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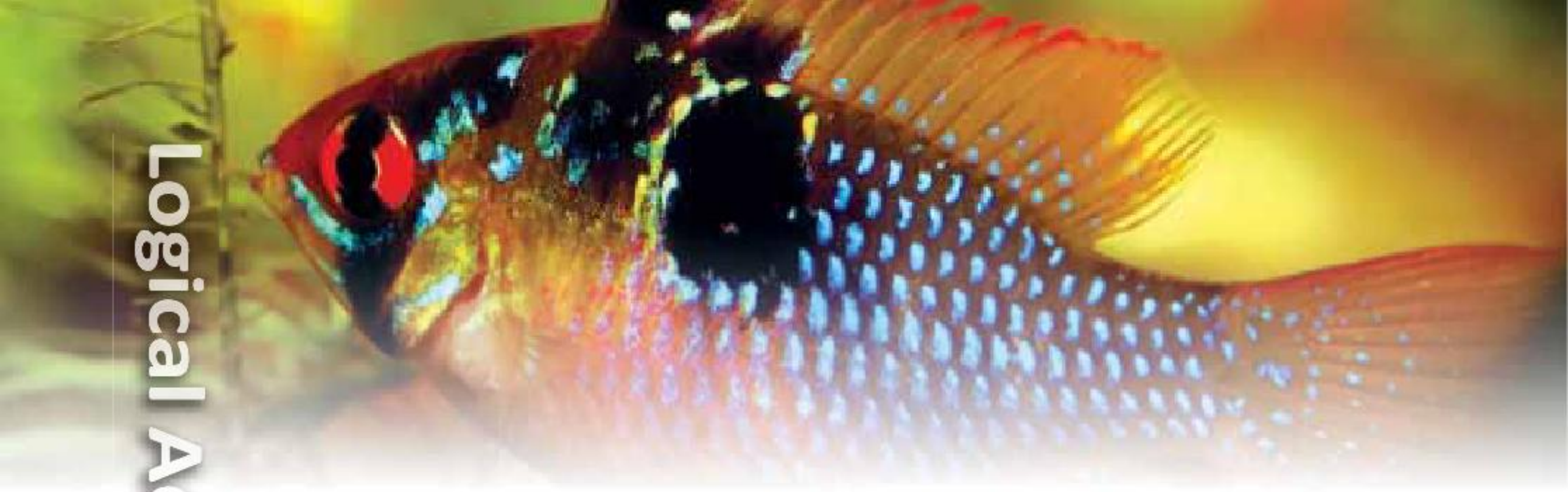

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COVER:
Top left: Melon Swordplant, *Echinodorus osiris*, photo: M. Wilstermann-Hildebrand. Top right: Java Fern, *Microsorum pteropus* "Windeløv", photo: H.-G. Evers. Center left: Water Wisteria, *Hygrophila difformis*, photo: M. Wilstermann-Hildebrand. Bottom: *Cryptocoryne wendtii* "Lilac-brown", photo: M. Wilstermann-Hildebrand.

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CONTENTS • VOLUME 1, NUMBER 3

Dear Reader,

The cover theme of this issue of *AMAZONAS* is devoted to aquatic plants, and we have set out to focus on the fundamentals rather than on aquascaping ideas. We have been able to secure the services of two of the best known, internationally recognized experts on the subject, and we hope that aquarists who are purely into fishes will also enjoy their article on aquatic plants in the wild. This topic is a little more complicated than we might expect. Up until now, the habitats of aquatic plants have been dealt with only in specialized literature largely unfamiliar to the general public, but once you have read this piece, I believe you will better understand why some plants are less than willing to grow properly in the aquarium. A second article addresses the issue of carbon dioxide in the aquarium. Anyone planning to set up an attractively planted aquarium should definitely read both of these articles. In addition, this issue contains two articles on propagating aquarium plants and a piece on summer water gardens.

Fish aficionados will find plenty to read in this issue, too. We introduce a number of species that, with a bit of luck, can be found in any store offering a decent selection—yes, they do still exist, although nowadays the majority of retailers seem to stock the same 150 species. But in keeping with our usual philosophy, we also present a number of species that are relatively unknown to date. This time we have a particularly large number of such "novelties," including both cultivated forms and practically unknown species from Asia, South America, and Africa. For example, have you ever heard anything about the genus *Denticeps*? Even the all-knowing Internet is short on information about and photos of live fishes of this genus.

We also take a look at efforts in conservation breeding to preserve species that are now extinct in the waters of Lake Victoria, and we present a small and rather colorful rainbowfish, previously unknown in the aquarium hobby, that some friends and I were lucky enough to catch.

What more could anyone ask? But please read the magazine yourself, as I am already working on the next issue and must get back to it!

Yours sincerely,
Hans-G. Evers

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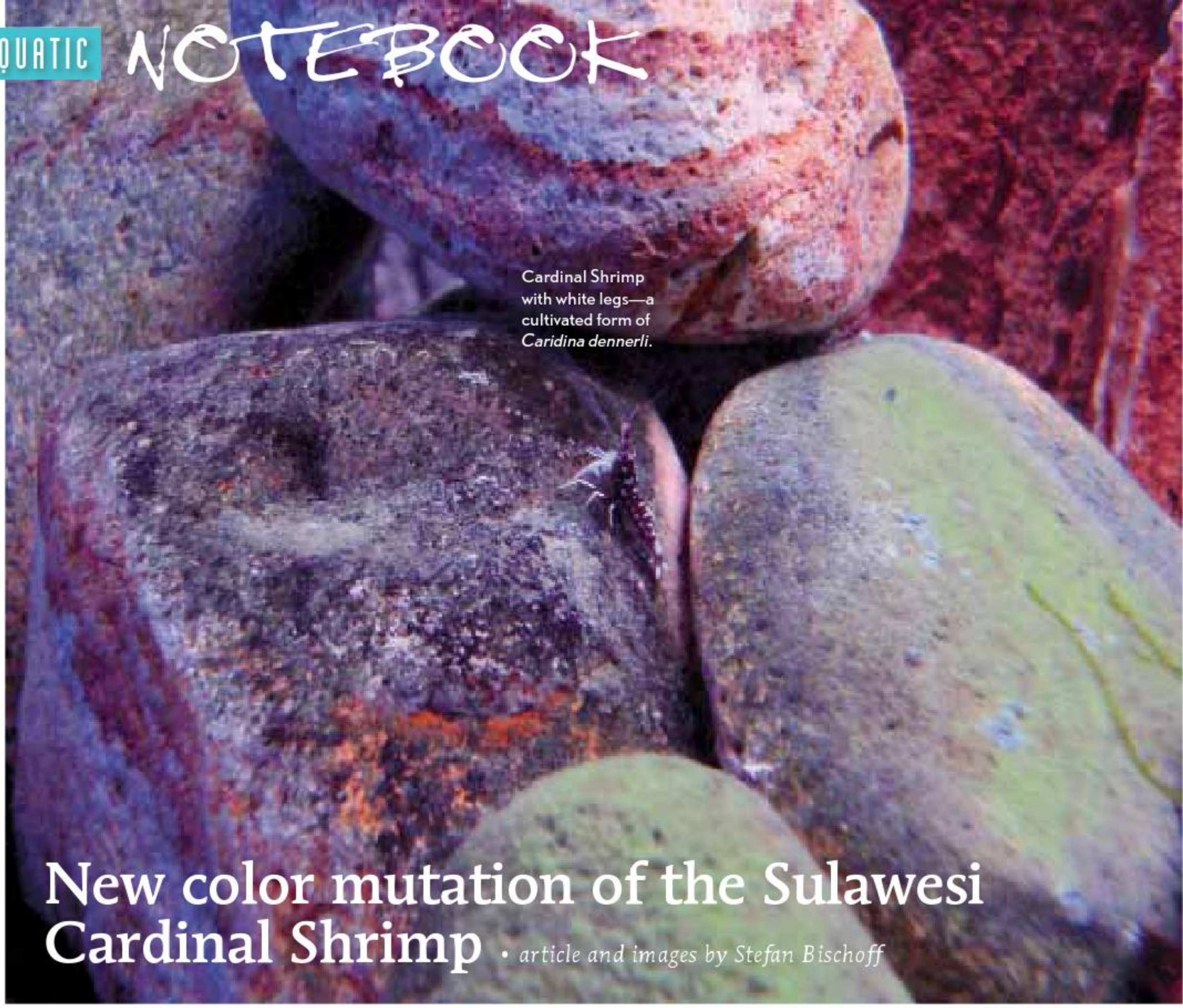

Cardinal Shrimp with white legs—a cultivated form of *Caridina dennerli*.

New color mutation of the Sulawesi Cardinal Shrimp

• *article and images by Stefan Bischoff*

Since 2009 I have been keeping and breeding one of the loveliest of freshwater shrimps, the Sulawesi Cardinal Shrimp, *Caridina dennerli*. Over the course of time a large group of several hundred has developed from the original 10 individuals. *AMAZONAS* (March/April 2012) has published a wonderful, informative issue about *Caridina* spp., so I don't need to go into their provenance and general maintenance conditions here.

I maintain my *Caridina dennerli* in an 18.5-gallon (70-L) aquarium in tap water with a temperature of 84°F (29°C), a pH of 7.9, a carbonate hardness of 7°KH, and a general hardness of 11°dGH. The weekly 50-percent water change is performed using warm tap water with dissolved montmorillonite (clay) dust added. No other water conditioning is employed. I feed in much the same way as most breeders, but with two fasting days per week.

About six months ago one of my breeding groups produced individuals that are aberrantly patterned. Unlike normal Cardinal Shrimps (red to dark body with white to bluish dots, two pairs of white claws, and red legs), these individuals exhibit partially or wholly white legs. They differ from the other Cardinal Shrimps only by virtue of their white legs; all other characters are identical.

For three months now I have had 20 of these white-legged Cardinal Shrimps in a 10.5-gallon (40-L) species tank set up especially for them. A few weeks ago my hopes were raised by the presence of two females carrying eggs, and my patience was rewarded. After around three weeks the first little Cardinals hatched, and by the fifth day they actually exhibited white legs. I was immensely pleased, especially when the second clutch turned out the same. The markings vary from white thighs to completely white legs.

This new color mutation of the gorgeous *Caridina dennerli* is thus a strain that breeds true. I will be interested to see what other color mutations these little shrimps from Sulawesi produce in the future.

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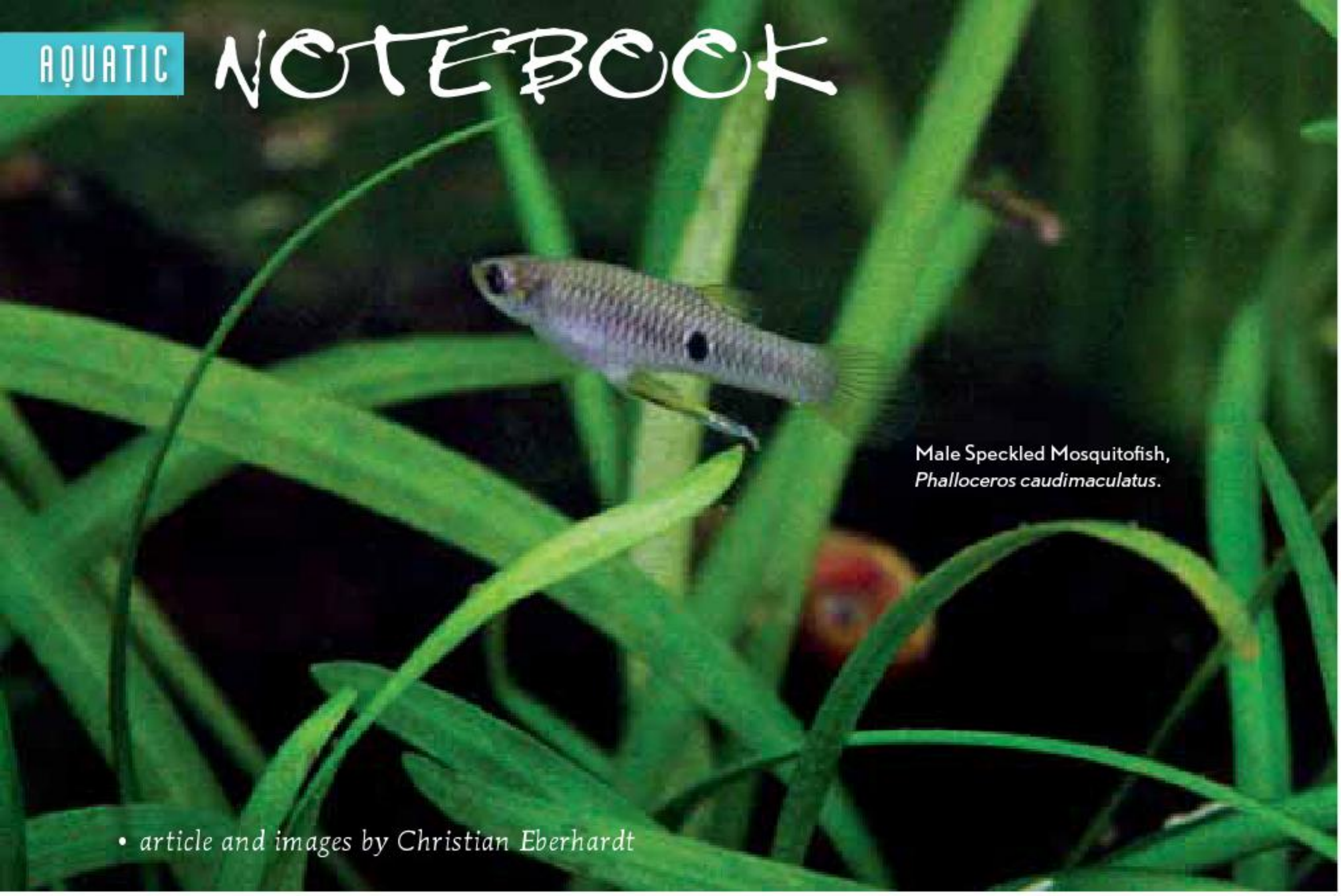

Male Speckled Mosquitofish, *Phalloceros caudimaculatus*.

• *article and images by Christian Eberhardt*

An almost forgotten aquarium fish—the Speckled Mosquitofish

When my parents and I visited my sister in Buenos Aires last Christmas, I, being an aquarist, packed a net and some plastic bags in my luggage. I wanted to see what I could find in the Río de la Plata area while I was there. As the only fish-mad member of my family, I had little hope that they would permit me much time to go fishing in peace. But there was actually a golden opportunity one day when we made a family excursion to the so-called Tigre Delta on the Río de la Plata north of Buenos Aires.

Boats are the only means of transport in this close-packed network of river channels, and the boat trip was fascinating. It was a glorious sunny day, and we traveled past flowering *Echinodorus* spp. sword plants and dense stands of *Sagittaria*, probably *S. montevidensis*, on our way to Tres Bocas, the confluence of three channels, where we went ashore to explore. We crossed lots of small channels and ditches, and here and there I saw a number of small fishes swimming away—but they were always too far from the bank to catch.

My mother had eyes mainly for the burgeoning flowers of the oleanders, while I spent more time looking at the water than at the path ahead. As we passed a still, overgrown section of water we came to a narrow jetty, and I spotted a multitude of small fishes hovering in the sunlit, muddy bank region and readily accessible from the jetty. In next to no time the net was unpacked, and after one, two, three sweeps I had captured a number of small livebearing toothcarps.

Naturally, I was immensely pleased and excited! The fishes were very attractive to look at. The males were around 0.75–1 inch (2–2.5 cm) long, and some had a black lateral spot (sometimes ringed with silver), a large yellow gonopodium (male sex organ) with a black lower edge, and a yellowish sheen on the dorsal fin. The females were larger (1.5–2 inches/4–5 cm long) and not as pretty, but they also had the black spot on the flank. I thought these fishes were very interesting and unusual, so I bagged up a few and took them home with me.

A veteran aquarium fish

Back at home, I initially placed these fishes in a small aquarium with a dense stand of Eurasian Water Milfoil, *Myriophyllum spicatum*. On studying the literature, I was very surprised to discover that I had brought home the Speckled Mosquitofish, *Phalloceros caudimaculatus*, one of the first fishes to be maintained in the aquarium hobby. I had seen photos of a number of cultivated forms of this species, such as the checkered, speckled color variant.

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The Speckled Mosquitofish was already being kept in the aquarium as long ago as the end of the nineteenth century, so I got a lot of pitying smiles from my friends when I told them about my "new import."

The maintenance and breeding of this fish in the aquarium is relatively problem-free, just as it was back in our grandparents' day. Speckled Mosquitofishes will happily eat dried foods. The tank should be heated in winter so that the temperature doesn't drop below 62.5°F (17°C). If the tank is densely planted, you will regularly see little Speckled Mosquitofishes growing on under the cover of the vegetation.

One interesting note: this is considered an invasive pest species, especially in Australia, sometimes known as the Dusky Millions Fish, Leopardfish, or Speckled Caudy. (Never release aquarium fish into your local waters, including small fry that might be inadvertently flushed during water changes.)

Although the wild forms of some livebearing toothcarps aren't as brightly colored as the cultivated forms, perhaps more attention should be paid to them, as they are attractive and interesting to keep nonetheless!

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(*Recommended to any fish enthusiasts visiting Argentina.*)

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The area of water where the fish was found in the Rio de la Plata, north of Buenos Aires, Argentina.

