Synonyms: *Lythrum triflorum* L. f. (1781), *Trotula trianthis* Commerson, *Ammannia triflora* Wallich, *Nesaea capitellata* Presl.

Etymology: *Nesaea*: see *N. crassicaulis*; *triflora*: three-flowered.

Distribution: Comores, Madagascar, Mauritius, Réunion, Sri Lanka.

Description: Marsh plant with ascendent shoots. Stem 3–4 mm thick, glabrous, green to reddish. Internodes 3–5 cm. Leaves sessile or very short petiolate, decussate. Blade lanceolate to oblanceolate, 2–4.5 cm long, 1–1.5 cm wide, entire, light olive green. Leaf apex acute or mucronate (magnifying glass!); base round. Midrib distinct, reddish on the base, pinnate veins indistinct.

Inflorescences solitary, short petiolate; 2 bracts, about 7 × 4 mm in size. Inflorescence with 3 about 1–2 mm petiolate 1-cm sized flowers. Bracts 2 × 0.5 mm in size; 4 sepals, about 3 mm in length, acuminate; calyx appendages absent; 4 petals, deep violet, 3–4 mm; 8 stamens, about 3 mm long; 1 style, as long as the stamens. Ovary wine red. Seed

capsule 3 mm, globular, transparent; numerous seeds.

Culture: *Nesaea triflora* is not suited for cultivation in aquariums, but has excellent use in paludariums. There, the plants should be provided with conditions of high humidity, temperatures between 24–30 °C, a nutritious substrate (soil), as well as especially good lighting. Under optimum conditions, growth will be so rapid that the shoots will have to be trimmed regularly. Inflorescences are numerous during summer under a lot of light and warmth.

Ecology: The Albers collected the species 30 km south of Tamatave (Madagascar). The plants grew shaded on moist sandy ground on the edge of a canal bight.

Other: Koehne (1903) mentions 4–5(6)-merous flowers with 8–10(12) stamens in *N. triflora*. The author, however, could not find any deviation from the description given above. An identification of the specimens collected by the Albers was conducted by J. Bosser (Paris).

Emersed shoot of *Nesaea triflora*.



Flower of *N. triflora*.



Nuphar japonica

de Candolle (1821)

Family: Nymphaeaceae.

Synonyms: *Nymphaea lutea* Thunberg, *Nuphar japonicum* DC. var. *subintegerrimum* subvar. *rubrotinctum* Caspary, *N. subintegerrimum* subvar. *rubrotinctum* (Casp.) Makino.

Etymology: *Nuphar*: possibly from Arabic nunfar; *japonica*: originating from Japan.

Distribution: Japan.

Description: Floating leaf plant with strong creeping rhizome. Petiole round, glabrous. Submersed leaves sagittate, up to 20 cm long, 12 cm wide, very soft, transparent and undulate on the margin, light green or brownish. Floating and emersed leaves oblong to wide ovoid-sagittate, coriaceous, dark green. Apex round or obtuse acuminate; basal lobes acutely rounded.

Flower long petiolate, 4–5 cm in size. Calyx 5-leaved, petaloid, reflexed with age; 10–18 inconspicuous petals, not spread out as in *Nymphaea*. Stamens numerous. Sepals, petals and stamens yellow, in var. *rubrotincta* (Caspary) Ohwi filaments and base of the reflexed sepals more or less dark red in color. Stigmatic disc 9–16-radiate, deep crenate.

Cross-fertilization essential. Fruit bottle-shaped, restricted on the collar, many-seeded, maturing above the water surface. Seeds without arillus.

Culture: With its light green sagittate leaves, *N. japonica* is an especially decorative and conspicuous aquarium plant. It is relatively undemanding and can be kept in both soft and hard water under medium lighting without any problems. It is not recommended to use a too nutrient-rich substrate because the plants might then grow very large and develop floating leaves. Generally, though, the formation of floating leaves within the aquarium is relatively rare. Optimum temperature range is 20–28 °C. The Dennerle company imported *N. japonica* var. *rubrotincta* a couple of years ago from Japan (refer to appendix).

Ecology: The species populates pools, lakes and rivers. In Japan, the rhizomes are consumed as food and the juvenile leaves used as tea.

Nuphar japonica.



Nymphaea* × *daubenyana

Hortorum (1863?)

Family: Nymphaeaceae.

Synonyms: *Nymphaea* “stellata prolifera” hortorum, *N.* “stellata bulbifera” hortorum.

Etymology: *Nymphaea*: see *N. glandulifera*; *daubenyana*: after Prof. Daubeny, Director of the Oxford Botanical Gardens; hortorum: from the gardens (garden hybrid).

Distribution: No native distribution.

Description: Floating leaf plant with tuberous rhizome. Submersed juvenile leaves entire, ovoid, peltate, delicate, base-lobes acute rounded, up to about 20 × 15 cm in size, more or less green to brown-red in color and with more or less intense dark red spots. Floating leaves ovoid to round, entire or slightly denticulate, up to 30 cm long, medium green, underside reddish. Adventitious plants on the leaf base, on which short petiole smaller flowers will develop. Primary veins 5–15.

Flowers 5–18 cm in size, sweet-scented, day-flowering plant; 4 sepals; 10–18 petals, pale purple or light blue in color, white or yellowish at the base. Up to 100 stamens, filaments and stigmatic disc yellow; anthers

with pale violet connective appendages. No seed production since the hybrid is sterile.

Culture: This cultured hybrid is being cultivated in botanical gardens due to its propensity to flower, but is, quite inexplicably, only occasionally commercially available. The rapid propagation through adventitious plants on the leaf bases, which also occurs regularly in strong submersed leaf blades (see also *N. micrantha*), make this hybrid a recommendable aquarium plant. For optimum growth, the hybrid requires a nutritious substrate, high light intensity and warmth (optimum temperature over 25 °C). Soft or medium-hard water, with pH-values in the acid to neutral range, is recommended. A regular additional supply of iron fertilizer, as well as CO₂, will also have a positive effect. Floating leaves are to be regularly removed.

Other: *Nymphaea* × *daubenyana* hort. is a cross between *N. micrantha* Guill. and Perr. and *N. caerulea* Savigny.

Nymphaea × *daubenyana*.



Nymphaea glandulifera

Rodschied (1794)

Family: Nymphaeaceae.

Synonyms: *Nymphaea blanda* G. Meyer, *Castalia blanda* (G. Meyer) Lawson, and others.

Etymology: *Nymphaea*: from (Gr.) *Nympha* = name of a goddess; *glandulifera*: gland-carrying (reference not known).

Distribution: Central and South America.

Description: Small-leaved water lily. Rhizome ovoid, small. Petiole in the aquarium usually 1.5–2 mm thick, 5–20 cm long, glabrous or pubescent. Juvenile leaves sagittate or hastate, about 6 cm long. Adult leaves wide elliptic to orbicular, about 5–8 cm wide, 4–8 cm long, entire, round on the apex, base-lobes mostly obtuse to round, wide divaricate, upperside shiny light green, underside pale green. Floating leaves rare in the aquarium, 21 × 19 cm in its habitat; 9–15 veins.

Flowers white, usually about 5–7 cm in size and up to 25 cm petiolate; 4 green sepals; 12–20 petals; 45–98 stamens, with appendages. Stigmatic disc 19–39-radiate. Fruit production often. Numerous seeds, with long pubescence, seed surface smooth.

Culture: This rare small-leaved water lily is excellently suited for culture in aquariums, especially in smaller tanks. The rosettes, about 5–15 cm tall and consisting of light green foliage, can be best utilized in the foreground. This *Nymphaea* will grow well in soft to medium-hard water. A slightly acid environment, though, is advantageous for growth. Washed sand is adequate as a substrate, even though the specimens will grow more densely leaved and decorative in loamy soil. Light requirements are only moderate. Due to its tropical origin, this water lily loves higher temperatures: optimum range 24–28 °C. Vegetative propagation through short runners.

Ecology: *Nymphaea glandulifera* was collected by the author at the end of January 1990 in Ecuador, about 20 km north of the town of Coca, and subsequently introduced as a cultivation plant. In its habitat, dense communities could be found in humus-rich, boggy soil in a narrow, shallow ditch containing stagnant water. The location was sunny, the water soft and slightly acid.

***Nymphaea glandulifera*.**

Nymphaea lotus

Linné (1753)

Family: Nymphaeaceae.

Synonyms: *Nymphaea thermalis* DC., *N. zenkeri* Gilg, and others.

Etymology: *Nymphaea*: see *N. glandulifera*; *lotus*: Greek plant name.

Distribution: Widespread in tropical Africa, Madagascar, introduced in Europe in thermal waters; running wild in North, Central and South America; Asian plants belong to a different species (Verdcourt 1989).

Description: Strong floating leaf plant with a tuberous rhizome, which is often absent in aquarium specimens. Submersed juvenile leaves triangular, hastate, then ovoid to almost round, peltate, entire, deep notches at the base, with acute or round base-lobes, delicate, up to about 25 cm in diameter; the margin is emarginate toothed in strong submersed leaves.

Two color formations are regularly available as 'Green' and 'Red' *N. lotus*. For better differentiation cultivar names are introduced at this stage: 'Green' cultivar with strong light green-colored leaf blades and brownish spots, 'Red' cultivar with a deep dark red-

colored blades which are more or less dark-spotted. Floating leaves orbicular, peltate, base-lobes round, hardly divaricate, more or less coriaceous, up to 50 cm in size, emarginate toothed, upperside glabrous, underside glabrous or slightly pubescent, dark red. Venation strong, 11–15 primary veins.

Flowers 8–17(–25) cm in size, sweet-scented, opened at night; 4 sepals, green, often with cream-colored veins. About 12–20 white petals, in the 'Red' cultivar slightly reddish; 40–90 yellow stamens; obtuse anthers, usually without connective appendages. Stigmatic disc 20–30-radiate, yellow, in *N. lotus* 'Red' stigma appendages with a strongly red-colored ring (always?) on the outside. Fruit globular, large, with countless seeds.

Culture: *Nymphaea lotus* is a water lily popular with and often kept by aquarists. Two color formations are regularly commercially available ('Red' and 'Green' cultivars). Both are defined by their rapid, unproblematic growth. Under optimum conditions these solitary plants grow very large and require spacious aquariums. The development of unwanted strong specimens, however, can be

Nymphaea lotus 'Green'.





Nymphaea lotus 'Red'.

prevented by using a nutrient-poor substrate (e.g., unwashed sand) as well as through planting in a pot, which is then inserted into the substrate. A free-standing spot with intense lighting is essential because with too dense plant growth, as well as lack of light, the unwanted long petioles will develop pretty quickly. The species prospers well in soft and hard water, although soft, moderately acid water is best. Optimum temperature range is 22–28 °C (not only up to 24 °C as is sometimes indicated). Vegetative propagation occurs on strong plants through runners. The formation of floating leaves can be suppressed for a long time by consistently removing too large leaves. Flowers, however, will develop only after the formation of several floating leaves. Flowers are comparatively rare in aquariums (night-flowering plant). Seeds are easily produced and germinate well.

Ecology: In its native habitat *N. lotus* grows in very different types of waters. On the one hand, shallow, temporary pools and small lakes are populated, in which plants will develop giant blades. Such biotopes were observed by the author both in Tanzania as well

as quite often in Senegal (photo p. 27) and Gambia. On the other hand, the 'Green' variety is found in western Cameroon in flowing waters (this flowing water variety used to be identified as *N. zenkeri*). It could not be definitely determined if the 'Red' variety of *N. lotus* also occurs in moving waterways. Assumptions were made according to which both color forms supposedly occur together. The following water values were recorded at one habitat of the 'Green' *N. lotus* in western Cameroon between Kribi and Campo: temperature 24–25 °C (air temperature 27 °C at 14:00 h), pH 5.5–5.7, GH 0.5 °dH, KH < 0.1 °dH, 40 µS/cm, Fe not detectable.

Other: *Nymphaea lotus* obviously seems to be a polymorph species, the forms of which populate very different habitats. If they will continue to be classified as one species remains to be seen.

Flower of *Nymphaea lotus* in its natural location in Senegal.



Nymphaea micrantha

Guillemin and Perrottet (1830)

Family: Nymphaeaceae.

Synonyms: *Nymphaea caerulea* Guillemin and Perrottet (non Savigny), and others.

Etymology: *Nymphaea*: see *Nymphaea glauca*; *micrantha*: small-flowered.

Distribution: West Africa (Senegal to Cameroon).

Description: Floating leaf plant. Rhizome up to 4 × 2 cm in size. Submersed leaves entire, transparent, up to 18 cm long, 14 cm wide, upperside green or reddish to deep brown, more or less spotted, underside more or less purple. Floating leaves smaller than the submersed leaves, upperside light green, underside violet with small dark spots. Blade round to cordate or peltate. Base-lobes acute to cuspidate, hardly divaricate.

Flowers white or blueish, 5–10 cm in size, hardly scented; 4 sepals. Up to 16 petals, up to 5 cm long, equal in length or a little shorter than the sepals. Numerous stamens, yellow, appendages white. Stigmatic disc 15–20-radiate, yellow.

Culture: A recommended and decorative medium-sized water lily which grows well in

soft and medium-hard water with pH-values of 6.5–8 and a temperature of 24–28 °C. The substrate should be rich in nutrients (e.g., added loam). Propagation of *N. micrantha*—in contrast to many other water lilies—is easy and productive through adventitious plants, which are formed under intense lighting on the base of the leaf blades. To prevent them from drying out on the floating leaves within the aquarium, the leaf undersides are turned upside down. Strong leaves may also be cut away. Occasionally no submersed leaves, only floating ones, will develop, which can be avoided by restricting the lighting period to 12 hours. This measure, however, will lead to the increased formation of floating leaves in other *Nymphaea* species.

Ecology: Populates stagnant and very slow-moving waters. The author located *N. micrantha* in Senegal and Gambia, mostly under intense sunlight as well as in boggy soil with a strong smell of hydrogen sulfide.

Nymphaea micrantha with young adventitious plants.



Nymphaea rudgeana

G. Meyer (1818)

Family: Nymphaeaceae.

Synonyms: *Nymphaea ampla* var. *rudgeana* (G. Meyer) de Candolle, and others.

Etymology: *Nymphaea*: see *N. glandulifera*; *rudgeana*: after the botanist E. Rudge (1763–1846).

Distribution: Central America, eastern and northern South America.

Description: Floating leaf plant with a strong rhizome; no runners. Leaf blade in the aquarium mostly up to 25 cm petiolate and 15 cm in size, almost orbicular, entire, pink coloration. Apex round; base-lobes acute rounded, wide divaricate. Floating leaves in the native habitats up to 45 cm in size, irregularly toothed on the margin. (11–)15–23 veins.

Flowers cream-colored, yellowish or a pale purple-red, about 7–10 cm in size; 4 sepals; 12–29 petals; 39–186 stamens, with appendages. Stigmatic disc 11–31-radiate.

Culture: *Nymphaea rudgeana* has so far been a rare water lily which is, however, not difficult to cultivate. A problem-free maintenance was achieved in soft to medium-hard water with a slightly acid to slightly alkaline

pH-value. Good lighting and a nutritious substrate (loam) are the most important prerequisites for satisfactory growth. Medium-sized, compact rosettes with conspicuous pink-colored blades will form in aquariums. Floating leaves have so far not been detected which is why this species is predestined for aquarium culture. Temperature range is 23–29 °C.

Ecology: *Nymphaea rudgeana* populates standing and moving, even brackish waterways. The author collected the species in two locations in the Gran Sabana in Venezuela: 1) Small river, dense populations in soft loam in slow-flowing, 1–2-m deep water. Water analysis (8/1989): temperature 23.5 °C (air temperature 24.5 °C at 14:00 h), pH 5, GH < 1 °dH, KH 4 °dh, 60 µS/cm; and 2) Rio Curital, in the catchment area of the Rio Caroni. Small river, individual specimens in shallow water, unshaded. Water analysis (4/1992): temperature 29 °C (air temperature 32 °C), pH 6, GH/KH < 1 °dH, < 10 µS/cm.

Further reading: Wiersema (1987).

***Nymphaea rudgeana*.**

Nymphoides aquatica

(Walter) O. Kuntze (1891)

Family: Menyanthaceae.

Synonyms: *Anonymos aquatica* Walter (1788), *Villarsia aquatica* Gmelin, *Menyanthes trachysperma* Michaux, *Limnanthemum aquaticum* Britton.

Etymology: *Nymphoides*: genus name *Nymphaea* and *eidos* (Gr.) = habit; *aquatica*: existing in water.

Distribution: U.S. (New Jersey, Florida, Texas).

Description: Small floating leaf plant. Numerous about 2–5-cm long and up to 6-mm thick root tubers—which is reminiscent of a “banana leaf”—on a short rhizome, also fleshy roots. Submersed juveniles leaves 4–8 cm, in the aquarium about 5 cm petiolate, slightly stiff, fleshy, slightly undulate, yellowish green to a weak brownish color, stem and leaf underside red-spotted. Floating leaves wide ovoid to orbicular, with a deep cut, fleshy, 5–12 cm in size.

Inflorescence many-flowered. Pedicel up to 8 cm long, sepals 4–5 mm long, purple-red-spotted. Corolla white, 10–14 mm long. Style absent; stigma with 2 lobes. Capsule

10–14 mm long, with many seeds. Seeds distinctly mammillate.

Culture: Compared to other *Nymphoides* species, which have very delicate and usually short-lived submersed juvenile leaves, and where the floating leaf phase will occur after only a short time, *N. aquatica* demonstrates an entirely different behavior in the aquarium. The juvenile leaves are located on very short shoots and display a relatively long life. Floating leaves and inflorescences will not usually develop in the aquarium. Due to these characteristics, *N. aquatica* is a regularly cultivated species which is suited for planting in the foreground where it will grow for many months. However, the author observed that the conspicuously thick roots (“bananas”) which serve as a nutrient storage break off or rot away regularly after only a couple of months, with growth stalling thereafter. Low aquariums are required for the formation of floating leaves. Temperature range is about 20–26 °C.

Ecology: *Nymphoides aquatica* populates quiet waters in coastal regions.

Nymphoides aquatica.



Nymphoides ezannoi

Berhaut (1967)

Family: Menyanthaceae.**Synonyms:** *Limnanthemum senegalense* auct. non (G. Don) N.E. Brown, *Limnanthemum indicum* auct. non (L.) Thwaites, *Nymphoides indica* auct. non (L.) O. Kuntze.**Etymology:** *Nymphoides*: see *N. aquatica*; *ezannoi*: after the collector Père Ezanno.**Distribution:** Senegal, Mali, Niger, Chad, Sudan.**Description:** Floating leaf plant with a short rhizome and intense production of runners. After several submersed, delicate, light green, up to 5 × 5-cm large juvenile leaves, only floating leaves will develop, which are located on an up to 80 cm long stem. Petiole 0.5–1 cm long. Blade ovoid to orbicular, entire, with a deep cut at the base, 5–10(–14) cm in size, upperside olive green, underside spongy, whitish green or wine red in color.

Inflorescence seemingly originating from the pedicel of the floating leaf, with about 10–25 successively opening, bisexual, short-lived flowers. Flowers up to 5 cm petiolate, 5-merous, not heterostyled. Calyx 5 mm long. Corolla with 5 lobes, funnel-shaped, white, yellowish in the throat, almost glabrous, 0.8–2 cm in size; petal-lobes wide aliferous on the margins, as well as with a crest in the center, occasionally crenate hardly fimbriate; 5 stamens; very short filaments; 1 very short style; stigma with 2 lobes. Capsule almost dice-shaped, with 2–20 seeds; these 1.5–1.9 mm in size, almost globular, mammilately acanthaceous.

Culture: *Nymphoides ezannoi* is an especially recommendable, fast-growing floating leaf plant which will satisfy the aquarist with its propensity to flower. Not planted, but with shoots merely floating on the surface, it will increasingly degenerate, which is why it is imperative to insert the plants into the substrate. If the developing floating leaves are regularly removed, only the submersed small

leaves will form for a couple of months. After entry into the floating leaf phase, inflorescences will develop, with adventitious shoots with roots at their base which can be cut off and replanted again. Individual floating leaves, too, which are laid on a moist substrate and covered with a glass panel, will rapidly develop adventitious shoots. It is not uncommon for a plant to display nearly 30 floating leaves, with the numerous flowers creating a marvelous effect. Regular removal of floating leaves causing too much shade will not harm the plant. Both a nutrient-rich substrate as well as good lighting are recommended. *Nymphoides ezannoi* grows equally well in soft and hard water. The species can not handle strong water movement. Temperature range should be 24–30 °C.

Ecology: *Nymphoides ezannoi* populates stagnant, permanent and temporary waters. In November 1983 the author observed a large temporary pool near the village of Kaolack in Senegal, featuring dense populations growing in shallow water under intense sunlight. The species was associated with *Nymphaea lotus*, *Lemna* and *Salvinia*.

Other: Has been cultivated since about 1988.

Flowers of *Nymphoides ezannoi*.



Nymphoides fallax

Ornduff (1969)

Family: Menyanthaceae.

Synonyms: None.

Etymology: *Nymphoides*: see *N. aquatica*; *fallax*: misleading, probably refers to the similarity to *N. indica*.

Distribution: Mexico, Guatemala.

Description: Perennial (also annual?) small floating leaf plant. Stem up to about 75 cm. Petiole 0.5–2.5 cm long. Leaf blade almost orbicular, 4–12 cm in diameter, upperside green, underside occasionally brownish coloring.

Inflorescence with 5–20 flowers. Flowers 5-merous, bisexual, heterostyled. Pedicel 2–5(–7) cm long. Sepals 6–7(–10) mm long. Petal-lobes aliferous, deep yellow, fimbriate pubescence, 12–15 mm long. Capsule ovoid-globular with 10–25 seeds; seed 2–2.5 mm in diameter, tuberculate or almost smooth, slightly compressed.

Culture: Nothing is known so far about the culture of *Nymphoides fallax*. One can assume, however, that it is a species that grows well in aquarium conditions and the importation of which would be welcomed.

Ecology: *Nymphoides fallax* occurs in native habitats in stagnant waters such as flood areas, lakes and ponds, as well as slow-moving rivers in altitudes of between 1600 and 2500 m above sea level. In Mexico, on the road between San Cristobal las Casas and Palenque in the mountains, the author discovered dense populations existing in a dried out pool under intense sunlight.

Other: *Nymphoides fallax* was, for many years, mistaken for *N. indica* (Linné) O. Kuntze [Syn. *N. humboldtiana* (Kunth) O. Kuntze] because both species have identical vegetative features. They do, however, differ distinctly in their flower characteristics as well as their seeds, and also have a different distribution as to altitude. Whereas *Nymphoides indica* is generally found in tropical regions in lower altitudes, *N. fallax* populates higher altitudes. However, *N. fallax* occurs sympatrically with *N. indica* in the highlands of Guatemala.

Further reading: Ornduff (1969).

Flower of *Nymphoides fallax*.



Nymphoides forbesiana

(Grisebach) O. Kuntze (1891)

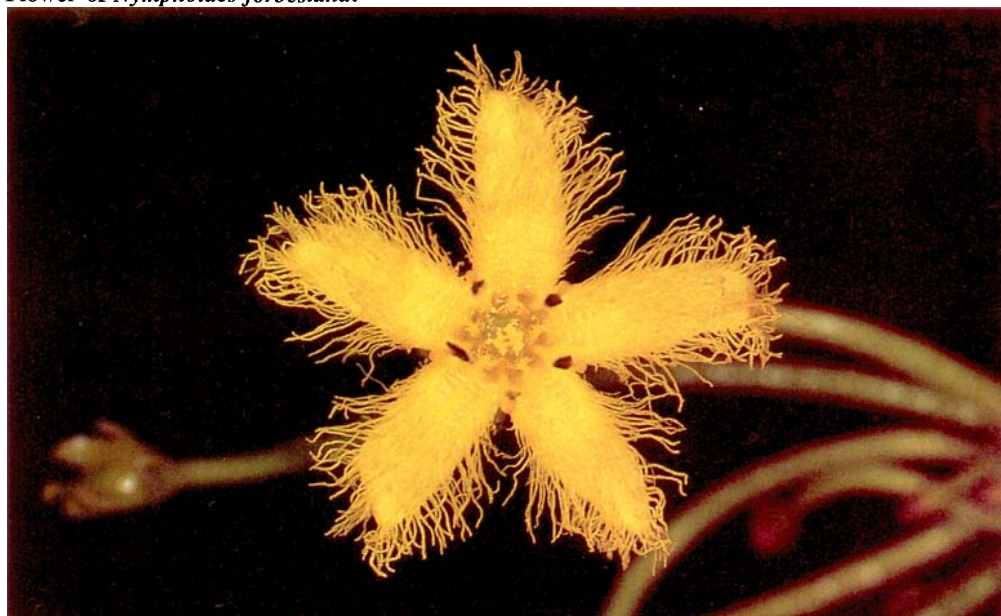
Family: Menyanthaceae.**Synonyms:** *Limnanthemum forbesianum* Grisebach (1839), and others.**Etymology:** *Nymphoides*: see *N. aquatica*; *forbesiana*: after the English gardener and collector of the plant, J. Forbes (1773–1861).**Distribution:** Widespread in tropical and subtropical Africa with a humid climate.**Description:** Annual or perennial, runner-producing floating leaf plant with a short rhizome. Floating leaves on long stems. Petiole 5–10(–30) mm long. Blade almost orbicular, entire, deeply indented, up to 12 cm in size, upperside light green, underside slightly spongy, dark red color.

Inflorescence with about 10–20 successively flowering, short-lived about 3–7-cm petiolate flowers. Flowers bisexual, 5-merous, 1.5–2 cm in size. Sepals 3–5 mm long. Petallobes 1 cm long, bright yellow, fimbriate pubescence. Style with stigma longer (5–6 mm) or shorter than the stamens (heterostyled flowers, heteromorphic); stigma bifid. Capsule ovoid, with 2–10 seeds; these almost globular, 2 mm in size, smooth to strongly acanthaceous.

Culture: *Nymphoides forbesiana* has been cultivated in an aquarium only once. Specimens imported from Mafia Island were able to be maintained for a few months without incurring problems, but then died off. They might possibly be short-lived (annual) plants which for this reason cannot be continually kept in aquariums. The import of this interesting and actively flowering plant would be desirable.

Ecology: In June 1982 the author located *N. forbesiana* on Mafia in a small temporary pool, which dries out regularly. About 6 weeks after the rainy season, the large populations with their numerous yellow flowers provided an impressive appearance. The plants grew in shallow water on a sandy soil under intense sunlight. These locations, which were revisited in December 1980 and 1981, had entirely dried out during the dry season. It can be assumed that the seeds display a strong resistance to drying out.

Flower of *Nymphoides forbesiana*.



Nymphoides hydrophylla

(Loureiro) O. Kuntze (1891)

Family: Menyanthaceae.

Synonyms: *Menyanthes hydrophylla* Loureiro (1790), *M. cristata* Roxburgh, *Villarsia cristata* Sprengler, *Limnanthemum cristatum* Grisebach.

Etymology: *Nymphoides*: see *N. aquatica*; *hydrophylla*: with aquatic leaves.

Distribution: Sri Lanka, India, Malaysia, South China.

Description: Perennial floating leaf plant with a short rhizome. Stem up to 85 cm. Floating leaves up to 2.5 cm long petiolate, ovate to orbicular, deeply cordate-sagittate indented, slightly crenate, round lobes, up to 13 cm in diameter, upperside green, underside purple-red in color.

Inflorescence with more than 20 successively flowering, short-lived flowers. Flowers 2.8–6.0 cm long petiolate, 5-merous, not heterostyled, 1.4–2.0 cm in size. Calyx up to 5 mm long. Petal-lobes 5–6, white, pale yellow at the base, a little undulate on the margins and with an undulate crest on the upperside. Filaments short. Style very short; stigma bifid. Capsule wide ovoid, with 5–10 seeds;

these are globular or lenticular, 2 mm in diameter.

Culture: *Nymphoides hydrophylla* was rarely imported but has found no regular use in aquaristics. The species is obviously not difficult to cultivate. Detailed information on maintenance conditions etc., is, however, not yet available.

Ecology: As is known from other *Nymphoides* species, *Nymphoides hydrophylla* populates tranquil waters, such as pools, ponds and lakes, up to 150 m above sea level. The species is found very often on Sri Lanka. The author located *N. hydrophylla* associated together with *N. indica* in massive populations in a lake not far from the town of Beliatta. In January 1985 the following water values were recorded: temperature 32 °C, GH and KH 4 °dH, pH 7, 482 µS/cm, redox potential 183 mV.

Further reading: Cramer (1981).

***Nymphoides hydrophylla* in its native habitat in Sri Lanka.**



Nymphoides indica

(Linné) O. Kuntze (1891)

Family: Menyanthaceae.

Synonyms: *Menyanthes indica* L. (1753), *Nymphoides humboldtiana* (Kunth) O. Ktze., and others.

Etymology: *Nymphoides*: see *N. aquatica*; *indica*: originating from India.

Distribution: Pantropical.

Description: Stem up to 2 m. Petiole mostly 1.5–6 cm. Blade up to 30 cm, in the aquarium about 10 cm in size, upperside green, underside may also be colored reddish, occasionally spongy.

Inflorescence with 20–30 flowers. Pedicel 2–12 cm. Flowers 1.2–3 cm in size. Calyx up to 7 mm long. Petal-lobes (4–)5(–7), fimbriate pubescence, white with more or less intensive yellow base. Flowers with long (7–11 mm) or short (2–4 mm) style (heterostyled, hydromorphous). Capsule ovoid, more than 10 seeds; these are lenticular, smooth or mamillate, 1.5–2.2 mm long.

Culture: As described for *N. ezananoi*.

Ecology: *Nymphoides indica* grows in stagnant water in marsh areas, lakes and ponds. Some data on habitats follows: 1) Papua New

Guinea (7/1988): marshy lake with dense population. Temperature 31 °C, pH 7.5, GH 11 °dH, KH 15 °dH, 510 µS/cm; 2) Venezuela (7/1989): flood area, stagnant to slow-flowing knee-deep water. Substrate sandy-boggy, stony; 3) Sri Lanka (1/1985): lake. Temperature 32 °C, pH 7, GH/KH 4 °dH, 482 µS/cm, rH 183 mV; 4) Mexico (8/1985): Pond with dense populations. Temperature 29 °C, pH 6.9, GH/KH 3 °dH, Fe and NO₂⁻ not detectable, NH₄⁺ < 0.5 mg/L; 5) Bali: Beriatan Lake, large populations. pH 5.7–5.9, GH/KH 1 °dH, 100 µS/cm; and 6) Sulawesi (7/1981): Matana and Towuti lakes. Conspicuous small-leaved plants. Temperature 29 °C, in a depth of 2.5 m still 28.5 °C, pH 6.5–7.2, GH 6.0/3.4 °dH, KH 1.8/1.4 °dH, 185/125 µS/cm.

Other: Ornduff (1970) proved that the New World plants of *N. indica* (Syn. *N. humboldtiana*) always display a tetraploid set of chromosomes, whereas the specimens of the Old World are diploid or tetraploid. Raynal (1974) described the subsp. *occidentalis* from Africa. Also known is a hybrid from Cameroon, *N. brevipedicellata* × *indica* subsp. *occidentalis*.

Nymphoides indica with flowers.



Nymphoides microphylla

(St. Hilaire) O. Kuntze (1891)

Family: Menyanthaceae.

Synonyms: *Villarsia microphylla* St. Hilaire (1833), *Limnanthemum microphyllum* Griseb.

Etymology: *Nymphoides*: see *N. aquatica*; *microphylla*: small-leaved.

Distribution: Brazil, Bolivia?, Paraguay?

Description: Floating leaf plant with intensive production of runners. Petiole 5–6 cm long. Floating leaf blade wide ovoid to orbicular, entire, wide cordate indented at the base with round lobes, up to 11 cm in diameter, upperside yellowish green, underside lighter, dotted and spongy.

Inflorescence with 9–15 successively flowering, bisexual, short-lived flowers. Pedicel up to 7 cm long. Flowers 5-merous, about 1.5 cm in diameter. Calyx 5–7 mm long, longer than the capsule. Corolla with 5 lobes, funnel-shaped; petal-lobes about 8 mm long, yellow, fimbriate pubescence. 5 stamens; filaments about 3 mm, anthers 2 mm long. Style with stigma 4 mm long; stigma bifid. Ovary ovoid, 3 mm long. Capsule obovate, about 5 mm long, with about 6 seeds, these almost

globular, slightly compressed, almost smooth, light brown with dark spots, 1.5 mm in size.

Culture: Nothing is known about the culture of this interesting plant.