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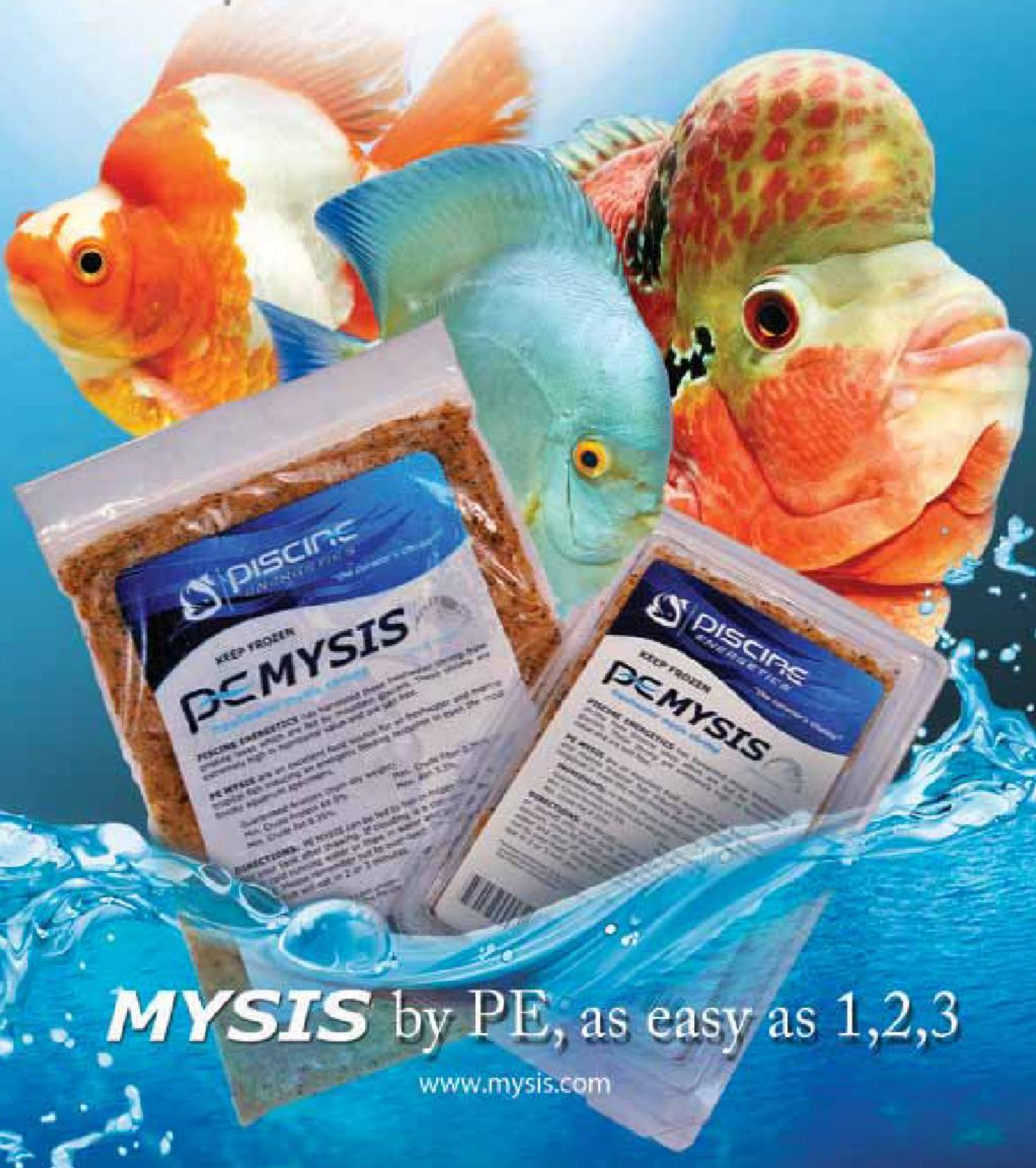

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• *article and images by Vladko Bydzovsky*

Breeding a *Myloplus* species

Barely a year after becoming the first Czech to breed the Altum Angel (*Pterophyllum altum*) in 2002, Jan Haidinger embarked on a new project. He purchased a number of serrasalmid characins under the name *Myleus arnoldi*. Because he had also bred *Metynnis argenteus* successfully in the interim, he knew what he was in for.

Myleus and *Myloplus* come from South America, where they are found in the Guianas, the Amazon drainage, and even in the drainage of the Río Paraná south to Argentina. Both genera belong to the same family as the piranhas, the Serrasalmidae, but are regarded as vegetarians. These up to 10 inch (25 cm) long characins usually live in shoals. The males are usually smaller than the females and are characterized mainly by the difference in the anal fin. In females this fin resembles that of a young piranha—the anterior part is longer. In males the

Right: Females are larger and more robust than males, and their finnage resembles that of juveniles. They are often sold as "silver dollars" in the trade.

Below: The fin hasn't had a bite taken out of it—this pennant-like extension to the anal fin is typical in males and distinguishes them from females.

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fin looks as if a bite has been taken out of it: the anterior part is only slightly prolonged, while the central portion forms a point like a little pennant.

The specific status of these fishes is unclear. Our determination suggested *Myleus gurupyensis*, a species that is now regarded as a synonym of *Myloplus asterias*. However, this fish is generally known in the aquarium hobby under the name *Myleus rubripinnis luna*, which is, in turn, regarded as a synonym of *Myloplus rubripinnis*, the so-called Redhook. Possibly it is that species. It is characterized by red spots on the flanks in adult fishes.

Not just plants

A tank for serrasalmids doesn't need to be a precise copy of conditions in the wild, but it is advisable to use an aquarium with a volume of 50 gallons (200 L) or so, decorated with large rocks, bogwood, or even plastic plants. Live plants are not a good idea—they may be eaten. The water must be clean, with good aeration and plenty of oxygen. Large, peaceful fishes, including cichlids, catfishes, and other large characins, will make suitable tankmates.

Myloplus rubripinnis (or whatever you prefer to call it) isn't fussy when it comes to the chemical composition of the water, although soft, slightly acid water with a temperature of around 77–80.5°F (25–27°C) is ideal. Even with good filtration, water changes should be performed regularly.

According to the literature, these fishes feed mainly on vegetable matter—spinach, lettuce, or aquatic plants. However, it has been found that in practice they show little interest in such foods. What they do like is the dry food specially formulated for discus (*Symphysodon*). They also like live or deep-frozen bloodworms. It is particularly important to feed juveniles a varied diet, so introduce as many different types of flake food as possible.

Spawning process

Breeding took place by chance after six years of maintenance, and has always occurred when the fishes have been kept in groups rather than pairs. The actual spawning procedure, which takes place on the open sandy bottom, is as follows: The male swims next to the female and excavates a small hole (up to 0.75 inch/2 cm across) in the sand with jerky movements. Next, the female lays a few eggs in this hole and the male then fertilizes them. The rest of the group quietly watch the spawning. And so it continues, but with different pairs taking turns. The males don't care for the eggs thereafter, unlike many other serrasalmids.

We have tried several times to separate the pairs and get them to breed, but without success. The fishes generally showed no interest. We have also tried regular water changes, but that didn't produce any results either.

The first young were noticed by chance—the actual spawning had not been observed. Although we had noted that the females

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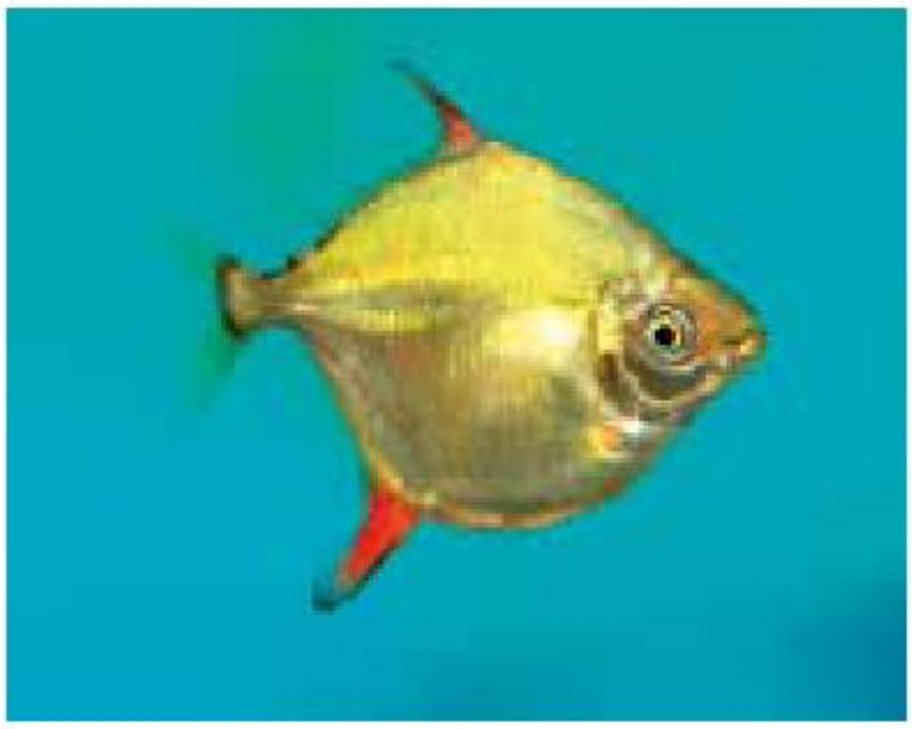

Left: Juvenile at around six weeks. Right: At the age of two months, the young have a silvery sheen and the anterior rays of the dorsal and anal fins are bright red.

had swollen bellies, there had been no other indication of breeding taking place. The young were reared in normal tap water at 77–80.5°F (25–27°C), general hardness 5°dGH, carbonate hardness 2°dKH, and pH 6–7. The fry grew on very rapidly.

A good clue that spawning is going on is the presence of lots of little holes in the substrate. If you notice this in advance you can be better prepared and keep an eye on the fishes. We have not noticed fungusing of the eggs, but it is possible that the parent fishes remove any fungused eggs themselves.

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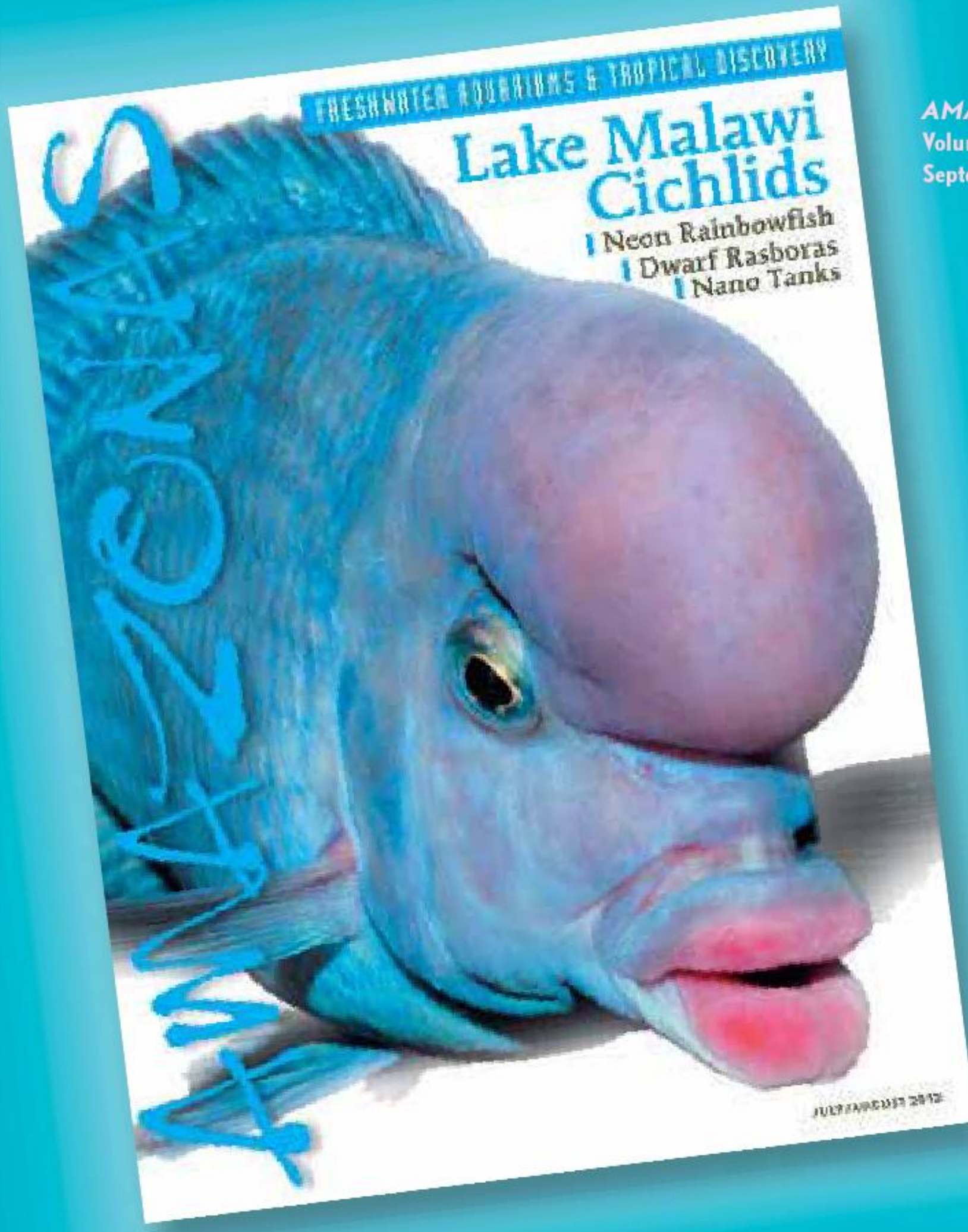
Rearing tank containing three-month-old youngsters of varying sizes.

"Wow!"



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The LukugaRiver at Kalemie.

• *article by Mary Bailey, with images by Ad Konings*

The Great Escape

Large lakes usually have several affluent rivers feeding them with water, but only one outlet, and Lake Tanganyika in the Great Rift Valley of East Africa is no exception: its outlet is a small river called the Lukuga, which leaves the lake at Kalemie (formerly Albertville) about halfway along the western shore. But the Lukuga is very different from the outlets of the other two major East African lakes, Lake Victoria (drained by the Nile) and Lake Malawi (drained by the Shire, a tributary of the Zambezi). Most of the water loss from Lake Tanganyika takes place via evaporation, and the Lukuga is little more than an overflow; if the lake level is low and there is not much spare water to be drained away, the river's mouth silts up and there is minimal flow. It is likely that at times of drought and exceptionally low water levels, the section of the Lukuga immediately adjacent to the lake dries up completely (Keith Banister, pers. comm.), although further downstream it is fed by tributaries and so probably continues to flow. There is a record of the lake level being high and then dropping relatively rapidly when the "dam" that had formed across the outlet to the Lukuga was breached during the nineteenth century (Hore, 1882).

Ctenochromis horei

Simochromis babaultli

After leaving the lake, the Lukuga flows west for around 220 miles (350 km) to join the Lualaba, a major headwater of the Congo. This link is important in considering the biogeography and evolutionary history of the lamprologine cichlids, which are found only in the lower Congo and Lake Tanganyika; the jury is still out as to whether these fishes originated in the lake and escaped down the Lukuga/Lualaba to colonize the Congo, or whether they originally evolved in the Congo. The second option may initially sound implausible—how could such small fishes swim all that way against the current, surmounting rapids and waterfalls, to reach the lake? But it is thought that the Congo formerly flowed from west to east to join the Zambezi system, until the tectonic events that created the Great Rift Valley and its lakes severed this connection—much as the Amazon flowed from east to west to empty into the Pacific before the geological up-thrust that created the Andes. Moreover, the Lukuga outlet is almost opposite the Malagarasi, a major affluent of Lake Tanganyika, and similarities in the fish fauna of the two rivers have led to speculation that they may have constituted a single river in the past.

The story has become even more interesting with the recent publication of a paper by Kullander and Roberts (2011). Roberts, well known for his work on the fishes of the Congo, traveled the Lukuga in 1986 and discovered a number of cichlids and other fish species, nominally endemic to Lake Tanganyika, living happily in the river near its confluence with a major tributary, the Niemba, about 62 miles (100 km) from the lake. (Unfortunately, taxonomists and systematists can't always quickly process material that is collected, so the preserved specimens that Roberts brought back have only now been identified and documented.) Of course, Lake Tanganyika fishes have often been found in the Lukuga near Kalemie, but not so far downstream.

The progress of the "emigrants" downriver appears to have been stopped by a large waterfall; at least, no specimens were found below it. Since waterfalls do not

Telmatochromis dhonti, "Tel Dhonti"

Tanganicodus irsacae, Spotfin Goby Cichlid

normally prevent (unintentional) downstream migration, a possible explanation is that any fishes that did take the plunge fell victim to the very different water chemistry further downriver. While the Lukuga from Lake Tanganyika to Niemba is similar to the lake in its chemistry, the influx of water from the River Niemba produces very different conditions that, on the basis of aquarium observations of the effects of soft acid water on Lake Tanganyika endemics, are probably not conducive to their survival.

The escaped endemics include cichlid species known in the hobby (for example, *Ctenochromis horei*, *Simochromis babaulti*, and *Telmatochromis dhonti*), as well as a "lake sardine," *Stolothrissa tanganicae*. Both *Simochromis* and *Telmatochromis* are normally regarded as endemic to Lake Tanganyika, though *Ctenochromis* species are known from elsewhere. Perhaps most exciting of all, there is a member of another Lake Tanganyika "endemic" genus, *Tanganicodus*, in the Lukuga at Niemba. Hitherto this "goby cichlid" genus has been regarded as monotypic (containing just one species) and represented solely by *T. irsacae*; the specimens from Niemba are very similar to that species but exhibit differences in coloration and dentition, and the implication must be that this putative new species has evolved in the Lukuga from *irsacae* ancestors.

Nobody knows how long ago these fishes made their excursion, or whether they all left together—perhaps during a period of exceptional overflow and strong current—or separately, at intervals. Current geology means that the trip was inevitably one-way, as there are rapids in the upper Lukuga to prevent any return. Due to political instability, lack of infrastructure, and the local terrain, exploration of the area is difficult and only attempted sporadically, but hopefully, sooner or later there will be new expeditions to the Lukuga to further investigate the "Great Escape" and determine whether it is still ongoing.

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Aquatic plants in the wild

• *by Ole Pedersen and Claus Christensen*

Our aquarium plants either occur in the wild or are cultivated forms of wild species. But very few aquarists have the opportunity to observe these plants in their natural habitats. Those who do often note that these plants look quite different than they do in the aquarium. In addition to facing constant competition for space, they are affected by the presence of fishes and invertebrates and are often in poor condition. In this article we will look at what can be learned from the examples of three selected aquarium plants in their natural habitats, and why it is sometimes better not to copy those environments too faithfully.

Only rarely do plants enjoy absolutely ideal living conditions in the wild. The occurrence of a plant in a specific habitat is the result of complex processes that have led to its success. This begins with the germination of the seeds or spores. If conditions are not ideal for this process, the plant can spread only via vegetative reproduction, including the breaking off and drifting away of viable pieces to other habitats, where they immediately have to compete with other plant species for space, light, nutrients, and CO_2. They must form new leaves more rapidly than the existing ones are removed by feeding insects or other enemies that are invariably present.

It is impossible to predict who will win this battle for existence, even where conditions are optimal for one plant species or another. Even the tiniest difference between species can be decisive. On the other hand, it may happen that changes in the environment allow a large variety of plant species to thrive alongside one another. So there is little sense in studying a single biotope of *Cryptocoryne crispatula* (Cryptocorne Balansae), for example, or in recording data such as light intensity, CO_2, nitrate, ammonia, phosphate, electrical conductivity, carbonate hardness, or the number of potential plant enemies on a given day in order to come to the conclusion that precisely those values constitute the ideal conditions for that plant. Who can say whether or not the chance presence of the very vigorous *Limnophila sessiflora* (Dwarf Ambulia), for example, in the same habitat will lead to the disappearance of the *Cryptocoryne*?

Nevertheless, we can derive a wealth of useful information from conditions

C. CHRISTENSEN

Left: Madagascar Lace Plants blossoming.
Right: Typical Lace Plant habitat in Madagascar (Biotope 1) with moderate water currents.

Above: The leaf forms of the three different varieties of the Madagascar Lace Plant, *Aponogeton madagascariensis*. From left to right: *A. madagascariensis* var. *madagascariensis* (the two narrow and elongate leaf forms on left), *A. madagascariensis* var. *major*, and *A. madagascariensis* var. *henkelianus*. The last two both have rounded leaves, but clearly differ in their grid-like vein structure.

Below: One of the authors at Biotope 3 with a huge Madagascar Lace Plant.

in a plant's natural habitat and apply it to the aquarium hobby. We can learn a lot about the adaptability of particular species, especially if we investigate several different sites and build up a picture of the range of environmental conditions that it will tolerate. But that doesn't mean that we can't also cultivate a plant species successfully under totally different conditions in the aquarium; after all, there may be no predators or enemies in the aquarium, and competing species can be curbed quickly.

FABLES AND FACTS

FABLE: *Aponogeton madagascariensis* requires low water temperatures, if possible less than 75°F (24°C).
FACT: Not one of the many locations studied in Madagascar had a water temperature lower than 75°F (24°C). At one site we found the plant at 88°F (31°C)!
FABLE: *Aponogeton madagascariensis* will only grow in crystal-clear water.
FACT: One of the biotopes visited contained very murky water, but the Lace Plants were in good condition. This murky "soup" wasn't entirely natural in origin: the rainforest had been clearcut along the river, and soil had been washed into the water by heavy rains, clouding the water. After a number of rain-free days the river became clear again, so this particular fable is plausible.
FABLE: *Aponogeton madagascariensis* is difficult to cultivate in the aquarium.
FACT: Only a small number of aquarists have succeeded in maintaining the Madagascar Lace Plant over a period of years and in propagating it from seed. It seems that some local variants are more difficult to cultivate than others, but as far as we know this hasn't been confirmed by systematic study. So this fable is confirmed: the Madagascar Lace Plant is difficult to cultivate in the aquarium.

Aponogeton madagascariensis

Aponogeton madagascariensis, the Madagascar Lace Plant, is probably the most striking plant in our hobby, and for many people it is the queen of aquarium plants. It has historically been collected mainly from the wild, although it is now being propagated via tissue culture in at the University of Florida by Dr. Michael Kane. High demand from aquarists has resulted in over-collecting. Moreover, the corms of the plant are prized as a vegetable by the Malagasy people, and even today it is not uncommon to find the corms for sale in the markets. However, the increasing environmental pollution and destruction of natural habitat is of even more concern than the collection of this plant, which has become very rare in its native waters in Madagascar and is now regarded as an endangered species.

Three varieties of the species are known (Bruggen

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A shallow pool in granite at Mukinbudin in Western Australia. These pools are home to a number of aquatic plants known in the aquarium hobby, for example *Glossostigma*, *Eleocharis* (hair grass), *Marsilea* (water clover), and *Crassula*.

1990): *Aponogeton madagascariensis* var. *madagascariensis*, *A. madagascariensis* var. *major*, and *A. madagascariensis* var. *henkelianus*. The veining of the leaves differs among the three varieties, which results in different leaf structures. The grid-like framework of veins with open spaces between them is caused by what is known as "programmed cell death" (PCD). Initially all the cells are present, and then the affected ones die, creating holes. The PCD phenomenon is fairly well researched scientifically, and it is believed that in some plant species it serves in part to prevent self-fertilization and thereby avoid inbreeding.

It appears that the development of the leaf structure is also influenced by the speed of the current. In fast-flowing streams the leaves tend to an elongate habit of growth, but this is not the case in more peaceful waters. Long leaves offer less resistance in strong currents and help the plant to avoid being uprooted or damaged. A Madagascar Lace Plant collected from a fast-flowing river tends to develop rounder, less elongate leaves in the aquarium, where the current is not as strong.

During a trip the two of us made in December, we were able to visit three Lace Plant habitats in Madagascar. Our first impression was that the three biotopes differed from one another more than we had expected. We were particularly surprised at the high water temperatures of 77–88°F (25–31°C), significantly above normal aquarium temperatures.

Biotope 1 was situated to the east of the capital, Antananarivo, and west of Andasibe. The water was clear, with a moderate current of 12–16 inches (30–40 cm) per second. The electrical conductivity was less than 10 µS/cm, the pH 7.9. This was the coolest site, with a water temperature of 77°F (25°C).

Biotope 2 was near Maravola. The water was very warm at 88°F (31°C) and fast-flowing (about 30 inches/75 cm per second). The carbonate hardness was low (3°dKH) and the pH was 7.5. The substrate consisted of sand and pebbles.

Biotope 3 was situated near Tampina, and it was here that we found the most unusual specimens of Lace Plants. Some of the leaves were 100 inches (2.5 m) long and the plants were enormous. The water

The pools are often only 4 inches (10 cm) deep and dry up during extended rainless periods. During the short time when there is adequate water, the plants must ensure their continued existence by flowering and producing seeds. Here we see flowering *Glossostigma* (lilac flower) and *Crassula* (white flowers, front) shortly before the pool dried up completely.

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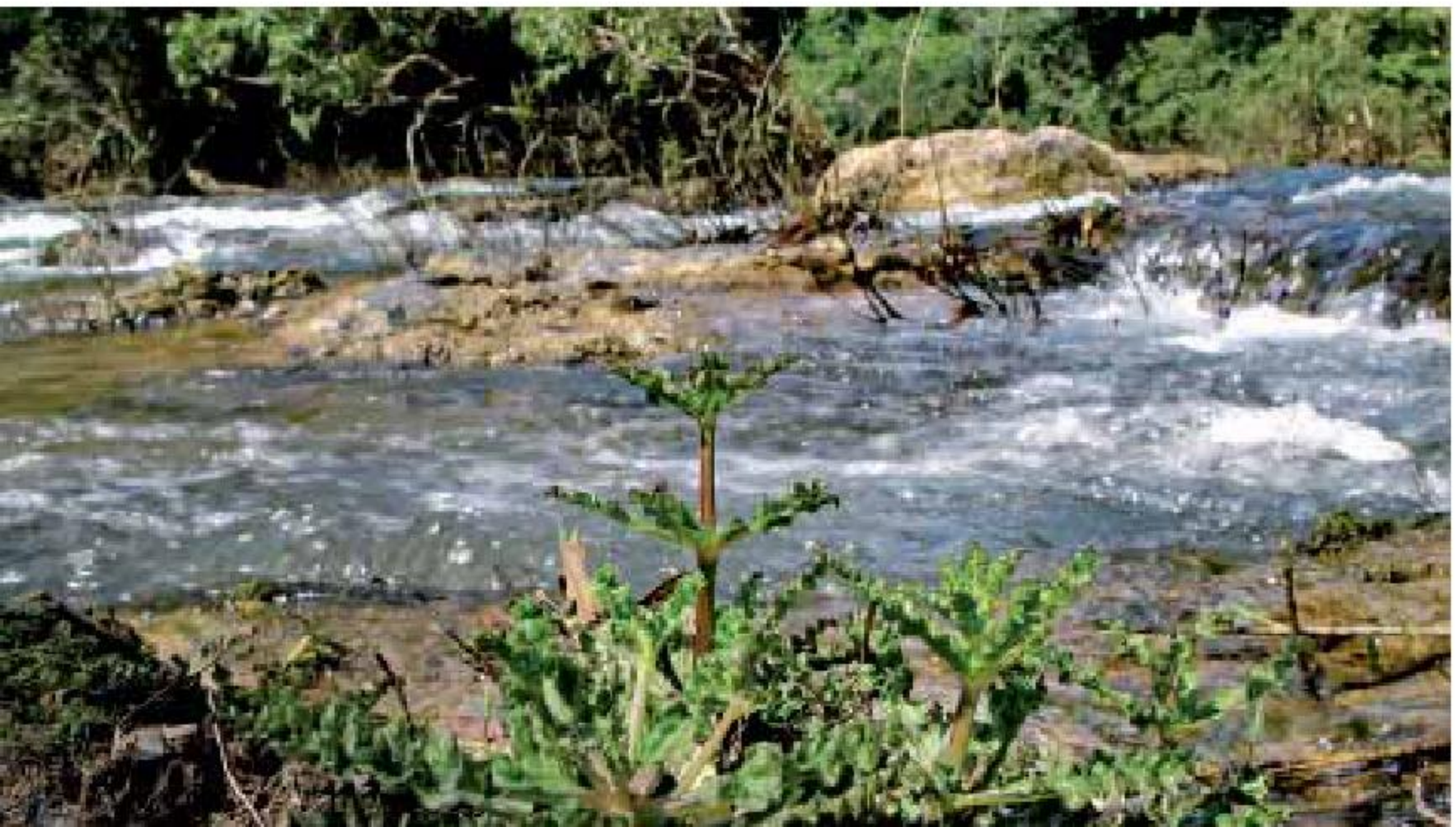
Glossostigma grows in dense mats here, bringing to mind the aquascaped aquariums of Takashi Amano. The bottom is still moist and sudden rainfall might fill the pools again—but if there is no rain, the plants will soon die.

A nano aquarium in the wild. This spectacular shot was taken in just 4 inches (10 cm) of water. The photosynthesis of dense stands of *Crassula natans* produces a mass of bubbles—a magical sight.



An emersed stand of *Pogostemon* helferi in its natural habitat in Thailand. The water has already receded and the plants are sprouting their long, flowering stems, which won't be submerged even if the water level rises again.

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was practically still (current was under 4 inches/10 cm per second), murky, and rather warm 84°F (29°C). The pH was 6.5 and the electrical conductivity measured 70 µS/cm. The substrate was soft and muddy.

Pogostemon helferi is an amphibious plant that grows both under and above the water. At the time of our November visit, the water level had already dropped.

Glossostigma

The species of the genus *Glossostigma* are native to Australia. In the western part of the continent in particular, there are bizarre granite formations with shallow depressions in which a small amount of soil accumulates, and during the rainy season these are transformed into shallow pools of water. Here we discovered the most spectacular aquatic habitats we have ever seen (Pedersen et al., 2009). The climate is almost Mediterranean, with cool, rainy winters, while the summers are very hot and dry. At the beginning of the cooler part of the year the depressions fill with water and remain wet for 3–5 months. The water is very shallow (less than 4 inches/10 cm), and the bottom is covered with a sandy substrate on which a thin layer of *Glossostigma* grows.

At least three species of *Glossostigma* grow there. The habits of the species are so similar that they can be reliably distinguished only on the basis of their flowers. The plants survive from year to year in these extreme biotopes only by producing seeds. The first seeds germinate soon after the first rain showers and develop into full-grown plants within a few weeks. Then they wait for a period of

Pogostemon helferi growing underwater alongside *Cryptocoryne crispatula*, the most common member of its genus in Thailand. Both are amphibious plants that require a short dry period in order to form flowers.

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We also found submerged stands of *Pogostemon helferi*, usually dense mats in strong current.

low rainfall and falling water levels, which triggers the flowering period. The plants require only about a week to produce ripe seeds to ensure the next generation of the species.

Glossostigma elatinoides became popular in the aquarium hobby during the 1990s, largely thanks to Takashi Amano, who used the plant for the carpet-like foreground plantings of his spectacular aquascapes. It is considered difficult to grow, as it requires a lot of light and develops the dense, carpet-like habit of growth only when fertilized with CO_2. If there is too little light the plant will grow upward instead of creeping along the bottom. Surprisingly, only *Glossostigma elatinoides* has found its way into the aquarium hobby. But when we visited the habitats of the genus, we found at least two additional species that may prove equally interesting for the aquarium hobby. Both species require a lot less light than *G. elatinoides* and also grow a lot tighter to the bottom.

Glossostigma shares these lovely habitats with other well-known aquarium plants. We found lovely stands of an *Eleocharis* (hair grass) species, and sometimes there was also a small *Marsilea* species growing in the pools. The invasive alien *Crassula natans*, introduced to Australia from South Africa in times past, was especially common in the rock pools. The genus *Crassula* is known for the phenomenon termed "Crassulacean acid metabolism" (CAM), a method of photosynthesis in which the stomata (respiratory pores in the leaves and stems of plants) open only at night to permit gas exchange. This minimizes the plant's loss of moisture and enables it to survive even in extremely dry areas. *C. natans* also lives underwater, where it is very successful in competing for scarce CO_2 by virtue of its special method of photosynthesis (Pedersen et al., 2010).

Because the rock pools are fed only by rainwater, the water is very soft with an extremely low conductivity (less than 5 µS/cm). There are no limestone inclusions in this area, so there is virtually no measurable carbonate hardness (less than 1°dKH). The CO_2 content of the water is in equilibrium with the atmosphere (less than 0.5 mg/L), and the pH is stable at 7.5.

The type of granite formation described also occurs in South Australia and New South Wales, where it is likewise possible to find such "natural nano aquariums"—small rainwater pools that sometimes contain just as little water as a real nano tank (Pedersen et al., 2009). But for most of the year these pools are dry, and during that time it is difficult to imagine the fantastic little underwater worlds they hold during the rainy season.

Pogostemon helferi

Pogostemon helferi (Downoi) is a relatively new aquarium plant (Christensen et al., 2008). The Thai aquarist Nonn Panitvong was the first to collect it, in the large rainforest area in the province of Kanchanaburi in western Thailand. The plant was immediately cultivated by a Thai plant nursery and offered for sale at a weekend market in Bangkok, where it was discovered by staff from the Danish company Tropica Aquarium Plants. Tropica propagated the plant fairly successfully and established it in the aquarium hobby in Europe, North America, and Japan.

The species forms small rosettes of very wavy leaves, which are colored bright green, sometimes even reddish. The species is easy to propagate from side shoots. It is commercially propagated *in vitro* on artificial substrate, so there is virtually no pressure on natural populations. The ability of this plant to root naturally on a wide variety of substrates means it can be used for many purposes, and it can be purchased already growing on lava rock or bogwood. When grown thus, however, it requires good fertilization via water, as it is a fast-growing plant that requires lots of nitrate and phosphate.

P. helferi has been recorded in various locations in both Thailand and Myanmar (Burma), but the best-known site is the one where it was discovered by Nonn Panitvong, near Highway 323 around 11 miles (18 km) south of the Three Pagodas Pass and north of Sangkhla

Buri in the province of Kanchananaburi. Here the plant lives in fast-flowing water (up to 40 inches/100 cm per second) and roots in the numerous holes and cracks in the limestone that forms the bed of the river.

During the high-water period (May to October) the plant survives as thick pieces of rhizome that start to sprout again as soon as the water level drops and there is a corresponding increase in light intensity. If the water recedes still further, leaving the foliage high and dry, then the plant produces flowers. Like many other aquarium plants, *P. helferi* is amphibious and grows equally well above and below water. Being a flowering plant, it requires low water levels to blossom and have its flowers fertilized by flying insects.

We visited the biotope in November, when the water level had recently dropped. We found the species both above and below water and on large limestone rocks protruding from the water in the middle of the rapids. The plant usually grows in small cushions formed in the fast-flowing water. The electrical conductivity measured 180 µS/cm at a water temperature of 77°F (25°C). The carbonate hardness was 5°dKH, the pH 8.3, and the CO_2 content less than 0.5 mg/L. We were able to record small amounts of phosphate but no trace of nitrate or ammonia, but the presence of blue-green algae (cyanobacteria) among the cushions suggests that a higher nutrient concentration is present at other times.

The majority of streams and rivers in this region are also home to *Cryptocoryne* species growing in shallow water and along the river banks. We found *Cryptocoryne crispatula* together with *P. helferi*, though the *Pogostemon* was frequently growing in deeper water as well.

The precise distribution of *P. helferi* is unknown, but its frequent occurrence in the Great Western Forest of Thailand is reason for optimism. Large parts of the region are in a national park and are protected, so the future of the species may be relatively secure. The little-collected habitats in Myanmar are not so well known, and it is possible that *P. helferi* still occurs in large parts of the country. The plant is propagated in large numbers in nurseries for the aquarium, rather than being taken from the wild.

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Carbon dioxide in

• *by Ole Pedersen, Troels Andersen, and Claus Christensen*

Carbon dioxide (CO_2) is without doubt the most important plant nutrient. Without the addition of adequate CO_2, plants cannot photosynthesize and convert carbon into energy-rich sugars, starches, and other materials. It may seem odd to call gas a nutrient, because when cultivating terrestrial plants we supply light, water, and fertilizer, but don't bother about carbon dioxide. Read on to learn why it is necessary to add CO_2 to planted aquariums, how the gas is processed by the plants, how much they need, and how to provide it.