Ecology: The author researched a native habitat of *N. microphylla* in Mato Grosso (north of the Pantanal in southwestern Brazil). This habitat is located between Cáceres and San Antonio, 53 km before San Antonio. In March 1986, dense populations grew in a temporary pool in shallow water under intense sunlight. The soil was loamy. In September 1992, in the southern Pantanal (Brazil), 30 km north of Miranda, W. Bock (Berlin) found dense groups of *N. microphylla* in a temporary pond in shallow water. At this location, too, the plants grew unshaded and in loamy soil.

Other: Even though this species had already been described as *Villarsia microphylla* in 1833, it is hardly known scientifically today. Its import would be desirable.

***Nymphoides microphylla* in its native habitat in Mato Grosso State (Brazil).**



Nymphoides thunbergiana

(Grisebach) O. Kuntze (1891)

Family: Menyanthaceae.**Synonyms:** *Limnanthemum thunbergiana* Grisebach (1839), and others.**Etymology:** *Nymphoides*: see *N. aquatica*; *thunbergia*: after the Swedish botanist C.P. Thunberg (1743–1828).**Distribution:** South Africa, Zimbabwe, Mozambique, Madagascar, Mauritius.**Description:** Perennial floating leaf plant, producing only few runners. Juvenile leaves about 5 × 5 cm in the aquarium. Petiole up to 6 cm long. Leaf blade orbicular, deeply indented, slightly stiff, up to 20 cm in size, in culture about 10 cm, upperside green, underside green or slightly brownish red in color.

Inflorescence usually with more than 10 flowers. These are 4–8 cm petiolate, usually 5-merous, heterostyled, 2–3 cm in size. Sepals 4–6.5 mm long. Petal-lobes fimbriate pubescence, light yellow. In short-styled flowers, style about 2 mm, in long-styled ones up to 5 mm long and far protruding from the stamens. Stigma with 2 lobes. Capsule ovoid; seeds slightly globular, almost smooth, 1.3–1.8 mm in size.

Culture: According to cultivation experience gathered by the collector P.J. van der Vlugt, this rare plant can be cultivated in aquariums without any problems. The specimens can be maintained in their submersed juvenile phase if reared from seeds and if all developing floating leaves are regularly removed. So far it is not known which water composition is required for the optimum growth of *N. thunbergiana*. The substrate should be nutritious because good results were achieved by adding loam. Cultivation is also possible in garden ponds. The species can handle temperatures between 15 and 30 °C, but is not hardy.

Ecology: *Nymphoides thunbergiana* grows in stagnant or slow-moving waters. Van der Vlugt located it in Natal Province in South Africa. In a small lake, not far from the Mhlang River in Vernon Crookes National Park, the plant was found in about 50-cm deep water in October, at a water temperature of 21 °C.

Further reading: Van der Vlugt (1993a).

Flower of *Nymphoides thunbergiana*.



Ottelia alismoides

(Linné) Persoon (1805)

Family: Hydrocharitaceae.

Synonyms: *Stratiotes alismoides* L. (1753), and others.

Etymology: *Ottelia*: after a vernacular name of Malabar; *alismoides*: similar to the *Alisma* genus.

Distribution: Asia, Australia.

Description: Annual, perennial in culture, aquatic plant, up to 75 cm tall. Juvenile leaves linear. Mature leaves up to 50 cm petiolate. Blade wide ovate, cordate, bag-shaped curled up, transparent, fragile, slightly bullate, up to 20 × 15 cm, light green.

Peduncle up to 60 cm long, spirally twisted after the anthesis. Flowers usually bisexual (according to Cook & Urmi-König [1984b] also female and male flowers), chasmogamous or cleistogamous. Spathe (15–)20–40(–50) mm long, transparent, green, aliferous, ribbed, with (3–)4–10(–12) wings or ribs. Petals white. Numerous seeds.

Culture: A light-requiring but otherwise unproblematic and fast-growing plant, its culture requires spacious and high aquariums. Maintenance is possible in both soft as well

as hard water. Strong specimens can also be achieved in a nutrient-rich substrate and with regular fertilization as well as CO₂ being added. Multiplication has to be done by seeds. Flowers, which are self-pollinating, are also often formed in aquariums. The seeds will mature after about 2 weeks. Breeding in a separate container is not difficult and very productive, but also time-consuming. Beware of snails! Unfortunately, this magnificent plant has to remain a rarity because of its fragility. Optimum temperature range is 22–26 °C.

Ecology: Grows in standing and flowing waters. The author can report on two habitats: 1) Bali (8/1981), (photo p. 78): Marsh area, dense populations in a boggy soil, pH 7.5, GH 5.3 °dH, 785 µS/cm; and 2) Papua New Guinea (7/1988): Small river with a strong current. Few *Ottelia* on the bank in boggy-sandy soil. Location sunny-shady. Water temperature 26 °C (air temperature 28 °C at 15:00 h), pH 8.2, GH 8 °dH, KH 14 °dH, 470 µS/cm.

***Ottelia alismoides*.**



Female flower of *Ottelia acuminata*.



Flower of *Ottelia brasiliensis*.



Flower of *Ottelia ulvifolia*.



Male flower of *Ottelia mesenterium*.

Ottelia brasiliensis

(Planchon) Walpers (1852)

Family: Hydrocharitaceae.

Synonyms: *Damasonium brasiliensis* Planchon (1849), *Benedictaea brasiliensis* (Planchon) Toledo.

Etymology: *Ottelia*: see *O. alismoides*; *brasiliensis*: originating from Brazil.

Distribution: Southern Brazil, Paraguay, northeastern Argentina.

Description: Aquatic plant with up to 2-m long leaves in a rosette. Leaves very long petiolate; blade ribbon-shaped, transparent, linear or slightly spathulate to oblanceolate, elliptic or obovate, light green or reddish. Decurrent base; margin entire, slightly undulate; apex acute to acuminate.

Flowers bisexual, peduncle up to 2 m long, not aliferous, spirally after the anthesis. Spathe transparent, 30–65 mm long, 6–18 mm wide, smooth or with 2 longitudinal ribs or small wings. Corolla 4.0×3.5 cm, yellow; 6–9(–17) stamens; 3 bifid styles. Fruit with few, large seeds.

Culture: An interesting and very decorative aquatic plant which has not been previously imported, the author attempted cultivation in

medium-hard water, which failed. The species probably requires a very soft, strongly-moving water, similar to conditions in its native habitats.

Ecology: Hardly anything is known about its ecology. The author collected *O. brasiliensis* in Mato Grosso (Brazil) in the upper reaches of the Rio Guaporé where the species is evident in large populations. The water level varies by about 1.5 m. During the dry season, the plants grow on both the riverbanks in shallow water, on sand banks, but also in a depth of over 3 m. In July 1987 (dry season), the leaves and flowers flood on the water surface in unshaded conditions and intense sunlight. On the riverbanks, the plants were always subjected to a strong current and never grew in stagnant water. The soil consisted of fine sand. See detailed water analysis Rio Guaporé p. 40.

***Ottelia brasiliensis* in its native habitat on the Rio Guaporé (Brazil).**



Ottelia mesenterium

(Hallier fil.) Hartog (1957)

Family: Hydrocharitaceae.**Synonyms:** *Boottia mesenterium* Hall. f. (1915), *B. crispifolia* Sarasin (nom. illeg.).**Etymology:** *Ottelia*: see *O. alismoides*; *mesenterium*: refers to the strongly crispate leaf blade.**Distribution:** Sulawesi, endemic in the Matana, Towuti and Mahalona lakes.**Description:** Perennial, continuously submerged existing plant, 15–25 cm tall. Strong rhizome, up to 6×1.5 cm, erect or horizontal growth. Leaves with a 10-cm long sheath. Leaf blade linear, coriaceous, strongly crispate, up to 20 cm in length, 7–15 mm wide, rounded on the apex, initially light, later dark green in color.

Flowers unisexual, on an up to 1.5-m long twisted peduncle. Male spathe with 10–16 flowers. Male flower with 3 white, boat-shaped sepals, 3 obovate to orbicular; white petals; 12 fertile stamens; 3 staminodes (sterile stamens) and 3 pistillodia (sterile pistils). Female spathe with only 1 flower. Sepals lanceolate, persistent and recurved. Female petals as the male ones; 6, seldom 7 or 8 staminodes; 3 nectaries. Fruit with about 80 smooth, light brown seeds, up to 2.4×0.8 mm in size.

Culture: *Ottelia mesenterium* is a conspicuous, decorative, very slow-growing plant which has been collected in only isolated cases and was first imported in 1974 into Italy. So far it has proved impossible to continuously successfully cultivate the species as an aquarium plant. It possibly has a too weak adaptability to culture conditions.

Ecology: In its native habitat, *O. mesenterium* usually grows individually or in groups of only a few specimens in a loamy-sandy soil in a depth of 0.8–3 m (seasonal variations of the water level about 0.8 m). The rhizomes are deeply and securely anchored in the soil. In July 1981 the author recorded the following water values during both sunny and cloudy days in Matana and Towuti lakes: GH

6.0/3.4 °dH, KH 1.8/1.4 °dH, pH-value neutral to slightly alkaline, conductivity 185/125 $\mu\text{S}/\text{cm}$, temperatures in Lake Matana and Lake Towuti 29 °C on the water surface, 28.5 °C in a depth of 2 m. Propagation occurs through the partitioning of rhizomes and seeds. During the flowering stage and a totally calm lake early in the morning, the banks are covered with flowers which will mostly be destroyed by water movement during the course of the day, leaving only a few remaining open by the evening. They are visited by small gray moths (Heterocera) about 1.5 cm in size, which deposit their eggs inside them and quite possibly also perform pollination. The yellow, about 2-cm long larvae pupate on the outside of the fruit. Only rarely will the fruit remain untouched. Seeds stored briefly in water will germinate well and the embryos will develop rapidly within the first couple of days. Further growth, however, is extremely slow, and the rearing turns out to be very difficult. In the author's aquarium, plants 1 year old had reached a height of only 5 cm. Seeds stored in dry conditions did not germinate.

Further reading: Cook and Urmi-König (1984b).

***O. mesenterium* from Lake Matana.**

Ottelia ulvifolia

(Planchon) Walpers (1852)

Family: Hydrocharitaceae.**Synonyms:** *Damasonium ulvifolium* Planchon (1849), and others.**Etymology:** *Ottelia*: see *O. alismoides*; *ulvifolia*: refers to the genus *Ulva*.**Distribution:** Tropical Africa, Madagascar.**Description:** Annual (?) aquatic plant with leaves arranged in a rosette. Juvenile leaves ribbon-shaped, up to 32 cm long and 0.5–2 cm wide. Mature leaves 5–20 cm long petiolate; leaf blade oblong to elliptic, usually up to 20 cm long and 8.5 cm wide, transparent, bag-shaped. In stagnant water long petiolate floating leaves are sometimes formed. Coloring light to medium green, under intense light also a strong red-brown.

Flowers bisexual, on a 7–20(–60)-cm long peduncle. Spathe compressed, exalate or with 2 wings, ribbed, slightly transparent, 2–5 cm long. Petals up to 3 × 1 cm in size, yellow (also white?); 3–6 stamens; 3–6 bifid styles. Fruit with relatively large seeds.

Culture: *Ottelia ulvifolia* is very light-demanding, but has no other specific requirements. The plants are fast-growing and willprosper well in soft as well as medium-hard water with pH-values in the slightly alkaline range. A nutritious substrate is suggested. Under healthy growth conditions, the plant will create a decorative effect. Medium-sized specimens grow better than small ones. Unfortunately, the leaves of this sensitive plant are so fragile that transportation, as well as rearrangement within the aquarium, can quickly lead to its loss. This might be the reason why *O. ulvifolia* has so far not been made commercially available. The aquatic plant nursery Barth (Dessau) has recently commenced to propagate and distribute this rare beauty.**Ecology:** In its native habitat, the species grows in very different locations, i.e., in both stagnant water in small pools and marsh areas, as well as in fast-moving waters. The following water analyses were compiled at natural habitats: 1) Zanzibar (12/1980): Small lake with a boggy soil, pH 6.7, GH and KH 7 °dH; 2) Madagascar (12/1986): Rice paddy. Air temperature 28.5 °C at 13:00 h, water temperature 31.4 °C, pH 6.6, GH and KH < 1 °dH, Fe 0.05 mg/L; 3) Fast-flowing water with especially magnificent specimens in a water depth of 50 cm. Air temperature 25.5 °C at 11:30 h, water temperature 21.5 °C, pH 5.6, GH and KH < 1 °dH, 30 µS/cm. The substrate consisted of yellow, solid loam, mixed with a little sand and individual small rocks; 4) Stream with fast-moving water. Air temperature 26.2 °C, water temperature 22 °C, pH 5.3, GH and KH < 1 °dH. The specimens sometimes grew in a depth measuring more than 1 m. The soil consisted of yellow-reddish loam; and 5) Malawi (3/1988): River with slow-flowing, clear water. Air temperature 30 °C, water temperature 27 °C, pH 7.4, GH 3 °dH, KH 4 °dH, 220 µS/cm. The flowering plants grew in a gravelly-loamy and solid substrate. Leaves and flowers of *Ottelia ulvifolia* are supposedly used for medicinal purposes.***O. ulvifolia* from Madagascar.**

Phyllanthus fluitans

Mueller Argoviensis (1863)

Family: Euphorbiaceae.

Synonyms: None.

Etymology: *Phyllanthus*: *phyllon* = leaf, *anthos* = flower, with flowers on the leaves/twigs; *fluitans*: swimming, floating.

Distribution: Mexico, Brazil, Peru, Paraguay, possibly in Ecuador and Bolivia.

Description: Free-floating plant with 5–15-cm long, multibranched, strongly root-producing shoots. Internodes short. Leaves sessile, alternate, arranged in 2 rows. Blade almost round, 1–2 cm in size, with 2 blister-like swellings, with 1 on each side of the midrib, pubescent, from light green to a deep red-brown color.

Plant monoecious; flowers unisexual, short petiolate, about 2 mm in size. Usually 6 white tepals, alternating in 2 circles. Male flower with 3 stamens. Female flower with 3 bifid styles. Fruit is a globular green berry.

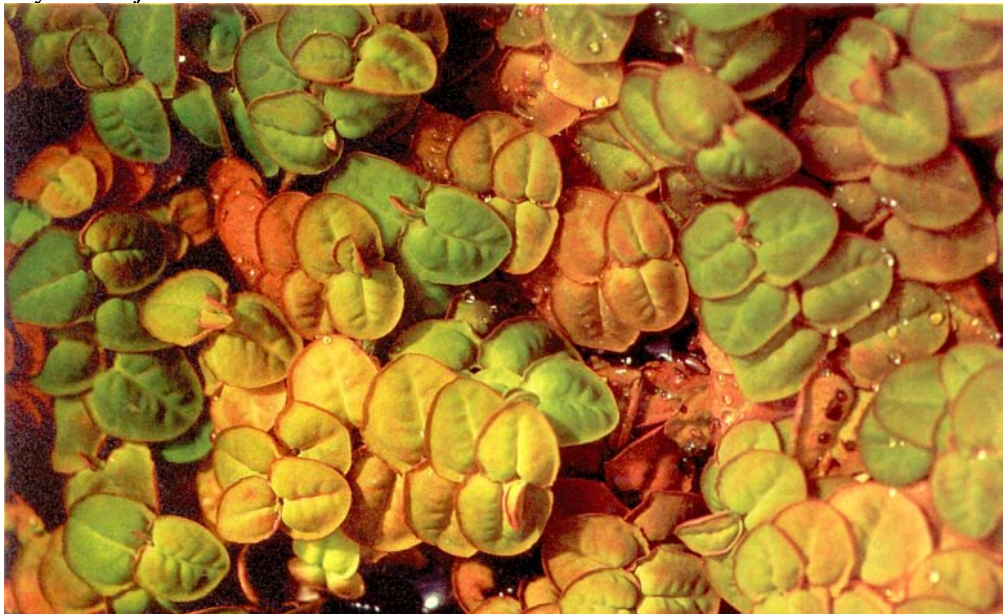
Culture: The culture of this beautiful, small floating plant is rarely successful in the aquarium, which is also why it is rarely commercially available. It is extremely light-hungry as well as warmth-loving (temperature 25–

28 °C), and will cope with only a moderate water movement. Soft, slightly acid to neutral water is optimal. Maintenance is best done in a greenhouse in flat dishes above a boggy substrate in a sunny, warm location. During autumn the inconspicuous flowers and fruit will develop. Due to lack of light plants will, to a large extent, retreat during winter. Propagation occurs through lateral shoots with generative multiplication so far unknown.

Ecology: The author collected *P. fluitans* in several locations in the Amazon, in Brazil and also, for the first time, in Peru. The plants grew protected among other floating plants in larger rivers with strong water level fluctuations. Water values near Manaus follow (3/1986): temperature 27–27.5 °C, GH/KH < 1 °dH, pH 6.5–7.2, conductivity 20–100 µS/cm. See detailed water analysis for Rio Yanayacu, biotope No. 6, p. 40.

Other: Only one other aquatic species, *P. leonardianus*, from Zaire, is known.

Phyllanthus fluitans.



Physostegia purpurea

(Walter) Blake (1915)

Family: Lamiaceae.**Synonyms:** *Prasium purpureum* Walter (1788), *Dracocephalum purpureum* (Walt.) Gleason, and others.**Etymology:** *Physostegia*: *physa* = bubble, *stegein* = to cover, refers to the bubbly calyx; *purpurea*: purple-red in color.**Distribution:** North America.**Description:** Marsh plant. Leaves in a basilar rosette, up to 8 cm petiolate, glabrous. Blade lanceolate or oblanceolate, up to 17 cm long, 5 cm wide, dark green. Apex round; base obtuse. Margin distinctly sinuate. Submersed plants about 10 cm tall. Margin indistinctly sinuate.

Fertile plants up to 1 m tall. Leaves on the peduncle decussate, sessile, almost amplexicauline, becoming smaller towards the top. Inflorescence an up to 60-cm long spike with up to 80 flowers. Solitary flower sessile or 1–2 mm petiolate. Bracts about 7 × 2 mm. Calyx 5-lobed, 8 mm long. Corolla 3 cm long, 2-lipped, deep reddish violet; lower lip trilobular, with dark violet veins as well as vio-

let spots, upper lip entire; 4 stamens. Style slightly overtopping the stamens.

Culture: Very slow-growing in the aquarium, *P. purpurea* is a relatively undemanding plant for the foreground. Under conditions of nutrient and light deficiency, only frail and very small rosettes will develop, therefore a nutritious substrate as well as good lighting are recommended. Emerged cultivated strong specimens are best used for submersed keeping. Adventitious plants, too, which form on peduncles as well as cut off leaves floating in the water, may be used for submersed culture. The species has no specific requirements as to water values. CO₂ fertilization is recommended. Temperatures should not be above 25 °C. In summer the plant is also usable on edges of garden ponds. During mild winters, *P. purpurea* will cope in outside conditions. **Ecology:** Populates moist locations in lowlands and coastal plains. Flowering period usually May to August.**Other:** Also available as *Armoracia*.***Physostegia purpurea*.****Flower of *P. purpurea*.**

Pistia stratiotes

Linné (1753)

Family: Araceae.

Synonyms: Numerous (see Engler 1920).

Etymology: *Pistia*: *pistos* = watery, derivation uncertain; *stratiotes*: reminiscent of the *Stratiotes* genus.

Distribution: Pantropical.

Description: Plant with very long, blueish black branched roots, usually floating on the water surface, on the edges of waterways and also anchored in the substrate during receding water levels. Leaves arranged in rosette formation, sessile, mostly erect. Leaf blade obovate to spatulate, slightly crenate on the apex, up to 25 cm long and 12 cm wide, but usually smaller, dense pubescence, light green color; underside with up to 11 very distinct veins. Forms featuring spongy-thickened leaf blades are also known.

Inflorescence inconspicuous, short petiolate. Spathe usually about 10 mm long, pubescent on outside, inside white and outside greenish. Spadix shorter than the spathe. Flowers naked. Only 1 female flower, above it (2–)5–8 male flowers arranged in a ring. Each synandrium consisting of 2 adnate stamens. Fruit is a multiseeded berry with persistent style. Seeds cylindrical.

Culture: This magnificent floating plant is regularly commercially available in spring and summer for use in garden ponds. *P. stratiotes*, however, can also find good use in the aquarium as a floating plant, but will remain considerably smaller there. It will develop best in highly polluted, nitrate-rich water and may produce rosettes with a diameter of up to 80 cm(!). The plants will prosper equally well in both soft as well as hard water and will even cope with a limited to medium light intensity. Warmth and intense lighting, however, will enhance the development of strong specimens. Optimum temperature range is 22–30 °C. Due to its productive multiplication through runners, it will rapidly produce a

dense blanket of floating plants which has to be cleaned out regularly. Inflorescences will often form. Breeding with seeds is possible (store seeds in moist conditions). When keeping the plant in garden ponds, be aware that the plant is not hardy. Specimens from greenhouses, too, will recede strongly during winter because they then lack intense light.

Ecology: Due to the rapid multiplication and good adaptability to the conditions of the native habitats, the species will more often than not constitute a bothersome “weed” in slow-moving tropical and subtropical waters. It also offers ideal living conditions for mosquitos. Occasionally it is also found in brackish water. Numerous water analyses are summarized as follows: water temperature 15–28 °C, pH 5.9–8.4, GH < 1–25 °dH, KH < 1–24 °dH, 20–785 µS/cm. Detailed water analysis Rio Yanayacu p. 40.

Other: Engler described four varieties which, however, do not have a taxonomic value. Literature sometimes mentions that *P. stratiotes* cannot cope with condensation moisture. This assertion, however, is incorrect.

Pistia stratiotes on the banks of Lake Malawi.



Potamogeton gayi

A. Bennett (1892)

Family: Potamogetonaceae.**Synonyms:** None.**Etymology:** *Potamogeton*: (Gr.) *potamos* = river, *geiton* = nearby river; *gayi*: after the French botanist J. Gay (1786–1864).**Distribution:** Southern South America.**Description:** Aquatic plant with a buried, often branched rhizome. Stem erect, thin, soft, up to 1 m long. Leaves alternate, in 2 rows, entire. Leaf blade linear, sessile, 4–12 cm long, 2–5 mm wide, transparent, delicate, green, under intense light also brownish on the shoot tip. Apex acute to acuminate. Midrib distinctly visible, brownish. An 8–24-mm long, transparent, short-lived stipule is found at the base of the blade.

Inflorescence on drifting shoots at the surface, very rare in the aquarium, 1.5–6 cm long petiolate. No floating leaves. Spike up to 1.5 cm long, with about 6 flowers. Solitary flower bisexual, without a perianth, 4 roundish appendages instead, at the base of which is one sessile and bilocular stamen each. Fruit unknown.

Culture: Unfortunately, this undemanding

and gracile *Potamogeton* has been increasingly displaced over the last couple of years by numerous new decorative imports, so that it is rarely commercially available today. *Potamogeton gayi* is an ideal aquarium plant. According to previous experience with cultivation, hardness and pH-value of the water have only a subordinate function, but water values measured at native habitats might point to the fact that the shoots possibly grow best in soft, slightly alkaline water. A medium light intensity is sufficient. The optimum temperature range lies between 16 and 26 °C, but higher and lower temperatures may be handled for short periods. After an often long adjustment phase, abundant multiplication through the branching of the creeping rhizome takes place. Unfortunately, this rapid reproduction may also become bothersome because the rhizomes—under optimum growth conditions—rapidly proceed to criss-cross the aquarium floor, which must then be regularly “deweeded.” *Potamogeton gayi* looks best if planted as a group. It is also excellently suited for use in small breeding aquariums.

Ecology: Hardly anything is known so far about the native habitats of *P. gayi*. In July 1993 (cold season), the author found small populations of this species in Argentina in a large pond between the cities of Mercedes and San Roque, 44 km before the latter. The water was a milky cloud and the plants were densely covered with decaying rot and algae. At 14:00 h the standing water measured a temperature of 16 °C, a pH-value of 7.2, GH and KH values < 1 °dH, as well as a conductivity of 30 µS/cm. The conspicuously strong shoots of *P. gayi*, which grew under intense sunlight but did not flower, measured a leaf length of 10–12 cm and a width of 4–5 mm. The substrate consisted of sand. Determination of the herbarium specimens was done by Dr. G. Wiegand.

***Potamogeton gayi*.**

Potamogeton schweinfurthii

A. Bennett (1901)

Family: Potamogetonaceae.

Synonyms: *Potamogeton lucens* Baker, non Linné, and others.

Etymology: *Potamogeton*: see *P. gayi*; *schweinfurthii*: after the German botanist G.A. Schweinfurth (1836–1925).

Distribution: Tropical Africa.

Description: Aquatic plant with a buried, often branched rhizome. Stem erect, up to 3.5 m long, 1.5–3 mm thick. Leaves alternate, sessile or up to 2 cm petiolate. Leaf blade very narrow elliptic to narrow lanceolate, usually up to 16 × 2 cm in size, transparent, soft or hard, olive green to brownish red. Leaf base acute; apex acuminate. Margin smooth or finely crispate. Up to 5 veins on each side of the distinct midrib. Stipule free, transparent, 3–6 cm long.

Inflorescence long petiolate. Spike 2–6 cm long, many-flowered. Otherwise as described for *P. gayi*. Fruit 3–4 mm long, with a short beak.

Culture: *Potamogeton schweinfurthii* is a rare but nevertheless undemanding and adaptable cultivation plant. The shoots, however,

remain considerably smaller in the aquarium, compared to the native habitat. Plants from Lake Tanganyika and Lake Malawi grow especially well in hard, alkaline water. Propagation is achieved without any special effort through creeping rhizomes and lateral shoots. Temperature range is 20–26 °C.

Ecology: In the Tanganyika and Malawi lakes, the species often grows together with *P. pectinatus* L. and actually forms real underwater carpets in a depth of up to 4 m. Preferred habitats are protected sand coves or the transitional area between rubble and sand. On the open coastline, the plants seem to be entirely absent due to their lack of resistance to strong surf. Especially conspicuous are the hard and sturdy leaf blades for adaptation purposes to the existing ecological environment, as well as the lime deposits on the leaves, which can be traced back to the extreme water values in the lakes (analysis p. 41). In March 1988 large populations flowered in Lake Malawi underwater. Plants in Lake Tanganyika, in contrast, were sterile in August 1986.

Flowering populations of *Potamogeton schweinfurthii* in Lake Malawi (underwater photo).



Potamogeton wrightii

Morong (1886)

Family: Potamogetonaceae.**Synonyms:** Numerous, see Wiegleb (1990).**Etymology:** *Potamogeton*: see *P. gayi*; *wrightii*: after C. Wright (1811–1885).**Distribution:** Eastern Asia.

Description: Aquatic plant with buried, thin, branched rhizome. Erect stem up to 3 m long, round. Internodes 3–40 cm long. Leaves alternate, up to 8 cm petiolate. Leaf blade linear, 5–23 cm long, 1–3 cm wide, with 9–13 veins. Blade transparent, fragile, undulate, finely crispate and denticulate on the margin, with a 5–8-mm long apex, which may also be absent in some populations. Base acute or truncate. Coloration light to dark green, some forms also with reddish leaves. On the base of the petiole a conspicuous up to 9-cm long stiff and fragile stipule. Floating leaves very rare, more roundish than the submersed blades, about 5–12 cm long, 1–2.5 cm wide.

Inflorescences on shoots drifting on the surface, up to 10 cm petiolate. Spike up to 4(–5.6) cm long, with up to 40 omnilateral flowers. The bisexual solitary flower has 4 free appendages on the base of which is at-

tached one sessile and bilocular stamen each. Pollen white. Fruit is rare, 2–3 mm long, 1 mm thick, diamond-shaped, flattened, occasionally with 1–3 dorsal ribs.

Culture: *Potamogeton wrightii* is an unproblematic, recommendable species with few requirements. Its cultivation will succeed in both moderately and well-illuminated aquariums. Medium-hard to hard, alkaline water as well as good lighting enhance the development of strong leaf blades. Optimal temperature range is 22–28 °C. The long internodes appear hardly decorative so that several cuttings should be arranged together in a group. Shoots drifting on the water surface appear very appealing but they easily block too much light from plants existing below them. Lateral shoots will form on every node of the buried creeping rhizome. A stem that has grown too long may also be trimmed; the remaining shoot will again sprout. Drifting, strong plants will often develop inflorescences, during both short- and long-days.

Ecology: The species usually grows in up to 3-m deep quick-flowing water of rivers, but is sometimes also found in pools, rice paddies and lakes in altitudes up to 2000 m and more. Water analyses point to a preference for waters with hard, salt-rich and alkaline water.

Other: *Potamogeton wrightii* was commercially introduced in 1954 as *P. javanicus*, but disappeared again from aquariums only a short time after. Despite the huge distribution area, plants were only again collected by the author in 1981 in Sulawesi, which were described as *P. malaianus* and made commercially available under that name. According to later research (Wiegleb 1990), *P. wrightii* is, however, the correct name for the species in cultivation. *Potamogeton malaianus* is a synonym for *P. nodosus* Poir. Plants traded under the name of *Potamogeton* sp. “Vietnam” are also in fact *P. wrightii*. Recently the species has also been imported from Japan.

Further reading: Wiegleb (1990).

Submersed shoots of *Potamogeton wrightii*.



Reussia rotundifolia

(Linné fil.) Castellanos (1951)

Family: Pontederiaceae.

Synonyms: *Pontederia rotundifolia* Linné fil. (1781), and others.

Etymology: *Reussia*: after C.F. Reuss (1745–1813); *rotundifolia*: round-leaved.

Distribution: Central and South America (tropics).

Description: Marsh plant. Submersed stem axis erect, thickset, with petiolate lanceolate blades, cordate on the base, about 5 cm in length, light green in color. Adult leaves floating and emersed; these are alternate, sheathed, long petiolate, cordate or reniform, usually not larger than 10 × 8 cm.

Inflorescence spike-like, oblong or globular, with numerous small flowers. Perianth 6-lobed, in 2 circles. Tepals different in size, pale pink-violet, with a 2-lobed spot on the largest tepal; 6 stamens, in 2 differing heights; 1 style. Fruit 1-seeded.

Culture: A rarely commercially available species, it can be used in the foreground or as floating plant in an aquarium as well as emersed in paludariums. Submersed the plants reach a height of 10–15 cm under intense

lighting. After a few months longer petiolate blades will develop, a distinct pointer that the plants want to form emersed leaves or rather floating leaves. For a time this desire to develop emersed leaves can be prevented by trimming the plant. Under continuous underwater cultivation, the plants will exhaust themselves so that it becomes necessary to maintain the plant as a floating plant for a while or keep it in the boggy section of a paludarium. The species does not seem to have any special demands as to water values, but it possibly will grow best in soft water. Vegetative propagation occurs through lateral shoots off floating shoots.

Ecology: In its native habitat, the plants grow predominantly with floating shoots or emersed leaves on the edges of streams and small rivers, partially in strong currents and under intense sunlight.

Other: Some scientists record the *Reussia* genus as a synonym to *Pontederia*.

Inflorescence of *R. rotundifolia*.



Reussia rotundifolia.



Riccia fluitans

Linné (1753)

Family: Ricciaceae.

Synonyms: *Riccia canaliculata* Hoffmann, *Riccia fluitans* var. *canaliculata* Roth, *Riccia eudichotoma* Bischoff, *Riccia nodosa* Boucher, *Ricciella fluitans* A. Braun.

Etymology: *Riccia*: after P.F. Ricci; *fluitans*: floating.

Distribution: Cosmopolitan.

Description: Plant floating at the water surface or rooted in moist substrate, consisting of dichotomous thalli. Branches narrow linear, thin, slightly widened at the apex, narrower in floating plants compared to terrestrial plants, up to 2 mm wide and 10–40 mm long, forked angle of 45–80°, light to medium green in color. Terrestrial form upper side with a slight groove, underside with scales on the thalli and rhizoids.

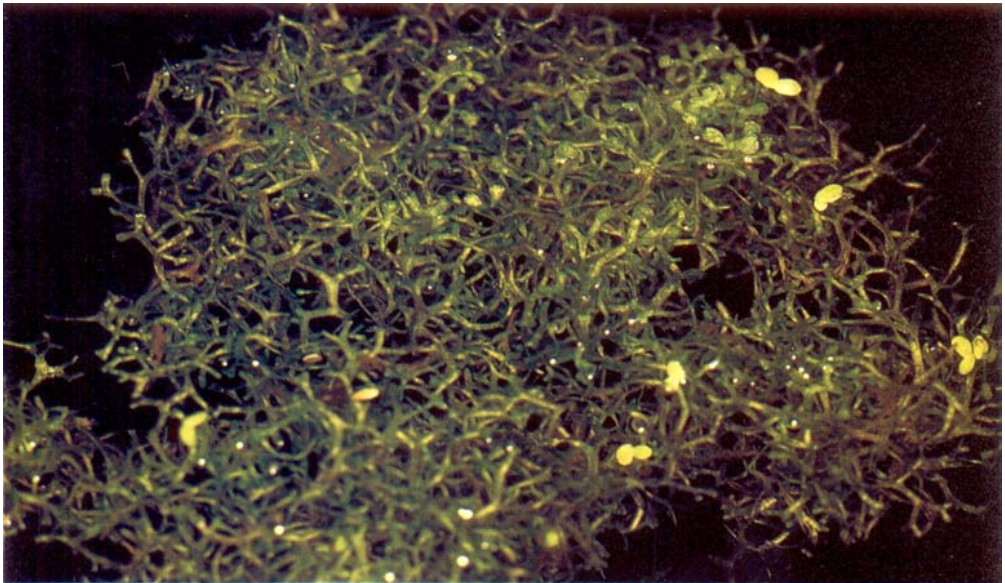
Monoecious moss. Sporangiums located on the thallus underside. Spores 80 µm, with areolae.

Culture: Excellent as a floating plant under conditions of not too much water movement. The species is adaptable to water values, but requires intense light to develop strong thalli.

It forms dense cushions at and on the water surface, which is why it is considered an excellent spawning location for labyrinth fish. It can also provide juvenile fish with safe protection from enemies. Optimum water temperatures range from 20 to 27 °C, with far lower and higher values being tolerated temporarily. If the plants are cultured on a moist substrate, wider and shorter thalli will develop. Spore formation occurs only in the terrestrial plant.

Ecology: *Riccia fluitans* is supposed to typically occur in eutrophic waterways.

Other: A differentiation between *Riccia* species in a vegetative state can generally be made by comparing the shape of the thalli and the size of the angle in the branch fork.

***Riccia fluitans*.**

Ricciocarpus natans

(Linné) Corda (1829)

Family: Ricciaceae.

Synonyms: *Riccia natans* Linné (1759), and others.

Etymology: *Ricciocarpus*: after *Riccia* (see *R. fluitans*) and *karpos* = fruit; *natans*: floating.

Distribution: Cosmopolitan.

Description: Plant floating on the water surface or rooted in a moist substrate. Thallus cordate, 4–10 mm long, almost as wide, once to three times dichotomous, slightly spongy, branches on the apex more or less crenate, dark green, brownish on the margin. Upperside with a distinct groove, which will fork just before the end of the thallus in an acute angle. Underside with conspicuous linear dark scales.

Presumably a dioecious moss. Sporangiums on the upperside of the thallus in the mentioned groove. Spores 45–86 µm.

Culture: A rare and difficult-to-cultivate floating plant. According to Wendt (1952–1955) the best cultivation results were achieved with plants kept outside in the open and placed in flat glass bowls on decaying

aquarium rot and a little loam. To survive the cold season they have to be placed in a light, cool place. The plants used for cultivation back then were probably endemic specimens which were used to low temperatures. Tropical forms are presumably more suited for aquarium culture, results, however, on this are not yet available. When attempting cultivation, emphasis should be placed on intense lighting together with as little water movement as possible.

Ecology: *Ricciocarpus natans* exists on the water surface of standing and very slow-moving waterways in sunny places. Four locations were researched: 1) Lake (Greece, 6/1980): water temperature 25 °C (air 26 °C at 13:15 h), pH 7.2, GH 5.8 °dH, KH < 1 °dH, 81 µS/cm; 2) Flood area of the Rio Paraguay (Brazil, 8/1987): water temperature 27 °C (air 34.5 °C at 14:00 h), pH 6.9, GH/KH < 1 °dH, 15 µS/cm; 3) Rio Yanayacu (Peru, 7/1990): a detailed water analysis of biotope No. 6 on p. 40; and 4) Pool (Argentina, 7/1993): water temperature 13 °C, pH 5.5, GH/KH < 1 °dH, 10 µS/cm, Fe 0.05 mg/L.

Ricciocarpus natans in its native habitat in Argentina.



Rorippa aquatica

(Eaton) Palmer and Steyermark (1935)

Family: Brassicaceae.

Synonyms: *Cochlearia aquatica* Eaton (1829), *Armoracia aquatica* (Eaton) Wiegand, and others.

Etymology: *Rorippa*: apparently from Rorippen, a German plant name; *aquaticum*: existing in water.

Distribution: U.S. (Minnesota to Florida, Texas)

Description: Small marsh plant with an erect, up to 2-cm thick rhizome. Leaves of sterile plants in a basilar, up to 10-cm tall rosette, occasionally with an erect shoot and alternate leaves. Petiole up to 3 cm long. Leaf blade oblanceolate, either entire, then with narrowed base, acute apex and crenate margin, or more or less pinnate, up to 13 × 3 cm in size, glabrous, soft, dark green in color. Submersed leaves hard and fragile.

Fertile plants in the long-day, up to about 70 cm tall. Leaves on the peduncle alternate, entire, with a crenate margin, short petiolate or sessile, becoming smaller towards the top, up to 9 × 2 cm in size, slightly caducous.

Inflorescence is a raceme with many 0.5–

1.5 cm petiolate flowers. Flower about 1 cm in size; 4 green sepals, 3 mm long; 4 white petals, spathulate, 5 mm long; 6 stamens, about 3 mm long. Style with stigma hardly longer than the stamens, persistent. Ovary 3 mm, oblong. Fruit is a 5.8-mm long bean.

Culture: *Rorippa aquatica* is a relatively undemanding, submersed, very slow-growing plant, which, due to its growth height of about 10 cm, is suited only as a plant for the foreground. For optimum cultivation in aquariums a medium to intense lighting, a nutrient-rich substrate as well as a temperature range between 20 and 25 °C are recommended. Multiplication in marsh cultivation is possible through cuttings on the rhizome. Vegetative propagation is achieved by letting some leaves float to the surface, on which adventitious plants will develop. Conditionally hardy when used on the edges of garden ponds.

Ecology: *Rorippa aquatica* populates boggy banks of tranquil waterways.

Rorippa aquatica.



Inflorescence of *R. aquatica*.



Rotala macrandra

Koehne (1880)

Family: Lythraceae.

Synonyms: *Ameletia rotundifolia* Wight.

Etymology: *Rotala*: from *rota* = wheel, refers to the whorled leaf arrangement in the type-species *Rotala verticillaris* Linné; *macrandra*: refers to the long stamens.

Distribution: Southern India.

Description: Marsh plant. Emerged leaves as in *R. rotundifolia*. Submersed shoots erect, up to 60 cm in length, branched. Leaves decussate. Blade sessile, semiamplexicauline, lanceolate to wide ovate, delicate, 2–4(–5) cm long, 1.5–2.5(–3) cm wide, olive green to strong brown-red. Apex acutely rounded, base occasionally slightly auriculate. Margin slightly undulate and toothed-crenate in stronger leaves.

Inflorescence as in *R. rotundifolia*, but: bracts 0.5 mm long. Stamens longer than the calyx-lobes and petals. Style about 3.5 mm long; stigma very small.

Culture: A very decorative, conspicuous but also demanding and difficult aquarium plant which will only rarely display optimum growth. The shoots will grow best in soft to

medium-hard, acid water (additional CO₂ supply), under intense lighting and a substrate deficient in lime. A balanced nutrient supply (iron, etc.) seems just as important as good water movement. Optimum temperature range is 24–28 °C. The species is supposedly sensitive to sudden cold (Benl 1972). Due to the high light requirement, care has to be taken that the shoots are arranged individually and with a sufficient distance between each other. Several well-growing strong shoots can create a more effective eye-catcher than a group of struggling small-leaved plants.

Ecology: Cook (1979) located the species in its native habitat in permanent waters with a fast-moving current. *R. macrandra* is found submersed more often than *R. rotundifolia*.

Other: Emerged and flowering shoots of *Rotala macrandra* are distinguishable from *R. rotundifolia* by very few features, so that both were initially considered to constitute only a single species.

Rotala macrandra.

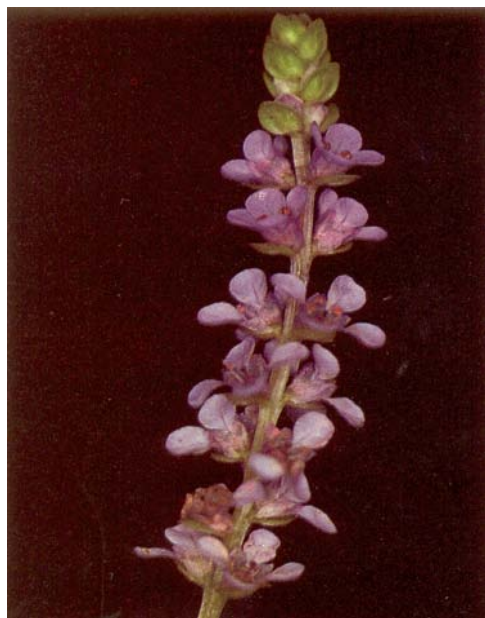


Rotala rotundifolia

(Roxburgh) Koehne (1880)

Family: Lythraceae.**Synonyms:** *Ammannia rotundifolia* Buchanan-Hamilton (1820), and others.**Etymology:** *Rotala*: see *Rotala macrandra*; *rotundifolia*: round-leaved.**Distribution:** Southeast Asia (India to Japan).**Description:** Marsh plant with creeping, ascendent or drifting shoots, up to about 70 cm long. Emerged leaves decussate, sessile or short petiolate, entire, obovate to round, about 1(–2) cm long, upperside olive green, underside slightly reddish. Submersed shoots erect, very branched. Leaves opposite or in 3–4-merous whorls. Blade lanceolate, in drifting shoots also almost round, up to 2.2 cm in length, upperside olive green to reddish, underside pale to a strong violet color.

Inflorescence densely flowered, at the base often branched raceme, up to 11 cm petiolate. On each node, 2 flowers with a cordate or almost round up to 6-mm thick bract. Solitary flower short petiolate. Calyx with 4 triangular calyx-lobes without appendage. Bracts about 1 mm; 4 petals, pale purple, obovate, about

1.5 mm long; 4 stamens, about 1.5 mm long, not longer than the calyx-lobes. Style 0.5–1.5 mm long; stigma capitate. Ovary globular. Capsule about 1.5 mm, with 4 valves opening. **Culture:** An especially recommendable, adaptable, decorative and quick-growing stem plant, good lighting is necessary to achieve strong, reddish shoots. The species will tolerate large fluctuations in hardness and pH-values. Optimum temperature range is 24–28 °C. Propagation is unproblematic through lateral shoots. The plants do not display good protruding growth from the water so that adaptation to emerged cultivation is not easy. However, once this has been established cultivation in the paludarium or greenhouse is so rapid that the species can become a real weed. Inflorescences occur only above the water surface.**Ecology:** The species grows in marshy areas and often in cool mountain regions, in China up to an altitude of 2650 m.**Other:** Was introduced in 1960 as *Rotala indica*. This, however, is a different species.***Rotala rotundifolia*.****Inflorescence of *R. rotundifolia*.**

Rotala wallichii

(Hooker fil.) Koehne (1880)

Family: Lythraceae.

Synonyms: *Hydrolythrum wallichii* Hooker fil. (1867), *Ammannia wallichii* (Hooker fil.) Kurz, *Ammannia myriophylloides* S.T. Dunn.

Etymology: *Rotala*: see *Rotala macrandra*; *wallichii*: after N. Wallich (1786–1854).

Distribution: Tropical Southeast Asia, from northeastern India to Malaysia, southeastern China.

Description: Small marsh plant. Stem up to 40 cm in length, slightly grooved, brownish. Emerged leaves arranged in (3–)6–9(–12)-merous whorls, rarely decussate. Leaf blade linear, up to 1 cm long and 1.5 mm wide, olive green in color. Apex obtuse or slightly sinuate; base narrowed. Submersed shoots appear totally changed. Stem distinctly grooved. Leaves filiform, in up to 15-merous whorls, up to 2.5 cm long, usually reddish brown in color.

Inflorescence a raceme. Bract 6 mm long. Solitary flower very short petiolate. Calyx 4-lobed, about 1.5 mm long, at the base with 2 up to 0.5-mm long bracts; 4 petals, pale violet (seldom white), about 2.5×1.5 mm in size; 4

stamens, protruding over the slightly shorter style. Stigma white, capitate. Fruit not seen.

Culture: This delicate, decorative *Rotala* is a demanding and sensitive aquarium plant. It has high demands especially with regard to light intensity if the shoot tips are to turn to a reddish color. Soft, acid water also has a vital function in ensuring healthy growth. Optimum temperature range is 24–28 °C. The substrate is less significant. The species can only be continuously kept in almost algae-free aquariums with clear water: blue and brown algae will suffocate the shoots in a very short time. The plant also reacts very sensitively to any chemical additives. Plant-consuming fish also love to feed on the delicate leaves. *Rotala wallichii* will have a decorative effect only if arranged as a group. Propagation is through lateral shoots. Inflorescences will form during summer on emerged shoots.

Other: The submersed shoots of *R. wallichii* are similar to those of *Mayaca fluviatilis*.

Inflorescence of *Rotala wallichii*.



Rotala wallichii.



Sagittaria lancifolia

Linné (1759)

Family: Alismataceae.

Synonyms: *Sagittaria falcata* Pursh, and others.

Etymology: *Sagittaria*: *sagitta* = arrow, refers to the leaf shape of several species within this genus; *lancifolia*: lance-leaved.

Distribution: Eastern U.S., Central and South America (southern to northeastern Brazil, Colombia).

Description: Strong, erect marsh plant with a creeping rhizome. Leaves usually emerged, rarely semiaquatic, 30–60 cm petiolate. Leaf blade very narrow to narrow elliptic or narrow lanceolate, 20–26 cm long, 2.5–7 cm wide, coriaceous, green. Apex acute or acuminate; base without basal-lobes; 7–11 veins.

Plants monoecious; flowers unisexual. Peduncle up to 125 cm long. Inflorescence unbranched or many-branched at the lowest whorl, up to 45(–55) cm long, overtopping the plant, with up to 10 3-flowered whorls. The lower whorls with female, the upper ones with male flowers. Bracts 4–5 × 2–4 mm in size, mammillate or ribbed. Pedicel 1–3 cm long; 3 green sepals, mammillate or ribbed; 3

white petals. Numerous stamens; filaments pubescent. Carpels numerous. Nutlets 2–3 mm long, mostly entire, with a beak, with 1 wing and 1 gland.

Culture: This very large and rare *Sagittaria* is no aquarium plant, but can be cultivated quite well in a greenhouse or large paludarium. Also, the plant may be easily kept at the edges of a garden pond during summer. The species can sometimes be seen in botanical gardens, though it is rarely commercially available. The elliptic leaf blade in *S. lancifolia* is unusual compared to many *Sagittaria* species with base-lobes on the blades.

Ecology: The species is often found in brackish, boggy locations in the vicinity of coastlines.

Other: Bogin (1955) described the subspecies *lancifolia* and *media*. The sepals and bracts of the subsp. *media* are more or less mammillate, whereas those in subsp. *lancifolia* are ribbed. Subsp. *lancifolia* is distributed in South America, the West Indies and Florida, subsp. *media* in Central America and the eastern U.S.

***Sagittaria lancifolia* in its natural habitat in Mexico.**



Sagittaria montevidensis

subsp. *montevidensis*

Chamisso and Schlechtendal (1827)

Family: Alismataceae.

Synonyms: Numerous (see Bogin 1955).

Etymology: *Sagittaria*: see *S. lancifolia*; *montevidensis*: originating from Montevideo.

Distribution: Tropics and subtropics in South America.

Description: Strong marsh plant. Juvenile leaves submersed, ribbon-shaped. Adult leaves rarely floating, usually emersed. Petiole sagittate, up to 28 cm long, 23 cm wide, with more or less large, long extended, acute and aciculate base-lobes, medium green. Leaf apex often with an imposed, up to 3-mm long tip. Up to 21 veins, distinct.

Plants monoecious; flowers unisexual, 2–5 cm in size. Inflorescence with 3–12 3(4)-flowered whorls. Flower with 3 green, tight-sitting sepals and 3 white petals which have distinct red dots at their bases, which may also be entirely absent. Female flowers: pedicel thick, recurved. Stamens are rare. Numerous carpels, yellow. Male flowers (more frequent than female ones): pedicel thin;

about 22 stamens; filament up to 5 mm. Infructescence up to 3.5 mm in size. Nutlets narrow aliferous, 2–3 × 1–1.5 mm in size, with a beak.

Culture: *Sagittaria montevidensis* is not suitable for aquarium keeping. A marsh cultivation at low water level on a boggy substrate and under intense light, however, is not difficult, and can occasionally be seen in botanical gardens. For short periods temperatures close to 0 °C as well as over 35 °C can be tolerated. Simply because of its magnificent flowers, it is well worth cultivating this *Sagittaria*.

Ecology: Subspecies *montevidensis* grows on the edges of stagnant, often temporary waters in shallow water. The author located dense populations in northeastern Argentina, always in very soft water and in a muddy-sandy soil.

Other: Bogin (1955) distinguished four subspecies.

Sagittaria montevidensis in northeastern Argentina.



Sagittaria platyphylla

(Engelmann) J.G. Smith (1894)

Family: Alismataceae.**Synonyms:** *Sagittaria graminea* var. *platyphylla* Engelmann (1867), *S. recurva* Engelmann ex Patterson, *S. mohrii* J.G. Smith.**Etymology:** *Sagittaria*: see *S. lancifolia*; *platyphylla*: wide-leaved.**Distribution:** Southern U.S., Central America, introduced to western Java and Italy.**Description:** Marsh plant with a short rhizome. Leaves in a rosette, submersed up to 20 cm tall, ribbon-shaped, up to about 25 cm long, 1.5–2.0 cm wide, sturdy, light green. Emerged leaves up to 40 cm long petiolate, elliptic to narrow ovoid, rarely with small base-lobes, 8–15 cm long, 2.5–10 cm wide, coriaceous, medium green.

Plants monoecious; flowers unisexual. Peduncle up to 30 cm long. Inflorescence with 3–6(–8) 3-flowered whorls, the lower ones with female, the upper ones with male flowers. Pedicel of the female flowers 1–3 cm long, thickened and recurved during fructation period; 3 adnate bracts; 3 recurved green sepals; 3 white petals; 15–21 stamens; filament pubescent. Numerous carpels. Infruc-

tescence 1–1.5 cm in size; nutlets spongy-wrinkled, 1.2–2 mm long, beak 0.3–0.6 mm in length.

Culture: Even though *S. platyphylla* has been kept as an aquarium plant for many years, it is only occasionally commercially available today. The plant is undemanding and slow-growing in submersed conditions. Successful cultivation requires a not too high temperature (about 20–24 °C), intensive lighting in a free-standing location, as well as a nutrient-rich substrate (e.g., additional supply of loam). Good water movement seems to enhance growth. Soft or medium-hard water with a weak acid pH-value is optimal. *Sagittaria platyphylla* can be planted as a group or individually. Propagation through runners is rare. It can be used in garden ponds during summer.**Ecology:** In stagnant or moving water above a buggy substrate.**Other:** Bogin (1955) considers *S. platyphylla* as a variety of *S. graminea* Michaux.***Sagittaria platyphylla*.**

Sagittaria subulata
(Linné) Buchenau (1871)

Family: Alismataceae.

Synonyms: *Alisma subulatum* Linné (1753), *S. natans* Michaux, *S. pusilla* Nuttall, and others.

Etymology: *Sagittaria*: see *S. lancifolia*; *subulata*: refers to the submersed, subulate leaves.

Distribution: Eastern U.S., South America.

Description: Marsh plant producing runners. Leaves in a rosette. Commercially available plants will produce 5–60-cm long and up to 6-mm wide linear or strap-shaped light green submersed leaves. Emerged growth height 5–10 cm. Floating leaves rare in the aquarium, 2–6 cm long as emerged leaves, 0.5–2.5 cm wide, mostly ovoid.

Peduncle up to 1 m long and more, with 1–10 whorls made up of male and female flowers. Bracts adnate. Pedicels of the female flower slightly thickened, recurved, 1–15 cm long; 3 spreading green sepals; 3 white petals. Male flowers 1–3.5 cm long petiolate; 7 or 9–15 stamens. Infructescence 0.5–0.7 cm in size; nutlets obovate, 1.5–2 mm long, beak subulate, 0.15–0.4 mm long.

Culture: *Sagittaria subulata*, the most delicate of the cultivated *Sagittaria* species, belongs to those foreground plants available most regularly. It is a fast-growing species which displays productive multiplication through runners, which will form a dense, about 5–7-cm thick “carpet” within a few weeks. In specimens arranged very densely, the leaves will reach a length of up to 60 cm, thereby appearing very decorative in the central or rear section of the aquarium. Intense lighting will enhance slightly reddish leaf apices. Such long-leaved specimens will form floating leaves and inconspicuous inflorescences in the aquarium as well. *Sagittaria subulata* grows best in medium-hard to hard water with a pH-value within the moderately acid to alkaline range. Iron deficiency often occurs. Fine-graveled sand is best for these delicate plants. Optimum temperature range is 18–28 °C.

Ecology: The species will develop expansive communities in rivers; it is found in both freshwater and brackish water.

Sagittaria subulata.



Salvinia auriculata

Aublet (1775)

Family: Salviniaceae.

Synonyms: *Salvinia hispida* HBK, and others.

Etymology: *Salvinia*: after the Italian Prof. A.M. Salvini (1633–1720); *auriculata*: small-eared.

Distribution: Tropical Central and South America, widespread.

Description: Rootless fern, floating freely on the water surface. Stem branched, thin. Leaves in trimerous whorls, 2 are formed as floating leaves; the third is submersed, divided into filiform pubescent segments, and takes over the functions of the missing roots. Floating leaves boat-shaped, deeply crenate at both ends, wider than long. Numerous rows of papilla are found on the leaf upper-side on which are found 3–4 hairs which are joined at their tips (typical for the *S. auriculata* complex).

The sporocarps develop on the submersed organs on a usually short, branched axis. These are unisexual, globular, petiolate, unilocular and mostly fertile (in contrast to *S. molesta*). Microsporangiums are numerous,

long petiolate, each with 64 microspores. Macrosporangiums are few, short petiolate, each with a solitary large macrospore. Number of chromosomes $n = 54$.

Culture: Refer to *Salvinia cucullata*.

Ecology: *Salvinia auriculata* grows in standing and slightly moving water. The species does form dense populations but not on such a massive scale as *S. molesta*. The author researched three different locations in which *S. auriculata* grew together with a lot of other floating plants: 1) Brazil (3/1986): Amazon, near Manaus, water temperature 27 °C, pH 6.7, GH/KH < 1 °dH, 100 μ S/cm; 2) Brazil (8/1987): marsh area near Caceres, water temperature 27 °C (air temperature 34.5 °C at 14:00 h), pH 6.9, GH/KH < 1 °dH, 15 μ S/cm; and 3) Peru (7/1990): Rio Yanayacu, detailed water analysis of biotope No. 6 p. 40.

Other: The cell structure of the leaves is essential in differentiating between similar species within the *S. auriculata* complex (*S. biloba* Raddi, *S. molesta* D.S. Mitchell, *S. herzogii* de la Sota).

***Salvinia auriculata* in its native habitat in eastern Brazil.**



Salvinia cucullata

Bory (1833)

Family: Salviniaceae.

Synonyms: None.

Etymology: *Salvinia*: see *S. auriculata*; *cucullata*: hood-shaped, refers to the leaf shape.

Distribution: Tropical Asia.

Description: As described for *S. auriculata*. *Salvinia cucullata*, though, differs in the following features: floating leaves in strong plants are conspicuously bag-shaped, curled up, submersed in water only with that part of the leaf attached to the petiole, longer than wide. Leaf upperside covered with pubescence, which is irregular and individually spread over the entire surface (not on papillae or arranged in rows, as is the case with *S. auriculata* and *S. molesta*). Leaf underside with short bristle hairs.

The sporocarps will form on a short axis of the submersed organs. Initially 2 oblong and strongly pubescent macrosporocarps will form, followed by 6–7 globular and hardly pubescent microsporocarps. About 20 macrosporangiums, each with a large macrospore. Numerous microsporangiums, with 32 microspores each.

Culture: *Salvinia auriculata*, *S. molesta* and *S. cucullata* are basically not difficult to maintain in an aquarium, but optimal keeping is rarely achieved. The plants will seldom attain the strong growth of specimens in native habitats because *Salvinia* species are exceptionally light- and warmth-requiring, and love a very nutrient-rich and hardly disturbed water. Under aquarium conditions the plants will mostly degenerate after a short time and will not form boat- or bag-shaped floating leaves anymore, but only very small flattened leaf blades which simply lie on the water. Such stunted plants of *S. cucullata* can easily be confused with those of *S. auriculata* and *S. molesta*. Satisfactory cultivation is most easily achieved in summer under intense daylight and warmth in shallow water above a boggy substrate. During winter the plants will retreat strongly.

Ecology: Grows in sunny locations.

Salvinia cucullata in a location on Java.



Salvinia molesta

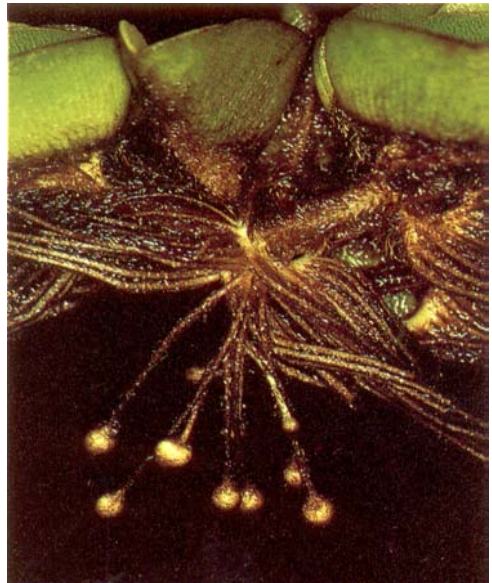
D.S. Mitchell (1972)

Family: Salviniaceae.**Synonyms:** None.**Etymology:** *Salvinia*: see *S. auriculata*; *molesta*: bothersome, damaging.**Distribution:** Southeastern coastline of Brazil, introduced to Asia, South Africa, Australia.**Description:** As described for *Salvinia auriculata*, but distinguishable by the following features: *S. molesta* develops a large number of sporocarps which are arranged on 2–4 long axes. The sporocarps are sessile to very short petiolate, up to 1 mm in diameter, ovoid, aciculate and mostly empty (without spores, hybrid!). Number of chromosomes $n = 45$.An important morphological feature to distinguish between *S. molesta* and *S. auriculata* is the cell structure of the leaves (see Forno 1983).**Culture:** The aquarium populations are, in most instances, not *S. auriculata* but *S. molesta*. For the culture of both species, refer to *S. cucullata*.**Ecology:** *Salvinia molesta* is considered a bothersome weed in its areas of distribution.

The plants will inhabit stagnant or slow-flowing, nutrient-rich waters in large populations, for example rice paddies, pools, lakes and rivers. The author saw dense populations with many sporangium-carrying plants on the Sepik river in Papua New Guinea (July 1988), together with individual specimens of *Pistia stratiotes*, *Azolla pinnata* and *Ceratopteris thalictroides*. A water analysis recorded the following values: water temperature 29 °C, pH 7.1, GH 5 °dH, KH 6 °dH, 275 µS/cm.

Other: It can be assumed that *S. molesta* is a hybrid; an important pointer in this direction are the often empty sporocarps. Mitchell (1972) suspects that it is a cross between *Salvinia biloba* Raddi and *S. auriculata* Aublet which could have originated in the botanical gardens of Rio de Janeiro. It seems that *S. molesta* has often been incorrectly identified as *S. auriculata* in aquaristic and scientific literature.

In comparison: the arrangement of sporocarps in *S. molesta* (left) and *S. auriculata*.



Samolus valerandi

Linné (1753)

Family: Primulaceae.

Synonyms: *Samolus floribundus* Humboldt and Bonpland and Kunth, *S. parviflorus* Rafinesque, *S. valerandi* subsp. *parviflorus* (Raf.) Hultén, and others.

Etymology: *Samolus*: Roman plant name; *valerandi*: after Douvez Valerand.

Distribution: Cosmopolitan.

Description: Marsh plant with a 10–15-cm tall and 10–20-cm wide basilar rosette. Leaves up to 4 cm long petiolate, glabrous. Leaf blade entire, oblanceolate to narrow obovate, 2–9.5 cm long and 1–3.7 cm wide, light green or yellowish green coloration. Apex acute or obtuse; base decurrent.

Peduncle 10–50 cm tall, with alternate, short petiolate or sessile leaves which become smaller towards the top. Inflorescence a many-flowered raceme. Pedicel up to 10 mm long; 1 bract, about 1 mm long. Flowers 5-merous. Calyx 2 mm long. Corolla 2–5 mm in diameter, white. Capsule globular, opening itself with 5 valves; numerous seeds, small.

Culture: *Samolus valerandi* is a slow-growing plant for the foreground, often commercially available, but which only rarely displays satisfactory growth in the aquarium. Intense lighting, a nutrient-rich substrate, hard water as well as temperatures below 26 °C are recommended for optimum growth. Submersed specimens can reach a height and width of 15 cm. Cultivation is also possible in cold-water aquariums. The species displays a good tolerance of salt. Experiments by the author with aquarium plants showed that a salt concentration of 30 g/L, which corresponds to pure ocean water, can still be handled. In contrast to the often problematic maintenance in the aquarium, emersed culture in paludariums or hydrocultivation on the window sill are both very easy; from spring to autumn *S. valerandi* can also be used for planting on the edges of garden

ponds. In emersed cultivation inflorescences and infructescences will regularly develop during spring. Vegetative propagation is possible in a limited way through rhizome partitioning and the formation of adventitious plants on the peduncle. More simple and more productive, however, is the sexual multiplication through seeds. These are sowed on a moist soil.

Ecology: The species prospers in moist and wet locations in brackish and fresh water. The author found it on the island of Korfu in a lagoon in large quantities. The plants grew under intense sunlight, in both a moist sand-loam soil as well as in shallow fresh water. Water values: temperature 26.5–35.5 °C (air temperature 26 °C at 13:00 h), pH 8, GH 32 °dH, KH 12 °dH. A productive multiplication through seeds was recorded at the above location.

Other: *Samolus parviflorus* and *S. floribundus*, which are sometimes mentioned in aquaristic literature, have to be classified as synonyms of *S. valerandi* because the supposed differences in the size of the flowers and fruit can be explained by environmental factors, such as light, moisture of the soil and temperature (Kasselmann 1981a).

***Samolus valerandi*.**



Saururus cernuus

Linné (1753)

Family: Saururaceae.**Synonyms:** *Saururus lucidus* Donn, *Mat-tuschkia aquatica* Gmelin.**Etymology:** *Saururus*: *sauros* = lizard, *oura* = tail; *cernuus*: nodding, both terms refer to the inflorescence.**Distribution:** Eastern North America, introduced to northern Italy.**Description:** Sturdy marsh plant with a long, creeping, branched rhizome. Stem about 1 m tall, 2–8 mm thick, hard, round, more or less pubescent. Leaves alternate, 3–5 cm petiolate. Petiole with a sheath, curled up, about 1 cm wide. Above the petiole an inconspicuous 2-mm long stipule. Blade entire, ovoid to wide ovoid, 10–13 cm long, 5–9 cm wide, much smaller in the aquarium, medium green. Apex acute or cuspidate; base cordate. Emerged upper and undersides plumy pubescence, submersed glabrous. Slightly aromatic.

Inflorescence spike-like with numerous solitary flowers, 15–20 cm long, nodding, cream-colored, slightly aromatic. Flowers 2 mm petiolate. Bracts 1–3 mm long, 1 mm wide, white to green. Sepals and petals ab-

sent; (5)6–7(8) stamens, 6 mm long; (3)4(5) carpels, 2 mm long. Inflorescence erect. Fruit 1-seeded.

Culture: In the 1950s the species was used as a plant for the edges of garden ponds, where its use is described as indestructible and could even be bothersome because of the strong branching of its rhizome (Wendt 1952–1955). It is very light-demanding in the tropical aquarium. Furthermore, it should not be subjected to high temperatures for extended periods of time (up to about 25 °C). In Dutch aquariums, a terraced group arrangement as a “street” is not uncommon (“Leidener Plant”). Shoot tips and lateral shoots are used for planting. Hardy under certain protected conditions.**Ecology:** In marshy locations and slow-moving waters, in Italy in the reed belt of lakes. Very adaptable to prevailing temperatures and pH-values of the water.***Saururus cernuus*, the “Leidener Plant,” in the aquarium’s foreground.**

Saururus chinensis

(Loureiro) Baillon (1871)

Family: Saururaceae.**Synonyms:** *Spathium chinense* Loureiro (1790), *Saururus cernuus* Thunberg (non Linné), *S. loureiri* Decaisne, *Saururopsis chinensis* Turczaninow, *S. cumingii* C. de Candolle.**Etymology:** *Saururus*: see *S. cernuus*; *chinensis*: originating from China.**Distribution:** Eastern Asia.**Description:** Marsh plant with an up to 1-cm thick branched rhizome. Stem initially erect, then decinate, 3–5 mm thick, hard in the lower part, flexible in the upper part, glabrous, round to slightly angular. Leaves alternate, 1.5–8 cm petiolate. Petiole with a sheath, curled up, about 5 mm wide; stipule 2–5 mm long. Blade entire, narrow ovoid with slightly cordate-truncate or auriculate, often slightly unequal base and acute apex, up to 10 cm long, 4.5 cm wide (remaining smaller in aquariums), upper- and undersides slightly plummy pubescent, upperside olive green, underside lighter in color. Aromatic.