Aquarium plants require water, light, carbon dioxide, and, in most cases, substrate. Photosynthesis cannot take place if any one of these components is lacking. CO_2 is a prerequisite for photosynthesis, during which the gas, along with water (H_2O), is converted into energy-rich sugar ($C_6H_{12}O_6$) and oxygen (O_2) using light as a source of energy (see "From Carbon Dioxide to Sugar," page 37).

We all know people who maintain beautiful planted aquariums without the addition of CO_2, but this is possible only because carbon dioxide is already present in the water; it is a product of respiration, which is the reverse of photosynthesis. During respiration energy is released, and sugars are broken down into CO_2 and water.

Aquarium plants breathe, and in fact they do so 24 hours a day. However, when light is available they produce far more organic carbon compounds via photosynthesis than they burn up through respiration. No photosynthesis takes place in the dark of night, and carbon dioxide is given off through the respiration of plants, invertebrates, fishes, and microorganisms. Of course, the last three also produce carbon dioxide during the day.

Carbon dioxide uptake

Carbon dioxide dissolves very readily in water. A liter of water can take up almost as much CO_2 as a liter of air where a state of equilibrium has been established. When carbon dioxide dissolves in water it creates an equilibrium between dissolved CO_2, carbonic acid (H_2CO_3), bicarbonates (HCO_3^-), and carbonates (CO_3^{2-}) (see box, "From Carbon Dioxide to Sugar," page 37). This balance is highly dependent on the pH. At low pH, carbonic acid predominates and there are practically no carbonates or bicarbonates present, and at neutral pH, bicarbonates predominate. Only at high pH do carbonates predominate. However, the majority of aquatic plants can process only dissolved CO_2 and carbonic acid, which are often

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planted aquariums

Although some of the plants in a planted aquarium like this will grow without the addition of carbon dioxide, they won't develop these fantastic colors, and species such as *Utricularia gramenifolia* won't grow at all.

lumped together as "free carbonic acid"—so we need to set the pH so that an appropriate concentration of free carbonic acid is available in the aquarium.

All aquarium plants can take up carbon dioxide directly from the water. Terrestrial plants obtain CO_2 via the stomata (respiratory pores) in their leaves, as most of the remaining surfaces of the leaves are covered with an almost impenetrable waxy cuticle (skin). The stomata play an important role, as they can open and close as required. In so doing they must maintain a balance between carbon dioxide uptake and dehydration, as water is also lost through them.

True aquatic plants, on the other hand, have no stomata and less cuticle than their land-dwelling relatives. They take up CO_2 from the surrounding water through passive diffusion, which conveys the CO_2 directly to the photosynthetically active cells. In aquatic plants even the epidermal cells on the leaf surfaces contain chloroplasts (the organelles in which photosynthesis takes place), so the carbon dioxide has only a short distance to travel.

In water, carbon dioxide uptake is limited by the slowness of molecular diffusion. The diffusion of gases

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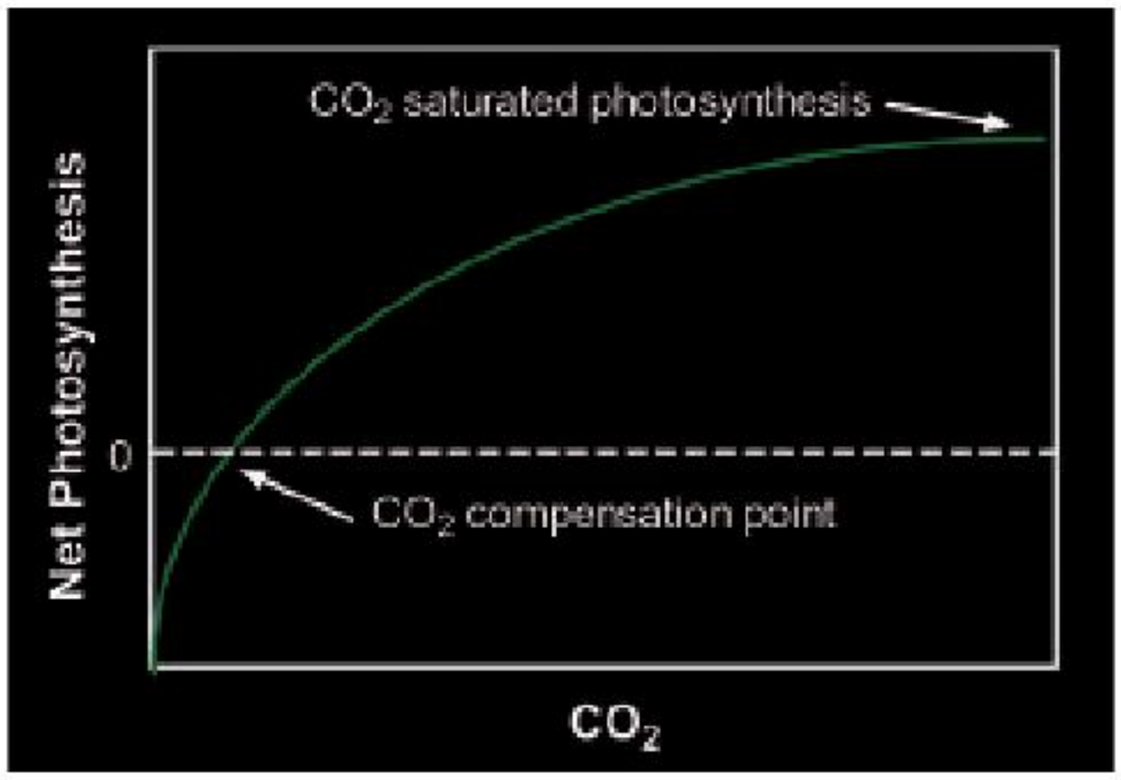
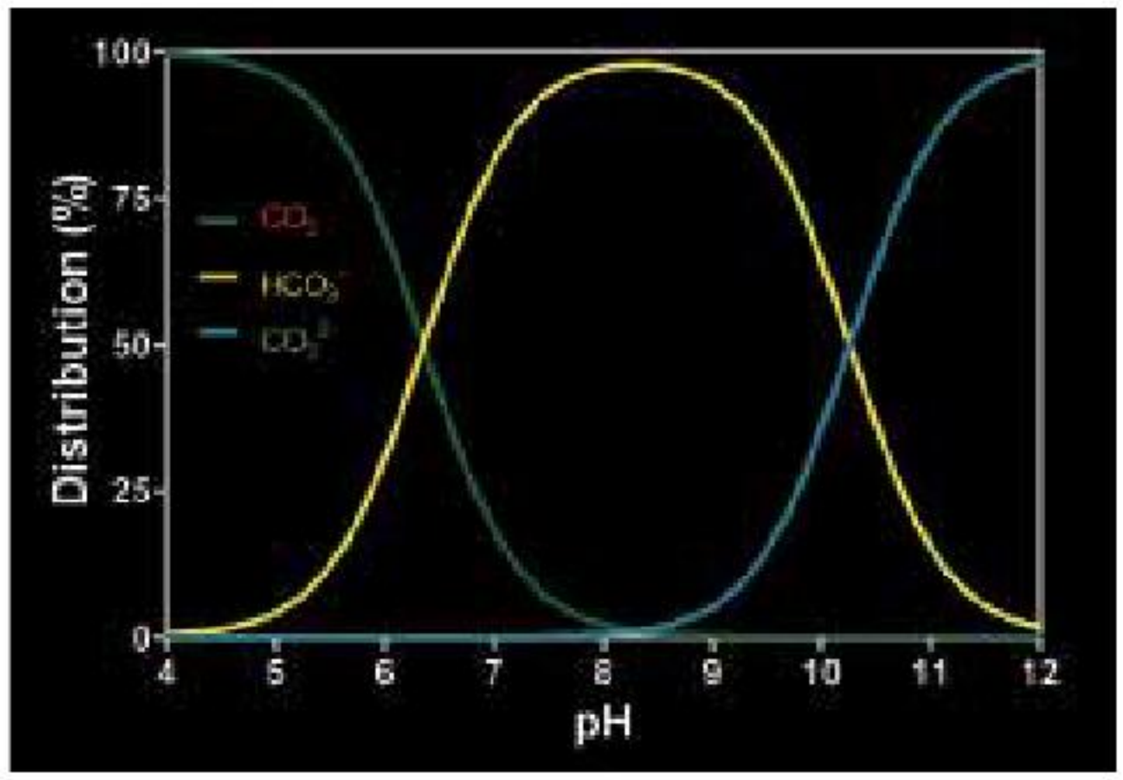
This continuous CO_2 tester uses a small water reservoir with a pH indicator. The carbon dioxide dissolved in the aquarium water interacts with the liquid in the reservoir and alters its pH value. Too much CO_2 in the water will turn the liquid yellow, too little will turn it blue, and dark green indicates the correct CO_2 concentration in the aquarium.



This model shows the relationship between carbon dioxide in the aquarium water and net photosynthesis. At very low CO_2 concentrations, the net photosynthesis is negative (below 0) and the plants slowly die. The effects of respiration and photosynthesis counteract one another at the compensation point, and only above it is new plant material formed. The curve flattens out with increasing saturation, as other factors now limit plant growth.



The amount of carbon dioxide as a function of pH and carbonate hardness. At low pH most of the inorganic carbon is present as CO_2. Bicarbonates predominate at neutral pH, and carbonates at high pH. It is not necessary to commit these graphs to memory, and many successful aquatic gardeners are able to dose CO_2 in their aquariums without fully understanding the complex chemistry processes at work.

takes place some 10,000 times more slowly in water than in air. We aquarists can redress the balance to a certain extent by adding carbon dioxide to the aquarium. In the majority of cases we raise it relative to the air-water balance, but only by around 50-fold, so aquarium plants are still at a disadvantage compared to terrestrial plants.

Interactions with other nutrients and light

With a good supply of CO_2, the plants can make do with smaller amounts of other important nutrients and will grow even in relatively poor light conditions. We have discussed this phenomenon in *The Aquatic Gardener* (2001), where we used submersed-cultivated *Riccia fluitans* as a subject for study. Our research showed that with a raised CO_2 concentration, aquatic plants can achieve a growth rate that would otherwise require stronger lighting and more nitrogen. We conclude that it is often easier to increase the carbon dioxide supply in the aquarium than to improve the lighting. Therefore, we recommend aiming for a higher CO_2 concentration, especially if the aquarium is not particularly well illuminated.

In addition, the nutrient concentration in the aquarium can be lowered without losing the benefits of CO_2 fertilization. High carbon dioxide concentrations allow the plants to use less nitrogen in the production of RuBisCO (ribulose-1,5-bisphosphate carboxylase/oxygenase), the most common plant enzyme. This enzyme catalyzes the first step in the Calvin cycle (also known as the Dark Reactions), in which carbon dioxide is added to ribulose 1,5 bisphosphate. All enzymes are proteins and hence contain a lot of nitrogen, so if the RuBisCO requirement is reduced, more nitrogen is available for other processes leading to the formation of new biomass.

CO_2 in the aquarium

If you have a diaphragm or other air pump, switch it off! If you have two pumps, switch both of them off! It cannot be stated often enough that such a device should never be part of a planted aquarium. Its function is to provide fishes and invertebrates with oxygen in aquariums where the oxygen supply from the plants is inadequate. In all planted aquariums there should be sufficient oxygen available to fishes and invertebrates, even at night when no photosynthesis is taking place. (Check out the graph on page 35, which shows the CO2 and O2

Given the correct carbon dioxide concentration, *Hemianthus callitrichoides* "Cuba" forms gas bubbles, but these don't consist of pure oxygen because the gas in the bubbles undergoes exchange with gases dissolved in the water. However, photosynthesis produces enough oxygen to make respiration possible for plants, invertebrates, and fishes during the night.

During intense photosynthesis the pH rises on the upper surfaces of the leaves, and in some cases this can lead to the precipitation of calcium carbonate. Here a thick crust of calcium carbonate has formed on the leaves of *Cryptocoryne crispatula*, a species that can only process CO_2.

concentrations in a planted aquarium with and without the addition of CO2).

When plants, fishes, and invertebrates breathe at night, carbon dioxide is produced and dissolves in the water. As soon as the light is switched on the next day, this CO_2 can immediately be processed by the plants via photosynthesis. Running an air pump is like shaking a bottle of soda or beer: the CO_2 will be driven out of the water. So give your air pump a well-deserved rest!

We recommend using a continuous CO_2 test to monitor the carbon dioxide concentration. This ingenious little device can be installed in the aquarium so that it is visible from the outside. It uses a chemical indicator (bromthymol blue), which is green if the carbon dioxide concentration is within the recommended range. The device doesn't actually measure the CO_2 concentration but the pH, so it gives only a rough indication. The carbonate hardness/pH table below shows how much the carbon dioxide concentration changes at a particular pH as a function of carbonate hardness.

Always use water with a carbonate hardness between 4 and 8°dKH in the continuous CO_2 test device; otherwise the results will be unreliable. Most retailers supply the device already filled with water of the correct hardness. If yours doesn't come pre-filled, you need to mix distilled water and tap water until the carbonate hardness is in the correct range.

CO_2 (mg/L)

pH	dKH 2	4	6	8	10	12	14	16	18
6,0	67	133	193	257	321	386	450	500	562
6,1	53	106	153	204	255	307	357	397	447
6,2	42	84	121	162	203	244	284	315	355
6,3	33	67	96	129	161	193	225	250	282
6,4	27	53	77	102	128	154	179	199	224
6,5	21	42	61	81	102	122	142	158	178
6,6	17	33	48	65	81	97	113	125	141
6,7	13	27	38	51	64	77	90	100	112
6,8	11	21	30	41	51	61	71	79	89
6,9	8	17	24	32	40	49	57	63	71
7,0	7	13	19	26	32	39	45	50	56
7,1	5	11	15	20	25	31	36	40	45
7,2	4	8	12	16	20	24	28	31	35
7,3	3	7	10	13	16	19	22	25	28
7,4	3	5	8	10	13	15	18	20	22
7,5	2	4	6	8	10	12	14	16	18
7,6	2	3	5	6	8	10	11	12	14
7,7	1	3	4	5	6	8	9	10	11
7,8	1	2	3	4	5	6	7	8	9
7,9	1	2	2	3	4	5	6	6	7
8,0	1	1	2	3	3	4	4	5	6

This table shows the reciprocal effects of carbonate hardness and pH. We recommend 15–30 mg/L carbon dioxide in planted aquariums (dark green shading). If you are growing less demanding plants, try to achieve concentrations between 8 and 15 mg/L.

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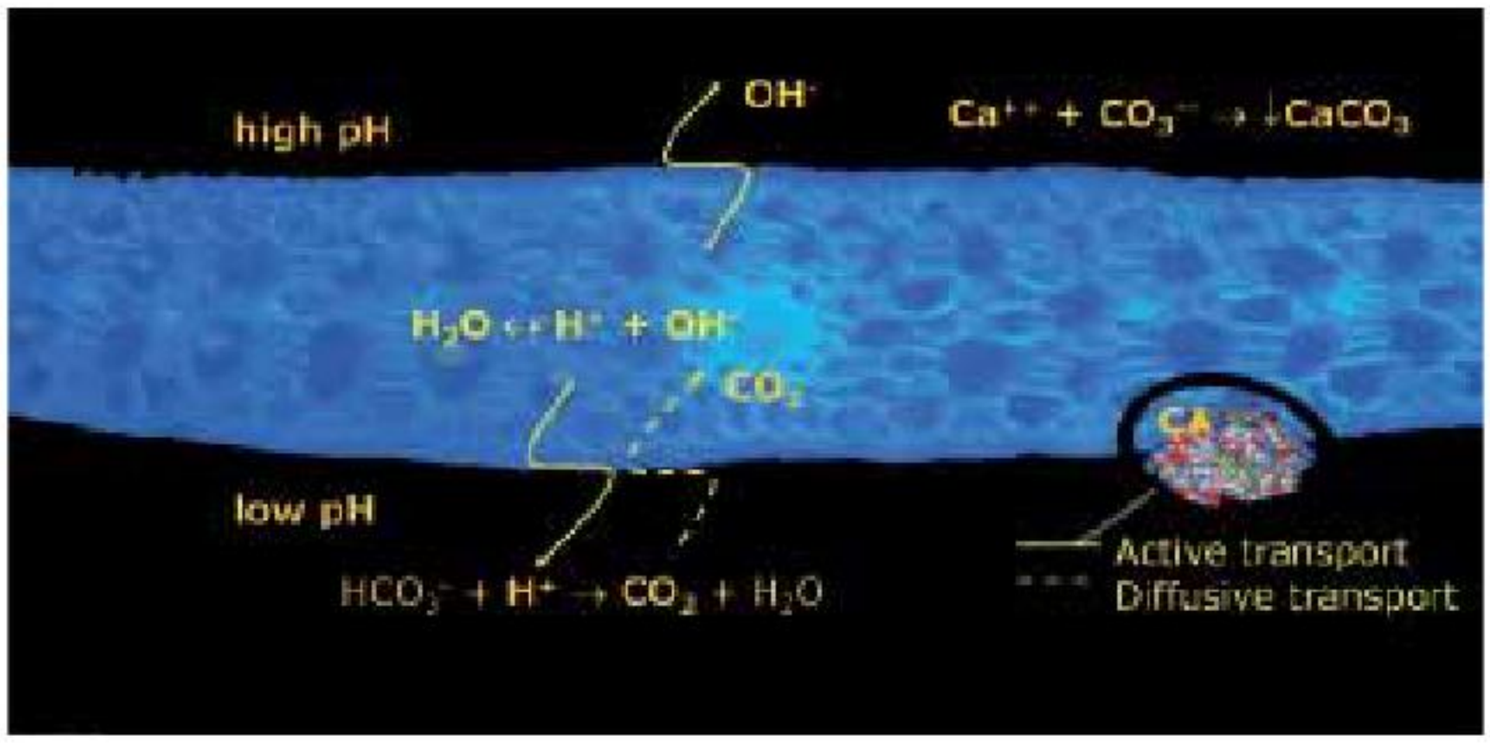


This table shows the reciprocal effects of carbonate hardness and pH. We recommend 15–30 mg/L carbon dioxide in planted aquariums (dark green shading). If you are growing less demanding plants, try to achieve concentrations between 8 and 15 mg/L.