Inflorescence straight, with white, sweet-scented solitary flowers, up to 12 cm long.

Bract 1–2 mm long, 1–2 mm wide, more or less fimbriate. Sepals and petals absent; 4–8 stamens, filaments less than 1 mm in length; 4 carpels, 1.5 mm long. Infructescence erect. Fruit 1-seeded.

Culture: *Saururus chinensis* is to be used as described for *S. cernuus*. Both species have only moderate use in aquariums and require intensive light and not too high temperatures. Emerged maintenance on the window sill in moist soil is not difficult, however.**Ecology:** *Saururus chinensis* populates marshy locations. In China, the plant is used for medicinal purposes.**Other:** *Saururus chinensis* differs from *S. cernuus* mainly in the shape of the leaf blade and leaf base, the erect inflorescence as well as shorter stamens. Wendt reports on the import of *S. chinensis* as early as 1890. In the last decades the species has not been cultivated, and renewed importation was arranged by the German nursery Dennerle only in 1992.**Emerald shoots of *Saururus chinensis*.**

Shinnersia rivularis

(A. Gray) R.M. King and H. Robinson (1970)

Family: Asteraceae.

Synonyms: *Trichocoronis rivularis* A. Gray (1849).

Etymology: *Shinnersia*: after the botanist L.H. Shinners; *rivularis*: growing along streams.

Distribution: Northern Mexico, Texas.

Description: Marsh plant. Stem up to 1 m in length, 3 mm thick, very branched, emerged strongly pubescent, submersed glabrous. Leaves decussate, very variable, oblanceolate or spatulate to obovate. Emerged blade up to 6.5 × 5 cm in size, underside pubescent on the veins. Submersed blade up to 7.5 × 3 cm in size, glabrous, light green to reddish brown in color. Leaf margin more or less emarginate, occasionally denticulate.

Inflorescence is an 8–9-mm wide and 4–5-mm tall capitula with 90–100 florets. Involucre with up to 14(–30) elliptic glabrous, obtuse, green leaflets almost equal in length, arranged in 2–3 circles, up to 3 mm wide, 5.5 mm long. Calyx without pappus. Receptacle convex to conical, mammillate. Corolla 5-lobed, 2.0–2.2 mm long, wide campanulate,

glandular, white; ray flowers are absent. Stamens almost as long as the tube. Style forked. Stigma about 1.2 mm long, widened, slightly flattened, upperside mammillate. Ovary cylindrical, about 1.5 mm long, green. Fruit (achenes) prism-shaped, 2.0–2.5 mm long, with 4–5 bristly ribs.

Culture: *Shinnersia rivularis* is an extraordinary rapid-growing marsh plant with good adaptability to aquarium conditions. The high light requirement, however, has to be remembered when culturing the plant, even if the plants still grow under little light. Good indicators for sufficient light conditions are the size of the leaf blade and the associated number of denticles on the margin. This can easily be observed as the shoots grow towards the water surface: the blades will become increasingly stronger, and the notches on the margin will increase.

Shinnersia rivularis can be kept successfully in both soft and hard water, with a pH-value in the acid to alkaline range, and with temperatures between 18–30 °C. The substrate is of lesser importance. Even unplanted shoots, placed on the water surface, will continue to grow rapidly and will form numerous

Shinnersia rivularis.



Inflorescence of *S. rivularis*.



lateral shoots. Due to its quick multiplication and its good growth, *S. rivularis* is not always popular with aquarists because it normally has to be replanted and thinned out continuously. The shoots will grow well emersed as well, so that the plant can also be used in paludariums and in garden ponds during summer. Inflorescences will form abundantly during summer, but fruit have so far not been detected during cultivation.

Ecology: Exists in streams and rivers with slow-moving water.

Other: Several of the plant's features (shape of the leaves and corolla, structure of the fruit pedicel, absence of a pappus, structure of the pubescence on the achenes, and others) led King and Robinson to separate the species from the *Trichocoronis* genus in 1970 and to transfer it into the new monotypical *Shinnersia* genus.

E. Hnilicka collected *Shinnersia rivularis* in northern Mexico in the Rio Alamos. The plant was introduced to aquaristics under the old name of *Trichocoronis rivularis*.

***Shinnersia rivularis* “White-Green”**

This cultivar is distinguishable by its whitish venation of the leaf blades. In the aquatic plant nursery H. & L. Dennerle, a partial deficiency of chlorophyll appeared in the veins of *Shinnersia rivularis* when cultivated alongside the “White-Green” cultivar of *Hygrophila difformis*. Even though it was possible—through selection—to stabilize the white or slightly red marking, which refers almost exclusively to the venation, it is nevertheless not consistent (although more constant than in *Hygrophila difformis* “White-Green”). It is especially pronounced when the plants are cultured in a nutrient-deficient substrate. This condition points to a virus infection.

Further reading: Kasselmann (1983a, 1984b); King and Robinson (1970).

Emersed shoots of *Shinnersia rivularis* ‘White-Green’.



Spiranthes graminea

Lindley (1840)

Family: Orchidaceae.**Synonyms:** *Gyrostachys graminea* (Lindl.) Kuntze.**Etymology:** *Spiranthes*: spike with twisted flowers, *speira* = thread, *anthos* = flower; *graminea*: grass-like.**Distribution:** Arizona, Mexico, Guatemala.**Description:** Orchid existing in marshes or entirely submerged, 10–20 cm tall. Roots 2–5 mm thick, fleshy. Rosette with 3–6 leaves which are present during the flowering stage. Blade very narrow elliptic, 10–20 cm long, 0.7–1.0 cm wide. Leaves fleshy, soft, medium green, slightly shiny.

Flower description as in *S. odorata*, but with smaller flowers. Spike and upper part of the peduncle densely pubescent. Lip about 8 mm long, 4 mm wide, slightly yellowish on the inside. Number of chromosomes $2n = 44$ (for the collection described here).

Culture: Even though *S. graminea* can be found entirely submersed in its natural habitat for a certain period of time, a satisfactory cultivation in the aquarium under varying conditions has so far not been achieved. On

the other hand, keeping this orchid in both a paludarium as well as on the window sill in moist soil or in hydroculture is highly recommended. Inflorescences will form regularly. After the flower formation—as described for *S. odorata*—vegetative propagation occurs through root cuttings.

Ecology: *Spiranthes graminea* inhabits marshy locations. The author collected the plants described here in August 1985 in the highlands of Mexico, between the towns of Toluca and Villa Victoria. The orchid grew in large populations in a depth of about 1 m. The water surface was densely covered with flowering *Eichhornia crassipes*, with numerous orchid inflorescences protruding through the water surface. Despite the habitat being unshaded, the plants, which were only loosely anchored in the very soft boggy soil, grew under extremely little light because of the floating plants.

Other: *Spiranthes graminea* can be distinguished from *S. odorata* by its narrower leaves.

Inflorescence of *Spiranthes graminea*.**Inflorescences of *Spiranthes odorata*.**

Spiranthes odorata
(Nuttall) Lindley (1840)

Family: Orchidaceae.

Synonyms: *Neottia odorata* Nuttall (1834), *Spiranthes cernua* (Linné) L.C. Richard var. *odorata* (Nuttall) Correll, and others.

Etymology: *Spiranthes*: see *S. graminea*; *odorata*: sweet-scented.

Distribution: Eastern and southeastern U.S.

Description: Orchid, existing in marsh areas, 10–20 cm tall. Roots up to 5 mm thick, fleshy. Rosette with 4–6 leaves. Leaf blade very narrow elliptic or narrow oblanceolate, 10–30 cm long, 1.5–3 cm wide. Leaves fleshy, soft, medium green, greasy shiny.

Peduncle 50–80 cm tall, glandular pubescent, with 5–8 stem leaves. Spike 10–15 cm long, with 20–35 white flowers, either spiral-shaped or densely arranged in vertical rows. Bracts up to 2.1 cm long, cuspidate, glandular pubescence. Lip 1.2 cm long, 0.5 cm wide, curved downwards at the front, green yellowish on the inside. Column 4 mm long, green. Capsule 1 × 0.4 cm in size; number of chromosomes $2n = 30$.

Culture: A slow-growing adaptable orchid, it can continuously exist in a submersed state. With its thick-fleshy roots, a coarse-grained substrate should be used in the aquarium. Light requirements are only moderate. Optimum temperature range is 22–26 °C. Hardness and pH-value are of minor importance for healthy growth. Under water, too, the inconspicuous rosette will not form more than six leaves, so that several specimens have to be used to achieve a decorative effect. *Spiranthes odorata* is very recommended for emersed cultivation on the window sill, in the paludarium or in the greenhouse. A large flowering population creates a magnificent effect. Compost soil, for example, is suitable as substrate, which has to be kept wet, but hydroculture is also possible. The plant will often react sensitively with a loss of leaves to the transfer to another environment (humid-

ity, light). If the plant's growth remains undisturbed, inflorescences will regularly occur, which may also develop within the aquarium. Only with a correspondingly high cover, or an open aquarium, is the spike able to fully develop. At the time of flower formation up to eight plantlets develop over the root tips, which can be severed after reaching a size of about 5 cm. Root cuttings will also develop regularly within the aquarium, even if the flower formation fails to occur. Therefore never trim the roots! Plantlets at the base of the peduncle are rare. The adult plant will die off after flower formation. Rearing of the tiny seeds on an artificial soil is unknown within aquaristics.

Ecology: *Spiranthes odorata* inhabits marshes, marsh forests and permanent waterways, but is also found in brackish and fresh water on moving waterways which are subject to tidal variation. The orchid grows in both deep shade as well as under intense sunlight in a substrate of clay, peat, mud and sand.

Other: Plants cultivated here are nonaromatic. For a long time, *S. odorata* had been classified under the name of *S. cernua*.

Emersed flowering plants of *S. odorata*.



Spirodela polyrhiza
(Linné) Schleiden (1839)

Family: Lemnaceae.

Synonyms: *Lemna polyrhiza* Linné (1753), and others.

Etymology: *Spirodela: speira* (Gr.) = thread, *delos* = distinct, refers to the distinct spiral vessels in the veins of the fronds; *polyrhiza*: multi-rooted.

Distribution: Worldwide in regions featuring a temperate climate, isolated only in South America.

Description: Small aquatic plant, floating on the water surface. Fronds leaf-like, underside with scales on the base; 7–21 roots, often colored red, 1 or (rarely) 2 primary roots perforate the prophyllum at the base. Frond round to ovoid, aciculate, 1.5–10 mm long, 1.5–8 mm wide, thin or (rarely) bullate arched, upperside green, often with a red spot, underside mostly purple-red; 7–16(21) veins. Daughter fronds borne in 2 ventral budding pouches on the base of the mother frond; 1–2 flowers, in the same lateral pouches as the daughter fronds. Each flower is enclosed in a membranous sheath, with 2(3) stamens which develop successively and 1 style. Ovary with

1–2 ovules. Fruit aliferous; 1 (rarely 2) seed, with 12–20 distinct ribs.

Culture: Well suited for cultivation in a sunny location in the garden pond, but also with little water surface movement and good lighting in the aquarium. It flowers very rarely.

Ecology: *Spirodela polyrhiza* inhabits usually stagnant waters. The species will tolerate even very acid water with a pH-value of 4 and is present under higher conductivity values. The roots do not have any major part in the absorption of nutrients; they serve predominantly as a stabilizing aid (wind, strong water movement). *Spirodela polyrhiza* is able—with the help of turions—to cope with temperatures as low as -40°C , and to survive dry periods in the mud and bog of temporary waters. The highest growth rate was recorded at a temperature of 30°C , with growth ceasing at 38°C .

Further reading: Landolt (1986).

Spirodela polyrhiza.



Stratiotes aloides

Linné (1753)

Family: Hydrocharitaceae.

Synonyms: *Stratiotes alismoides* L., and others.

Etymology: *Stratiotes*: soldier, refers to the sword-shaped leaves; *aloides*: similar to the genus *Aloë*.

Distribution: Europe.

Description: Aquatic plant, drifting freely below the surface, or with unbranched long roots anchoring in the substrate. Leaves in a basilar rosette, sessile, linear or narrow triangular, sword-shaped, stiff, up to 60(110) cm long, 1–4 cm wide, with acanthoid-serrate margin, light to medium green.

Plants dioecious; flowers unisexual, surrounded by a spathe. Male inflorescence with 3–6 flowers; 3 white sepals and petals. Up to 41 stamens, the inner 5–17 fertile, the outer ones sterile. Female inflorescence with 1(2) flowers; 3 sepals and petals; 15–30 staminal nodes; (3–)6 styles. Capsule with large seeds.

Culture: *Stratiotes aloides* is often cultivated as a decorative aquatic plant in garden ponds, where it requires stagnant, nutrient-rich water and a sunny location. It cannot cope with

strong pollution. Plants adapted to higher temperatures (up to about 28 °C) can be continuously cultured in tropical aquariums as well. One specimen, drifting below the water surface, is adequate for decorative purposes in the aquarium. Water movement must remain minimal. Under optimum growth conditions, a magnificent rosette will develop which will anchor its long white roots in the aquarium floor. The plants grow well in medium-hard water, and with pH-values around neutral, with additional CO₂ fertilization having a positive effect. Propagation is through runners.

Ecology: In autumn the species will drop to the bottom where it will survive in the mud. At the beginning of the warmer season the specimens will again climb to the water surface. In autumn numerous winter buds will form, which will remain suspended in the water in the form of little rosettes during summer.

Other: Protected species.

Further reading: Cook and Urmi-König (1983b).

Stratiotes aloides.



Trapa natans

Linné (1753)

Family: Trapaceae.

Synonyms: Numerous.

Etymology: *Trapa*: from *calcitrappa* = man trap, possibly because of the horned fruit; *natans*: swimming, floating.

Distribution: Polymorphous species, widespread in Eurasia, Africa, introduced to North America, Australia (compare Other).

Description: Floating aquatic plant. Juvenile leaves submersed, sessile, opposite, linear, short-lived. Floating leaves alternate rosette-like. Petiole 5–20 cm long, 3–4 mm thick, often wine red, with an up to 3-cm long and 1.5-cm thick spongy air cushion, which may also be entirely absent. Leaf blade rhombic, 4–7 cm wide, 3–5.5 cm long, serrate on the upper margin, entire at the lower part. Coloring upperside light to dark olive green, underside green, reddish to strong wine red. Flowers bisexual, inconspicuous, solitary, short petiole; 4 sepals (remaining as horns on the fruit); 4 white, caducous petals; 4 stamens. Nut with 2 to 4 horns.

Culture: Due to its conspicuous appearance, the aquarist is easily lead to attempt cultiva-

tion of this species in a tropical aquarium. Unfortunately continuous keeping is exceptionally difficult and is seldom successful. On purchase the buyer should attempt to find out if the plant originates from tropical or native waters, and cultivate accordingly. Regardless of its origin care has to be taken. The plant is very light-demanding, and also cannot handle a too high level of pollution or too strong movement of the water. Vegetative propagation occurs through runners, sexual propagation through seeds (nuts).

Ecology: Populates different habitats, but grows generally in tranquil or slow-flowing, hardly polluted waters. In many countries the nuts are consumed as a vegetable.

Other: Because of the polymorphic fruit, one is able to distinguish up to 20 species which other authors classify as a single species (*Trapa natans*).

Trapa natans.



Utricularia aurea

Loureiro (1780)

Family: Lentibulariaceae.

Synonyms: *Utricularia flexuosa* Vahl, and others.

Etymology: *Utricularia*: from *utriculus* = small hose (trap); *aurea*: golden (yellow-gold flowers).

Distribution: Asia, Australia.

Description: Rootless, aquatic plant drifting below the water surface, up to 1.50 m long. Rhizoids up to 6 cm long. Leaves alternate, several times very finely pinnate; each leaf with 2–4 segments different in length, the longest up to 7 cm long and 2 cm wide. Traps short petiolate, 1–4 mm in size. Mouth opening with 2 small lateral, hardly branched setae or without setae.

Inflorescence 15–25 cm tall, with 3–7 short-lived flowers. Calyx distichous, 0.5 cm long. Corolla gamophyllous, 10–15 mm long, bright yellow. Lower lip slightly larger than the upper lip, inside with red stripes. Seed capsule 4–5 mm in size; numerous seeds, black.

Culture: A fast-growing plant which can cover the water surface entirely within a short

period, it grows in both soft as well as hard, slightly acid to slightly alkaline water, within temperatures of 22–30 °C. In its native habitat, one often finds strong, thickset, slightly fragile shoots, which have a deep red color and have 4-mm sized, almost black utricles. Aquarium specimens are colored only slightly red if subjected to high light intensity. The utricles will reach a size of only 1–2 mm, or are entirely absent. Careful with large plants having big utricles! They can easily endanger small-fry. Inflorescences and infructescences will also develop in the aquarium. According to the author's observations, the seeds of *Utricularia aurea* require a dry phase of at least a few days in order to germinate. They were still germinating well beyond 1 year.

Ecology: The species inhabits stagnant waters such as ponds, rice paddies and marshes up to an altitude of 1500 m. Two water analyses follow, Sri Lanka (1/1985): 1) pH 7.36, GH 21 °dH, KH 14 °dH, 1710 µS/cm, rH 179 mV; and 2) Temperature 30 °C, pH 6, GH/KH < 1 °dH, 85 µS/cm, rH 201 mV.

***Utricularia aurea*.**

Utricularia gibba

Linné (1753)

Family: Lentibulariaceae.

Synonyms: *Utricularia gibba* L. subsp. *exolata* (R. Brown) P. Taylor, and many others.

Etymology: *Utricularia*: see *U. aurea*; *gibba*: bumpy (reference unknown).

Distribution: Pantropical, introduced to Europe.

Description: Very delicate aquatic plant. Rhizoids are absent or are very short. Stem up to and over 20 cm in length, often branched, very thin. Leaves alternate, numerous, 0.5–1.5 cm long, furcate and then again split into up to 4 (rarely up to 8) hair-fine segments. Traps petiolate, 1–2.5 mm long; mouth with a lateral opening, with branched setae.

Inflorescence up to 20(–30) cm tall, usually with 2–4 (rarely up to 12) flowers. Sepals almost round, 1–3 mm. Corolla yellow, often with reddish brown veins, 4–25 mm long. Upper lip almost orbicular, more or less distinctly trilobular. Lower lip a little smaller, elliptic to orbicular. Seed capsule globular, 2–3 mm in size.

Culture: This inconspicuous *Utricularia*, which is sometimes unintentionally “intro-

duced” with other aquatic plants, can be very easily cultivated in the aquarium. To ensure proper growth, it requires a hardly disrupted water surface, a nutrient-rich, acid water, as well as good lighting. Under optimum conditions, *Utricularia gibba* will form felted cushions which will drift below the water surface and will occasionally also display inflorescences. They are most likely to appear on plants which are cultured in wet soil.

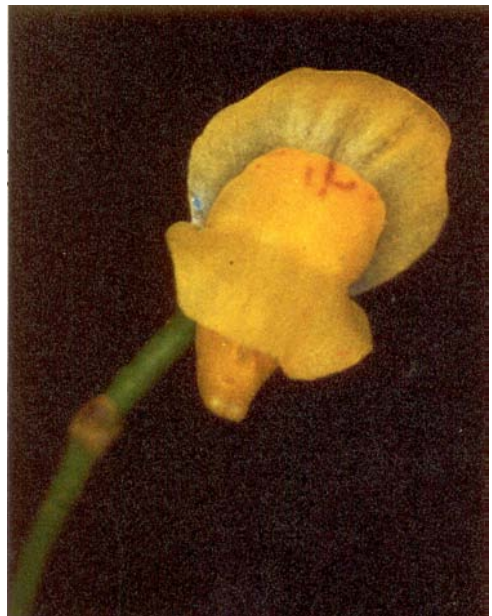
Ecology: Populates stagnant or very slow-moving waters, the levels of which are subject to strong seasonal tidal fluctuation. The plants will usually flower in shallow water, and they are not uncommon on wet mud.

Other: In his monograph on the genus, Taylor (1989) considers *U. gibba* as a species with very variable flowers, which is why he no longer upholds his previous differentiation into different varieties.

Utricularia gibba.



Flower of *U. gibba*.



Utricularia inflexa

Forskal (1775)

Family: Lentibulariaceae.

Synonyms: *Utricularia thonningii* Schumacher, *U. stellaris* var. *inflexa* C.B. Clarke, *U. inflexa* var. *inflexa*, and others.

Etymology: Utricularia: see *U. aurea*; *inflexa*: curved inwards, refers to the spongy floats.

Distribution: Tropical and subtropical Africa, Madagascar.

Description: Rootless aquatic plant, drifting below the water surface. Stem up to 1.5 m long, light green or dark red in color. Rhizoids up to 15 cm long. Scales up to 6(–15) mm on strong leaves, which are toothed, fimbriate or more or less indented. Leaf with 3–6 pinnate segments, these 4–10 cm long, but mostly smaller in aquariums. Traps up to 2 mm, short petiolate and with a lateral mouth opening. Upper lip with 2 setae.

Inflorescence about 10–15(–33) cm tall, having 6–9 narrow cylindrical air-filled floats at the base, usually arranged as a whorl; 4–16 bright yellow, white in the throat, successively open (according to Taylor white and malvern-colored ones as well). Calyx-lobes

green, up to 19 mm long, 16 mm wide. Flower with a 7-mm long, rounded upper lip and a lower lip, equal or larger in size. Corolla more or less densely pubescent, usually distinctly red-striped; 2 stamens. Style hardly longer than the stamens. Ovary 1 mm, globular. Capsule 5 mm in size; seeds 1 to 2 times as wide as high. Cells of the testa relatively small (about 0.06 mm long) and oblong.

Culture: As described for *Utricularia stellaris*.

Ecology: *Utricularia inflexa* inhabits shallow, stagnant or slow-moving waters up to an altitude of 1700 m. For a detailed water analysis of a lake on the island of Mafia (Tanzania), see p. 41.

Other: The species was introduced to aquaristics from Tanzania by the author in 1980. The identification of all listed *Utricularia* species was done by P. Taylor, Kew.

Further reading: Taylor (1989).

Utricularia inflexa: inflorescence with floating bodies and utricle (microscope photo).



Utricularia stellaris

Linné fil. (1781)

Family: Lentibulariaceae.

Synonyms: *U. inflexa* var. *stellaris* Taylor, and others.

Etymology: *Utricularia*: explanation in *U. aurea*; *stellaris*: star-shaped, refers to the arrangement of the floats.

Distribution: Tropical Africa, Madagascar, Mauritius, Comores, Asia to northern Australia.

Description: Differences to *Utricularia inflexa*: floats elliptic or ovoid, up to 10×5 mm in size. Calyx-lobes about 7×7 mm in size. Upper and lower lip of the yellow corolla approximately equal in length, hardly red-striped. Seeds 2–3 times wide as high. Cells of the testa relatively large (about 0.1 mm long). Otherwise as in *U. inflexa*.

Culture: This rare, well-growing *Utricularia* will usually remain a bit smaller in the aquarium compared to its native habitat. Under natural conditions, the shoots will grow in soft to medium-hard shallow water with an acid to slightly alkaline pH-value. Essential for successful cultivation are high light intensity, an aquarium free of algae, and a certain

supply of nutrients. Which nutrients the plant requires for good growth is, to a certain extent, still not known. Next to nitrogen, potassium and magnesium are among the most important elements in the nutrient chain. As scientific research has shown, an additional supply of animal matter did not effect much change in a nearly optimal nutrient medium, whereas in an inadequate medium animal food had a positive effect on growth and enhanced the formation of traps. This indicates under which conditions traps are formed, and that they are not important for the development of strong shoots. Sowing is as in *U. aurea*.

Ecology: As described in *U. inflexa*. Water analysis from Zambia follows (8/1986): Temporary pool, temperature 30 °C, pH 7.5, GH < 1 °dH, KH 2 °dH, 585 µS/cm. See also the detailed analysis on p. 41, biotope No. 8.

Other: It was proven in *U. stellaris* that the flower formation is enhanced by an additional organic nutrient supply.

Utricularia stellaris in its natural habitat in Cameroon.



The *Vallisneria* Genus

Nomenclaturic Modifications

The taxonomy of the many *Vallisneria* species described has long been a problematic issue, because the vegetative features of the individual species react to different growth conditions with a great deal of variability. Research on the genus by Lowden (1982), which has found no recognition in aquaristics so far, follows far-reaching changes in the nomenclature that are relevant to aquarists. Conducting research on the genus was problematic because of the difficulty of finding reliable differentiating criteria. Both the leaf width as well as the appearance of the margins have proven to be unsuitable features. The arrangement of the carpels in female flowers, as well as the number of stamens in male flowers, have turned out to be relevant taxonomic criteria. Taxonomic-systematic work on this genus was made especially difficult by the fact that, on the one hand, one requires both male as well as female flowers for such work, but, on the other hand, both

plant types occur only very rarely in nature and are therefore very difficult to obtain.

Independent from Lowden, the Swiss botanist Cook (1982) arrived at the same important result: all previously described species within the genus are classified as *Vallisneria spiralis* Linné and *V. americana* Michaux with two varieties each, with the endemic Australian species not being considered. This has the following consequences for aquaristics: the well-known aquarium plants *Vallisneria asiatica* Miki and *V. neotropicalis* Marie-Victorin must now be considered synonyms of *V. americana* Michaux var. *americana*. *Vallisneria gigantea* Graebner is also to be seen as a synonym of *V. americana* Michaux, *V. asiatica* Miki var. *biwaensis* Miki is a synonym of *V. americana* Michaux var. *biwaensis* (Miki) Lowden. Jacobs and Frank (1997) clarified the species categorization of the Australian populations of the *Vallisneria* species (see *Vallisneria nana*).

It is interesting to note that the areas of distribution of *V. americana* and *V. spiralis* overlap. Habitats of *V. spiralis* var. *denseser-*

Leaf contour with denticles of *V. americana*.



Male inflorescence of *V. americana*.



rutata and *V. americana* var. *americana* are known to exist on the Philippines and New Guinea, where both species occur either sympatric or rather within the same area. Noticeable in the author's research of the native habitats was the consistently high pH-value and also the water, which was comparatively hard for tropical plant biotopes. It is known from cultivation, too, that the *Vallisneria* species grows better in hard, alkaline water, compared to soft, acid water. At this point, the author follows the nomenclaturic changes which have resulted from research done on the *Vallisneria* genus. Even though the aquarist might only be familiar with the flowers of the *Vallisneria* species in exceptional cases, and will therefore rarely be able to follow the differentiating features listed in the description, the necessity to list a simplified version of the key (according to Lowden) arises nevertheless from the previous remarks.

Key to the Species and Varieties

- 1) Stamens of the male flower free and protruding diagonally; stigma of the female flower fimbriate 2
- 1a) Stamens of the male flower partially or completely adnate and erect; stigma of the female flower not fimbriate 3
- 2) Staminodes of the female flowers attached to the short slit of the joined stigmatic lobes ... *Vallisneria spiralis* var. *spiralis*
- 2a) Staminodes of the female flowers attached to the deep slit of the joined stigmatic lobes ... *Vallisneria spiralis* var. *denseserrulata*
- 3) Staminodes of the female flowers adnate up to the styles *Vallisneria americana* var. *americana*
- 3a) Staminodes of the female flowers free *Vallisneria americana* var. *biwaensis*

Microscope photo of a male flower of *V. americana* with two stamens.



Vallisneria americana

Michaux var. *americana* (1803)

Family: Hydrocharitaceae.

Possible Synonyms: *Vallisneria spiralis* L. var. *americana* (Mich.) Torrey, *V. asiatica* Miki, *V. neotropicalis* Marie-Victorin, *V. gigantea* Graebner var. *higoensis* (Miki) Kitamura, *V. natans* (Lour.) Hara var. *higoensis* (Miki) Hara, and others.

Etymology: *Vallisneria*: after A. Vallisneri (1661–1730); *americana*: from America.

Distribution: North and Central America, eastern and southeast Asia, Oceania (including Japan).

Description: Aquatic plant, producing runners, with a short rhizome. Leaves rosette-like, strap-shaped, flaccid, rough, up to 2.3 m long. Narrow-leaved forms: blade up to 10 mm wide, with 3–5 veins and more or less distinct transverse lines. Wide-leaved form: blade 10–25 mm wide, with 5–9 veins. Parallel veins run almost to the apex. Margin usually with spines.

Plants dioecious; flowers unisexual.

Male plant: Peduncle thick, short, 1.5–5.0 mm thick, 3–16 cm long. Flowers 1.0–1.4 mm wide, numerous, white, enclosed by a transparent 2-valved spathe; flower with 3 sepals (2 large, 1 small), 1 very small petal rudimentary; 1 staminode and 2 fertile erect stamens, the filaments of which are partially or completely adnate.

Female plant: Flowers on long, spirally twisted petioles, solitary, 2–3 mm in size, white. Flowers with 3 large sepals, 3 small petal rudimentaries, 3 large staminodes adnate to the styles, 3 bifid, not fimbriate stigmas. Flowers rarely set in a 3–6-flowered umbel or a spike-like inflorescence. Fruit oblong, about 10 cm long. Numerous seeds, elliptic, grooved, 1.3–2.0 mm long, without nutrient tissue.

Culture: *Vallisneria americana* is an often kept species which is commercially available in various growth forms which differ in leaf

length and leaf width. Some forms achieve leaf lengths of over 2 meters. When purchasing such large-growing specimens, one has to consider that the leaves will float on the water surface in too-low tanks and will thus considerably reduce the amount of light. One can also slightly shorten the leaves, but this will decrease the plant's growth. The plants are most comfortable in medium-hard to hard, alkaline water with a strong circulation. Since they develop a strong root network, they should be set in a sandy substrate with a minimum depth of 7 cm. The growth forms of *V. americana* appear best in very large display aquariums. Even in such high tanks, the amount of light will be sufficient for the plants' growth.

Ecology: Grows in standing or fast-flowing water. In July 1988 the author studied a location with female populations of *V. americana* var. *americana* in Papua New Guinea. The plants grew in dense populations in a river with a strong current in a depth of up to 80 cm. The substrate was muddy-loamy, the location shaded-sunny. Water analysis follows: temperature 26 °C (air 28 °C), pH 8.2, GH 8 °dH, KH 14 °dH, 470 µS/cm.

Vallisneria americana var. *americana*.



Vallisneria americana

Michaux var. *biwaensis* (Miki) Lowden (1982)

Family: Hydrocharitaceae.

Synonyms: *Vallisneria asiatica* Miki var. *biwaensis* Miki (1934), *V. biwaensis* (Miki) Ohwi, *V. gigantea* Graebner var. *biwaensis* (Miki) Kitamura, *V. natans* (Loureiro) Hara var. *biwaensis* (Miki) Hara.

Etymology: *Vallisneria*: see *V. americana* var. *americana*; *biwaensis*: after Lake Biwa in Japan, which constitutes the location of the type species.

Distribution: Haiti, Venezuela, Japan.

Description: As outlined for var. *americana*, but differing in the following features: leaves often spirally twisted, conspicuously narrow, 3–5 mm wide and 5–50 cm long. Leaf blade with indistinct longitudinal and horizontal veins. Margin with many small denticules (clearly visible to the naked eye), which become more dense towards the apex.

Description of flowers essentially as in *V. americana* var. *americana*. In var. *biwaensis* the staminodes of the female flowers are free and not—in contrast to var. *americana*—adnate to the styles.

Culture: *Vallisneria americana* var. *biwaensis* was imported from Lake Biwa (Japan) to Germany by the aquatic plant nursery Dennerle. According to previous experience with cultivation it is a recommendable, and, because of its spirally twisted, narrow leaves, an especially decorative aquarium plant with medium requirements. In the author's aquarium, the specimens reached a growth height of 20–40 cm which makes the plant useful even for the foreground of larger aquariums. *Vallisneria americana* var. *biwaensis* is more light-demanding than other *Vallisneria* forms, so it should be given a bright location. The plants will prosper especially well in medium-hard or hard water. Optimum temperature range is about 22–28 °C.