Yeast reactors

A yeast reactor is probably the cheapest method of raising the CO_2 content of the aquarium water. It relies on the ability of yeast cells to process sugar or starch into carbon dioxide and alcohol in the absence of oxygen. The gas can then be introduced into the aquarium water via an airstone or a CO_2 diffuser. Various alcohols may be produced during the process, including methanol—so don't drink the liquid! You will find a wide variety of yeast reactors on the Internet, and suitable devices are also available in the trade.

A yeast reactor is certainly better than nothing, but it has the major disadvantage that the carbon dioxide output cannot be closely controlled. Sometimes the yeast cells process a lot of sugar and thereby produce lots of carbon dioxide. At other times there is less activity and insufficient carbon dioxide is produced. Some people believe that these fluctuations, which lead to a correspondingly unstable pH, have harmful effects on fishes, invertebrates, and even plants. This may be true in some cases, but in the wild both lakes and flowing waters may be subject to huge fluctuations in CO_2 content and pH on a daily basis. For example, lowland streams in northern Europe may contain as much as 20 mg/L CO_2 in the morning and only 5 mg/L in the late afternoon (Sand-Jensen & Frost-Christensen, 1998). The natural density of the aquatic vegetation is so high that the plants can take up correspondingly large amounts of carbon dioxide in the course of the day, although it is constantly replaced by the CO_2-rich groundwater. Most plants, fishes, and invertebrates remain unaffected by these dramatic carbon dioxide fluctuations. However, some fishes and invertebrates maintained in the aquarium may be a little more sensitive, so you should always check their sensitivity to pH fluctuations in the literature before installing a yeast reactor.

Compressed CO_2

Compressed CO_2 in pressurized bottles is the best alternative to a yeast reactor. The gas in a pressurized bottle is liquid and the pressure is approximately 58 bars. CO_2 can also be purchased in containers not specifically designed for aquarium use, since it is also used in the production of seltzer, soda, and beer, as well as in the welding process. In principle all these commercially available types of CO_2 can be used, but in practice it depends on the thread of the pressure regulator.

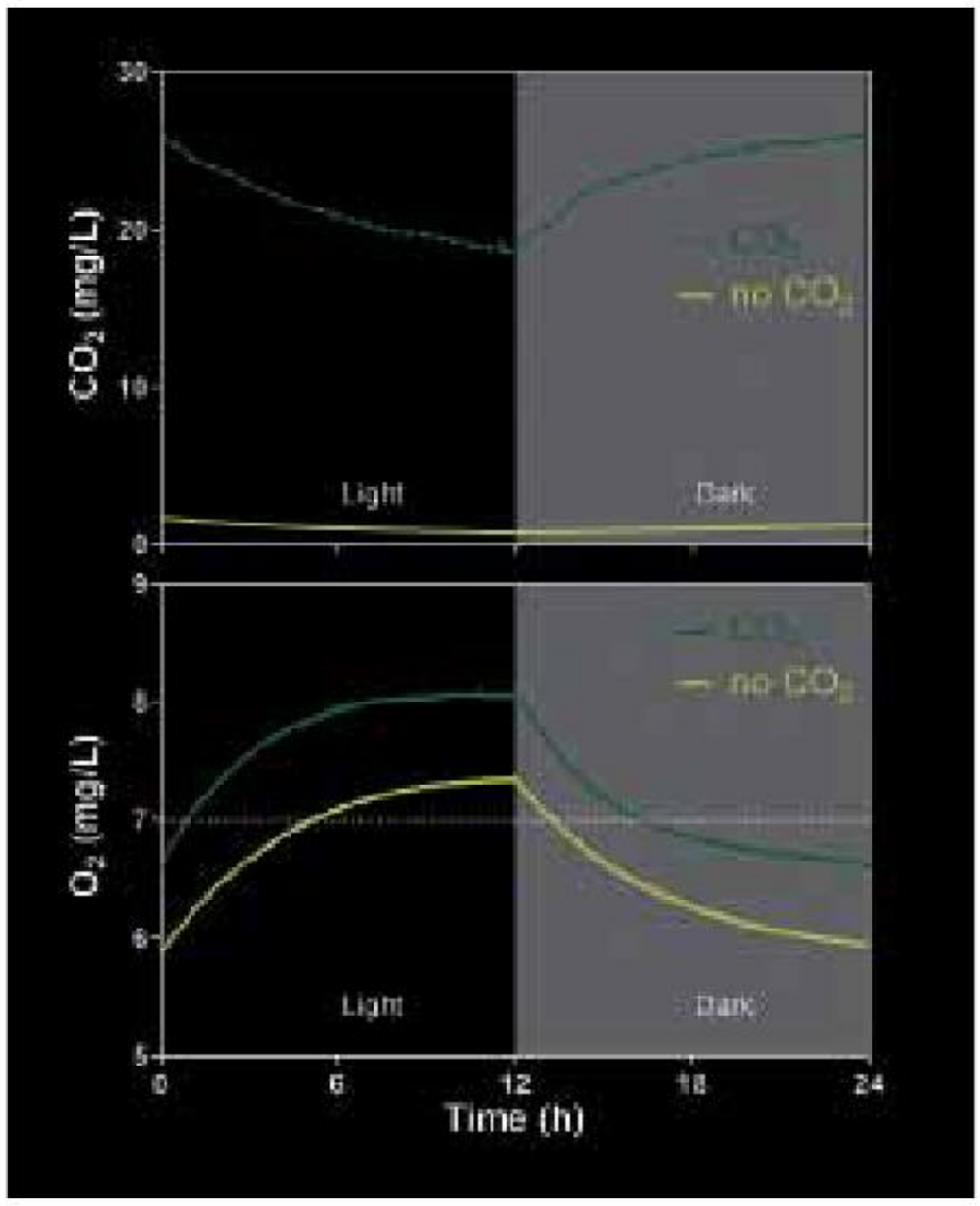
In its simplest form, such a system will consist of a pressurized container, a pressure reducer with manometer, and a regulator for the fine-tuning of the CO_2 supply, linked to an airstone or a CO_2 diffuser. There is regular debate as to whether the CO_2 supply should be switched off at night. As already mentioned, many plants, invertebrates, and fishes are adapted to daily fluctuations in CO_2, so the purpose of turning it off at night would simply be to reduce the CO_2 consumption.

A somewhat more expensive system may include a magnetic valve and a time switch that automatically turns off the CO_2 supply at night. Top-quality systems may include a pH meter with an electrode, so that the CO_2 supply can be independently regulated in line with a given pH value. (Consult the pH/carbonate hardness table on page 33 to find the amount of CO_2 relative to pH.) When the effect of photosynthesis exceeds that of respiration, CO_2 is consumed and the pH rises. If it rises above the pre-set value, the valve is opened and carbon dioxide is released into the water. When the pH has dropped back to the pre-set point, the pH meter closes the magnetic valve again. A system of this type keeps the pH very stable and conserves carbon dioxide. However, the pH electrode must be calibrated regularly; otherwise, over time the pH can deviate substantially from the pre-set value.

Additional methods

Another option is to use calcium carbonate tablets that release CO_2 into the water when they dissolve. We have no personal experience with these, but on the Internet you can find a wide variety of reports from people who have used them in planted aquariums. The effects reported range from positive to non-existent.

The Carbo-Plus system came onto the market a few



This curve shows the result of a study during which carbon dioxide was introduced into a tank planted with *Cabomba* and *Egeria*. A control aquarium was set up with the same numbers of plants but no addition of CO_2. It turned out that far higher oxygen concentrations were measurable, both in light and in darkness, in the aquarium with CO_2 added at the rate of 20–25 mg/L than in the one with no addition of CO_2. The dotted line shows the point of equilibrium with the atmosphere. The aquarium with no addition of CO_2 shows an oxygen content above this level for only six hours per day. The carbon dioxide in the aquarium with no addition of CO_2 derives from respiration by the plants and diffusion from the surrounding atmosphere.

years ago. It produces CO_2 electrolytically from solid carbon and works satisfactorily in well-buffered aquariums with a carbonate hardness of 8–12°dKH, but users report the replacement carbon blocks can get expensive.

Club soda or seltzer (unflavored, of course!) can also be used in a planted nano aquarium to increase the carbon dioxide content of the water. It isn't easy to get the dose right and a little experience is required in order to achieve the desired pH value. We have seen aquariums in which the fishes were hanging and gasping at the surface following the addition of club soda. Moreover, certain plants, for example *Cryptocoryne* species, are sensitive to drastic changes in pH, so soda must be used with care. But because the majority of suppliers now offer CO_2 reactors for nano aquariums, the planted nano aquarium can safely benefit from CO_2 fertilization as well.

Recently, various organic carbon fertilizers have come onto the market, for example EasyCarbo from EasyLife in the Netherlands and FlourishExcel from Seachem in the U.S. We have tested these products on *Hygrophila corymbosa* "Siamensis" (Narrow Leaf Giant Hygrophila, a popular aquarium plant that can utilize only CO_2) and *Egeria densa* (Brazilian Waterweed, a widespread plant that can also use bicarbonates), and found neither positive nor negative effects when we evaluated the photosynthesis rate on the basis of oxygen production. Nevertheless, various aquarists have observed improved plant growth using these organic carbon fertilizers.

We recently conducted a series of experiments in which we investigated the effects of EasyCarbo and FlourishExcel on algae. Both products strongly limited algae growth. Our interpretation of the two experiments is that the organic carbon fertilizers killed the biofilm on the plants. Once this practically invisible layer of microalgae was gone, the plants no longer had to compete with them for light, carbon dioxide, and other nutrients, so that in some cases they were able to grow better. However, further study is required to establish the pros and cons of these products.

Which plants require the addition of CO_2?

Those plants that cannot utilize carbonates and bicarbonates are particularly in need of carbon dioxide supplementation. But not all of them are dependent on an additional carbon dioxide supply in order to thrive in the aquarium. The majority of slow-growing species can do relatively well without such measures. Good examples include mosses such as *Vesicularia* and *Taxiphyllum*, ferns such as *Microsorum* and *Bolbitis*, plus many *Cryptocoryne* species and the popular *Anubias* species.

At the other end of the spectrum we find difficult-to-cultivate and demanding plants that won't grow satisfactorily without CO_2 fertilization. Good examples of these are *Glossostigma*, *Pogostemon*, *Utricularia*, *Riccia* (cultivated submerse), *Rotala*, and numerous other beautiful and colorful plants.

Luckily, plant nurseries usually provide information about CO_2requirements, either on their websites or on stickers on the plant pots. So check the carbon dioxide requirement of a new plant before buying it. Consider whether or not it will do well in your aquarium. If not, the plant will slowly but surely die, and your initial enthusiasm will be replaced by disappointment.

Processing bicarbonates

Vallisneria and *Egeria* often thrive even without an additional CO_2 supply—but not in very soft water. The reason for this is that they are able to use bicarbonates (HC_3–) as an alternative source of carbon. Some plants make use of this capability when free CO_2 is in short supply. Bicarbonates are available in large measure in water with adequate carbonate hardness at a pH between 7 and 10. On the other hand, free CO_2 is rare at pH values above

A good diffuser is required for introducing carbon dioxide into the water. If the bubbles produced using a normal airstone are too large, only some of them will dissolve in the water before they reach the surface.

8, regardless of the carbonate hardness. Hence those plants that are able to use bicarbonates as a source of carbon have an advantage over those that can only utilize CO_2.

The uptake of bicarbonates by aquatic plants is a science in itself, but a model will serve to explain the basics of how the majority of such plants function. This model was first devised by Prins & Elzenga (1989) and describes plants in which the upper surfaces and undersides of the leaves perform different tasks. In these plants hydrogen ions (H+) are pumped out of the undersides of the leaves, with the result that the pH in the adjacent water can drop to as low as 4. Here bicarbonates are converted into CO_2, which then diffuses into the tissue and serves for photosynthesis. The residual negatively charged hydroxide ions (OH–) are released from the upper sides of the leaves, where the pH can rise to above 10. These high pH values can lead to the precipitation of calcium carbonate on the leaves. Examples of these bicarbonate processors include *Elodea canadensis* (Canadian Pondweed), *Egeria densa* (Brazilian Waterweed), and the majority of *Potamogeton* species. Other bicarbonate processors such as *Vallisneria* do not have leaves of this type. In such cases bicarbonates are taken up via ion pumps in the leaves and converted into CO_2 there.

Regardless of the method used, bicarbonate conversion is a process that uses a lot of energy. Hence even good bicarbonate processors produce the necessary enzymes only when they really need them. For this reason they require a certain amount of transformation time before they can begin to process bicarbonates. These plants, too, benefit from the addition of CO_2, because it allows them to avoid the costly processing of bicarbonates.

Alternative methods of CO_2 processing

There are a few other tricks that plants can use to compensate for the slowness of CO_2 diffusion in water (Madsen & Sand-Jensen, 1991; Bowes, 1987). One of these is C4 photosynthesis, which is known from some terrestrial plants that live in dry surroundings. In such cases the oxygen-producing processes are separate from CO_2 fixing, so the plants can use lower CO_2 concentrations as oxygen is kept away by the RuBisCO enzyme. However, among the aquatic plants this type of photosynthesis is so far known only from *Hydrilla verticillata* (Water Thyme).

Another strategy is the fixing of CO_2 in the dark by so-called CAM (Crassulacean acid metabolism) plants (Pedersen et al., 2001a, 2011b). In this case, carbon dioxide is stored in the form of malic acid during the hours of darkness and released when photosynthesis takes place in the light.

Finally, a number of aquatic plants use CO_2 taken up via the roots for photosynthesis. Carbon dioxide diffuses into the roots in the substrate, where it is always pres-

FROM CARBON DIOXIDE TO SUGAR

When carbon dioxide (CO_2) dissolves in water (H_2O), an equilibrium is established between carbonic acid (H_2CO_3), bicarbonates (HCO_3^-), and carbonates (CO_3^{2-}):

$$H_2O + CO_2 <-> H_2CO_3 <-> H^+ + HCO_3^- <-> 2\,H^+ + CO_3^{2-}$$

The pH rises when CO_2 is used during photosynthesis. This is because hydrogen ions are removed from the solution when dissolved CO_2 is used and replaced by CO_2 originating from bicarbonates and carbonates. During the night, when respiration is dominant, the pH drops, as more hydrogen ions become free when CO_2 is added to the left-hand side of the equation.

The sum of the carbonates and bicarbonates is termed the carbonate hardness and is measured in degrees (°dKH). Chemically speaking, the term "carbonate alkalinity" is more correct, but hasn't as yet made its way into the aquarium hobby.

During photosynthesis, inorganic carbon dioxide (CO_2) is converted into organic sugar ($C_6H_{12}O_6$):

$$6\,CO_2 + 12\,H_2O <-> C_6H_{12}O_6 + 6\,O_2 + 6\,H_2O$$

Of course this is a gross oversimplification, as the transformation takes place in stages via various chemical reactions. It is, however, important to bear in mind that photosynthesis uses light energy and hence can take place only by day. The first stage is catalyzed by the RuBisCO enzyme, which, like all other enzymes, is a protein and therefore contains a lot of nitrogen. This is the reason for the interactions between carbon dioxide, nutrients, and light described in the text (Andersen & Pedersen 2002, Pedersen et al. 2001).

ent in high concentrations, and travels via the gas-conducting tissue to the leaves, where photosynthesis then takes place. It was formerly believed that among aquatic plants this was the case only in *Lobelia dortmanna* (Water Lobelia), *Littorella uniflora* (American Shoreweed), and *Isoetes* (quillwort) species, but new research by Winkel & Borum (2009) has shown that carbon dioxide obtained from sediment is also important for photosynthesis in *Vallisneria americana* (American Eel Grass) (Winkel & Pedersen, 2008).

Summary

Carbon dioxide is without doubt the most important plant nutrient, and must be present in adequate measure in planted aquariums. In most cases the CO_2 produced in the aquarium via respiration is insufficient to permit adequate photosynthesis in plants that can utilize only CO_2. CO_2 fertilization is necessary for these more demanding plants.

We recommend concentrations of 15–30 mg/L for planted aquariums, although smaller quantities have a positive effect on most plants. Concentrations of more than 30 mg/L can cause narcosis in fishes and invertebrates, so the CO_2 concentration should be monitored and measured regularly. Try adding carbon dioxide and see how your aquarium flourishes!

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A seedling of *Samolus valerandi* (Seaside Brookweed). This plant can only be propagated effectively from seed.

Propagating

Plants have the ability to regenerate themselves from cuttings, and this can be exploited to propagate them. The only prerequisite is that the plants should be thriving. Commercial propagation is rather expensive, so it is always worthwhile for the aquarist to increase his plant population via cuttings or plantlets. • *article and images by Maike Wilstermann-Hildebrand*

In order for plants to grow well they require water, nutrients, warmth, and light. Our aquarium plants are predominantly marsh and aquatic plants from the tropical and subtropical regions of the world. Most grow at water temperatures of 72°F (22°C) or higher. At lower temperatures they have problems with nutrient uptake, are inclined to symptoms of deficiency, and are vulnerable to pests. A photoperiod of around 10 to 12 hours daily is necessary for vigorous growth.

Conditions favorable for plant propagation occur naturally in Southeast Asia, but in cooler regions plants must be protected from the weather in greenhouses. The water must be heated, at least during the winter months, and additional lighting is often necessary. This makes the commercial production of aquarium plants very expensive in northerly latitudes. But they can be propagated year-round at minimal cost in a terrarium or aquarium on a window ledge in the house.