Ecology: According to the information from the Dennerle nursery, *V. americana* var. *biwaensis* inhabits sunny locations in shallow water in Lake Biwa. There the plants supposedly occur in large populations.

***Vallisneria americana* var. *biwaensis*.**

Vallisneria spiralis

Linné var. *spiralis* (1753)

Family: Hydrocharitaceae.

Possible Synonyms: *V. michelii* Savi, *V. jacquini* Savi, *V. micheliana* Sprengel, *V. jacquiniana* Sprengel, *V. pusilla* Barbieri.

Etymology: *Vallisneria*: see *V. americana*; *spiralis*: spirally twisted, refers to the peduncle of the female plants.

Distribution: Europe, southwestern Asia.

Description: Aquatic plant, producing runners, with a short rhizome. Leaves set rosette-like, ribbon-shaped, thin, flaccid, smooth, flat or twisted, usually less than 10 mm wide, up to 1 m long. Blade with 3–5 veins and less distinct transverse lines. Margin entire or fine denticulate.

Plants dioecious; flowers unisexual.

Male plant: Peduncle thin, short, 1.0–1.3 mm thick, 1–3 cm long. Flowers very small, 0.9–1.1 mm wide; both stamens are free and diagonally facing towards the side.

Female plant: Flowers solitary. Staminodes are very small, attached to the short slit of the joined stigmatic lobes. Stigmas fimbriate. Description of flowers otherwise essentially as in *V. americana* var. *americana*.

Culture: *Vallisneria spiralis* is an undemanding aquatic plant, which prefers alkaline, medium-hard to hard water rich in carbonates. Fine-grained sand is recommended as substrate. The temperature depends on the plants' origin and they have a wide geographic distribution. Most populations, however, prosper without any problem at temperatures between 20 and 28 °C. Vegetative propagation is assured through the usually quickly forming and numerous runners. Several forms of *V. spiralis* are commercially available. One form, featuring screw-like twisted, about 5–10-mm wide leaves, is in special demand due to its decorative appearance and, with a height of 30–50 cm, is well-suited for small aquariums. A group of several specimens is quite adequate to achieve a

beautiful eye-catcher. There are narrow-leaved and wide-leaved forms which can develop leaves up to 1 m in length. The long-leaved forms of *V. spiralis* are well suited for the planting of side and rear panels.

Ecology: *Vallisneria spiralis* often inhabits nutrient-rich, stagnant or slow-moving waters. The plants form large communities in depths of up to 3 m above a muddy substrate.

Other: *Vallisneria* species are occasionally confused with *Sagittaria* species. For differentiation *Vallisneria* have fine thin roots, *Sagittaria* rough thick ones. The longitudinal veins of the leaves run parallel almost to the leaf apex in *Vallisneria*, in *Sagittaria* the two outer longitudinal veins turn away to each side just before the apex and disappear in the margin. *Vallisneria* usually have a denticulate apex, in *Sagittaria* it is untoothed.

Hint: The complex flower biology and the many different pollination mechanisms of the *Vallisneria* genus are especially interesting.

V. spiralis var. *spiralis*.



Vallisneria spiralis

Linné var. *denseserrulata*
Makino (1914)

Family: Hydrocharitaceae.

Possible **Synonyms:** *Vallisneria aethiopica* Fenzl, *V. denseserrulata* (Makino) Makino, *V. natans* (Loureiro) Hara, and others.

Etymology: *Vallisneria*: see *V. americana*; *spiralis*: spirally twisted; *denseserrulata*: *densus* = dense, *serrulatus* = finely serrate (leaf blade).

Distribution: Africa, Asia, Oceania, and Australia.

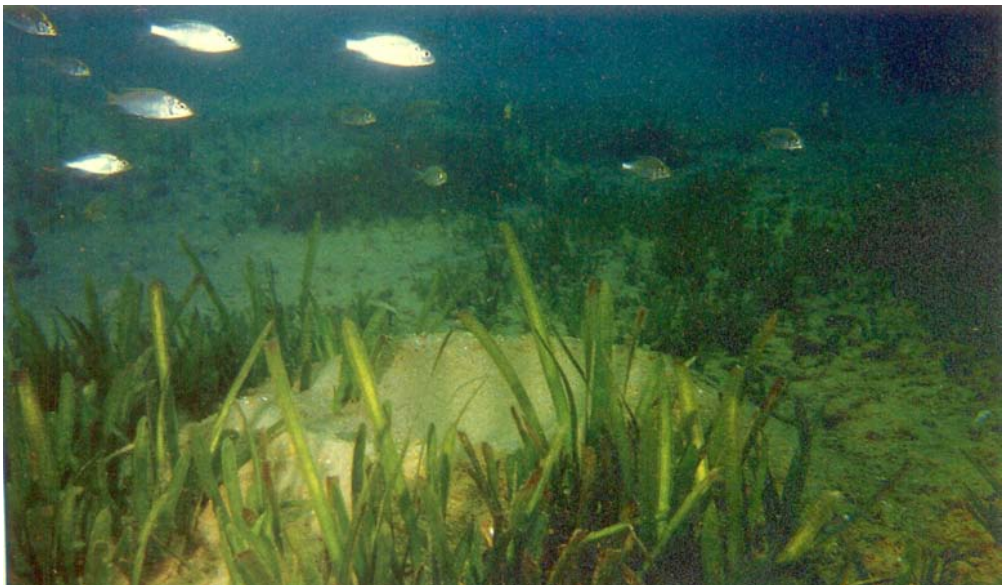
Description: As in *V. spiralis* var. *spiralis*, but in var. *denseserrulata* the staminodes of the female flowers are attached on the deep slit of the joined stigmatic lobes. Distinctly toothed in African and Japanese populations.

Culture: As described in *V. spiralis* var. *spiralis*. In the aquarium, plants from the East African Rift Lakes developed the structurally much softer, longer leaves common to *V. spiralis*.

Ecology: Among other locations, *V. spiralis* var. *denseserrulata* also occurs in the African Rift Lakes of Tanganyika and Malawi. The author was able to find a male population on

Cape Chaitika (southwestern coastline of Lake Tanganyika). All other populations studied in Lake Tanganyika (8/1986) and Lake Malawi (3/1988) proved to be sterile. Living environments of large *Vallisneria* populations are the sand zones and the transitional zone to the rocks. In small bays, which have a lesser wave movement than the open coastline, they grow deeply anchored in the sandy soil up to a depth of 6 m, protected by stones. The author located specimens with a rather more thickset growth with leaves (about 5 cm tall) curved towards the substrate, and some with a height of 40 cm, with the leaf length probably being related to the strength of the water movement: small, thick-set specimens grew in mostly unprotected, open locations, whereas plants with longer leaves generally occurred only in front of or between stones, i.e., in more protected locations. The hard leaf structure is conspicuous, a fact that can be traced back to the extreme water values (for water analysis see p. 41).

Underwater photo of *Vallisneria spiralis* var. *denseserrulata* in Lake Malawi.



Vesicularia dubyana

(C. Mueller) Brothaus (1908)

Family: Hypnaceae.

Synonyms: *Hypnum dubyanum* C. Muell. (1851), and others.

Etymology: *Vesicularia*: *vesicularis* = covered with little bubbles; *dubyana*: after the Swiss botanist J.E. Duby (1798–1885).

Distribution: Sunda Islands, Philippines.

Description: Monoecious, perennial moss which forms a dark green cushion with its loose to dense foliage. Stem soft, often branched, up to 17 cm long, often with tuft-like, reddish brown rhizoids (root hairs). Lateral branches unequal, 5–22 mm long, with an omnilateral round to apparently distichous, flattened foliage. Leaves a little erect, hollow, slightly asymmetrical, lanceolate to ovoid, acuminate or with long stretched apex, about 1 mm long. Leaf blade toothed. Leaf cells 5–10 µm wide, up to tenfold in length.

Spore-producing plant. Capsule 1.5–3 cm long petiole, red; capsule horizontal to nodding, with capsule lid and short apex, 1–1.5 mm long, 0.5–0.7 mm wide, red-brown on maturity. Spores are green, smooth and roundish.

Culture: A very recommended moss which is often used for decoration and as a spawning plant. It grows everywhere without problems, in good or bad light conditions, in soft or hard, acid or alkaline, even slightly brackish water, in temperatures of 15–30 °C. Algae infestation can be damaging but can be temporarily prevented by turning the moss cushion over. Also, the moss can quickly turn into an unwanted dirt collector; it can, however, easily be “rinsed.” Decorative objects covered by the species are very effective. Spore capsules are formed emersed and submersed. The maturing period of the spores can take up to 2 months. Their progressive development can be followed with a microscope in a separate container.

Ecology: *Vesicularia dubyana* grows in dry and moist places on the ground, on tree trunks and rocks, often on banks of periodically flooded rivers.

Vesicularia dubyana.



Family Lemnaceae

The *Lemna* genus with 13 species, *Spirodela* with three species, as well as *Wolffia* and *Wolffiella* with 10 species each, all belong to the Lemnaceae family. Important differentiating features are roots, veins, stomata, the formation of daughter frond flower structure, fruit and seeds (compare the descriptions of the individual species).

The flowers are interpreted in different ways. In Lemnaceae, the inflorescences are extremely reduced and consist of only a style and 1–2(–3) stamens which are additionally surrounded in *Spirodela* and *Lemna* by a membranous sheath (spathe), which is absent in *Wolffiella* and *Wolffia*. In the two last mentioned genera, the flowers are located in a small cavity on the surface of the fronds. Another author (e.g., E. Landolt) interprets the reduced inflorescences as solitary flowers, a line of argument which this author is following here as well.

The presence in the aquarium of any species belonging to this family is generally rarely desired because of the often occurring mass multiplication. An intensive study and

involvement with the world's smallest flowering plant is, however, well worth the effort because of its unusual reproduction and fascinating flower biology. For aquarists interested in this family, the study of *The Family of Lemnaceae—a Monographic Study* (Landolt 1986) is warmly recommended.

Wolffia arrhiza

(Linné) Horkel (1857)

Family: Lemnaceae.

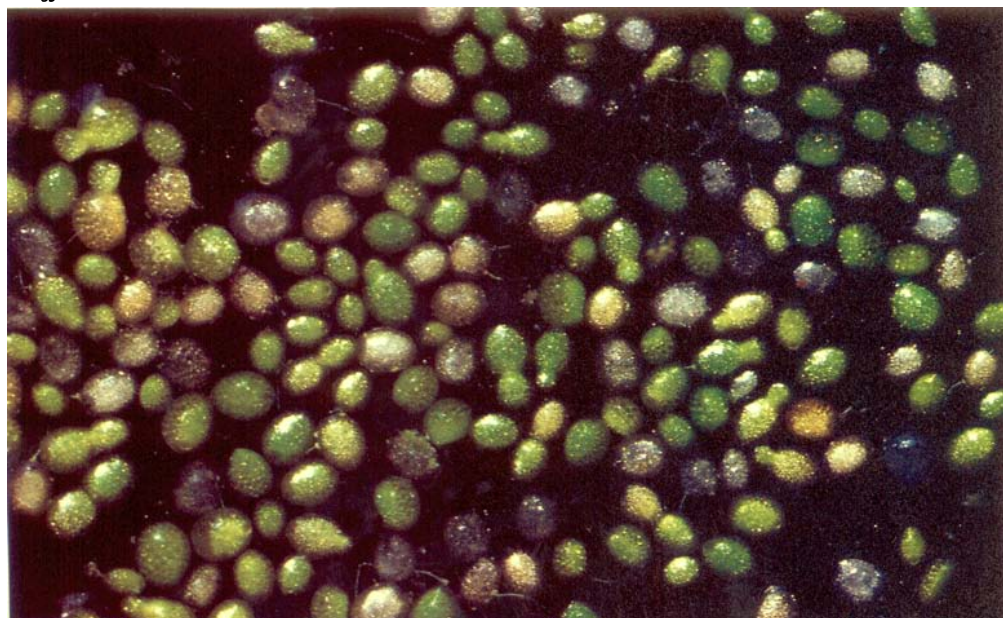
Synonyms: *Lemna arrhiza* Linné (1771), and others.

Etymology: *Wolffia*: see *Wolffia neglecta*; *arrhiza*: without roots.

Distribution: Europe, Africa, isolated in western Asia, Brazil (Rio de Janeiro); temperate, subtropical and tropical regions with mild winters and not very hot summers.

Description: Very small rootless aquatic plant, floating on the water surface. Fronds globular to elliptic, entire, 0.5–1.5 mm long, 0.4–1.2 mm wide, thick, underside bulbous, not transparent, light green; 10–100 stomata. No veins. Daughter fronds form only in a

***Wolffia arrhiza*.**



conical pouch on the base of the mother frond.

Flowering fronds unchanged in their habitus. Flowers upperside on or near the center line in a cavity; 1 flower per frond. Flower with only 1 stamen and 1 style. Ovary with 1 ovule. Seed glabrous.

Culture: This plant is a tiny *Wolffia*, occasionally kept in botanical gardens, which has only limited importance for aquaristics. It can best be kept in small aquariums with weak movement on the water surface, intense lighting and a good nutrient supply. Growth cessation occurs at 32–33 °C, and optimum temperature range is 20–28 °C.

Ecology: *Wolffia arrhiza*, which counts among the world's smallest flowering plants, populates stagnant, wind-protected waters with a temporarily insufficient nutrient supply, where it has the advantage over other *Wolffia* through its formation of turions.

Other: The turions, which drop to the bottom during winter, are just as sensitive to very low temperatures as the normal fronds. However, temperatures of –2 °C can be tolerated over a period of 4–10 days. The turions have more strength than the normal fronds, a low chlorophyll content, and the intensity of both respiration and photosynthesis are weaker too. Outside the water they will die off within a few hours (Landolt 1986).

Wolffia neglecta

Landolt (1994)

Family: Lemnaceae.

Synonyms: None.

Etymology: *Wolffia*: after the doctor J.E. Wolff (1778–1806); *neglecta*: overlooked, neglected (reference see Other).

Distribution: India, Pakistan, Sri Lanka.

Description: Very small rootless aquatic plant, floating on the water surface. Fronds elliptic to boat-shaped, 0.6–0.9 mm long,

0.4–0.6 mm wide, 1.5–2 times as thick as wide, upperside intense green, transparent margin; 8–20 stomata.

Flowers form occasionally, fruit rarely. Further description as for *Wolffia arrhiza*.

Culture: Not much is known about the aquarium culture of the second smallest flowering plant of the world (the smallest being *W. angusta* Landolt). Plants first identified by the author in a temporary waterway in Sri Lanka were able to be cultivated without encountering any problems within an aquarium under conditions of intense light and moderate water movement.

Other: *Wolffia neglecta* differs from *Wolffia angusta*, with which it has been associated since 1980, in only a few features. In 1994 Landolt separated *W. neglecta* as an independent species. In contrast to *W. neglecta*, the fronds of *W. angusta* have a whitish green surface with intense green edges, are 0.5–0.8 mm long, 0.2–0.4 mm wide and 2–3 times as thick as wide.

Further reading: Landolt (1994).

Flowering plants of *Wolffia neglecta*.



Wolffiella welwitschii

(Hegelmaier) Monod (1949)

Family: Lemnaceae.

Synonyms: *Wolffia welwitschii* Hegelmaier (1865), *W. congruensis* Trimen, *Wolffiopsis welwitschii* den Hartog and van der Plas.

Etymology: *Wolffiella*: diminutive form of the name *Wolffia*; *welwitschii*: after the Austrian botanist and discoverer of the plant, F. Welwitsch (1806–1872).

Distribution: Tropical regions of Africa, Central and South America.

Description: Small aquatic plant, rootless, floating on the water surface. Fronds solitary or 2–3 joined, leaf-like, ligular to saddle-shaped, entire, 3–7 mm long, 2.5–5.0 mm wide, thin, light green. The base touches the water surface, the round apex is curved downwards; 0–12 stomata. Veins absent. Daughter fronds develop from a flat pouch at the base.

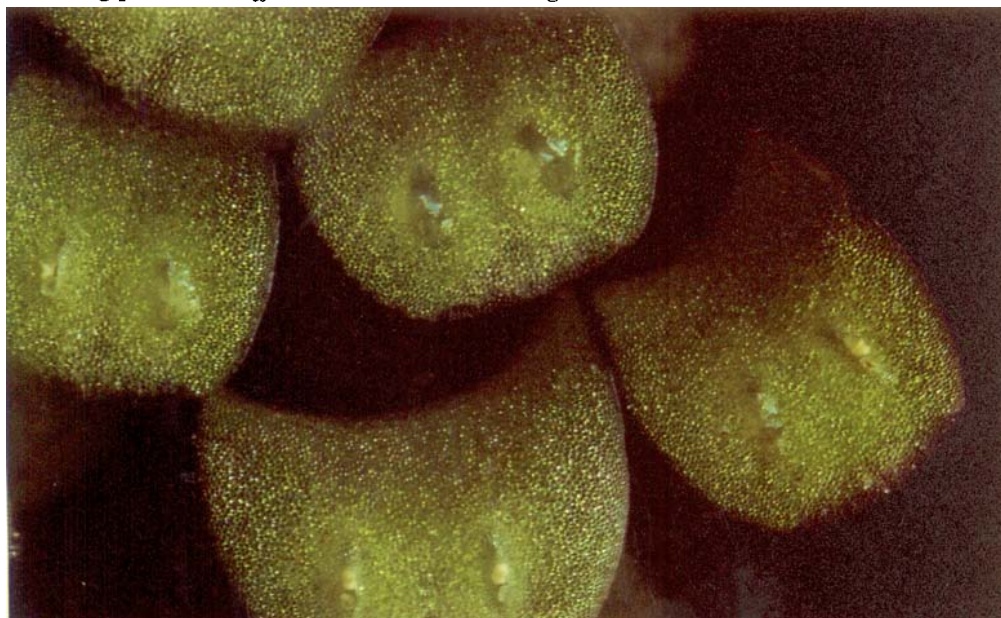
Commonly 2 flowers per frond at the side of the central line on the upperside, each in a separate cavity. Each flower consisting of only 1 stamen and 1 style. Ovary with 1 ovule. Seeds almost glabrous.

Culture: This *Wolffiella* is easy to cultivate in aquariums, with excellent multiplication un-

der good growth conditions, but does not turn into a “plague.” Cultivation is achieved in soft or hard, slightly acid or slightly alkaline water. A not too high water movement, high light intensity and a temperature higher than 24 °C are recommended. The plant reacts sensitively to algae-combating agents. Flowers and fruit develop relatively often.

Ecology: The species lives in permanent and temporary waters. Dry periods can be survived with the aid of fruit lying in mud. The author studied different locations in Brazil, Senegal and Venezuela. Two examples follow: 1) Amazon near Manaus (Brazil, 3/1986), quiet bay: water temperature 27 °C (14:00 h), GH/KH < 1 °dH, pH 6.7, 100 µS/cm; and 2) Fernando de Apure (Venezuela, 8/1989), large pond with dense populations: water temperature 33 °C (air temperature 34 °C at 10:30 h), GH 3 °dH, KH 5 °dH, pH 7.3, 250 µS/cm.

Flowering plants of *Wolffiella welwitschii* from Senegal.



Zosterella dubia

(Jacquin) Small (1913)

Family: Pontederiaceae.**Synonyms:** *Commelina dubia* Jacquin (1768), *Heteranthera graminea* Vahl, *H. dubia* Mac-Millan, and others.**Etymology:** *Zosterella*: similar to the *Zostera* genus (seagrass); *dubia*: doubtful, dubious (reference unclear).**Distribution:** Central and eastern U.S., Mexico, Cuba.**Description:** Perennial aquatic plant with shoots more than 1 m in length. Internodes up to 5 cm. Leaves alternate, sessile, semiamplexicaul. Blade linear, entire, up to 15 cm long and 6 mm wide, green in color. Base surrounded by a 2-cm long inconspicuous sheath.

Inflorescences develop on floating shoots. Solitary flower axial, sessile, sheathy below, on a tube of about 5–10(–25) cm length, which creates the expression as if the flower was petiolate (as in *Heteranthera*). Flower about 3.5 cm in size; 6 yellow tepals, 1.7 × 0.2 cm in size; 3 stamens, equally upright, 0.5 cm long and slightly recurved. Style with stigma about 0.7 cm long, slightly longer than the stamens. The flower opens in the morning for only a few hours, but does not close again, with the tepals lowering instead. Fruit with few seeds, rare.

Culture: For many years, *Zosterella dubia* was a popular aquarium plant in aquaristics. Today, however, due to its gramineous and inconspicuous growth, it is hardly prevalent in aquariums anymore. Its upkeep is unproblematic, which is why it deserves more attention. It is a fast-growing and ideal species, recommended for just about any aquarium. It should not, however, be planted in too dark locations because the lower stem segments will easily elongate. Shoots often replanted in a small group appear more decorative than long ones having turned leafless below. Obviously, *Z. dubia* loves water rich in calcium

because optimum growth is achieved in medium-hard to hard water and alkaline pH-values. The temperature should preferably be in the 15–27 °C range. Higher values may be tolerated for short periods. Propagation through lateral shoots poses no problems. The species is suitable for planting only in the middle and rear aquarium zones. The side panels may also be covered with a few shoots. Use in cold-water aquariums or garden ponds during summer is entirely feasible. Even though the plants develop long shoots, they are also recommended for small breeding aquariums because of their herbaceous growth. It is not rare for shoots floating on the water surface to produce flowers.

Ecology: The plants occur in flowing or standing waters. On reaching the water surface, the shoots will continue to grow floating and will flower.

Other: Due to the stamens being equal in length, the species was separated from the *Heteranthera* genus and classified as *Zosterella*. In 1937, a second species, *Zosterella longituba*, was described by the North American botanist, E.J. Alexander.

Zosterella dubia.

Newly Introduced Aquarium Plants

All plants pictured in this section are in the aquarium unless otherwise stated.

Alternanthera aquatica

(Parodi) Chodat (1926)

Family: Amaranthaceae.**Synonyms:** *Mogiphanes aquatica* Parodi (1878), *Alternanthera hassleriana* Chodat.**Etymology:** *Alternanthera*; see *Alternanthera reineckii*; *aquatica*: growing in the water.**Distribution:** Brazil, Bolivia, Paraguay.**Description:** Floating or creeping marsh plant. Shoots up to 3 m long, rooting on all nodes. Internodes up to 10 cm long, 2.5 cm thick, tubular, hollow (distinctive feature), pubescent, the nodes reddish. Leaves up to 7 cm long petiolate, opposite, glabrous. Blade oblanceolate to spatulate, margin entire, obtuse or rounded, base cuneate, 7–10 cm long, 4.0–5.5 cm wide, medium green. Inflorescence an axillary, short pedunculate, ovoid with an approximately 1.5-cm long spike. Flowers 5-merous, 6 mm large. Bracts 2 mm long, white. Tepals 6×2.5 mm long, white. Stamens 5. Ovary globular. Style short; stigma capitate, papillose.**Culture:** *Alternanthera aquatica* is an interesting and undemanding aquatic plant which, due to its several-meters-long shoots, is

suited only for very large and well-lighted aquaria. It is best cultivated in marshes or big ponds in botanical gardens where, on nutritious clay and under much light and warmth, it develops to an impressive size and branches frequently.

Ecology: This species inhabits riverbank vegetation of large rivers, but can also be found at the edges of lakes or in marshes. There it roots in the bottom and grows with its long shoots into the open water. The air-filled internodes, which can be seen as an ideal adaptation to life on the water surface, enable the plant to float. *Alternanthera aquatica* forms plant communities with other floating plants like *Azolla filiculoides*, *Limnobium laevigatum*, *Phyllanthus fluitans*, *Eichhornia crassipes*, *E. azurea*, and *Ludwigia helminthorrhiza*.

Other: This species was collected in 1991 by B. Wallach, Munich, in Lake Gaiba in the Bolivian part of the Pantanal (Bogner 1996).

Flowering shoot of *Alternanthera aquatica*.



***Anubias barteri* “Bonsai”**

Family: Araceae.

Synonyms: None.

Etymology: *Anubias*: see *Anubias afzelii*; *barteri*: see *A. barteri* var. *barteri*; “Bonsai”: refers to the stunted growth.

Distribution: Not known for sure.

Description: Leaf blade under aquarium conditions 1.5–2.5 cm long, 1.0–1.5 cm wide, narrowly ovoid, for the rest like *Anubias barteri* var. *barteri*.

Culture: This form of *Anubias barteri* is characterized by a striking stunted growth. In general, it can be cultivated like *Anubias barteri* var. *nana*. Due to the very small size and extremely slow multiplication of this Bonsai-*Anubias*, it is advisable to tie the rhizome down to a stone or root to prevent it from coming loose in the aquarium. The origin of *Anubias barteri* “Bonsai” is not known for sure. It is suspected to have originated in Cameroon. This plant is sold by aquatic plant nursery Dennerle, Vinningen, among others.

***Anubias* “nangi”**

Family: Araceae.

Synonyms: None.

Etymology: *Anubias*: see *Anubias afzelii*; “nangi” = fancy name originating from the initial letters of the parents *nana* and *gillettii*.

Distribution: No natural distribution.

Description: Leaf blade under aquarium conditions 5–10 cm long petiolate, lanceolate, cuspidate; base weakly cordate, 8–11 cm long and 3–4 cm wide, dark green in color. Margin weakly undulate.

Culture: *Anubias* “nangi” is a well-growing and recommendable hybrid for aquarium culture. Culture like *A. barteri* var. *barteri*. Optimum temperature range is 24–28 °C.

Other: This hybrid between *A. barteri* var. *nana* and *A. gillettii* was grown by R.A. Gasser, owner of an aquatic plant nursery in Florida; *Anubias* “nangi” has been marketed since 1986. Sale is also by aquatic plant nursery P. Schneider, Zuzgen (Switzerland).

***Anubias* “nangi.”**

Apalanthe granatensis

(Humboldt and Bonpland) J.E. Planchon (1848)

Family: Hydrocharitaceae.

Synonyms: *Elodea granatensis* Humboldt and Bonpland (1813) and others.

Etymology: *Apalanthe*: from apalos (Gr.) = soft and anthos (Gr.) = flower; *granatensis*: originating from New Granada (now Colombia).

Distribution: Tropical South America.

Description: Fragile aquatic plant with erect or surface-floating, up to 40 cm long shoots. Leaves opposite or in 3–7-merous whorls (rarely more), sessile, linear to narrowly deltoid, 8–20(–30) mm long, 0.6–1(–1.3) mm wide, vivid green-colored. Margin finely serrate, top with a pointed tooth. The bisexual, 3- or 7-mm large flowers usually develop above the surface and are single within a spathe on top of an up to 5-cm long hypanthium; 3 sepals, oblong to narrowly oblong, 1.5–2 mm long, 0.6–1 mm wide, recurved, greenish; 3 petals, obovate to broadly obovate, larger than the sepals, 3–3.5 mm long, 2–2.5 mm wide, white; 3 free stamens; filaments longer than the anthers; 3 styles, on

top 2–3-parted; 6–7 seeds per fruit (description after Cook 1985).

Culture: *Apalanthe granatensis* is a noteworthy fragile, demanding, but recommendable plant for aquarium culture. This aquatic plant was first imported from eastern Brazil in 1994 and grows well in aquaria with average to intense illumination and temperatures of 22–30 °C by showing rapid growth and good plasticity in medium-hard, slightly alkaline water. The shoots in the aquarium often produce flowers and fruit (also submersed). The submersed, tiny flowers always open with an air bubble. Unfortunately, the author lost her plants due to snail damage. Although this species has been cultivated for years in botanical gardens and has propagated well, these plants have disappeared again. A renewed import of this species is desirable.

Ecology: The author found *A. granatensis* in several habitats in southwestern Brazil in the Rio Guaporé basin, forming small populations in stagnant water of temporary pools. The plants floated on the water surface above loamy soil. From one locality in eastern Brazil (64 km southeast of Campo Maior, State of Piauí) in April 1994, strikingly small-flowered shoots with only 3-mm large flowers were collected and brought home alive; this collection was analyzed by means of electronic microscopy by Prof. C.D.K. Cook, who without doubt assigned it to *Apalanthe granatensis*. In its natural habitat, the plants grew and flowered in knee-deep water and intense sunlight. The soil was loamy. Other aquatic plants in the same biotope were *Hydrocleys martii* and *Eichhornia diversifolia*. Water analysis showed the following results: temperature 28–30 °C, pH 6.2, GH/KH < 1 °dH, 20 µS/cm.

Apalanthe granatensis.



Bacopa reflexa*(Bentham) Edwall (1897)***Family:** Scrophulariaceae.**Synonyms:** *Herpestis reflexa* Bentham (1846), and others.**Etymology:** *Bacopa*: see *B. caroliniana*; *reflexa*: recurved, referring to the fruiting pedicel.**Distribution:** Cuba, Panama, Belize, Guyana, Venezuela, Brazil, Colombia.**Description:** Finely segmented, delicate aquatic plant. Shoots up to 50 cm long, olive green to intense dark red. Stem 2 mm thick, *glabrous*. *Leaves in 6–8-merous whorls, imparipinnate*, up to 3 cm long, 1.5–2 cm wide, with 14–20 filiform, 3–10-mm long segments.

Flowers solitary, axillary, up to 3 cm pedunculate. Bracts absent. Calyx 3 mm long, sepals 1 mm wide. Corolla 2-lipped. Upper lip 2-lobed, 4 × 2 mm large, lobes equally large, rounded, lower lip 3-lobed, 9 mm wide, middle lobe a little larger. Corolla pinkish violet, lower lip with yellow dot, upper lip with red lines. Stamens 4. Style 2 mm. Stigma 2-parted. Ovary obovoid. Capsule 3 mm long.

Culture: Culture of this unusual *Bacopa* in

the aquarium is not yet successful. Although *the fragile shoots of this water plant break easily*, the author was able to bring home living material from native habitats. Culture *failed, however*. Probably extremely soft, acid water is a necessary condition for successful culture. Aquarists going to the Tropics should try to import this species.

Ecology: Evaluation of research on natural habitats so far (Kasselmann 1997) shows *B. reflexa* to be a typical soft-water plant usually growing in stagnant or moderately moving water. Three biotopes that have been analyzed by the author showed extremely soft (GH/KH < 1 °dH), acid (pH 5.1–6.1) water with a very low conductance (5–26 µS/cm). The soil was loamy. Water temperatures measured between 27–32 °C, showing that *B. reflexa* favors warm water (see biotope No. 3, p. 35).**Other:** *B. reflexa* looks confusingly similar to *Myriophyllum tuberculatum* (convergence).*Bacopa reflexa*.Flower of *Bacopa reflexa*.

Blyxa japonica

(Miquel) Ascherson and Gürke (1889)

Family: Hydrocharitaceae.

Synonyms: *Hydrilla japonica* Miquel (1866), and others.

Etymology: *Blyxa*: see *B. aubertii*; *japonica*: originating from Japan.

Distribution: India to New Guinea, Japan, absent in Australia, naturalized in Italy.

Description: Annual or perennial aquatic plant with 10–25-cm long, erect, branched shoots (difference to *B. aubertii*). Leaves alternate, rosette-like, sessile, linear, acute, soft, pellucid, 3–7 cm long, 2–4 mm wide, dark green to brownish, midrib clear, 6–12 parallel veins.

Flowers bisexual, usually single within a spathe. Hypanthium 2–4.5 cm long. Sepals, petals, stamens and carpels each 3. Seeds fusiform. Var. *japonica*: seeds smooth; var. *alternifolia*: seeds thorny or ribbed.

Culture: *Blyxa japonica*, a very demanding, easily breaking aquatic plant, is a very rare aquarium plant. Satisfactory growth is uncommon; the shoots usually decay after a short period. For successful growth, absolutely soft, acid water with a very low con-

ductance is required. Also, a moderate to high light intensity is advisable. The elegant appearance of this fragile plant can be appreciated only in the aquarium's foreground. Substrate of sand or fine-grained gravel is needed for planting the delicate stem; the shoots will take hold more easily and will root better than in coarser substrate. A street of *B. japonica* and *Alternanthera reineckii* (see picture) creates an unusual piece of scenery. In successful culture, branching by side shoots is strong, however these should not be cut off before reaching a length of approximately 10 cm.

Ecology: Can be found in stagnant, shallow water of pools and marshes as well as in slow-moving, iron-rich forest waterways; frequent in rice fields.

Other: Although *Blyxa japonica* has been imported occasionally, successful culture has been rare. It has been imported by aquarium plant nursery Tropica since 1998.

“Street of plants” made of *Blyxa japonica*.



***Ceratophyllum demersum* “red-stemmed”**

Linné (1753)

Family: Ceratophyllaceae.

Etymology: see *C. demersum*.

Distribution: Mexico (further distribution of the species see page 164).