Vegetative or generative propagation

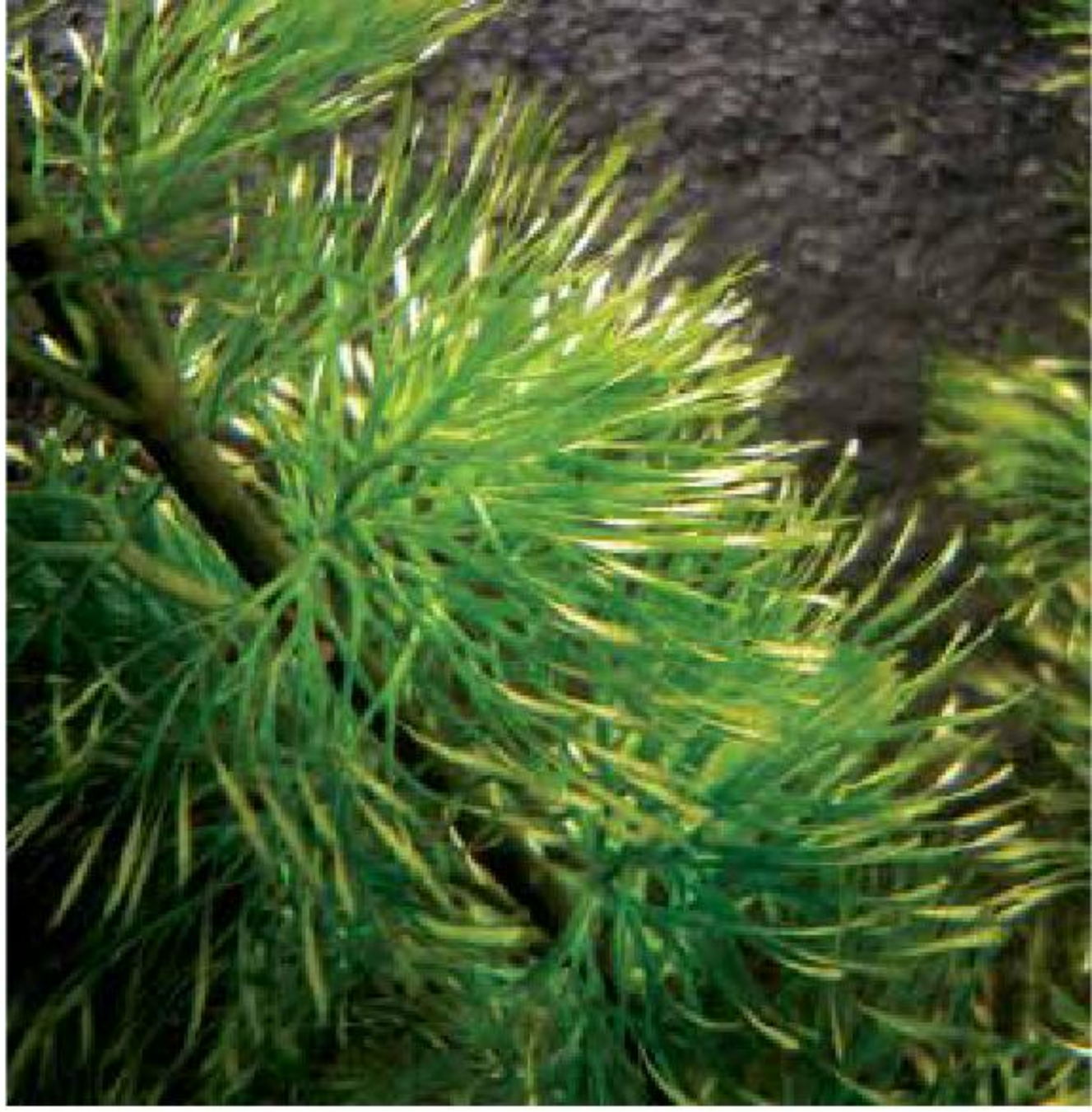
Vegetative propagation from sections of plants makes it possible to produce lots of plants with the same characteristics very quickly, although some plants can also produce a large number of young plants in a short time through generative propagation from seed. For example, the Seaside Brookweed (*Samolus valerandi*), opposite, cannot easily be propagated vegetatively, but grows well from seed.

In the course of generative propagation the genes of the parents are mixed, resulting in an individual with a new combination of characteristics. Which particular characteristics are inherited from the mother or the

The water comes from a nearby river; heat and light are available free of charge. Not much is required to propagate aquarium plants successfully in Malaysia.

aquarium plants

In the case of young *Echinodorus* hybrids, plants are harvested from the flower stems and then grown on.



Cabomba caroliniana "Silver Green" is a rare cultivar that can be propagated only via cuttings.

father is a matter of chance. The majority of *Echinodorus* cultivars are hybrids, and even if a plant pollinates itself, the young plants that grow from the resulting seeds will not be identical and won't look like the mother plant, but will exhibit a mix of the characteristics of their grandparents. This is not the case in species of uniform appearance, such as the pennyworts (*Hydrocotyle*) and the Australian *Glossostigma elatinoides*, and if mutations do occur, the only way to retain them is via vegetative propagation.

I will explain the significance of this using the example of *Cabomba caroliniana* "Silver Green". In this case a leaf node on a single stem produced a leaf in which the segments were twisted to point upward, while the underside reflected the light and looked silvery. German grower Hans Barth spotted this mutation and wanted to retain it. He shortened the stem above the leaf, which induced the bud in the leaf axil to sprout. It turned out that the mutation also affected the bud and the new side shoot produced only leaves with twisted leaf segments,

Propagation beds for *Limnophila sessiliflora* (Dwarf Ambulia) at Horticultura Las Lucanas in Tenerife.

A piece of *Echinodorus* "Apart" rhizome in a pot filled with rock wool.

so Barth was able to keep propagating the cultivar by taking cuttings. The seeds of the plants—if any can be obtained—do not produce offspring with the desired characteristics.

Cuttings and rhizome division

The propagation of stemmed plants is very easy. The stems are topped out to produce tip cuttings about 4–5 inches (10–12 cm) long that are planted in pots of rock wool to root. The severed pieces of plant continue to grow, after first liberating nutrients for the formation of roots from their own tissue. The roots develop from the leaf nodes on the lower parts of the cuttings. Once the plants are able to take up nutrients through their new roots, they also begin to grow upward again at the tip.

Cutting off the growing tip and planting it isn't really propagation—you've still got only one shoot. The real increase now takes place on the remaining, lower part of the original stem, as the lower nodes now sprout side shoots. This didn't happen before because their growth was inhibited by hormones from the original growing tip (this is known as apical dominance). After some weeks these side shoots can be harvested as additional cuttings. Anyone can propagate stemmed plants in the aquarium in this way. In nurseries the plants are grown in beds and regularly harvested as raw material for potted or bunched plants.

Larger *Echinodorus* and *Anubias* form rhizomes that can be divided. This involves cutting up the rhizome with a sharp knife so that each piece has three or four dormant buds, which will then sprout leaves and roots. This should yield several new plants within a few weeks.

In *Anubias barteri* var. *nana* and *A. b.* var. *barteri*, the rhizome may also fragment on its own. These plants are easy to propagate. However, in *Echinodorus*, bacteria or fungus may cause rot to set in, so this method of propagation should be used only if the variety doesn't flower (or does so only rarely) and doesn't form any adventitious plantlets, as is the case with *Echinodorus* "Apart".

Regeneration of plants from pieces is also used for *in vitro* culture, in which plant tissue is propagated under sterile conditions in the laboratory. The young plants thus obtained are then cultivated in nurseries for around 8–12 weeks until they have grown into sizeable specimens. For the slow-growing *Anubias* the culture takes about 10 months.

Formation of plantlets

The formation of plantlets on runners, from buds, or at the site of damage is widespread in aquatic and marsh plants.

Vallisneria, *Sagittaria*, *Cryptocoryne*, and other species produce creeping side shoots termed stolons. Young plants develop at the tips of the stolons, often remaining linked to the mother plant for a long time. The aquatic ferns *Ceratopteris pteridoides* (Floating Antler Fern) and *Microsorum pteropus* (Java Fern) form plantlets on their leaf margins and sporangia (spore containers) on the undersides of the leaves. In many *Echinodorus* (swordplants) they grow among the flowers, sprouting from the axils of the bracts.

In other genera, for example *Nymphoides* species and *Cryptocoryne elliptica*, new plants develop from buds at the base of the stems. In some water lilies, plantlets develop in the center of the upper side of the floating leaves.

In some species, detached, free-floating leaves develop roots and grow into new plants. Good examples of

Because each leaf node can produce new roots and side shoots, stemmed plants such as *Hygrophila polysperma* (Dwarf Hygrophila) can be quickly propagated from cuttings.

Above: Raising *Echinodorus* seedlings can be an interesting experiment.

this include *Bacopa caroliniana* (Blue Water Hyssop), *Gymnocoronis spilanthoides* (Senegal Tea Plant), and *Hygrophila difformis* (Water Wisteria). In vigorous specimens of *Nymphoides aquatica* (Banana Lily), damaged leaves may sometimes develop roots and then little plantlets at the site of the damage. Regeneration via detached leaves is a common method of propagation for ornamental houseplants such as *Begonia*, *Streptocarpus* (Cape Primrose), and *Sansevieria* (Mother-in-Law's Tongue). As far as I know, among the aquarium plants only the

Plantlets growing from the stem of a detached leaf of *Gymnocoronis spilanthoides* (Senegal Tea Plant).

The bud at the base of the leaf in *Cryptocoryne elliptica* is unique to the genus.

Microsorum pteropus (Java Fern) forms plantlets on detached leaves if they are left floating in the water or laid on a moist substrate.

From time to time, the bizarre flower spikes of *Cryptocoryne* species can be seen when they are grown emersed. This is the flower of *Cryptocoryne spiralis* (Spiral Cryptocoryne).

Java Fern is commercially propagated in this way. Fully grown leaves are removed from the mother plant, spread out on moist beds, and covered with plastic film. After some weeks they develop roots all around their margins and the first leaves begin to sprout.

Emersed propagation

Cuttings can be taken in the aquarium by pruning shoots that have become too long and planting the pieces. *Vallisneria* and *Cryptocoryne* will automatically produce runners after a few months as long as the plants are well fed and allowed to grow undisturbed. In summer, many aquarium plants can also be cultivated emersed in tubs or pots, in window boxes, in water gardens, or at the edge of a pond. They will then often grow faster and more vigorously. You can simply set plants reared underwater in a bowl filled with water or in a shallow part of a pond and wait for them to grow. *Echinodorus* and *Cryptocoryne* species are often sold as emersed plants. They can be planted by the pond right away, but should initially be protected from drying out using horticultural fleece or plastic film until they have rooted. However, even if the leaves wither, new ones will soon develop.

Indoors, a vivarium, a propagator, a terrarium, or any other convenient, closable, transparent container can be used. In winter the plants must be protected from the dry air often created by the heating system. From fall on, additional lighting is a sensible measure. In order to guarantee healthy growth, the water temperature should be above 71.5 °F (22°C), so additional heating may be required.

Echinodorus varieties produce numerous flower spikes, mainly in summer, and plantlets will develop on these. It can be interesting to plant the seeds. *Cryptocoryne* species will often produce flower spikes when cultivated emersed, but will rarely form fruits because suitable pollinators are usually lacking. Most species produce stolons more quickly when grown emersed.

Cryptocoryne spiralis (Spiral Cryptocoryne), for example, is a species that hardly ever proliferates in the aquarium but does so fairly quickly when grown emersed. Many other *Cryptocoryne* species will not produce the first young plants until they have been planted in the aquarium for six months or more, so it can be beneficial to initially grow them emersed and then plant them in the aquarium.

Tissue culture of aquarium plants

Tissue culture is used to produce a very wide variety of plants, and aquarium plants of this type currently are offered by various companies. Although customer acceptance remains limited, this method of production offers many advantages over the usual types of propagation. • *by Claus Christensen*

Tissue culture involves removing a small piece of a plant and sterilizing it to eliminate all other organisms, then cultivating the plant cells on a nutrient gel in a glass container, where they grow into little plants that can be further divided. In this way numerous new plants can be obtained from a single cutting.

The process can be continued for as long as desired. Because all the plants originate from the same cells, they are clones, so they are all identical. The plants are grown under sterile conditions, so they can be given sugar as a nutrient; under normal circumstances this would be used up by bacteria and yeasts. After the plants have left the laboratory they are planted in pots, in which they are grown on to saleable sizes.

Over the years various names have been used for this type of culture. It is variously called tissue culture (TC), *in vitro* culture, or—incorrectly—meristem culture.

There are many reasons for using this method. First and foremost, it produces plants that are free of pathogens. In addition, it is faster than traditional propagation via seeds or cuttings. The production of plants via tissue culture also has major benefits for the environment, as they can be cultivated in a temperature-controlled space with heat recovery. Otherwise it would be necessary to run a heated and artificially illuminated greenhouse. The transportation cost per plant is significantly lower, as they require little space and don't weigh much. Moreover, no pesticides are used during production.

Professor Michael Kane of the University of Florida is a specialist in tissue culture and has been trying for years to convince nurseries of its benefits. He has propagated numerous aquarium plants in this way, including *Apono-*

Left: An aquarium newly planted with plants grown by tissue culture. Above: The same aquarium after 90 days.

geton madagascariensis (Madagascar Lace Plant). During his presentations he displays plants in small bags that are also suitable for marketing to the end user.

Marketing attempts

Aquarium-plant nurseries have been using tissue culture since the mid-1970s. Initially it was *Anubias nana* (Dwarf Anubias) that was propagated in this way. In the 1990s the Dennerle company tried to sell plants from tissue culture directly to the end user, but without much success.

In 2007 Pixie Plants in Denmark was the first company to propagate TC aquarium plants in large quantities, in order to market them in the pet trade and on the Internet. The plants were packed in small bags printed with information about their culture. Pixie stopped production in 2010, but simultaneously other businesses adopted the idea. TC aquarium plants were exhibited at the 2010 Interzoo. Tropica Aquarium Plants in Denmark uses the trade name 1-2-GROW!, and Italy's Anubias sells their product in what they call LineaCups. Both are sold in pet shops. Oriental Aquarium in Singapore and Laboratorium Roslin in Poland supply to the wholesale and retail trades. Most aquatic plants sold in the U.S. come from wholesaler Florida Aquatic Plants in Fort Lauderdale.

More than 25 plant species are now being propagated via tissue culture. Many are widespread species such as *Rotala*, *Lilaeopsis* (grassworts), and *Hygrophila*. But specialty and new plants, such as *Staurogyne repens*, *Echinodorus uruguayensis* (Uruguay Swordplant), *Lomariopsis* sp., and various mosses are also being marketed in this way. The producers are constantly expanding their offerings.

Benefits for the aquarist

There are a number of advantages to the propagation of aquarium plants via tissue culture. Which of these are most important to the aquarist depends on the type of aquarium and the livestock maintained.

The growth of algae in the aquarium depends mainly on the amount of nutrients available in the water (especially phosphate and nitrate). Algae spores are introduced with fishes, for example, and can lead to an algal bloom under suitable conditions. If you purchase aquatic plants

J. EBDRUP

Right: Plants grown emersed are offered for sale underwater in the trade, in pots. "Dry" tissue-culture plants packed in plastic bags or tubs still haven't caught on.

Below: Preparing for tissue culture at Tropica in Denmark.

The pieces of tissue are carefully placed on the nutrient gel using forceps.

C. CHRISTENSEN

produced by normal methods, you can be sure that you are getting a whole cocktail of algae spores along with them. Plants from tissue culture don't carry any spores.

Algal growth is a fact of aquatic life, and it cannot be completely prevented—but using TC plants can delay it, and can also avoid the introduction of unwanted snails and Duckweed (*Lemna* spp.).

Nano aquariums have become ever more popular in recent years, and interest in maintaining snails and shrimps in this type of aquarium has increased. This has revealed two problems regarding plants. Aquarium plants are often sold in pots filled with rock wool, and this method of cultivation always introduces contaminants into the aquarium along with the plants. Shrimps and snails are very sensitive to some of these, for example, copper. Also, plant production normally takes place in greenhouses, where plants are susceptible to attack by pests and fungi. The pesticides used are generally toxic to shrimps and snails, which are often 100 times more sensitive than fishes in this respect. Even if the plants are removed from the rock wool and rinsed, the plant tissue remains contaminated for a long time.

Third-world countries sometimes use pesticides that contain substances not permitted in Europe or the U.S. But because plants grown via tissue culture generally don't contain pesticides, they are recommended specifically for nano aquariums containing snails and shrimps.

Benefits for the trade

Plants from tissue culture will survive for months without losing quality if they are kept in a light place; an aquarium store that doesn't have the facilities for maintaining delicate species long-term can store them without problems. I have left TC plants in their packaging for over a year and still managed to get them to grow in my aquarium. Only slow-growing plants can be stored in

H.-G. EVERS

Plants from tissue culture are sold packed in plastic tubs, like these Brazilian Micro Swords, *Lilaeopsis brasiliensis*.

this way, but this is a good thing, because it is the more delicate and expensive plants that belong to this group.

Another advantage is that the packaging can display more information than the usual label, and barcodes can be used so that the price can be scanned at the register. And in most cases, numerous small plants can be produced from a single tissue sample, so the prices are reasonable compared to those of normally propagated plants—depending, of course, on where you get them.

Planting tissue-cultured plants

Remove the contents, including the gel, from the packaging and rinse away the gel under running water. Any residue that remains will do no harm. Bottom-carpeting plants such as *Lilaeopsis* and *Eleocharis* (hair grass) can be split up into numerous small plantlets.

If possible, use forceps for planting. This requires a bit of practice, but doesn't disturb the substrate as much as fingers. So that the plants can root and start growing undisturbed, no fishes or shrimps should be introduced in the first week in case of nibbling. If TC plants are used for an already populated aquarium, they should initially be protected with a net.