Description: Stem 1.5 mm thick, soft, dark red; each node produces 2, up to 10-cm long side shoots which are shorter near the top of the stem, giving the plant a triangular outline. Leaves in 7–11-merous whorls, 3–4 cm large, bright to dark green. Leaf blade once (rarely double) furcate, with 2(–4) segments, the lower side with thorns in a row. Winter buds 1.5 cm long, 0.4 cm thick. Male flowers with 15–25 red stamens. Fruit not seen.

Culture: *Ceratophyllum demersum* “red-stemmed” from Mexico forms a decorative addition to the aquarium flora. It is easy to identify on the basis of its dark red stems and heavy branching. Male flowers and occasionally minute female flowers are produced in the aquarium. Based on experience so far, culture is successful under moderate lighting and average-hard to hard water with a pH between 6.5 and ca. 8.5. In an alkaline envi-

ronment and under intense light its growth is extremely robust, and shoots form a brittle and compact habit covered with calcium deposits. These plants are used either free-floating (rootless aquatic plant!) or in taller aquaria planted in groups in the soil, but in that case should be regrouped every week because of their rapid growth. Optimum temperature ranges from 24 to 29 °C. This hornwort produces winter buds in the aquarium. **Ecology:** This variety of hornwort was found by the author in July 1997 on the east coast of Mexico, where it was used in large amounts (probably) as food for consumption fish (*Tilapia*). A water analysis of Lake Catemaco provided the following results: water temperature on the surface 26.3 °C, pH 8.2, GH 3 °dH, KH 4 °dH, 140 µS/cm.

Ceratophyllum demersum “red-stemmed.”



Male inflorescences of *C. demersum*.



Cladophora aegagrophila

(L.) Rabenhorst (1868)

Family: Cladophoraceae.**Synonyms:** *Conferva aegagrophila* Linné (1753), *Cladophora sauteri* Nees, and many others.**Etymology:** *Cladophora*: from klados (Gr.) = branch, phora (Gr.) = the bearing, branch bearer; *aegagrophila*: from aigagros (Gr.) = goat, pilos (Gr.) = hair (supposedly referring to hairballs found in the stomach of moulting, wild goats).**Distribution:** Central and eastern Europe, eastern Asia (Japan? North America?).**Description:** Green algae. Thallus (plant body) consisting of an up to 3-cm long, dense row of cells, densely branched. A great number of closely grouped single plants, due to radiate branching, form globular dark green balls (sometimes also clumps or cushions), which can reach up to 21 cm in diameter. Of all *Cladophora* species, *C. aegagrophila* forms the longest single plants and the biggest balls.**Culture:** Lately, large numbers of lake balls of *Cladophora aegagrophila* from Romania and Russia with diameters up to 13 cm have

shown up in pet shops. According to the author's experience these algae balls, which have been mentioned often in legends and folktales, survive well in aquaria and make an unusual and long-lasting decoration as long as the following conditions are kept in mind: water temperature at most 24 °C, preferably a bit cooler, low to medium light intensity (shade-preferring species), slow water movement, soft to hard water with pH >7. Growth of the lake balls is extremely low and noticeable only under optimal conditions. In case of strong humus accumulation, the balls can easily be washed out; after putting them back in the aquarium, they will fill with water again and sink to the bottom within a few hours.

Ecology: *Cladophora aegagrophila* inhabits the bottom of lakes as flat pillows or floating balls and can be found in shallow water and, depending on the water movement, in water up to 25(35) m deep. In a gentle stream, the balls roll back and forth and in this way are illuminated equally on all sides. Attachment to a solid underground has been observed only every now and then. The lake balls usually live in clear, eutrophic, alkaline water. They need a certain amount of organic nutrients and, above muddy lake bottoms, reach the size of a human head. In its native habitats, heavy assimilation activity was noticed under already low light conditions as they were drifting up to the surface. *Cladophora aegagrophila* can survive very low temperatures; furthermore, it tolerates salt levels of 5–6%. Extremely big and dense algae balls become hollow due to the shortage of light and dying of the thalli inside. Vegetative multiplication takes place by cell division and dissolving or decay of single plants (fragmentation). The growth percentage of this green algae is very low: yearly cellular growth is 5–10 mm, which means 20–21-cm large balls are 14–16 years old! (van den Hoek 1963).

Algae balls as decoration.

Cryptocoryne annamica

Serebryanyi (1991)

Family: Araceae.

Synonyms: None.

Etymology: *Cryptocoryne*: see *C. affinis*; *annamica*: referring to the district of Annam, where this species is found.

Distribution: Central Vietnam (province of Quang Nam Da Nang).

Description: Marsh plant, up to 10 cm high. Leaves 2–4(–5.5) cm petiolate, sheath wide, reddish. Blade broadly lanceolate, acute, base clearly cordate, about 7 cm long and 3 cm wide, upperside light green, dark green or brownish, underside dark red. Sometimes the leaf blade is somewhat bullate. Spathe 4–5 cm long. Tube less than 1 cm long. Limb up to 2.5 cm long, cuspidate, spirally twisted once, rough and cherry red outside, strongly wrinkled and bright yellow inside. Throat red. Collar absent. Female flowers 6. Male flowers over 50. Fruit and seeds unknown. Chromosome number $2n = 34$.

Culture: The emersed culture of *C. annamica* is successful on a substrate of peat or an acid, mineral soil mixture. Nothing is known about its successful culture in the aquarium.

Ecology: No ecological data on *C. annamica* is known, not even from the only known natural habitat.

Other: The Russian herpetologist N. Orlov from St. Petersburg was the first to collect this plant in the mid-1980s. Additional collections are, however, necessary in order to study the intraspecific variation of this species. Color and shape of the limb of *Cryptocoryne annamica* resemble those of *Cryptocoryne usteriana*. The collection by Clemens in 1927, on which the first description of *Cryptocoryne annamica* is based as a paratype, can probably be assigned to *Cryptocoryne vietnamensis* (see below).

Literature: Serebryanyi (1991).

Cryptocoryne annamica in emersed culture with inflorescence.



Cryptocoryne vietnamensis

Hertel and Mühlberg (1994)

Family: Araceae.**Synonyms:** None.**Etymology:** *Cryptocoryne*: see *C. affinis*; *vietnamensis*: from Vietnam.**Distribution:** Central Vietnam (province of Quang Nam Da Nang).**Description:** Marsh plant, up to 30 cm high. Rhizome up to 6 cm long, 0.7–1 cm thick. Leaves 3–15 cm petiolate. Blade narrowly lanceolate to lanceolate, base cordate, 4–14 cm long, 1.5–5 cm wide, margin flat or finely crisped, both sides grass green and flat when emersed, submersed more brownish and somewhat bullate. Spathe up to 1.5 cm pedunculate, 3.5–4 cm long. Tube about 1 cm long, white and more or less reddish. Limb 1.5–2 cm long, cuspidate, usually curved diagonally over the throat, brownish to gray outside, deep purple inside, throat shining. A distinct collar is lacking. Female flowers 5–7. Male flowers about 40. Chromosome number $2n = 34$.**Culture:** In the aquarium, *C. vietnamensis* grows slowly and is hardly satisfying. An attempt by the author to grow this species in

medium-hard water only resulted in small-leaved specimens. Water analyses of the natural habitat can be of great help for successful cultivation. Emersed culture and propagation succeeds well on an acid, mineral soil mixture.

Ecology: This species was collected for the first time in 1927 by the Clemens couple on Mount Bana in the coastal mountain range 25 km from Da Nang. Due to incomplete herbarium material (without flowers), it has been a mystery as to what species this collection could be assigned. *Cryptocoryne vietnamensis* was collected again and imported by Hertel and Mühlberg in 1991, 24–25 km west of Da Nang in a ford and on the banks of the “Big Ba-Na-River.” In May, sterile *Cryptocorynes* grew partly emersed and partly submersed on riverbanks in the half-shade of thickets. J. Bogner found flowering specimens in March 1997 in both sandy-stony soil between granite rocks and in sand along the riverbank.**Literature:** Hertel and Mühlberg (1994).***Cryptocoryne vietnamensis* in emersed culture.****Inflorescence of *C. vietnamensis*.**

New *Echinodorus* Cultivars

ECHINODORUS 'APART'

(see page 231)

This cultivar originated at aquatic plant nursery Hans Barth, Dessau, from a cross between *E. uruguayensis* (synonym *E. horemanii* "red"), and *E. portoalegrensis*. *Echinodorus* 'Apart' has been cultivated in aquaria since 1994. Submersed, this hybrid develops a habit similar to *E. portoalegrensis*, but will become considerably larger under identical growing conditions. It builds rosettes up to 30 cm in diameter and about 15 cm high. Petioles up to 7 cm. Leaves narrowly elliptic, coriaceous and stiff, 10 to 12 cm long and 3 to 4 cm wide. Differing from *E. portoalegrensis*, the young leaves are more or less brownish, becoming dark green with age. Also striking is the slightly undulate margin. Culture recommen-

dations: a nutrient-rich soil, medium strength lighting as well as temperatures between 22 and 29 °C. The cultivar name 'Apart' refers in general to the plant habit. With *Echinodorus* 'Apart', the breeder succeeded in developing a cultivar which forms a considerable contribution to the protection of nature and species. Due to its rapid and uncomplicated growth and its similar appearance in the aquarium, this cultivar replaces *E. portoalegrensis* and *E. opacus*, which are highly endangered in their natural habitats. Therefore, it is advisable that *Echinodorus* 'Apart' be propagated in large amounts by in vitro culture, so that this beautiful cultivar will be preserved.

ECHINODORUS 'DSCHUNGELSTAR'

In the early 1990s in Julius Hoechstetter Nursery, Trostberg, many beautiful hybrids

Echinodorus 'Dschungelstar' No. 16.



originated from targeted hybridization experiments, some of which have been propagated and traded by aquatic plant nursery Dennerle, Vinningen. The recommendable hybrids are presented below.

A 40–50-cm high cultivar is traded under the name ‘Dschungelstar’ No. 1, which strongly resembles *Echinodorus uruguayensis* (syn. *E. horemanii* “red”) in appearance, but differs in having deep red, almost black leaf coloring and a clearly dentate and strongly undulate margin. The petiole grows to 25 cm long; leaf blades are coriaceous and reach sizes up to 30×4 cm. Since this relatively slow-growing cultivar forms a few-leaved rosette in the aquarium, it is recommended to plant at least two plants together.

The plant traded by aquatic plant nursery Dennerle under the name ‘Dschungelstar’ No. 3 is extremely decorative and well growing. This recommendable cultivar reaches

sizes of 10–20 cm high in the aquarium and consequently is fit for the front section of larger aquaria. Distinctive features of the submersed plants are the narrowly elliptic, about 10–15-cm long and 2.5–3.5-cm wide, olive green leaf blades, showing a dark red, irregular variegated pattern (similar to *E. schlueteri* ‘Leopard’). Under intense lighting the young leaves are brownish red as well. Emerged plants form compact rosettes of bright green, faintly red-dotted leaves, of which the margin is slightly undulate.

The cultivar ‘Dschungelstar’ No. 16 refers to a magnificent hybrid, reaching a height of 50–60 cm in the aquarium and building a dense rosette of deep dark red, almost black, narrowly elliptic, coriaceous leaves. Leaf blades reach sizes of $25\text{--}35 \times 6\text{--}7$ cm, petioles 10–25 cm. When grown on a nutrient-rich soil and under intense lighting, numerous leaves are produced rapidly. Shape and color-

Echinodorus ‘Dschungelstar’ No. 3.



ing of this hybrid remind us of *Echinodorus* 'Rubin', from which it can easily be distinguished by its only slightly protruding longitudinal veins.

***ECHINODORUS* 'GROßER BÄR'**

Under the name *Echinodorus* 'Großer Bär', aquatic plant nursery Dennerle trades a hybrid which, when emersed, produces middle to dark olive green, ovate, acute or obtuse at the top, basely obtuse or slightly cordate leaf blades. A striking feature of the emersed plants is the red veins. A dense rosette of narrowly lanceolate, short petiolate leaves is formed under water; the submersed leaves are also deep dark red. The florist of this recommendable fast-growing cultivar is Hoechstetter.



Echinodorus 'Indian Red'.

***ECHINODORUS* 'INDIAN RED'**

According to the breeder, Hans Barth, the cultivar 'Indian Red' is a hybrid between *Echinodorus aschersonianus* and *E. uruguayensis* (syn. *E. horemanii* "red"). This cultivar has been available in pet shops since 1998. Emersed plants produce short petiolate, ovate, obtuse, at the base somewhat cordate, medium green leaves. Depending on the light intensity in the aquarium, the leaves are bright red brown to dark red under high illumination and green under poor illumination. The cultivar name refers to the color of the submersed leaves. The tops of the submersed leaf blades are faintly twisted; another distinctive feature of this decorative cultivar is the faintly undulate leaf margin. The submersed leaves are narrowly elliptic and reach sizes up to 20 × 4 cm. With a height of 10–20 cm, the cultivar "Indian Red" is suitable for planting in smaller aquaria. It resembles the hybrid *Echinodorus* × *barthii*, but its leaf blades are not recurved.

***ECHINODORUS* 'KLEINER BÄR'**

(see page 230)

This extremely recommendable cultivar originated in the early 1990s in the aquatic plant nursery Julius Hoechstetter, Trostberg, from hybridization experiments and has been propagated for trade by aquatic plant nursery Dennerle. According to the florist's information, *E.* 'Kleiner Bär' is a hybrid of *E. parviflorus*, *E.* × *barthii*, and *E. uruguayensis* (syn. *E. horemanii* "red"). Of the numerous hybrids *Echinodorus* 'Kleiner Bär' is one of the most beautiful and recommendable cultivars, because it combines fancy appearance and rapid growth in almost perfect balance. Furthermore, it clearly distinguishes itself from other *Echinodorus* cultivars by habit, coloring, and maximum height, thus forming a remarkable enrichment to aquarium flora. In submersed culture, *Echinodorus* 'Kleiner Bär' forms a compact, average-sized rosette of rusty red to

deep dark red leaves, the color fades to greenish with age or under poor light. Full-grown specimens reach up to 15–25 cm high and almost the same size in diameter. The petiole is 5–10 cm long; the elliptic leaf blades are 10–15 cm long and 4–7 cm wide. The top is obtusely rounded, the base round. The venation, consisting of 3–5 veins, does not differ in color from the leaves. Intense lighting for the development of intense colors, as well as a nutrient-rich soil and temperatures of 22–30 °C are recommended for successful cultivation of *Echinodorus* 'Kleiner Bär' in the aquarium. Culture succeeds in soft, slightly acid water as well as in an extremely hard, alkaline environment without additional carbon dioxide fertilization. Under good growing conditions in the aquarium, *Echinodorus* 'Kleiner Bär' regularly builds inflorescences with a small number (2–3) of adventitious plants each.

***ECHINODORUS* 'ORIENTAL'**

(see page 230)

Echinodorus 'Oriental', in culture since 1994, is said to be a spontaneous mutation which appeared during the in vitro culture of *Echinodorus* 'Rosé' in the aquatic plant nursery Oriental Aquarium Singapore. Hence, the cultivar name refers to the company's name. Indeed, the leaves of *E.* 'Oriental' show a certain similarity to those of *E.* 'Rosé', although *E.* 'Oriental' remains much smaller in height and diameter, and growth is significantly slower as well. The petiole is only a few cm long; the very narrowly ovate and acute leaf blades are 8–12 cm long and 2–3 cm wide. In the aquarium, *E.* 'Oriental' forms a compact rosette, the young and faintly transparent leaves of which are vivid pink. The reddish color, however, changes to bright olive green with age. Besides the color, the slightly pronounced venation and undulate margin grant this cultivar its distinct habit. Reaching up to 15 cm high, this cultivar is of much use only in the aquarium's front section

and is especially recommendable for small aquaria. Worth mentioning are the bracts produced on the inflorescences. These are 5–10 cm long and extremely narrow. The flowers do not open under water and decay. Also in the aquarium more or less horizontally-growing inflorescences are produced, with only a small number of adventitious plants, however.

***ECHINODORUS* 'OZELOT'**

(see page 231)

This cultivar from the nursery of Hans Barth has been known since 1995. It originated from the hybridization of *E. schlueteri* 'Leopard' with *E. × barthii*. The cultivar name 'Ozelot' refers to the spotted pattern on the leaf blades, which from a distance reminds one of the pattern on this American feline. The vitality of this beautiful cultivar is striking. New leaves are produced in quick succession, first brownish red with dark red spots, later fading to dark olive green with dark red spots. The difference from the color-spotted form of *E.* 'Rosé', which closely resembles this cultivar, is that the spots of *E.* 'Ozelot' are larger and more numerous. Also, *E.* 'Ozelot' produces a slightly smaller rosette of more erect leaves, while the leaves of *E.* 'Rosé' grow more horizontally in a loose rosette. The short petiole, narrowly elliptic leaf blades (10–15 cm long and 3–4 cm wide) give *E.* 'Ozelot' a maximum height of about 20 cm. Vegetative propagation by rhizome cutting or adventitious plants on inflorescences is uncommon in the aquarium. In vitro culture has proved effective for commercial trade propagation.

***ECHINODORUS* 'OZELOT GRÜN'**

This cultivar has been commercially available since the end of 1998. It differs from the typical *E.* 'Ozelot' only in the coloring of the leaves, which are vivid light green with brown spots. The young leaves will, however, show a reddish basic color under intense lighting



Echinodorus 'Ozelot Grün'.

and under strip lights with a relatively large proportion in the red wavelength.

Echinodorus 'Red Flame'.

***ECHINODORUS* 'RED FLAME'**

This cultivar has been grown since the end of 1998 in aquaria and originated from the aquatic plant nursery of H. Barth. According to Barth's indications, it was selected from a population of *E. 'Ozelot'*. One substantial difference with *Echinodorus 'Ozelot'* is that *E. 'Red Flame'* has more intense spots, hence the cultivar name 'Red Flame'. Submersed leaves show a pattern of contracted dark red spots on a bright brown-red basic color, which gives the cultivar a definite fancy appearance. An up to 30-cm high, dense rosette is formed in the aquarium. The petiole grows up to 10 cm in length; the leaves reach sizes up to 20 × 10 cm. *Echinodorus 'Red Flame'* is a very recommendable cultivar of high decorative value.



Egleria fluctuans

Eiten (1964)

Family: Cyperaceae.**Synonyms:** None.**Etymology:** *Egléria*: after W.A. Egler, manager of the Goeldi Museum in Belem (Brazil), Pará; *fluctuans*: floating.**Distribution:** Brazil, Venezuela.**Description:** Finely segmented aquatic plant with erect or floating, few-branched, thin shoots rooting in the soil. The hair-like, 3–7-cm long, light green culms are positioned in 15–25-merous clusters, alternating along the shoot and basely surrounded by a scale-like sheath. The inflorescence consists of one or more verticillate spikes. Spikes up to 15 cm long pedunculate, linear, 7–10 mm long, 1.0–1.5 mm thick, many-flowered (12–15 flowers). Flowers bisexual, all fertile (in contrast to *Eleocharis*). Glumes almost oblong, obtuse. Flowers with 3 stamens, one 5-mm long style and 3 strap-shaped stigmas. Perigone bristles persistent and forming barbs. Nutlet compressed triangular, about 1 mm large, with persistent, cylindrical style foot (after Eiten 1964).**Culture:** So far, *Egleria fluctuans* has been

imported by aquarists only a few times. Unfortunately, the culture of this delicate aquatic plant has so far succeeded only temporarily in very soft and mineral-poor water. An import of this unusual plant would be desirable.

Ecology: Although *E. fluctuans* has a wider distribution than previously assumed, little is known about its natural habitats. The first plants were found by A. Ducke in 1912 in Brazil in a tributary of Lago Supucua (state Pará), where it formed dense floating populations. In 1935, Ducke discovered the species a second time in Brazil (Amazonas state) in a big tributary of Lake José-Assú. Van der Vlugt (1984) found the species in 1973–1974 in the Gran Sabana (Venezuela) in the soft salt-poor water of the Rio Morocco, which flows into the black-water river Carrao. During the dry season in March, the water level was 10–20 cm. During the wet season in October, the plants grew at temperatures of 27–28 °C in mostly sandy soil together with other *Cyperaceae* (e.g. *Websteria confervoides*). The author collected *E. fluctuans* in March 1994 in eastern Brazil in the state of Maranhão, 11 km west of Caxias City, in a lake-like, overgrown swampland in the Rio Itapicuru basin. Besides *E. fluctuans*, submersed populations of *Bacopa reflexa*, *Echinodorus bolivianus* as well as two *Eleocharis* species also grew in the slow-moving water. In this habitat the soil consisted of loamy sand on which humus was deposited. Water analyses resulted in the following data: temperature 32 °C, pH 5.1, GH/KH < 1 °dH, 0–10 µS/cm.

Other: The genus *Egleria* is monotypic (containing only one species). The clustered and alternate positioning of the culms is typical for *E. fluctuans*. Dispersal of the plants probably occurs by the fruits; the barbs hook onto the fur of animals.

***Egleria fluctuans*.**

Eleocharis pusilla

R. Brown (1810)

Family: Cyperaceae.

Synonyms: *Scirpus pumilio* Sprengel.

Etymology: *Eleocharis*: see *E. acicularis*; *pusilla*: very small.

Distribution: Australia, New Zealand.

Description: It differs from *E. acicularis* in the following features: Culms up to 10 cm long. Spikelet few-flowered. Perigone bristles few or lacking, much shorter than the nutlet. Nutlet narrowly obovoid, about 1×0.5 mm large, weakly triangular, ribbed, knobby.

Culture: *Eleocharis pusilla* is a mat-forming, small plant for the aquarium's foreground. The few experiences in culture so far show that *E. pusilla*—like *E. acicularis*—does not tolerate long-lasting high temperatures above 25 °C. This species can also be cultivated with good success in medium-hard water. A soil of coarse sand is the best for this plant; the fragile culms do not present any problems and the thin rhizomes can branch freely. *Eleocharis pusilla* flowers easily above water. Keeping the plant in a garden pool during summer is recommended.

Ecology: This species inhabits wet habitats

where it flowers from December until April.

Other: The species was imported from Australia by Tropica Aquarium Plants and has been in trade occasionally since 1997. For a reliable distinction from *E. acicularis*, flowering and fruiting specimens are needed.

HYGROPHILA CORYMBOSA**“KOMPAKT”**

(see page 314)

This form of *Hygrophila corymbosa* supposedly originated via selection by the Dutch Aqua Flora Nursery. It distinguishes itself by a very slow growth as well as extremely short internodes. When taller, the shoots lose their lower leaves. Compact shoots are formed by the strong vegetative branching, which reminds us of Bonsai culture. The picture shows a 2-year-old shoot in the aquarium.

Eleocharis pusilla.



Hygrophila corymbosa “Kompakt.”



Lilaeopsis mauritiana

G. Petersen and Affolter (1999)

Family: Apiaceae.

Synonyms: None.

Etymology: *Lilaeopsis*: see *L. brasiliensis*; *mauritiana*: from the island of Mauritius.

Distribution: Mauritius.

Description: Grass-like marsh plant with creeping, branched, thin rhizomes, up to 13 cm high. Each node with 1–3(–4) leaves. Leaves erect, entire, glabrous, hollow, round to elliptic in cross-section, linear near the top spatulate and flatter, 6–13 cm long (submersed up to 9 cm), 0.4–1.3 cm wide, with 4–9 longitudinal veins. Inflorescence an axillary, 6–26-cm long umbel with 3–6 short pedicellate flowers. Bracts 0.4–2.0 mm long. Flowers bisexual, 5-merous. Petals greenish. Fruit globular to ellipsoid or obovoid, with 6–8 distinct rounded ribs.

Culture: *Lilaeopsis mauritiana* is imported by Tropica Aquarium Plants and has been part of the regularly commercially available aquarium plant stock since 1995. It is a mat-forming, undemanding plant for the aquarium's foreground, and has—like the other *Lilaeopsis* species used for aquaria—a con-

stant but very slow growth. A satisfying growth occurs under medium-strength lighting, in soft to medium-hard water, pH 6.5–7.5, and temperatures between 23 and 28 °C. Sand should be used as a substrate, in which the planting and branching of the fragile rhizomes is easier.

Ecology: H. Windeløv and M. Yeung collected this new species in March 1992 in Le Val Nature Park (near Le Val) in the southeastern part of the island of Mauritius. During the dry season, the plants grow in sandy-stony soil, emerged on the riverbanks as well as in shallow places completely submersed in slow-moving water.

Other: So far, the distribution of the genus *Lilaeopsis* has been confined to America, Australia, and New Zealand. The discovery of *L. mauritiana* near Africa is, therefore, of great interest (Gondwanaland).

Literature: G. Petersen and Affolter (1999).

***Lilaeopsis mauritiana*.**



Limnophila aromaticoides

Yang and Yen (1997)

Family: Scrophulariaceae.

Synonyms: none.

Etymology: *Limnophila*: see *L. aquatica*; *aromaticoides*: like *L. aromatica*.

Distribution: Taiwan, Japan?

Description: Variable marsh plant, strongly aromatic. Shoot decumbent to erect, up to 40 cm long, 3 mm thick, branched, round, glabrous. Emerged leaves decussate, sometimes in trimerous whorls, sessile; leaf blade lanceolate, 3–5 cm long, 1–2 cm wide, acute, with a long decurrent base, margin clearly toothed, dark green above, stem and lower side also somewhat dark red. Submersed leaves in 3–8-merous whorls, narrowly lanceolate, cuspidate, 3–4 cm long, 0.3–0.8 cm wide, denticulate, light green. Flowers solitary, axillary or in terminal racemes; petioles up to 1.5 cm long. Bracts up to 2 mm long. Calyx 5-lobed, about 6 mm long, slightly glandular. Corolla bilabiate, 5–10 mm long, outside slightly, inside roughly pubescent, white or rarely with pink margins; 2 short and 2 longer stamens. Capsule globular (ellipsoid?), 5 mm large. Chromosome number $2n = 68$.

Culture: *Limnophila aromaticoides* is a demanding aquatic plant, which grows best when placed in an unshaded well-illuminated site in the aquarium. Good culture results have been achieved in medium-hard water. An important condition for satisfactory growth of the shoots is the availability of ample free carbon dioxide (additional carbon dioxide fertilization). With an alkaline pH-value, growth stops quite soon. This species is very tolerant to temperature; temperatures between 20 and 30 °C are endured in the aquarium, the optimum lies between 24 and 26 °C; emerged shoots can hibernate. The graceful habit of *L. aromaticoides* will stand out well only in a more or less larger group. Propagation by side shoots is easy. In emerged

culture, which is easy on wet soil, the plants look completely different; they flower abundantly in the summer.

Ecology: This species can be found in pools, rice fields, and marshes. Other ecological information is not known.

Other: The most important distinguishing features to *L. aromatica* are the submersed leaves, being verticillate in *L. aromaticoides*, the white flowers (corolla tubes can have pink edges), and globular fruits. According to contradictory data in the first description, these data are partially unreliable. For the past few years, bluish violet flowering plants are also in trade. These plants form verticillate leaves in the aquarium and probably belong to *L. aromaticoides*. *Limnophila aromaticoides* can easily be mistaken for the meager shoots of *Eusteralis stellata*. A good distinguishing feature is the always lilac-colored leaf base of *Eusteralis*, forming good visible rings on the nodes.

Literature: van der Vlugt (1996), Yang and Yen (1997).

***Limnophila aromaticoides*.**

***Marsilea* sp.**

A. Braun (1870)

Family: Marsileaceae.

Synonyms: None.

Etymology: *Marsilea*: after the Italian botanist G. Marsili, 18th century.

Distribution: Australia.

Description: Amphibious fern with creeping, branched stem axis, rooting on all nodes, glabrous or sparsely pubescent, 0.5 mm thick. Emerged leaves with petioles up to 12 cm long, leaf blade 4-foliolate, each 1–2 cm in diameter. Leaf segments entire, deltoid-cuneate, top rounded, soft, medium green. Submersed leaves very variable, short-petiole, entire, sometimes 2–3-parted, often hard and brittle, medium to dark green. Fruiting pedicel shorter than the fruit. Sporocarps solitary, bean-shaped, 3 mm long, 2.5 mm wide, 2 mm thick, more or less strongly pubescent, top rounded with 2 equally large teeth.

Culture: *Marsilea* sp. has been in culture for some decades, but almost completely disappeared in the 1980s. For the past few years, this species has again become popular and is marketed in pet shops under the name *M. crenata* or *M. exarata*. This is a creeping,

only a few cm-high plant for the aquarium's foreground, which grows slowly but is generally not difficult to keep. Newly planted shoots need a long period of acclimatization. *Marsilea* sp. can be kept in both soft as well as hard, slightly acid to slightly alkaline water under low to medium-strength lighting and at temperatures of 20–26 °C; long-lasting higher temperatures harm the plant's growth. Floating leaves are not formed in the aquarium. Dead parts of the plants should be removed regularly.

Other: The species described here has not yet been clearly identified. According to studies by the author, the fruit characteristics do not point to *M. crenata* or *M. exarata*. Sometimes, *M. hirsuta*, *M. quadrifolia*, and *M. drummondii* are cultivated semiaquatically.

***Marsilea* sp.**

Myriophyllum ussuriense

(Regel) Maximowicz (1874)

Family: Haloragaceae.

Synonyms: *Myriophyllum verticillatum* Linné var. *ussuriense* Regel (1861).

Etymology: *Myriophyllum*: see *M. aquaticum*; *ussuriense*: from the Ussuri River (eastern Asia).

Distribution: Japan, Eastern Asia (Manchuria).

Description: Submersed shoots over 1 m long, branched, medium green. Submersed leaves in 4-merous whorls, 2–3.5 cm long, 1.5–2.0 cm wide, imparipinnate with 5–12 filiform segments on each side. Emerged leaves pinnate, with shorter and wider segments than the submersed ones. Winter buds 0.5–1.5 cm long, cylindrical. Plants monoecious. Inflorescence erect above the water surface, about 20 cm long, with 15–20 whorls of flowers. The lower whorls contain some female flowers, followed by the middle whorls with a few bisexual flowers and on top of the shoot are the numerous male flowers. Bracts comb-like pinnate, 0.5–1.5 cm long; 2 prophylls, 0.6 mm large, irregularly toothed. Male flower: calyx 2 mm long, green; 4 calyx-lobes, 0.7 mm long, deltoid acute; 4 petals, narrowly oblanceolate, 3.5 × 1.2 mm large, white, top rounded; 8 stamens; filament 0.5 mm, anther 2 mm long; pollen yellow. Female flower: petals absent; 4 white pubescent stigmas. Fruit not seen.

Culture: Of all *Myriophyllum* species, *Myriophyllum ussuriense* is the easiest to keep in the aquarium. It combines a decorative appearance and optimal growth. Culture succeeds without any problems in medium-hard to hard water with pH-values of 6–8. According to the author's experiences, extreme high temperatures up to 32 °C are tolerated. The cultivated plants are probably hardy, so long-lasting growth in a garden pool is possible. Low to medium-strength lighting is sufficient, but the shoots become more vigorous and compact in well-illuminated aquaria. Winter buds which do not fall are observed

from time to time in the aquarium. Unfortunately, this very recommendable and beautiful *Myriophyllum* is cultivated only by special hobby clubs (Aqua-Planta); as it grows poorly emerged, this plant is of little value to aquatic plant nurseries.

Ecology: According to Wendt (1952–55), *M. ussuriense* inhabits the banks of rivers, lakes, and others types of waterways. There in the shallow water, the shoots reach up to 5–20 cm high and produce only emerged leaves, no submersed leaves.

Other: *Myriophyllum ussuriense* was already being imported in 1907. According to Wendt's information, in those days the cultivated plants dropped their leaves when emerged shoots were formed, and with temperatures above 10 °C. Apparently this species disappeared from culture again. A renewed import by Dennerle Nurseries took place in 1992. The plants described here do not show the growing behavior seen in the early days. *Myriophyllum ussuriense* rarely flowers, therefore it took the author several years to identify the species. A distinction from the very similar species *M. verticillatum* is easy because of the 4-merous leaf whorls of *M. ussuriense*.



***Nuphar japonica* de Candolle
var. *rubrotincta* (Caspary) Ohwi**

Description: See page 380.

Culture: In the beginning of this century, *N. japonica* var. *rubrotincta* was already being cultivated as an ornamental plant and, because of its strong red-brown-colored leaves, was named “red” *Nuphar*. In the last few years, *Nuphar japonica* var. *rubrotincta* has been occasionally available at pet shops. It is a cultivar and more demanding than the original form. The high demand for light should be especially noted, or the red-brown color will switch to olive green. The plant grows satisfyingly in both soft and hard water at pH-values between 6 and 8. The optimum temperature range is 24–28 °C. This variety, which is known only from cultivation, can be easily grown emersed where it propagates vegetatively by branching of the rhizome. *Nuphar japonica* var. *rubrotincta* rarely flowers in the garden pool. It is winter-hardy (Kasselmann 1997).