Marketing problems

Potential customers are used to seeing aquarium plants underwater in stores. As a result, TC plants are often not regarded as "real" aquarium plants, as they are not packed in water. The majority of customers simply do not realize that most aquarium plants are amphibious and are actually produced emersed.

Many aquarium shops have tried to offer "dry" aquarium plants. This makes them easier to handle and is also better for the plants, as they have to switch to underwater growth only when they are placed in the buyer's aquarium. Unfortunately, dry plants are struggling to catch on—the psychological barrier seems to be too great. Another problem with TC plants is that it takes longer for them to attain their full size. Slow-growing plants can test the patience of an aquarist.

In addition, aquarium store staff members need to be familiar with TC plants before they can advise customers about them.

There is no doubt that the market for TC aquarium plants will keep growing, and there may already be additional suppliers that I don't know about. The range of plants available is sure to expand, particularly mosses and new introductions. If tissue culture makes it easier for shops to handle delicate species without damage, the selection of such plants will increase. Tissue culture helps to preserve endangered species, is environmentally friendly, and guarantees that the aquarist isn't contaminating his or her tank with harmful substances. These benefits will surely help to win over customers as time goes on.

ON THE INTERNET:

Tropica Aquarium Plants 1-2-GROW! at Interzoo: www.tropica.com/about-tropica/interzoo-2010.aspx

Tropica plant selection: www.tropica.com/plants.aspx

Tropica production facilities: www.tropica.com/about-tropica/new-production-facilities.aspx

Anubias: http://en.anubias.com/

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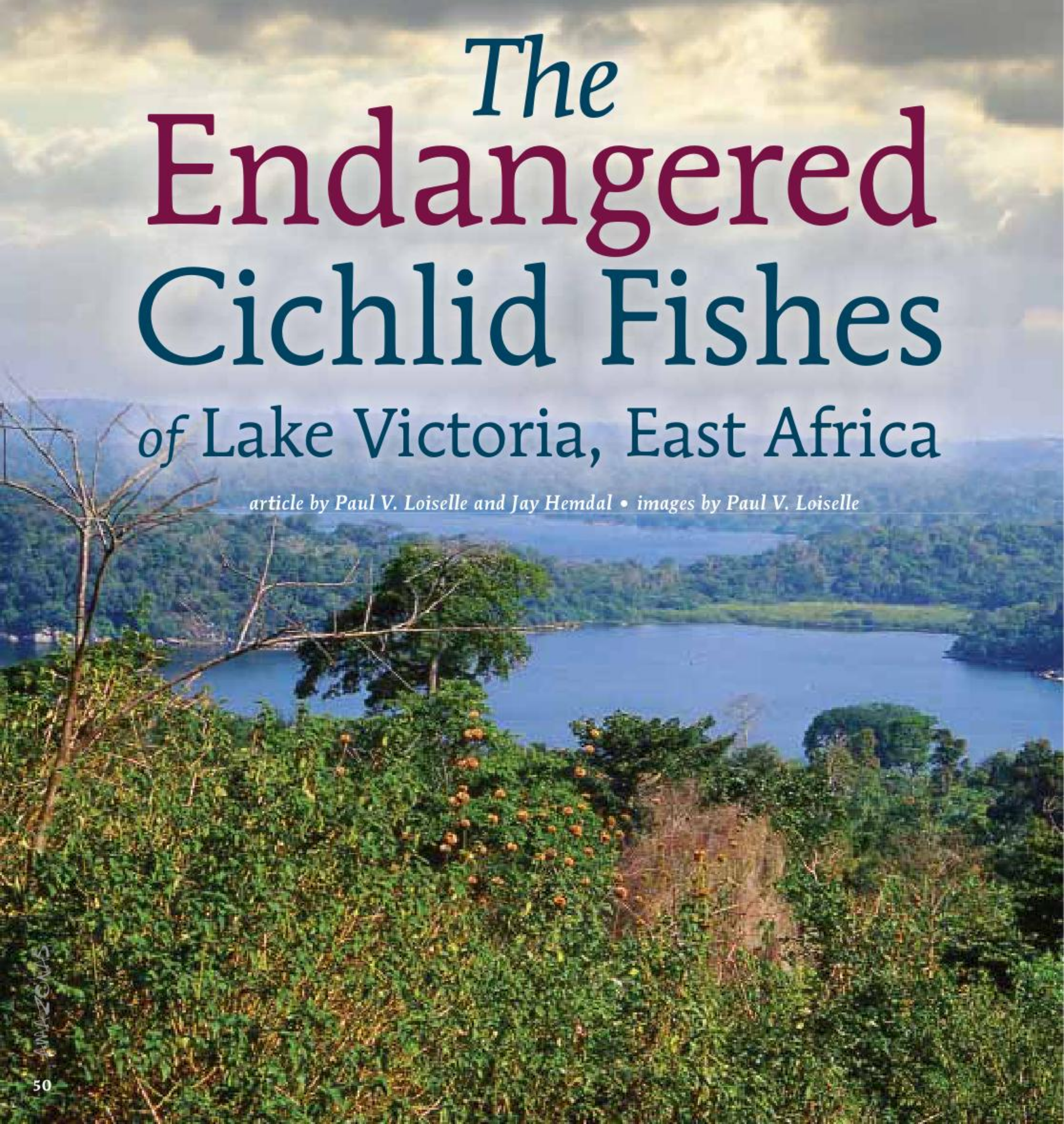
The Endangered Cichlid Fishes of Lake Victoria, East Africa

article by Paul V. Loiselle and Jay Hemdal • images by Paul V. Loiselle



PECOLD/SHUTTERSTOCK

Lake Victoria, the world's largest tropical lake, used to be home to a unique "species flock" of over 500 haplochromine cichlids, of which perhaps 200 still survive in the wild or in captivity. This assemblage of cichlids is of extreme scientific interest, as it represents the best-documented case of explosive evolution. A recently published genetic study has shown that the current species flock has evolved following a dramatic genetic bottleneck between 18,000 and 15,000 years ago, precipitated by a major dry spell that resulted in the desiccation of the lake.

The current plight of Lake Victoria's endemic cichlids chiefly arises from the introduction of an exotic predator, the Nile Perch, an action precipitated by the collapse of the lake's traditional fishery—which was based upon two endemic tilapia species, the ngege (*Oreochromis esculentus*) (Figure 1) and the mbiru (*O. variabilis*)—due to overfishing. The situation is exacerbated by the interaction of a number of environmental factors, the most important of which is progressive eutrophication due to poor land management practices within its catchment area and the influx of raw sewage from the growing cities situated on the Kenyan, Tanzanian, and Ugandan lakeshores.

Figure 1. A courting male ngege, *Oreochromis esculentus*. This endemic tilapia was formerly the staple of the traditional fishery; the collapse of its population as a result of over-exploitation was the primary motivation for introducing Nile Perch to Lake Victoria, seen from the Uganda shore (left).

Lake Victoria cichlids made their aquaristic debut in the 1970s. A pilot working for British Airways, Bob Heath, brought out founders of several species, which were successfully bred. Efforts to expand these tentative beginnings were stymied by the difficulty of matching females, which are generally lacking in species-specific color patterns, with appropriate males, and hobbyists' greater interest in Lake Malawi's more flamboyantly colored cichlids. A Swedish hobbyist, Bo Selbrink, established European breeding populations of over a dozen Lake Victoria haplochromines in the early 1980s. While the response of hobbyists on both sides of the Atlantic to this second influx of Lake Victoria cichlids was rather muted, the progeny of Selbrink's fish were widely disseminated, and several of the species currently being maintained in captivity

Figure 2. A male *Prognathochromis perrieri*. Now extinct, this smallest of Lake Victoria's piscivorous haplochromines appears to have been a specialized fry predator. It owes its survival in captivity to the efforts of Swedish aquarist Bo Selbrink.

are their descendants (Figure 2).

In the late 1980s Dr. Les Kaufman (then of the New England Aquarium in Boston) brought the plight of Lake Victoria to the attention of public aquariums in the United States. Dr. Kaufman spearheaded the captive maintenance in an institutional setting of those species he was able to acquire from Africa and Europe and developed the first studbook for them (Figure 3). Since that time, groups of these fish have been maintained by public aquarists as "assurance populations" and for closer study. In the following years, there have been additional importations of haplochromine cichlids both from Lake Victoria proper and from its associated satellite lakes. The more colorful of these have become sufficiently popular in the aquarium hobby to have engaged the attention of commercial fish farmers, and remain episodically available through commercial channels (Figure 4). However, the continued availability of these cichlids is largely due to the efforts of informal groups of serious hobbyists in North America and Europe.

Historical biogeography of the region

Lake Victoria differs significantly in form from Africa's other two Great Lakes. Lakes Malawi and Tanganyika are rift lakes. Their basins, the result of the movement of tectonic plates, are narrow and very deep. In consequence, their waters are permanently stratified and devoid of oxygen below a depth of 300 feet (91 m). In contrast, Lake Victoria came into existence when mountain-building to the west of the present basin caused a number of formerly westward-flowing rivers to reverse course and fill a shallow basin. With a maximum depth of 300 feet, Lake Victoria was unusual in that its depths were not permanently deoxygenated and thus could support a distinctive assemblage of deep-water fish species.

However, Lake Victoria does share one feature with Lakes Malawi and Tanganyika—extreme sensitivity to relatively small changes in rainfall patterns. None of these lakes is characterized by a major inflowing river. Their water levels are thus determined by precipitation over their relatively limited catchment areas and the rate at which water evaporates from their surface. When the amount of water lost to evaporation exceeds the amount added annually by rainfall, these lakes shrink. Lakes Malawi and Tanganyika have seen dramatic drops in both their water level and surface area over time, but their persistence has never been threatened by climate change. Lake Victoria, a shallow lake with a much greater surface area, has been less fortunate in this regard, having undergone several periods of desiccation, the most recent between 15,000 and 18,000 years ago.

The Lake Victoria region has supported many different lakes since the Pliocene era. Fossil evidence suggests that the fish fauna of these precursor lakes was, like that of present-day Lake Turkana, very similar to that of the Nile River. It included such species as bichirs (*Polypterus* spp.) and large predators like the Nile Perch. Cichlids, while present, did not dominate this community of fishes. Following one of these episodes of desiccation, the lake's basin was cut off from the Nile while enjoy-

Figure 3. A courting male *Labrochromis ishmaeli*. Dr. Les Kaufman was instrumental in arranging the importation of founder stock of this and a number of other extinct snail-eating haplochromines from European laboratories, where they had been maintained as research subjects.

Figure 4. Its spectacular coloration has earned *Pundamilia nyrerei*, named in honor of Tanzania's first president, representation on one of that country's stamps and a firm place in the affection of aquarium hobbyists.

ing a link with Lake Kivu, a smaller but more stable lake whose fauna had long been dominated by haplochromine cichlids. Recent genetic studies have demonstrated convincingly that Lake Victoria's present species flock is descended from Lake Kivu haplochromines that colonized Lake Victoria between two and three million years ago and, in the absence of competition from other fish groups, radiated to fill most of its available ecological niches (Figure 5).

The lake's bewildering variety of insectivores, snail eaters, algae grazers, and detritus feeders is less surprising—these are very "traditional" cichlid occupations (Figure 6). However, in the absence of large predators, Lake Victoria's haplochromine colonists also gave rise to an amazing array of piscivorous species. The true breadth of this adaptive radiation may be judged from the fact that it also included numerous pelagic plankton-feeders (Figure 7), at least one crab-eater, one scale-eater, one "cleaner" species that fed upon the external parasites of other fishes, and over a dozen species who, as adults, fed chiefly upon the embryos of other cichlids (Figure 8). Such paedophagous behavior is remarkable in light of the fact that all haplochromine cichlids are maternal mouthbrooders. While several hypotheses have been advanced to explain how these specialized predators manage to overcome the tenacity of ovigerous female haplochromines in holding onto eggs and larvae, their actual feeding mechanism remains very much a mystery.

Plight of the haplochromines

Lake Victoria's ecological problems began in the late nineteenth century when the British colonial administration, as part of a program to increase the productivity of the lake's fishery, introduced gill nets to local fishermen. Prior to this, the traditional fishery had relied upon hooks and lines, harpoons, and an array of sophisticated fish traps. Naïve fish populations are extremely susceptible to gill nets, and local fishermen were initially very pleased with their greatly increased tilapia catches. However, gill nets are size-selective in their operation and it was only a matter of time before the largest individuals had been removed from the

Figure 5. Left, top: Lake Victoria's initial haplochromine colonist was probably very similar to this territorial male *Astatotilapia nubila*. Widely distributed throughout Uganda and northwestern Kenya, this morphologically unspecialized omnivore is equally at home in streams, marshes, and lakes.

Figure 6. Left: A dominant male *Xystichromis phytophagus*. Although its species name suggests that it is a plant-eater, it actually exploits the community of microscopic animals present on decaying plant matter as a food source.

Figure 7. Lake Victoria was formerly home to over a dozen plankton-feeding haplochromines, ecologically analogous to Lake Tanganyika's *Cyprichromis* species. Extinct in the wild, *Yssichromis* sp. "argens" is one of the species that owes its survival to the AZA's Victoria Species Survival Program. Relict populations of two other *Yssichromis* species have managed to survive in the lake.

lake. The inevitable response of fishermen in the face of declining catches was to reduce mesh size in order to capture smaller fish. In the absence of a regulatory mechanism to prevent this, fish were being captured before they had attained minimum breeding size, resulting in a collapse of the tilapia fishery by the late 1940s.

Around the same time, the lake began to experience an increasing inflow of nitrates and phosphates due to the clearing of forest and the implementation of export-oriented plantation agriculture in the Kenyan portion of the watershed. Further eutrophication followed the drowning of riparian forest along the Ugandan shore of the lake by an exceptional high water stand in the 1950s. These forests were prime habitat for tsetse flies, the vectors of sleeping sickness. The prevalence of this deadly disease in the riparian zone had, up to this point, effectively blocked extensive cultivation along the lakeshore. The disappearance of riparian forest opened the northern and western coastal zones of Lake Victoria to subsistence agriculture and its associated nutrient run-off.

The response of the colonial administration in the 1950s to the collapse of Lake Victoria's tilapia fishery was to translocate several other tilapia species in the hope that they would come to replace the lake's indigenous species. These efforts were only partially successful. *Oreochromis niloticus*, *O. leucostictus*, and *Tilapia zillii* all succeeded in establishing breeding populations in the lake, but these never grew large enough to support a commercial fishery. The introduction of the Nile Perch, a voracious predator capable of attaining lengths in excess of 6 feet (2 m), was proposed as a means of converting the lake's commercially valueless haplochromine cichlids into an exploitable fish stock.

Figure 8. A young male *Lipochromis melanopterus*, one of Lake Victoria's paedophagous cichlids. The refusal of these embryo-eating predators to practice their habitual feeding behavior under aquarium conditions has frustrated efforts to understand how they extract their prey from mouthbrooding female cichlids.

Despite the East African Freshwater Fishery Research Organization's rejection of such proposals, an unsanctioned introduction of Nile Perch was made in the later years of the decade. Following the independence of the three riparian states in the 1960s, a second, sanctioned translocation of Nile Perch took place.

Like the exotic tilapias, the Nile Perch succeeded in reproducing in the lake, but their numbers initially remained too low to support a commercial fishery. However, by the 1980s the population of Nile Perch underwent a virtual explosion in the lake. The consequences for the lake's haplochromines were devastating. In short order, these cichlids disappeared from all parts of the lake except the rocky zones and heavily vegetated inshore habitats. A lucrative commercial export fishery quickly grew up to exploit the burgeoning Nile Perch population, a development that was initially considered a boon (Figure 9). However, from the standpoint of local people, for whom sun-dried cichlids had been a dietary staple, the situation was more problematic. The demands of this export-driven fishery quickly priced Nile Perch well beyond the ability of most people to pay.