***Nymphaea micrantha*
Guillemin and Perrottet (1830)**

Description: Like *N. micrantha* (see page 386), although differing in the following features: submersed leaves not bigger than 7–10 cm in diameter, bright green with intense red-brown spots.

Culture: This demanding, rare color form has been occasionally imported in recent years from West Africa. It can be distinguished from the cultivated form by the pattern of brown-red spots on a light green background. According to the author's experiences, average to high light intensities, temperatures of 23–28 °C, nutrient-rich soil (loam) as well as medium-hard water with pH-values between 6.5 and 8 form good growing conditions. This color form reacts negatively to high doses of micronutrient fertilizer. Propagation is by adventitious plants at the base of submersed leaves.

Ecology: Nothing is known about the exact origin and natural habitat.

Nuphar japonica var. *rubrotincta*.



Spotted form of *N. micrantha*.



***Nymphoides* sp. “Taiwan”**

Family: Menyanthaceae.

Synonyms: Unknown.

Etymology: *Nymphoides*: see *N. aquatica*.

Distribution: Taiwan (other distribution unknown).

Description: Perennial plant. Rhizome short. Long shoots up to 60 cm. Petiole 2–4 cm long. Submersed leaves reniform, basal lobes round, 5–10 cm large, shiny light green above, whitish green below. Floating leaves and flowers are not yet observed in culture.

Culture: *Nymphoides* sp. “Taiwan” is an unproblematic, very recommendable, fast-growing aquarium plant. In contrast to other *Nymphoides* species, this still unidentified species does not build floating leaves in the aquarium, only decorative submersed leaves. Under good growing conditions, leaves reach up to the surface very fast, but do not change their appearance. Shoots that have become too long should be removed if the adult leaves are to remain short petiolate. *Nymphoides* sp. “Taiwan” is undemanding with regard to water conditions and thrives in both soft, acid water and in hard, alkaline environments. This species has a high tolerance to tempera-

ture (between 18 and 32 °C) and becomes the most fancy in well-aerated aquaria. Vegetative propagation is easy and productive: strong leaves form a few cm below the leaf-base side shoots. Also, single leaves can be cut off and placed in substrate where they will root and produce a new shoot.

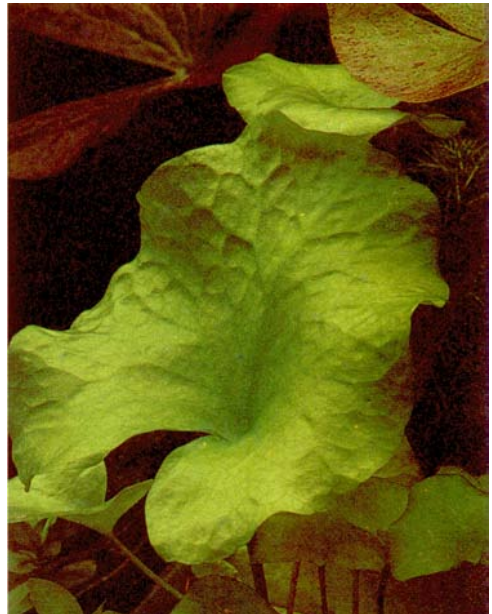
Ecology: Nothing is known about the natural habitat of this plant.

Other: Although the author has been cultivating *Nymphoides* sp. “Taiwan” for several years, surface-floating leaves, so characteristic for this genus, have never been produced. Also, specimens cultivated in shallow water produced neither floating leaves nor the flowers needed for identification. *Nymphoides* sp. “Taiwan” was imported from Taiwan around 1994 by Aquatic Plant Nursery Dennerle. Trade followed under the name *Nymphoides* sp. “Flipper.”

Nymphoides sp. “Taiwan.”



Aquatic leaf of *Nymphoides* sp. “Taiwan.”



Ottelia ulvifolia

Description: Differs from *Ottelia ulvifolia* (p. 400) by the following vegetative features: plant up to 75 cm high. Petioles 10–30 cm long. Leaf blade 30–45 cm long, 6–10 cm wide, margin undulate, light green with more or less pronounced pattern of brown-red spots and stripes, especially intense near the margins.

Culture: This aquaristically new form of *O. ulvifolia* is fast-growing and recommended for culture in the aquarium. Medium to high lighting intensities, nutrient-rich substrate, soft to medium-hard, somewhat acid water as well as temperatures of about 25 °C are the proper conditions for this species. This easily breakable solitary plant works well as a beautiful eye-catcher, especially in large and high aquaria (55 cm high or more). It flowers and fruits easily. Propagation is by division of the rhizome or by seeds. It has been available since 1994 from aquatic plant nursery H. Barth, Dessau.

Other: The origin of this form is unknown. The identification was carried out by J.-J. Symoens.

Polygonum sp.

Family: Polygonaceae.

Synonyms: Unknown.

Etymology: *Polygonum*: from polys (Gr.) = many, gony (Gr.) = nodes (stem with leaf nodes).

Distribution: Unknown.

Description: Marsh plant; shoots rooting in substrate or in water, branching, erect (also floating?). Leaves alternate, up to 2 mm petiolate. Leaf blade entire, narrowly lanceolate, up to 10 cm long, 2 cm wide, glabrous, emerged bright green with a faint dark spot in the middle of the leaf blade, submersed strong red-brown. Nodes thickened. Ochrea (stipular tube) up to 1 cm long, transparent, dark red, bristly pubescent, the top with fringes up to 5 mm long. Peduncle branched. Inflorescence an up to 2.5 cm long, cylindrical pseudo-raceme. Single flowers bisexual, 1.5–2 mm large; 5 white tepals; 5 stamens; 2 carpels. The fruit is lenticular, somewhat thickened in the middle, dark brown, about 1 mm large.

Culture: Of the approximately 20 aquatic *Polygonum* species, the as yet unidentified knotweed described here is the first suited for

Color form of *O. ulvifolia*.



Polygonum sp.



cultivation in the aquarium. Basically, this is a demanding species which forms the recognizable red-brown leaves (see picture) only under intense lighting. Experiences so far with the culture show that this *Polygonum* sp. can grow satisfactory in both soft as well as medium-hard water. The most important condition for successful culture is sufficient free carbon dioxide (additional carbon dioxide fertilization). The species does not tolerate alkaline pH-values. The optimum temperature range is 23–27 °C. For a very decorative effect, use small groups of 3–5 shoots in the middle section of the aquarium. Propagation is by end cuttings or side shoots. Emersed culture is easy under humid air and warm conditions.

Ecology: *Polygonum* sp. roots in the banks of stagnant or slow-moving water and, from there, forms floating mats into open water. Due to the high plasticity of the described species to life under water, we can assume that it can temporarily grow completely submerged in its natural habitat.

Other: *Polygonum* sp. was introduced to Europe by aquatic plant nursery Oriental Aquarium Singapore and has been traded by the

Danish company Tropica Aquarium Plants since 1998. Identification of this new species has not been carried out so far because, on the one hand, its natural distribution is unknown and, on the other, in a monograph of the ca. 150 species and counting, the cosmopolitan genus is absent.

Ranunculus limosella

Kirk (1871)

Family: Ranunculaceae.

Synonyms: *Ranunculus limoselloides* Hooker fil., non Turczaninow.

Etymology: *Ranunculus*: diminutive of the Latin rana = frog; *limosella*: from the genus *Limosella* (limosus = marshy)

Distribution: New Zealand.

Description: Grass-like marsh plant with creeping, branched, thin shoots, rooting at all nodes. Each node with 1 or 2 leaves. Petioles 3–5 cm long, erect. Leaf blade entire, glabrous, flat, linear, towards the apex narrowly spatulate, 1 cm long, 2–4 mm wide, without transversal veins. Flowers bisexual, 4-merous,

***Ranunculus limosella* in emersed culture.**



about 5 mm large, inconspicuous, up to 2 cm long petiolate; 4 sepals, ovate, thin, glabrous; 4 petals, narrowly linear, recurved, surpassing the sepals, faintly reddish; 1 carpel; 8–12 stamens. Achene ovoid, approximately 1 mm long, beaked.

Culture: In its natural habitat, *Ranunculus limosella* not only grows as a marsh plant, but can also be found completely submersed in water up to 1 m deep. Nevertheless, a satisfactory culture in the aquarium has rarely occurred. Additional data of the biotope may give us directions for successful culture.

Ecology: *Ranunculus limosella* grows on the banks of marshes, lakes, and rivers, often submersed, on a sandy soil or in the mud.

Other: This fragile marsh plant has been imported from New Zealand since 1998 by Tropica Aquarium Plants. It confusingly resembles species of the genus *Lilaeopsis*. Distinction though is easy on the basis of the leaf venation: the leaves of *Lilaeopsis* species show the typical transversal veins, while they are missing in *Ranunculus*. *Ranunculus limosella* was identified by Prof. C.D.K. Cook. The original name *R. limoselloides* Hooker f. had already been applied to another species.

***Rotala* sp.**

Family: Lythraceae.

Synonyms: Unknown.

Etymology: *Rotala*: see *Rotala macrandra*.

Distribution: Nothing is known about its natural distribution.

Description: The same as *Rotala rotundifolia*, except for the following vegetative features: submersed shoots with (always) decussate leaves; leaves never in whorls, light green in color. Aquatic leaves very narrowly elliptic, up to 1.7×0.3 cm large. The leaf blade often shows a small notch. Flowering plants not seen.

Culture: The same as for *Rotala rotundifolia*, to which species this plant may belong. Just as undemanding and recommendable, but somewhat slower growing.

Other: Nothing is known about the natural distribution, origin and ecology. Trade has been carried out by the Danish company Tropica Aquarium Plants since 1998. Inflorescences have not yet been formed in culture.

***Rotala* sp.**



***Rotala* sp. “Nanjenshan”**

Family: Lythraceae.

Synonyms: None.

Etymology: *Rotala*: see *Rotala macrandra*; Nanjenshan: name of the place near the only known location.

Distribution: Taiwan.

Description: Marsh plant with prostrate or ascending, often branched, 10–50-cm long shoots. Emerged leaves very short petiolate, opposite or in 3–4-merous whorls, entire, elliptic or lanceolate, blades 5–10 mm long and 2–4 mm wide, medium green in color. Submersed shoots very soft. Aquatic leaves very narrowly linear, in 3–6-merous whorls, 1.5–2.0 cm long and 0.5–1 mm wide, light green, the lower side often reddish. Flowers axillary, very short pedunculate, 4-merous, 3 mm in diameter. Calyx 2 mm long, green; calyx lobes triangular. Petals pale lilac, about 1 mm large. Stamens shorter than the petals and surpassing the style only a little. Stigma small, capitate. Fruit and seeds unknown.

Culture: *Rotala* sp. “Nanjenshan” is an elegant, demanding, but recommendable plant, and has been part of the regular stock of pet shops since about 1995. (It was traded under the name *Mayaca sellowiana* for a short time.) Culture succeeds best in well-aerated aquaria with soft to medium-hard and slightly acid water. Additional carbon dioxide fertilization is recommended. In order to facilitate the planting of the delicate shoots, a fine-grained soil consisting of sand should be used. Successful decoration is gained by using a large group of at least 10 shoots in the front or middle section of the aquarium. Vegetative propagation is by the production of side shoots. Emerged growth is fast and free of problems; the fragile shoots come to flower easily. *Rotala* sp. “Nanjenshan” is very tolerant to temperature. It can also be used for planting along the garden pool (see van der Vlugt 1996) and is winter hardy to a certain extent.

Ecology: So far, this plant is known only from a single site near Nanjenshan in Taiwan. Its fruit, which form a recommended identification feature in the genus *Rotala*, are still unknown. This may be a natural hybrid. Several *Rotala* species are indigenous to Taiwan, including *Rotala rotundifolia* and *Rotala wallichii*.

Other: *Rotala* sp. “Nanjenshan” has been imported from Taiwan by aquatic plant nursery Dennerle since 1993. In the aquarium, the shoots show great similarity to *Rotala wallichii*; the color of the shoots being a weak feature of distinction. Although they can be easily confused, *Rotala* sp. “Nanjenshan” can be distinguished from *Mayaca fluviatilis* by its verticillate leaf arrangement and longer leaves.

***Rotala* sp. “Nanjenshan.”**



Salvinia oblongifolia

Martius (1827)

Family: Salviniaceae.**Synonyms:** None.**Etymology:** *Salvinia*: see *S. auriculata*; *oblongifolia*: with oblong leaves.**Distribution:** Eastern Brazil.

Description: The same as *S. auriculata*, but differing in the following features: shoots up to 50 cm long. Floating leaves 3–4 times long as wide, up to 6×2.5 cm large, spreading, top round-toothed, base cordate. The lower side with a distinct keel (enlarges the buoyancy of the plant); keel 2.5–4.5 cm long, 1–2 cm wide, 0.5 cm thick, bristly pubescent. Papilla in very dense rows. Hairs spreading. Submersed organs up to 20 cm long. Macrosporocarpium 2 mm large, with 20–25 macrosporangia, each with 1 megaspore. Microsporocarpium with numerous microsporangia, these with 32 spores.

Culture: Being a sun plant, *S. oblongifolia* needs intense light for optimal growth. In the aquarium this floating fern forms—as an adaptation to poorly lighted habitats—a shade or withered form, remaining smaller than those plants grown under intense day-

light in botanical gardens. Nevertheless, the propagation rate of this largest *Salvinia* species in the aquarium is high and growth is satisfactory. The length-to-width ratio does not really change in the shade forms, and therefore *S. oblongifolia* can always be distinguished quite well from other *Salvinia* species. Slow-moving water as well as a lot of warmth are needed for successful culture. The author had good growing results in medium-hard carbonate-poor water. Sporocarps were only found on very strong plants.

Ecology: Prof. de la Sota found the species floating in shallow, turbid, and loamy water with much organic matter at a pH-value of 6.9.

Other: *Salvinia oblongifolia* had already been cultivated during the years 1910 to 1926, but then disappeared. It was reimported in 1995 (see Kasselman 1996).

***Salvinia oblongifolia*.****Papils and hairs on the upperside of the leaf.**

Tonina fluviatilis

Aublet (1806)

Family: Eriocaulaceae.**Synonyms:** *Eriocaulon amplexicaule* Rottboll, *Hyphydra amplexicaulis* Schreber.**Etymology:** *Tonina* = from a indigenous name in French Guiana; *fluviatilis* = living in or along the river.**Distribution:** Tropical Central and South America.**Description:** Amphibious marsh plant with decumbent, 20–40-cm long, thin, strongly branched shoots. Leaves alternate in a rosette, sessile, narrowly lanceolate, apex acute, often recurved, margin and basis pubescent, 1.0–1.5 cm long, 1–2.5 mm wide, light green. Flowers unisexual, both sexes united in dense heads. Heads single, axillary, short pedunculate. Involucre and bracts pubescent. Perigone 3-dentate, outer leaves connate. Male flower: inner tepals tubular, 3 bilocular stamens, carpels rudimentary. Female flowers: inner tepals free, style with 3 stigma branches.**Culture:** *Tonina fluviatilis* has only a low plasticity to the conditions of culture in the aquarium. The author was able to bring this common South American species home sev-

eral times from her tropical journeys in order to test it with regard to its suitability for the aquarium, but so far all trials of cultivation failed. If the reader has the opportunity to try this species in the aquarium, then very soft, acid water with a very low conductance is an essential for successful results in culture. Emerged cultivation succeeds on a slightly acid substrate, but growth is relatively slow. Tropica Aquarium Plants is attempting to get a new import.

Ecology: *Tonina fluviatilis* inhabits quiet banks of more or less fast-flowing clear water with a sandy soil. It is a indicator species for soft and very acidic water; e.g., often occurring in the black-water biotopes of Guyana together with *Mayaca fluviatilis* at pH-values between 3.9 and 4.2. The species also inhabits waters with pH-values up to about 6.0. See also the biotope description No. 2, pp. 34–35, as well as the extensive water analysis on page 40.**Other:** *Tonina fluviatilis* is the only species of this genus (monotypic).

Tonina fluviatilis submersed in a natural habitat in Venezuela.



Vallisneria nana

R. Brown (1810)

Family: Hydrocharitaceae.**Synonyms:** *V. gracilis* F.M. Bailey.**Etymology:** *Vallisneria*: see *V. americana*; *nana*: dwarf-like.**Distribution:** Northern Australia (Kimberley district, Queensland).**Description:** Perennial, stoloniferous aquatic plant with a short rhizome. Leaves in a rosette, light green. Two growing forms: leaves either stiff, up to 15 cm long or strap-shaped, thin, soft, glabrous, unusually narrow, up to 80 cm long, 1–2.5 mm wide, leaf apex acute. Longitudinal and transversal veins only faintly visible. Small teeth along the upper leaf margin, especially numerous at the top (magnifying glass!). Filaments of the male flowers either free or partly (75%) connate.**Culture:** *Vallisneria nana* is a undemanding fast-growing aquatic plant. It grows problem-free in medium-hard, alkaline water at temperatures between 24 and 29 °C; the tolerance of this species to the mentioned parameters is probably even greater. *Vallisneria nana* needs a longer period of acclimatization than other *Vallisneria* species. However, as soon as the

plants are rooted, many stolons are produced. *Vallisneria nana* can best be used as a small group in the middle or side part of the aquarium; under intense lighting, use at the foreground is sometimes possible, where a “lawn” only a few cm high is formed. As soon as this lawn has become dense and close, the plants push each other up by producing longer leaves.

Ecology: Little is known about its natural habitat. The first description of *V. gracilis* (synonym of *V. nana*) notes that the species was found in 1890 in quiet water as well as in the current on the side of the Mulgrave River (south of Cairns) in muddy soil. The leaves being 4–13 cm long and 1 mm wide, the plants were described as dwarf-growing. The imported plants in a package from Queensland obtained by H.W.E. van Bruggen (NL) in 1994 were only 10–15 cm high and had strikingly stiff leaves. The looks of these specimens changed rapidly in aquarium culture, producing the described much longer and softer leaves.

Other: *Vallisneria nana* can be very easily confused with *Echinodorus angustifolius*. Good distinguishing features are the clearly thickened leaf blades of *V. nana* (well visible in cross-section) and the small teeth at the apex and along the upper margin visible under high magnification. Jacobs and Frank (1997) distinguished five species in Australia: *V. caulescens* Bailey and F. Mueller; *V. americana* Michaux var. *americana*; *V. nana*; *V. triptera* Jacobs and Frank; and *V. annua* Jacobs and Frank. Although only female plants of *V. nana* are in culture and the male flowers necessary for identification are lacking, the information mentioned by Jacobs and Frank allows us to conclude that the newly imported species is *V. nana* (see Kasselman 1998).

***Vallisneria nana*.**

Appendixes

Appendix 1

Temperature Tolerance of Important Aquarium Plants

(compiled in cooperation with the J. Hoechstetter Aquatic Plant Nursery)

Plant names	Minimum °C	Optimum °C	Maximum °C
<i>Acorus gramineus</i>	limited hardiness	18–23	28
<i>Alternanthera reineckii</i>	4	17–25	28
<i>Ammannia senegalensis</i>	12	22–28	30
<i>Anubias afzelii</i>	12	22–26	30
<i>Anubias barteri</i>	12	22–26	30
<i>Aponogeton boivinianus</i>	5 (tuber)	22–25	27
<i>Aponogeton crispus</i>	15	25–32	34
<i>Aponogeton madagascariensis</i>	5	18–23	26
<i>Aponogeton rigidifolius</i>	12	23–26	28
<i>Aponogeton ulvaceus</i>	—	24–27	30
<i>Aponogeton undulatus</i>	17	22–28	30
<i>Bacopa caroliniana</i>	4	22–25	29
<i>Bacopa madagascariensis</i>	15	24–28	30
<i>Bacopa monnieri</i>	15	18–28	30
<i>Barclaya longifolia</i>	18	25–28	30
<i>Blyxa aubertii</i>	15–17	20–28	32
<i>Bolbitis heudelotii</i>	18	24–25	27
<i>Cabomba aquatica</i>	limited hardiness	23–25	30
<i>Cabomba caroliniana</i>	limited hardiness	20–25	27
<i>Cardamine lyrata</i>	hardy	18–23	27
<i>Ceratopteris cornuta</i>	18	22–28	30
<i>Ceratopteris thalictroides</i>	18	22–28	30
<i>Crassula helmsii</i>	hardy	18–23	25
<i>Crinum calamistratum</i>	12	23–26	30
<i>Crinum natans</i>	12	24–28	30
<i>Crinum thaianum</i>	15	22–27	30
<i>Cryptocoryne affinis</i>	12	22–26	30
<i>Cryptocoryne albida</i>	6	22–28	30
<i>Cryptocoryne aponogetifolia</i>	15	21–27	30
<i>Cryptocoryne beckettii</i>	15	22–26	30
<i>Cryptocoryne ciliata</i>	20	22–26	28
<i>Cryptocoryne cordata</i>	17	23–27	30
<i>Cryptocoryne crispatula</i>	6	20–26	28
<i>Cryptocoryne hudsoni</i>	18	24–26	30
<i>Cryptocoryne moehlmannii</i>	18	22–25	28
<i>Cryptocoryne parva</i>	15	23–28	30
<i>Cryptocoryne pontederiifolia</i>	18	22–25	28
<i>Cryptocoryne undulata</i>	15	22–26	28
<i>Cryptocoryne walkeri</i>	15	22–26	29
<i>Cryptocoryne wendtii</i>	15	22–26	30
<i>Cryptocoryne × willisii</i>	15	22–28	30

Appendix 1 *continued*

Plant name	Minimum °C	Optimum °C	Maximum °C
<i>Didiplis diandra</i>	limited hardiness	22–26	30
<i>Echinodorus amazonicus</i>	18	22–26	30
<i>Echinodorus</i> × <i>barthii</i>	4	18–26	30
<i>Echinodorus berteroi</i>	4	20–27	30
<i>Echinodorus bleheri</i>	18	22–28	30
<i>Echinodorus bolivianus</i>	20	22–28	30
<i>Echinodorus cordifolius</i>	15	20–28	30
<i>E. cordifolius</i> 'Tropica Marble Queen'	5	22–26	30
<i>Echinodorus horizontalis</i>	—	25–29	30
<i>Echinodorus martii</i>	18	24–26	28
<i>Echinodorus opacus</i>	12	18–24	27
<i>Echinodorus osiris</i>	12	18–26	28
<i>Echinodorus paniculatus</i>	15	20–28	30
<i>Echinodorus parviflorus</i> 'Tropica'	12	22–24	26
<i>Echinodorus portoaegrensis</i>	12	18–27	26
<i>Echinodorus quadricostatus</i>	15	22–28	30
<i>Echinodorus schlueteri</i>	4	22–25	30
<i>Echinodorus tenellus</i>	—	18–28	30
<i>Echinodorus uruguayensis</i>	limited hardiness	18–24	28
<i>Egeria densa</i>	limited hardiness	20–24	30
<i>Egeria najas</i>	15	15–26	30
<i>Eichhornia azurea</i>	6	15–24	33
<i>Eichhornia crassipes</i>	12	25–30	33
<i>Eichhornia diversifolia</i>	18	20–28	35
<i>Eleocharis acicularis</i>	hardy	20–25	27
<i>Eleocharis vivipara</i>	5	20–27	29
<i>Elodea canadensis</i>	hardy	15–20	28
<i>Eusteralis stellata</i>	16	22–28	30
<i>Glossostigma elatinoideis</i>	limited hardiness	22–26	30
<i>Gymnocoronis spilanthoides</i>	limited hardiness	15–28	30
<i>Hemianthus micranthemoides</i>	5	24–26	30
<i>Heteranthera zosterifolia</i>	5	23–27	30
<i>Hottonia palustris</i>	hardy	18–25	30
<i>Hydrilla verticillata</i> (normal form)	limited hardiness	20–27	30
<i>Hydrocotyle leucocephala</i>	5	20–28	30
<i>Hydrocotyle verticillata</i>	hardy	18–23	27
<i>Hydrocotyle vulgaris</i>	hardy	20–28	30
<i>Hydrothrix gardneri</i>	18	23–25	28
<i>Hydrotriche hottoniiflora</i>	18	21–24	26
<i>Hygrophila corymbosa</i>	18	24–28	30
<i>Hygrophila difformis</i>	18	24–28	30
<i>Hygrophila polysperma</i>	4	22–28	30
<i>Isoetes velata</i>	5	22–26	28
<i>Lagarosiphon madagascariensis</i>	18	24–28	30
<i>Lagarosiphon major</i>	hardy	20–23	25
<i>Lilaeopsis brasiliensis</i>	limited hardiness	22–26	28

Appendix 1 *continued*

Plant name	Minimum °C	Optimum °C	Maximum °C
<i>Limnobia spongia</i>	hardy	18–24	27
<i>Limnophila aquatica</i>	15	22–28	30
<i>Limnophila heterophylla</i>	15	25–28	30
<i>Limnophila indica</i>	15	25–28	30
<i>Limnophila sessiliflora</i>	15	20–26	28
<i>Lindernia parviflora</i>	limited hardiness	22–26	30
<i>Lobelia cardinalis</i>	limited hardiness	22–26	30
<i>Ludwigia arcuata</i>	12	24–26	28
<i>Ludwigia glandulosa</i>	10	22–25	27
<i>Ludwigia inclinata</i>	18	24–28	30
<i>Ludwigia palustris</i>	hardy	22–26	28
<i>Ludwigia palustris</i> × <i>repens</i>	4	23–28	30
<i>Ludwigia repens</i> × <i>arcuata</i>	4	24–28	30
<i>Lysimachia nummularia</i>	hardy	18–20	25
<i>Micranthemum umbrosum</i>	4	22–24	26
<i>Microsorium pteropus</i>	4	20–28	30
<i>Myriophyllum aquaticum</i> (female)	hardy	15–25	28
<i>Myriophyllum mattogrossense</i>	20	24–28	30
<i>Myriophyllum pinnatum</i>	limited hardiness	20–25	27
<i>Myriophyllum simulans</i>	limited hardiness	20–28	30
<i>Myriophyllum tuberculatum</i>	4	18–24	28
<i>Najas guadalupensis</i>	4	20–30	32
<i>Nesaea crassicaulis</i>	15	22–28	31
<i>Nesaea pedicellata</i>	15	22–28	31
<i>Nuphar japonica</i>	hardy	20–28	30
<i>Nymphaea lotus</i>	15	22–28	30
<i>Nymphaea micrantha</i>	18	24–28	32
<i>Nymphaea</i> × <i>daubenyanana</i> hort.	5	25–28	32
<i>Nymphoides aquatica</i>	15	20–26	28
<i>Nymphoides indica</i>	—	24–31	32
<i>Ottelia alismoides</i>	—	22–26	30
<i>Physostegia purpurea</i>	hardy	22–24	25
<i>Pistia stratiotes</i>	15	22–30	35
<i>Potamogeton gayi</i>	limited hardiness	18–26	28
<i>Riccia fluitans</i>	hardy	20–27	32
<i>Rorippa aquatica</i>	limited hardiness	20–25	27
<i>Rotala macrandra</i>	18	24–28	30
<i>Rotala rotundifolia</i>	4	24–28	32
<i>Rotala wallichii</i>	15	24–28	30
<i>Sagittaria platyphylla</i>	hardy	20–24	25
<i>Sagittaria subulata</i>	hardy	18–28	30
<i>Salvinia molesta</i>	10	24–28	32
<i>Samolus valerandi</i>	hardy	22–26	35
<i>Saururus cernuus</i>	hardy	20–25	27
<i>Shinnersia rivularis</i>	4	18–30	32
<i>Spiranthes odorata</i>	15	22–26	28

Appendix 1 *continued*

Plant name	Minimum °C	Optimum °C	Maximum °C
<i>Stratiotes aloides</i>	hardy	22–26	30
<i>Vallisneria americana</i> var. <i>americana</i>	10	22–26	30
<i>Vallisneria americana</i> var. <i>biwaensis</i>	4	22–25	28
<i>Vallisneria spiralis</i> var. <i>denseserrulata</i>	—	20–26	28
<i>Vallisneria spiralis</i> var. <i>spiralis</i>	5	20–28	30
<i>Vesicularia dubyana</i>	4	15–30	32
<i>Zosterella dubia</i>	5	15–27	30

Appendix 2

Light Requirements of Aquarium Plants

The following survey, covering the preferred locations of aquarium plants within their native habitats, is designed to provide the aquarist with essential information about the light requirements of individual species. From these determined requirements conclusions can be drawn regarding the optimum conditions for cultivation. The table is based on observations made by the author in the course of 25 trips to numerous tropical countries, during which most of the plants kept in aquariums were studied in their native living environment. At the same time, publications by other authors have also been considered if they contributed essential information about the natural habitats of aquarium plants. At present, such data cannot be compiled for every species because there is no reliable information—or no data at all—available on the habitats of a range of aquarium plants.

Plant name	Very shaded	Shaded	Shady-sunny	Full sun
<i>Alternanthera reineckii</i>			×	×
<i>Ammannia gracilis</i>				×
<i>Ammannia senegalensis</i>				×
<i>Anubias afzelii</i>	×	×	×	×
<i>Anubias barteri</i> varieties	×	×	×	
<i>Anubias gigantea</i>	×	×		
<i>Anubias gillettii</i>	×	×	×	
<i>Anubias gracilis</i>	×	×		
<i>Anubias hastifolia</i>	×	×		
<i>Anubias heterophylla</i>	×	×		
<i>Anubias pynaertii</i>	×	×		
<i>Aponogeton bernierianus</i>		×	×	×
<i>Aponogeton boivinianus</i>			×	×
<i>Aponogeton capuronii</i>		×	×	
<i>Aponogeton crispus</i>			×	×
<i>Aponogeton decaryi</i>				×
<i>Aponogeton distachyos</i>			×	×
<i>Aponogeton elongatus</i>	×	×	×	
<i>Aponogeton jacobsenii</i>			×	×
<i>Aponogeton longiplumulosus</i>		×	×	
<i>Aponogeton loriae</i>			×	×
<i>Aponogeton madagascariensis</i>	×	×	×	×
<i>Aponogeton natans</i>				×
<i>Aponogeton rigidifolius</i>		×	×	×
<i>Aponogeton robinsonii</i>			×	×
<i>Aponogeton tenuispicatus</i>		×		
<i>Aponogeton ulvaceus</i>		×	×	×
<i>Aponogeton undulatus</i>		×		
<i>Azolla</i> species			×	×
<i>Bacopa caroliniana</i>			×	×
<i>Bacopa crenata</i>			×	×

Appendix 2 *continued*

Plant name	Very shaded	Shaded	Shady-sunny	Full sun
<i>Bacopa madagascariensis</i>				×
<i>Bacopa monnieri</i>				×
<i>Bacopa myriophylloides</i>				×
<i>Barclaya longifolia</i>		×	×	×
<i>Barclaya motleyi</i>	×	×	×	×
<i>Blyxa aubertii</i>				×
<i>Bolbitis heudelotii</i>		×	×	
<i>Cabomba aquatica</i>				×
<i>Cabomba caroliniana</i>			×	×
<i>Cabomba furcata</i>			×	×
<i>Cabomba palaeformis</i>			×	×
<i>Ceratophyllus demersum</i>	×	×	×	×
<i>Ceratopteris cornuta</i>			×	×
<i>Ceratopteris pteridoides</i>			×	×
<i>Ceratopteris thalictroides</i>			×	×
<i>Crinum calamistratum</i>		×	×	
<i>Crinum natans</i>	×	×	×	×
<i>Crinum thaianum</i>		×	×	
<i>Cryptocoryne affinis</i>		×	×	
<i>Cryptocoryne alba</i>	×	×	×	×
<i>Cryptocoryne albida</i>	×	×	×	×
<i>Cryptocoryne aponogetifolia</i>		×	×	
<i>Cryptocoryne beckettii</i>	×	×	×	
<i>Cryptocoryne bogneri</i>	×	×		
<i>Cryptocoryne ciliata</i>		×	×	×
<i>Cryptocoryne cordata</i>	×	×	×	×
<i>Cryptocoryne crispatula</i>	×	×	×	
<i>Cryptocoryne keei</i>		×	×	
<i>Cryptocoryne lingua</i>	×	×		
<i>Cryptocoryne longicauda</i>	×	×	×	
<i>Cryptocoryne minima</i>	×	×		
<i>Cryptocoryne moehlmannii</i>		×	×	
<i>Cryptocoryne nevillei</i>			×	×
<i>Cryptocoryne nurii</i>		×	×	
<i>Cryptocoryne parva</i>			×	
<i>Cryptocoryne pontederiifolia</i>		×	×	
<i>Cryptocoryne purpurea</i>	×	×	×	
<i>Cryptocoryne retrospiralis</i>			×	×
<i>Cryptocoryne spiralis</i>		×	×	
<i>Cryptocoryne striolata</i>		×		
<i>Cryptocoryne thwaitesii</i>	×	×	×	
<i>Cryptocoryne usteriana</i>		×		
<i>Cryptocoryne walkeri</i>		×	×	
<i>Cryptocoryne wendtii</i>		×	×	×
<i>Cryptocoryne</i> × <i>willisii</i>			×	

Appendix 2 *continued*

Plant name	Very shaded	Shaded	Shady-sunny	Full sun
<i>Echinodorus amazonicus</i>	×	×		
<i>Echinodorus berteroi</i>			×	×
<i>Echinodorus bolivianus</i>		×	×	×
<i>Echinodorus cordifolius</i>			×	×
<i>Echinodorus grandiflorus</i>			×	×
<i>Echinodorus horizontalis</i>	×		×	×
<i>Echinodorus macrophyllus</i>				×
<i>Echinodorus opacus</i>		×	×	
<i>Echinodorus osiris</i>			×	×
<i>Echinodorus paniculatus</i>			×	×
<i>Echinodorus portoalegrensis</i>		×	×	
<i>Echinodorus subalatus</i>			×	×
<i>Echinodorus tenellus</i>		×	×	×
<i>Echinodorus uruguayensis</i>		×	×	
<i>Egeria densa</i>				×
<i>Egeria najas</i>				×
<i>Eichhornia azurea</i>				×
<i>Eichhornia crassipes</i>			×	×
<i>Eichhornia diversifolia</i>			×	×
<i>Eichhornia heterosperma</i>				×
<i>Eichhornia natans</i>				×
<i>Elodea canadensis</i>			×	×
<i>Gymnocoronis spilanthoides</i>				×
<i>Heteranthera zosterifolia</i>			×	×
<i>Hottonia palustris</i>			×	×
<i>Hydrilla verticillata</i>		×	×	×
<i>Hydrocleys martii</i>			×	×
<i>Hydrocleys nymphoides</i>		×	×	×
<i>Hydrocotyle leucocephala</i>		×	×	×
<i>Hydrocotyle ranunculoides</i>			×	×
<i>Hydrocotyle sibthorpioides</i>		×	×	×
<i>Hydrocotyle verticillata</i>			×	×
<i>Hydrocotyle vulgaris</i>		×	×	
<i>Hydrothrix gardneri</i>				×
<i>Hydrotriche hottoniiflora</i>			×	×
<i>Hygrophila corymbosa</i>			×	×
<i>Hygrophila guianensis</i>			×	×
<i>Hygrophila polysperma</i>			×	
<i>Lagarosiphon cordofanus</i>				×
<i>Lagarosiphon madagascariensis</i>				×
<i>Lagenandra jacobsenii</i>	×	×		
<i>Lagenandra nairii</i>	×	×		
<i>Lagenandra ovata</i>		×	×	
<i>Lagenandra praetermissa</i>		×	×	
<i>Lemna</i> species			×	×

Appendix 2 *continued*

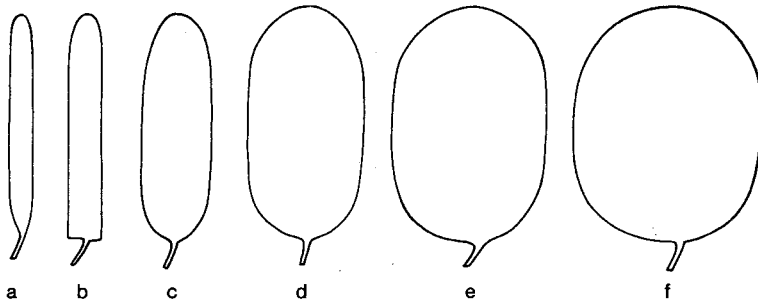
Plant name	Very shaded	Shaded	Shady-sunny	Full sun
<i>Limnobiium laevigatum</i>			×	×
<i>Limnophila aquatica</i>			×	×
<i>Limnophila aromatica</i>			×	×
<i>Limnophila dasyantha</i>				×
<i>Limnophila heterophylla</i>				×
<i>Limnophila indica</i>				×
<i>Limnophila sessiliflora</i>				×
<i>Limnophyton fluitans</i>		×	×	
<i>Lindernia parviflora</i>			×	×
<i>Lobelia purpurascens</i>			×	×
<i>Ludwigia inclinata</i>			×	×
<i>Ludwigia palustris</i>			×	×
<i>Ludwigia repens</i>			×	×
<i>Ludwigia sedoides</i>			×	×
<i>Lysimachia nummularia</i>			×	×
<i>Mayaca fluviatilis</i>			×	×
<i>Microsorium pteropus</i>	×	×		
<i>Myriophyllum aquaticum</i> (female)				×
<i>Myriophyllum simulans</i>		×	×	×
<i>Najas conferta</i>		×	×	×
<i>Najas horrida</i>		×	×	×
<i>Najas indica</i>			×	×
<i>Najas marina</i>		×	×	
<i>Nesaea crassicaulis</i>			×	×
<i>Nesaea pedicellata</i>			×	×
<i>Nesaea triflora</i>				×
<i>Nymphaea glandulifera</i>			×	×
<i>Nymphaea lotus</i>			×	×
<i>Nymphaea micrantha</i>				×
<i>Nymphaea rudgeana</i>			×	×
<i>Nymphoides ezannoi</i>				×
<i>Nymphoides fallax</i>				×
<i>Nymphoides forbesiana</i>				×
<i>Nymphoides hydrophylla</i>				×
<i>Nymphoides indica</i>				×
<i>Nymphoides thunbergiana</i>				×
<i>Ottelia alismoides</i>			×	×
<i>Ottelia brasiliensis</i>				×
<i>Ottelia mesenterium</i>		×	×	
<i>Ottelia ulvifolia</i>			×	×
<i>Phyllanthus fluitans</i>			×	×
<i>Pistia stratiotes</i>			×	×
<i>Potamogeton gayi</i>			×	×
<i>Potamogeton schweinfurthii</i>		×	×	
<i>Potamogeton wrightii</i>			×	×

Appendix 2 *continued*

Plant name	Very shaded	Shaded	Shady-sunny	Full sun
<i>Reussia rotundifolia</i>			×	×
<i>Riccia fluitans</i>		×	×	×
<i>Ricciocarpus natans</i>			×	×
<i>Sagittaria montevidensis</i>				×
<i>Salvinia auriculata</i>				×
<i>Salvinia cucullata</i>				×
<i>Salvinia molesta</i>				×
<i>Samolus valerandi</i>			×	×
<i>Shinnersia rivularis</i>				×
<i>Spiranthes graminea</i>	×	×		
<i>Spirodela polyrhiza</i>			×	×
<i>Stratiotes aloides</i>			×	×
<i>Trapa natans</i>			×	×
<i>Utricularia aurea</i>			×	×
<i>Utricularia gibba</i>			×	×
<i>Utricularia inflexa</i>				×
<i>Utricularia stellaris</i>				×
<i>Vallisneria americana</i> var. <i>americana</i>			×	
<i>Vallisneria spiralis</i> var. <i>denseserrulata</i>	×	×	×	
<i>Vallisneria spiralis</i> var. <i>spiralis</i>		×	×	
<i>Wolffia arrhiza</i>			×	×
<i>Wolffia neglecta</i>				×
<i>Wolffia welwitschii</i>				×
<i>Zosterella dubia</i>			×	×

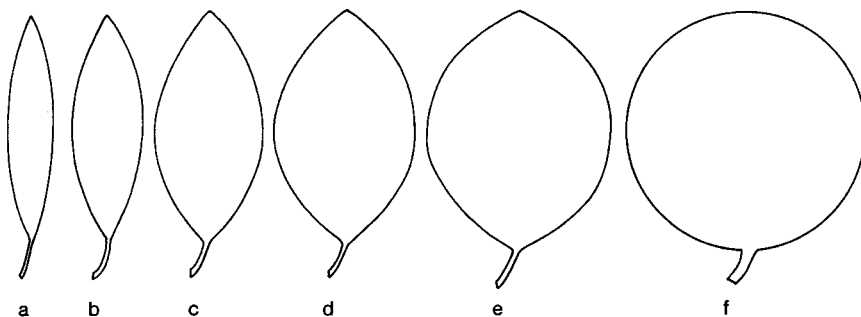
Appendix 3

Leaf Shapes



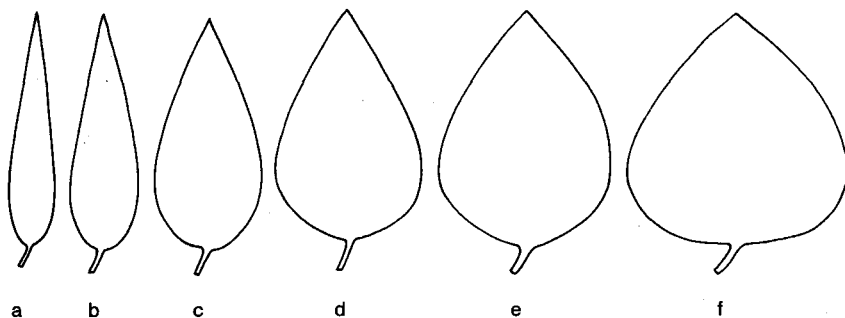
Oblong leaf shapes

- a) linear, width to length ratio 1:6 to 8, parallel margin
- b) ribbon-like or strap-shaped, 1:12 or higher
- c) narrow oblong, 1:3, margin relatively parallel
- d) oblong, 1:2, short segment of the margin parallel in the middle
- e) wide oblong, 2:3
- f) very wide oblong, 5:6, widest in the middle, from there narrowing toward both ends, both ends round, however.



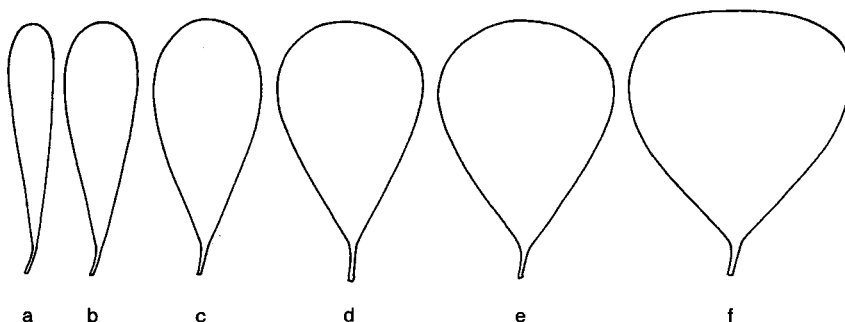
Elliptic leaf shapes

- a) very narrow elliptic, width of length ratio 1:6
- b) narrow elliptic, 1:3
- c) elliptic, oval, 1:2
- d) wide elliptic, 2:3
- e) roundish, 5:6
- f) round, circular, 6:6

Appendix 3 *continued*

Ovate leaf shapes

- | | |
|---|-------------------------|
| a) narrow lanceolate, width to length ratio 1:6 | d) ovoid, ovate, 2:3 |
| b) lanceolate, 1:3 | e) wide ovate, 5:6 |
| c) narrow ovate, 1:2 | f) very wide ovate, 6:6 |

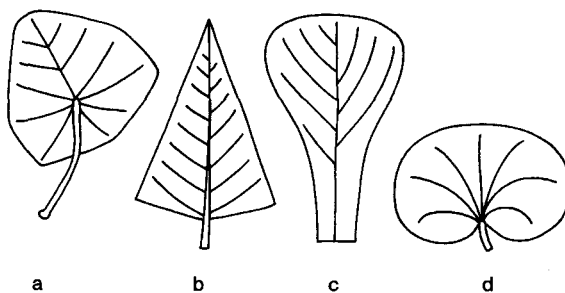


Obovate leaf shapes

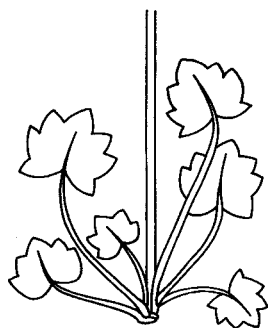
- | | |
|---|---------------------------|
| a) narrow oblanceolate, width to length ratio 1:6 | d) obovate, 2:3 |
| b) oblanceolate, 1:3 | e) wide obovate, 5:6 |
| c) narrow obovate, 1:2 | f) very wide obovate, 6:6 |

Special leaf shapes

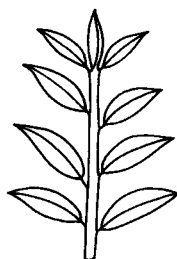
- a) peltate
 b) triangular
 c) spatulate
 d) reniform



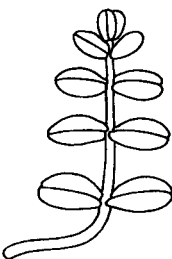
Appendix 4
Leaf Arrangements



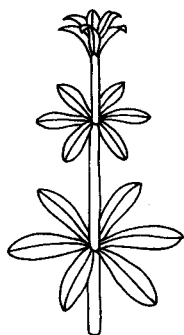
basilar



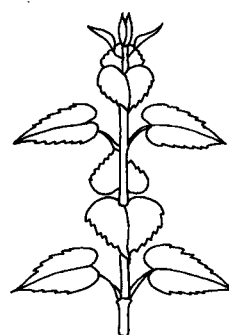
alternate



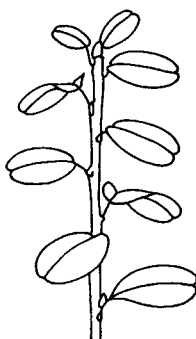
opposite



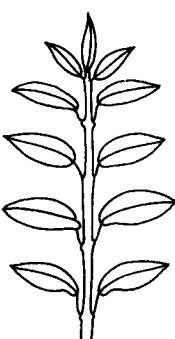
whorled or verticillate



decussate



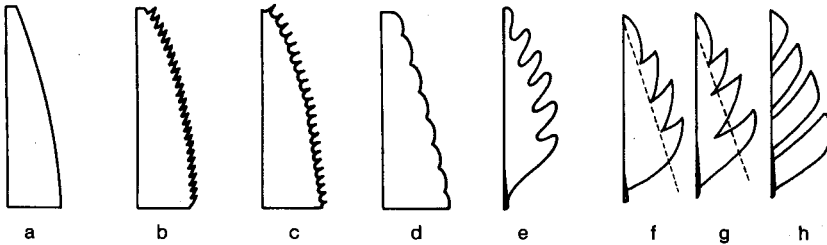
distichous coiled



distichous decussate

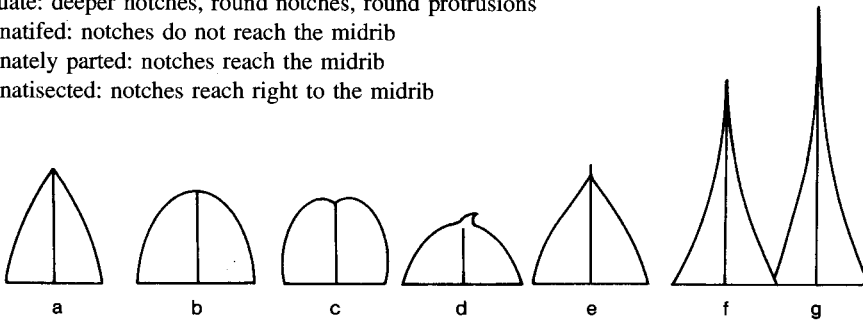
Appendix 5

Margin, Apex, Leaf Base



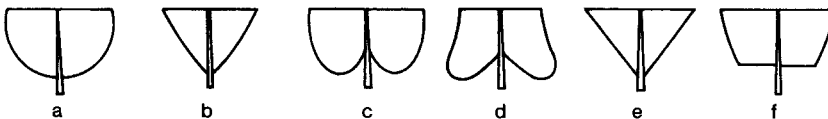
Margin

- a) entire: no notches
- b) serrate: denticles and notches in an acute angle
- c) denticulate: acute denticles, round notches
- d) crenate: round denticles, acute notches
- e) sinuate: deeper notches, round notches, round protrusions
- f) pinnatifid: notches do not reach the midrib
- g) pinnately parted: notches reach the midrib
- h) pinnatisect: notches reach right to the midrib



Apex

- a) acute
- b) obtuse
- c) emarginate
- d) fine acuminate
- e) mucronate
- f) cuspidate
- g) caudate



Leaf base

- a) round: both halves of the blade form a semicircle
- b) obtuse: the margins of both halves meet in an obtuse or right angle
- c) cordate: semicircle with deep notches
- d) auriculate: similar to the cordate shape, but further extended and protruding sideways
- e) cuneate: margin straight from the center to the base (not curved), becoming continuously more narrow
- f) truncate: leaf base cut off horizontally

Appendix 6

Frequently Used Common Names of Aquarium Plants

(Compiled by Dave Gomborg)

Common Name	Scientific Name
Amazon Sword	<i>Echinodorus</i> sp. (usually <i>E. bleheri</i>)
Ambulia	<i>Limnophila sessiliflora</i>
Anacharis	<i>Elodea</i> sp.
Baby's Tears	<i>Micranthemum umbrosum</i>
Banana Plant	<i>Nymphoides aquatica</i>
Bladderwort	<i>Utricularia</i> sp.
Broad Leaf Chain Sword	<i>Echinodorus quadricostatus</i>
Cellophane Sword	<i>Echinodorus berteroi</i>
Corkscrew Val	<i>Vallisneria</i> sp.
Crystalwort	<i>Riccia fluitans</i>
Duck Weed	<i>Lemna</i> sp.
Fanwort	<i>Cabomba</i> sp.
Filigree Frill	<i>Myriophyllum simulans</i>
Foxtail	<i>Myriophyllum pinnatum</i>
Frogbit	<i>Limnobium</i> sp.
Fuzzy Duck Weed	<i>Salvinia</i> sp.
Giant Hygro	<i>Hygrophila corymbosa</i>
Hair Grass	<i>Eleocharis</i> sp.
Hornwort	<i>Ceratophyllum</i> sp.
Java Fern	<i>Microsorium pteropus</i>
Java Moss	<i>Vesicularia dubyana</i>
Jungle Val	<i>Vallisneria americana</i>
Leiden Plant	<i>Saururus cernuus</i>
Lizard's Tail	<i>Saururus cernuus</i>
Madagascar Lace Plant	<i>Aponogeton madagascariensis</i>
Melon Sword	<i>Echinodorus osiris</i>
Mexican Oakleaf	<i>Shinnersia rivularis</i>
Microsword	<i>Lilaeopsis brasiliensis</i>
Onion Plant	<i>Crinum thaianum</i>
Parrot's Feather	<i>Myriophyllum aquaticum</i>
Pennywort	<i>Hydrocotyle leucocephala</i>
Pond Penny	<i>Lysimachia nummularia</i>
Pond Weed	<i>Potamogeton</i> sp.
Pygmy Chain Sword	<i>Echinodorus tenellus</i>
Radican Sword	<i>Echinodorus cordifolius</i>
Ruffled Sword	<i>Echinodorus martii</i>
Scarlet Hygro	<i>Alternanthera reineckii</i>
Star Grass	<i>Heteranthera zosterifolia</i>
Sunset Hygro	<i>Hygrophila polysperma</i> v. 'Tropic Sunset'
Temple Plant	<i>Hygrophila corymbosa</i>
Tiger Lotus	<i>Nymphaea</i> sp.

Appendix 6 *continued*

Common Name	Scientific Name
Water Lettuce	<i>Pistia stratiotes</i>
Water Meal	<i>Wolffia</i> sp.
Water Rose	<i>Samolus valerandi</i>
Water Sprite	<i>Ceratopteris</i> sp.
Water Wisteria	<i>Hygrophila difformis</i>
Willow Moss	<i>Fontinalis antipyretica</i>

Glossary

- achene:** indehiscent one-seeded dry fruit in which the pericarp and seed coat (testa) are adnate.
- adnate:** grown together; growing with one side adhering to a stem.
- adventitious buds:** buds found on leaves or roots which occur either spontaneously or after injury of the plant.
- alternate leaf arrangement:** the leaves are alternating (Appendix 4, page 489).
- amphibious:** existing both in water and on land.
- anaerobic:** without oxygen.
- anatomy:** science of the internal structure of organisms, covering cell and tissue research.
- annual:** the entire life-span of a plant from germination to maturity and final withering is concluded within one vegetative period.
- anther:** pollen-bearing portion of the stamen.
- anthesis:** period during which the flower is available for pollination.
- anthocyan:** color substances dissolved in the cell sap, the color characteristics of which depend, amongst other things, on the pH-value of the cell sap.
- apomixis:** propagation seemingly being sexual, but in fact occurring without fertilization. Seed production without prior fertilization.
- assimilation:** production of endogenous organic matter from inorganic matter or other organic substances. Often assimilation is specifically understood to be the formation of starch from carbon dioxide and water with the aid of light energy and chlorophyll (see photosynthesis).
- axis:** the main part of a plant body, consisting of the stem and root.
- basal, basilar:** at the base (Appendix 4, page 489).
- bisexual flowers:** female (carpels) and male (stamens) sexual organs are located within one flower.
- bract:** modified, usually reduced leaf in the inflorescence.
- bullate:** blistered, with bubbles.
- calyx:** the outer set of floral leaves making up the external part of the flower, usually green.
- carpels:** leaf organs of the plant which produce the ovules.
- chasmogamy:** pollination of flowers which open and are thus receptive to xenogamy (cross-pollination), see also cleistogamy.
- cleistogamy:** self-pollination within a closed flower.
- connective:** sterile connecting segment between the half of the anthers (theca).
- cosmopolite:** plant species which is more or less distributed over the entire world.
- corolla:** the inner set of floral leaves immediately surrounding the sporophylls.
- cotyledon:** the first leaf or one of the first pair or whorl of leaves developed by the embryo of seed plants or ferns that makes stored food in the endosperm available to the developing young plant.
- cuticle:** a wax layer secreted by the epidermis surface; in all higher plants a layer consisting of cutin which is hardly permeable to water and gas, thereby reducing evaporation.
- day-neutral plants:** lighting period without any impact on flower formation.
- decussate leaf arrangement:** the leaves are arranged opposite, but each pair at right angle to the ones above and below it (Appendix 4, page 489).

dichasium: pattern of branching in which two lateral branches form a continuation of the mother axis.

diffusion: a levelling of different levels of concentration without outside influence.

dioecious: male and female flowers are distributed on different unisexual plants.

diploid: cells with a double set of chromosomes.

distichous leaf arrangement: the leaves are all set in one plain (Appendix 4, page 489).

ecology: science covering the relationship of organisms to each other and their environment.

elliptic leaf shapes: largest blade diameter occurs in the center of the leaf with an acute-angled apex; *very narrow elliptic:* width to length ratio 1:6; *narrow elliptic:* width to length ratio 1:3; *elliptic:* width to length ratio 1:2; *wide elliptic:* width to length ratio 2:3; *roundish:* width to length ratio 5:6; *round, circular:* width to length ratio 6:6 (Appendix 3, page 487).

emersed: existing above the water surface.

endemics: plants which, in contrast to cosmopolites, are indigenous to only a relatively small area.

epidermis: (Greek: top skin), layer of cells on the outer surface of higher plants and animals.

eutrophic: rich in nutrients.

female flower: flowers which contain only carpels.

filament: stamen stalk.

generative propagation: propagation through sexual means (e.g., seeds).

geniculum: joint; in *Anubias*, a thickened petiole below the leaf blade.

glochidia: in Azollaceae, petiolate barbs on the surface of the floating microspores.

glumes: scarious bracts in grasses, surrounding and protecting the solitary flowers.

gramineous: relating to grasses, or grass-like.

gynoeceium: all female flower organs or carpels of a flower.

heteromorphic: different in structure.

heterostyled: a species is heterostyled if its flowers display styles of different length.

hydathode: water pore; group of small cells free of chlorophyll which assists in the secretion of water.

hypanthium: cupule, receptacle; a cylindrical axis between the ovary and the other flower organs.

indusium: the delicate veil covering the groups of sporangia in ferns.

intercellular space: cavities between cells, mainly found in the basic plant tissue, forming a structured air-filled system.

internode: the part of the stem axis located between two nodes.

involucre: group of bracts subtending a head-like inflorescence (e.g., Asteraceae).

lanceolate (ovate) leaf shapes: the largest diameter of the blade is below the leaf center; *narrow lanceolate:* width to length ratio 1:6; *lanceolate:* width to length ratio 1:3; *oblanceolate (obovate) shapes:* largest diameter is above the leaf center (Appendix 3, page 488).

linear leaf shapes: width to length ratio 1:6 up to 8, parallel margin (Appendix 3, page 487).

long-day plants: plants flowering under a daily lighting period of more than 12 hours.

macrosporangium: sporangium with macrospores.

macrospore: female (larger) spore.

male flowers: flowers which contain only stamens.

margin: *entire:* without notches; *serrate:* teeth (denticles) and notches are acute-angled; *toothed, denticulate:* teeth acute, notches round; *crenate:* teeth round, notches acute; *lobed:* deeper notches, fewer segments.

massula: roundish ball consisting of microspores, e.g., in *Azolla*.

mericarp: single part of a separating fruit.

microsporangium: sporangium with microspores.

microspore: male (smaller) spore.

- monoecious:** flowers which have either only stamens (male) or only carpels (female), and occur on the same plant.
- morphology:** science covering the outward shape or form of animals and plants.
- mutant:** individual with a new feature induced through mutation.
- mutation:** a spontaneously occurring modification of the genetic material.
- nectary:** honey gland, secretion organ producing nectar for the attraction of insects.
- node:** shoot joint.
- nomen conservandum:** a protected (conserved) name.
- nomen illegitimum:** a valid but superfluous name.
- nomen nudum:** “naked” (invalid) name; a name published without description.
- nomenclature:** science covering the naming of plants and the establishment, interpretation, and application of regulations governing the system. Linné introduced naming of animals and plants in genus and species (binary nomenclature). The “International Code of Botanical Nomenclature” provides strict rules for the description and naming of species.
- oblong leaf shapes:** margin which is more or less parallel in the center; *narrow oblong*: width to length ratio 1:3; *oblong*: width to length ratio 1:2; *wide oblong*: width to length ratio 2:3; *very wide oblong*: width to length ratio 5:6 (Appendix 3, page 487).
- oligotrophic:** deficient in nutrient content.
- opposite leaf arrangement:** the leaves are positioned opposite to each other (Appendix 4, page 489).
- ovary:** the hollow, basal region of a carpel, containing one or more ovules. In a flower with 2 or more united carpels, they form a single compound ovary.
- ovate leaf shapes:** the largest diameter of the blade will always be below the center of the leaf; *narrow ovate*: width to length ratio 1:2; *ovate*: width to length ratio 2:3; *wide ovate*: width to length ratio 5:6; *very wide ovate*: width to length ratio 6:6; obovate shapes: the largest diameter lies above the center of the leaf (Appendix 3, page 488).
- paludarium:** imitation of a marsh biotope for animals and plants preferring a moist environment, usually incorporating a terrestrial and an aquatic section.
- panicle:** a raceme with branched lateral axis.
- pappus:** bristly or scaly calyx (e.g., many Asteraceae).
- peltate:** petiole inserted in the middle of the leaf blade (Appendix 3, page 488).
- perennial:** the plant will flower and produce fruit over the course of several years.
- perianth:** a term used to describe the outer sterile floral leaves which surround the fertile floral leaves; the perianth leaves are either equal (perigone) or (more common) divided into different green sepals and conspicuously colored petals.
- pericarp:** layer of vegetative tissue covering a fruit body; the body of a fruit developed from the ovary wall, enclosing the seeds.
- perigone:** uniform perianth, consisting of uniformly structured and colored tepals.
- petiolate:** having a stalk or petiole.
- petiole:** a slender stem that supports the blade of a foliage leaf.
- photosynthesis:** physiological process during which organic substances (carbohydrates) are produced from inorganic substances under catalytic participation of the chlorophyll in leaves and utilization of the energy of sunlight. It is also often described as assimilation.
- pinnatisected:** leaf indentations go right to the midrib.
- pinnatifid:** small leaf indentations, not reaching halfway to the midrib.
- pinnately parted:** leaf indentations reaching halfway to the midrib.
- pistil:** female reproductive organ in flowering plants, consisting of ovary, style and stigma.
- pistillode:** sterile pistil.
- polygamy:** the occurrence of unisexual flowers

alongside bisexual ones within the same plant species.

polymorphic: multishaped or -structured.

primary leaves: in many plants the initial leaves following the cotyledons but preceding the later, different leaf foliage.

prophyll: the first leaf, or leaves, on a lateral shoot.

pseudospike: panicle with very short branches, resembling a spike.

raceme: inflorescence in which petiolate flowers occur on the stretched main axis.

reniform: kidney-shaped, the leaf blade is wider than it is long and deeply indented at the base (Appendix 3, page 488).

respiration: gaseous interchange between the atmosphere and the intercellular spaces within the leaf (the absorption of carbon dioxide and the release of water vapor).

rhizoid: single- or multicelled hair formation replacing the roots. Their function is primarily the anchoring of the plant in the substrate.

rhizome: subterranean, more or less thickened stem axis (caulome). Rhizomes often store starch.

ribbon-like leaf shape: width to length ratio 1:12 or more, parallel margin (Appendix 3, page 487).

rudimentary: reduced but still present organs which have lost their original functions.

scarious: thin and membranous in texture, with a dried-up appearance, usually at the tips and edges.

semiaquatic: plants which exist partially below the water surface and protrude partially from the water with their shoots.

sensu auct.: in a sense differing from the original sense.

sepal: one of the modified leaves comprising the calyx.

short-day plants: plants flowering under a daily lighting period of less than 12 hours.

spadix: a thick fleshy spike.

spathe: an often conspicuously colored bract; typical in Araceae.

spathulate: the leaf blade is longer than wide, apex truncate, blade widely decurrent along the base (Appendix 3, page 488).

spike: inflorescence with a stretched main axis with sessile solitary flowers.

sporangium: spore carrier.

sporocarp: in aquatic ferns: mass of spores completely encased by a thick veil (velum).

sporophyll: fern leaves carrying sporangia.

stamen: leaf organs of the plant which produce the pollen.

staminode: reduced sterile stamen not producing any fertile pollen.

stigma: portion of the pistil which receives the pollen grains.

stomata: small openings found in the epidermal layers of plants, allowing access for carbon dioxide and egress for water, and are surrounded by guard cells which control the pore size.

style: the usually elongated portion of a pistil that connects the ovary with the stigma of a plant.

submersed: existing under water, aquatic.

sympatric: description of groups with identical or overlapping areas of distribution.

synandrium: structure occurring through the adnating growth of all stamens.

syncarp: fruit emanating from two or several adnate carpels of one or several flowers, e.g., in *Cryptocoryne* or pineapple (formed by several adnate flowers).

synonym: invalid plant name.

syntopic: occurring in the same habitat.

systematics: branch of biology determining the phylogenetic history of relationships in plants and animals and to arrange it into a systematic order. Taxonomy is a sub-branch of systematics.

taxonomy: taxonomy has the task of describing and naming the organisms, and arranging them in a systematic order.

tepals: the similar limbs of a perigone, perigone leaves; the perianth is not divided into calyx and corolla.

thallus: plant body in algae, lichens and simple mosses; not segmented into stem, leaves, and roots.

theca: the anther consists of two compartments (theca); each theca, in turn, of two pollen sacs.

transpiration: release of steam.

triploid: cells with a three-fold set of chromosomes.

turions: winter buds (hibernacles) in numerous aquatic plants. They are formed in autumn, survive the winter on the floors of waterways, only to return to the water surface during spring where they will again develop into new plants.

umbel: inflorescence with a shortened main

axis on which solitary flowers radiate from about one point. The flowers are more or less equally long petiolate. If instead of single flowers small umbels are present, this is called a compound umbel.

unisexual: flowers which have either only female (carpels) or only male (stamens) sexual organs.

vegetative propagation: nonsexual propagation (e.g., through lateral shoots, cuttings, etc.).

velum: veil.

verticillate leaf arrangement: three or more leaves are arranged in a whorl (Appendix 4, page 489).

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About the Book

Translated from the popular 1999 revised German edition, this text describes the temperature, water, fertilizer, and light needs of more than 300 aquarium plants. Artificial lighting – lamp types, color temperatures, and mounting – is discussed in detail and the author provides advice on choosing the right plants for an aquarium. Ecological factors, flower biology and morphology, and reproduction methods receive detailed coverage. The book contains 525 color photographs with nearly all plants depicted with fully developed submerged foliage. Many of the photographs of rare plants were published for the first time in the German edition. Botanists as well as professional and amateur aquarium keepers will find this book indispensable.

About the Author

Christel Kasselmann passes on her experience from over 30 plant-collecting expeditions in the tropics. She has made several trips to the Americas to study the growing conditions of species of the genus *Echinodorus*, which is her specialty. Kasselmann has written over 150 articles and books about water plants and for 20 years she edited the German aquarium plant magazine *Aqua Planta*.



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