The lake's current elevated nutrient levels fuel massive algae blooms. These algal blooms formerly supported robust populations of plankton-feeding cichlids, but these consumers are no longer present in the lake. Now, when these algae die, they sink to the bottom of the lake, where their decomposition creates extensive "dead

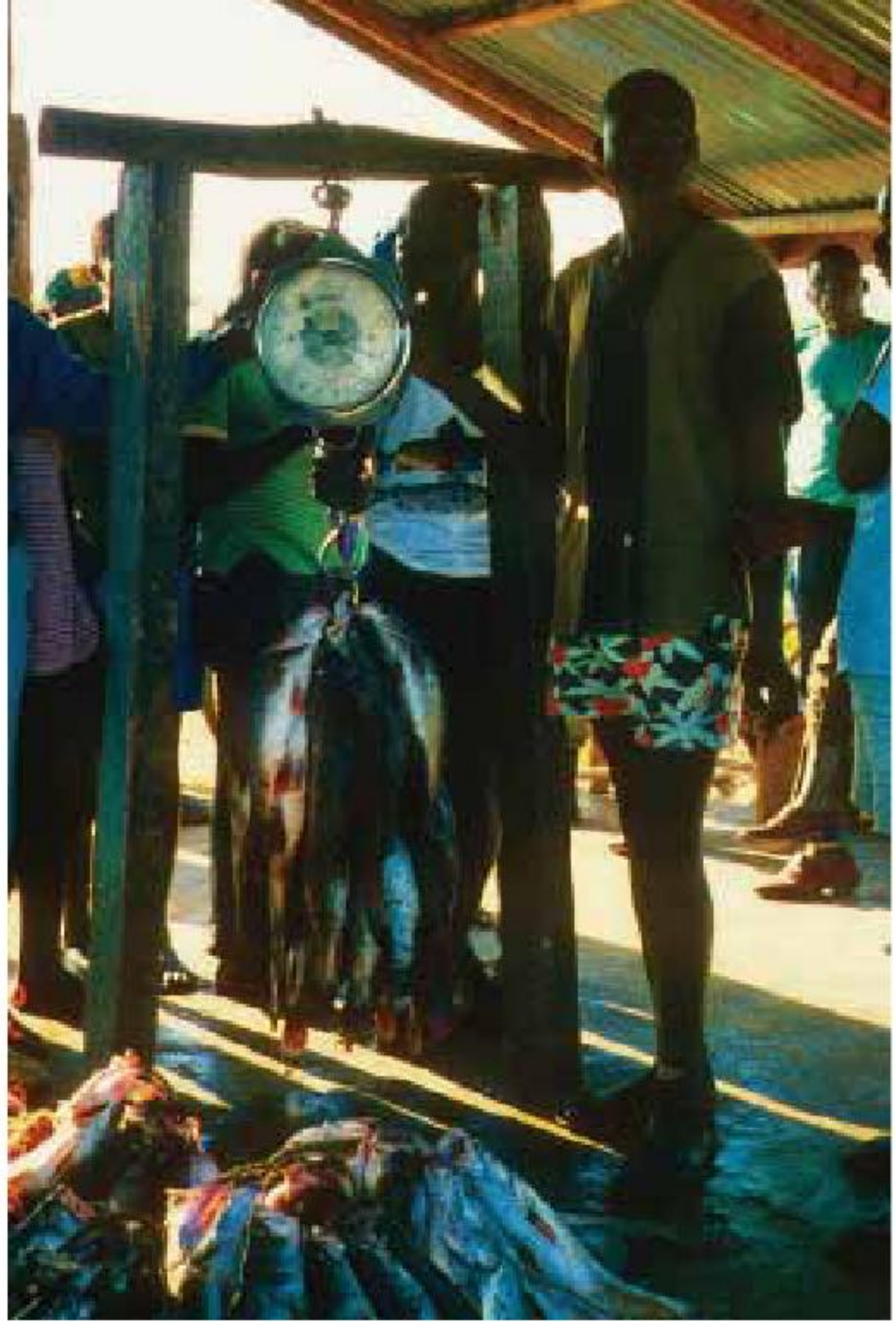


Figure 9. Nile Perch is the only species being weighed at this fish landing station at Uhanya Beach in Kenya. Lake Victoria's commercial fish catch now comprises two exotic species, the Nile Perch and the Nile Tilapia, and a small pelagic cyprinid, the Omena, which is native to the lake.

zones" completely devoid of oxygen. The deep waters of Lake Victoria, which formerly supported a diverse community of deep-water haplochromines, are now totally lacking in fish life—and this "dead zone" continues to creep steadily upward. Limnologists who have studied this phenomenon are uncertain at what point—if ever—this process will result in a stable equilibrium between the lake's biotic and abiotic zones.

Adding insult to injury, the water hyacinth *Eichhornia crassipes* was inadvertently introduced into Lake Victoria in the 1980s. This fast-growing, floating plant from South America took advantage of the eutrophic conditions and soon grew to choke the shorelines of many parts of the lake (Figure 10). Attempts were made in the 1990s to reduce the problem by introducing a beetle (*Neochetina*) that feeds on hyacinth. Partial control was initially achieved, but the hyacinth population has resurged in recent years. Because they further reduce the habitats capable of supporting fish life, these developments threaten the persistence of those haplochromines that managed to survive the depredations of the Nile Perch.

Aquarium husbandry of Lake Victoria haplochromines

Small and brightly colored, Lake Victoria's haplochromine cichlids make very satisfactory home aquarium residents. The simplest way to maintain a small group is to house a single male and two or three females in a 20- to 30-gallon (75–114-L) aquarium. These fish should never be kept on a single pair basis in anything other than a large community tank. Unlike most substratum-spawning cichlids, haplochromines do not form long-term pair bonds. Larger groups of up to 20 fish can be kept in 75 gallons (284 L) of water. Their ability to tolerate a wide range of water conditions is a further point in their favor. Virtually any water supply suitable for tropical freshwater fish will suffice. The pH should be held in a range of between 7.0 and 8.6, there should be no residual chlorine or chloramines in the water, and the ammonia and nitrite levels should be maintained below .1 and .5 PPM, respectively. General water hardness should be maintained between 5 and 30 DH. Frequent partial water changes should be made to maintain these values. Dissolved oxygen levels should not drop below 80 percent of the saturation level. A power filter scaled to the tank's volume can usually meet this target, but it is prudent to add a supplementary airstone to a heavily stocked tank. A temperature range of 70–85°F (21–29°C) is appropriate for these species, with 78°F (26°C) an appropriate target for day-to-day maintenance. Bear in mind that both the appetite and the aggressiveness of these cichlids increase at higher temperatures.

Although some species have specialized diets in the wild, these cichlids are undemanding about their menu in captivity. The Toledo Zoo's haplochromine populations are offered flake food, small and large freeze-dried krill, and frozen mysid shrimp in roughly equal proportions at a rate of between 3 and 4.5 percent of the fishes' body weight in food daily. All fish are fed twice per day; the adults receive a lower percentage of food by body weight than actively growing juveniles. This feeding plan has worked well for the nearly 20 years that the Toledo Zoo has maintained these fish. Hobbyists should have no difficulty adopting a similar feeding regime, as these cichlids accept a wide range of prepared and frozen foods. Predatory species should be occasionally offered live foods, with due attention to selecting prey that are not known to harbor transmittable diseases.

Lake Victoria haplochromines are hardy fishes. While stressed individuals are susceptible to the usual protozoan and bacterial diseases, treating these problems is relatively straightforward, as these cichlids are not overly sensitive to any commonly used aquarium medications. Pond-bred fish frequently carry heavy loads of the

Figure 10. This snapshot of the shoreline of Winam Gulf at Kusa Beach, taken in 1994, conveys some idea of the extent to which water hyacinth has come to dominate the inshore waters of Lake Victoria.

monogenean worms commonly known as gill and skin flukes. Labored respiration and repeated "flashing" as affected fish rub themselves against a solid surface are the usual symptoms of this problem. Gill flukes can seriously compromise respiratory efficiency, while untreated skin fluke infestations can lead to life-threatening secondary bacterial infections. These worms are very susceptible to the drug Praziquantel. Any commercially available medications that have this drug as their active ingredient will effectively treat such infestations when used as recommended by the manufacturer.

Reproduction and captive breeding

Hobbyists just starting with these cichlids will more likely have to deal with injuries arising from intra- and interspecific aggression than with disease. Male haplochromines aggressively defend breeding territories against conspecifics of the same sex and will even extend their intolerance to similarly colored males of different species. Their energetic and persistent courtship of females can also result in serious injury, should the object of their attentions prove unreceptive. These problems are easily avoided if a few simple rules are followed when managing Lake Victoria cichlids. To avoid intraspecific aggression, house these fish in single male, multiple female groups. Additional males can be housed in single-sex groups with minimum risk of damaging fights. Swapping males between the breeding and holding tanks offers all the males a chance to breed, a policy that minimizes the risk of inbreeding. If these fish are to be housed in a community setting, interspecific aggression is best managed by choosing only species with very different male breeding coloration as tankmates. Such a policy also lessens the risk of hybridization, although Lake Victoria haplochromines are much less given to cross-breeding under aquarium conditions than are their distant Malawian relatives.

All Lake Victoria haplochromines are maternal mouthbrooders, and fertilization occurs within the female's buccal cavity as she obtains a mouthful of sperm by biting at the conspicuously colored yellow or orange spots on the male's anal fin during spawning. In the wild, females leave the male's territory to incubate their 5 to 40 eggs in secluded nursery zones. As males have a tendency to harass ovigerous females under aquarium conditions, it is important to furnish the breeding tank with refuges that allow the female to avoid such unwanted attention. The incubation period lasts from 10 to 14 days, depending on water temperature and the species in question. Females continue to allow their mobile fry to take shelter in their mouths for another 7–18 days. Other adult fish present in the tank may well prey on the newly released fry. Females may respond to this potential threat by not allowing their fry to leave the protection of the maternal mouth long enough to forage for food, which can result in losses due to starvation. To avoid this problem, give a brooding female her own tank.

Alternatively, the fry can be manually stripped and moved to a rearing tank just prior to their natural release date. Stripping a female must be undertaken with care so as not to damage either mother or fry. First, gently capture the female in a net, open her mouth, and inspect the fry. If they have absorbed most of their yolk sacs, they are ready to be stripped. Now hold the female's head down over a small container of tank water, gently pry her mouth open, insert her head into the water, and shake it back

Figure 12. A courting male "*Haplochromis*" sp. "Kenya gold". Presently considered a low-risk species, this small insectivore is still vulnerable to potential habitat loss due to the lake's ongoing eutrophication and the spread of the invasive water hyacinth. Fortunately, its vivid coloration recommends it to the attention of informal captive breeding efforts such as the American Cichlid Association's CA.R.E.S. program.

Figure 11. A male of the Mwanza population of *Paralabidochromis* sp. "rock kribensis". This representative of the mbipi group of rock-dwelling haplochromines was dropped from the VSSP after it was discovered that robust populations still existed in Lake Victoria. It remains a popular aquarium subject and is generally available through commercial channels.

and forth. The fry will fall out into the container. In some cases, a few fry will stubbornly remain inside the female's mouth, requiring undue effort to release them. In these situations it is better to leave them with their mother rather than risk damaging the female from overhandling.

Juvenile fish recently released or stripped from the female should be offered finely crushed flake foods, live *Artemia* nauplii, or a mixture of both for the first three weeks. With frequent feeding and regular partial water changes, the fry grow rapidly. It is usually possible to distinguish the sexes on the basis of color differences within six to eight weeks of their release from the maternal mouth. Most Lake Victoria haplochromines are characterized by marked sexual precocity. While some species have been known to spawn at six months of age, the onset of sexual maturity usually comes between eight and ten months post-release. Contrary to popular belief, such precocious reproductive activity is not harmful to its practitioners. While such early spawns may only consist of a few eggs, the number of fry produced will increase as females grow older. Deferring breeding is a far chancier proposition for these cichlids. Older, larger males tend to behave more aggressively toward females. This increases the risk of injury, should the female fail to respond immediately to his courting. Furthermore, the effective reproductive lifetime of Lake Victoria cichlids is relatively brief. While it is possible for individuals to live up to seven years in captivity, reproductive senescence sets in for the majority of species somewhere between their second and fourth birthdays.

Genetic management

Many of the Victorian cichlids in captivity came through a "genetic bottleneck" in consequence of being descended from only two or three pairs of founders. This brings a risk of inbreeding depression, leading to lowered viability when harmful genetic information is enhanced and "set" in the population. The usual remedy for this problem is to bring in fresh genetic material from outside the population under management. Obviously, this is not possible for species that are rare or extinct in the lake. Very careful genetic management is possible through the use of a studbook, but this requires identifying the breeding fish as individuals, and then holding them separately for later breeding—something that is very difficult for most amateur aquarists to do. Another process, known as "line-breeding," entails each aquarist maintaining and managing a population of a given species as best he or she can. Periodically exchanging animals with other breeders maintaining the same species furnishes an influx of fresh genetic material and minimizes the risk of inbreeding. Managing a population this way is not an exact science, but it has served both hobbyists and commercial fish farmers well over the years.

Institutional captive breeding programs and Lake Victoria haplochromines conservation

The Association of Zoos and Aquariums (AZA) supports a Species Survival Plan (SSP) for Lake Victoria cichlids. This organization is known as the Victorian Cichlid Species Survival Plan (VSSP). The VSSP represents an institutionally based and rather formally structured approach to the long-term maintenance of a limited number of Lake Victoria haplochromine species known to be either extinct or critically endangered in the wild. The program's current studbook lists a population of 2,628 individuals representing 8 species being kept at 14 North American institutions.

Another facet of the VSSP in which professional aquarists have played an important role is *in-situ* conservation work. Focusing primarily on public education in the range countries, aquarists working at North American zoos and public aquariums have traveled to Africa to work on a variety of initiatives ranging from development of an educational coloring book for children to field research on *Mycobacteria* to training of aquarists and development of a small lakeside aquarium in Kisumu, Kenya.

While the captive populations of these fish seem routine to manage on a day-to-day basis, there are obstacles to their long-term maintenance. A major challenge comes from the very factor that makes the program so accessible to institutions: The motivated aquarists that make the program so successful at a given facility are very likely

to be promoted or move on to new jobs. This can lead to discontinuity in the program if replacements for these critical personnel are not at hand. In addition, several VSSP species have been diagnosed as carrying a potentially disease-causing *Mycobacterium*. While this problem can be managed by actively breeding fish before senescence weakens their immune systems, resulting in disease, there is presently no known cure for mycobacteriosis. This poses a challenge to VSSP's goal of releasing captive-bred fish back into Lake Victoria. If the strain of *Mycobacterium* present in program fish is not naturally found in the lake, this would preclude their return to the wild.

Nevertheless, VSSP participants are guardedly optimistic regarding these cichlids' future. Heavy fishing pressure over the past decade has seen a fall-off in both the total weight of Nile Perch landings and the average size of individual fish. Both are indices of a population in decline. As a result, a number of the lake's endemic cichlids whose numbers had been severely depressed have reappeared at sites from which they had long been absent. It is unlikely that overfishing will ever do to the Nile Perch what it did to the lake's native tilapias. However, it seems likely that intense fishing pressure can reduce this predator's population to a level that permits a larger selection of haplochromines to coexist with it. It is thus possible that the species presently being maintained by the VSSP will someday swim again in the waters of Lake Victoria.

How can hobbyists play a part in the conservation of Lake Victoria haplochromines?

Limited institutional resources have obliged the VSSP to restrict its efforts to a handful of species known to be already extinct or facing imminent extinction in the wild. A number of species currently available to hobbyists through commercial channels were dropped from the program because their status in the lake was judged to be relatively secure at the time (Figure 11).

However, as already noted, the Lake Victoria ecosystem is still in flux. The conservation status of species currently considered secure may well deteriorate rapidly in the face of unpredictable environmental changes. It would be more prudent to regard *all* Lake Victoria cichlids presently being kept by hobbyists as potential insurance populations of vulnerable species and to manage them accordingly (Figure 12). Serious hobbyists who are keeping and breeding these fish have already taken a significant step in this direction by coming together in informal interest groups. Less structured than the AZA's VSSP, such interest groups can still allow interested parties to track the status of captive populations of Lake Victoria cichlids and facilitate the exchanges of broodstock necessary to maintain genetically viable populations over the long term. The American Cichlid Association's C.A.R.E.S. Program and the Groupe Victoria of Association France

Cichlid are excellent examples of such initiatives, and we strongly urge hobbyists who wish to take a hands-on approach to responsibly managing Lake Victoria haplochromines to involve themselves in the activities of these groups.

In conclusion, vulnerability due to environmental degradation, interesting behaviors, small adult size, and overall hardiness make Lake Victoria cichlids a great choice for serious hobbyists. It is our hope that knowing the story behind their plight will spark readers' interest and motivate them to bring these fascinating cichlids into their homes.

About the Authors:

Dr. Paul V. Loiselle *is emeritus curator of Freshwater Fishes at the New York Aquarium and is actively involved in conservation programs focused on the fishes of Madagascar, the deserts of North America, and Lake Victoria. He serves as a scientific advisor to the Lake Victoria Cichlid Species Survival Program. He is the author of* The Cichlid Aquarium *and* The Fishkeeper's Guide to African Cichlids.

Jay Hemdal *is curator of fishes and invertebrates for the Toledo Zoo and has been the AZA's (Association of Zoos and Aquariums) studbook keeper for Lake Victorian Cichlids since 1993. He is the author of* Aquarium Careers *and* Aquarium Fish Breeding.

ON THE INTERNET

American Cichlid Association's C.A.R.E.S. Preservation Program:

http://www.cichlid.org/index.php?pageid=aca_cares_preservation_program (contact Claudia Dickinson, ivyrose@optonline.net)

Association France Cichlid http://www.francecichlid.com/ (contact for Groupe Victoria: M. Michael Negrini, michael.negrini@gmail.com)

AZA Species Survival Programs http://www.aza.org/species-survival-plan-program/

BREEDING STOCK SOURCES

www.cichlidsofvictoria.org.

www.hillcountrycichlidclub.org.

RECOMMENDED READING

http://www.coralmagazine-us.com/content/lake-victoria-haplochromine-recommended-reading

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Fair-weather ponding

Stocking a patio water garden

Self-contained ponds can have great appeal with a small footprint, and many small tropical fishes will respond to sunshine and live foods such as mosquito larvae by spawning.

LEFT: AQUASCAPE INC., WWW.AQUASCAPEINC.COM. RIGHT: CHRISTIAN PIEDNOIR

by Mary E. Sweeney • Often, in the warming days of spring, when those pondering instincts kick in (and a real dug pond is completely out of the question), I find myself struggling to do something decorative with barrel halves, water jugs, and a motley collection of other non-leaking vessels that will serve to give my favorite fishes a "vacation" in the great outdoors. Sometimes, I allow an aquarium to go *au naturel* on a screened porch, and an Amazon Swordplant (*Echinodorus* sp.) will grow up and out of the tank and down to the floor, drooping with flowers.

Dwarf Flag Cichlids, *Laetecara curviceps,* pair in courting mode. This species takes on iridescent colors and goes into spawning mode in the author's patio water gardens.

A small group of Dwarf Flag Cichlids, *Laetacara curviceps*, might glitter in the filtered sunlight, and soon there are fishlets at every stage of growth, from well-tended eggs to fry and juveniles and sub-adults. Snails are welcome, as their little droppings feed the infusoria that feed the fry. For various reasons, spawning happens in outdoor water gardens and small container ponds with nary a trace of encouragement from the keeper.

Water gardening with a patio pond is like the aquarium hobby in summer easy mode. Where there is a fishkeeper, there will be some water and some fishes, and when summer arrives, some fish can move outdoors along with the rest of the family. The art of keeping fish in water gardens is as ancient as the Babylonian-style hanging variety, and no self-respecting fishkeeper will be happy without some water about, some monument to the fascinating sights to be found in aquatic microcosms. Maybe in the summer, when the days are long, there will be a little time to relax and reflect in the quiet, with the fishes.

I can't count how many of those handy, dandy 5-gallon water jugs I've decapitated in the name of spawning a favorite species. Moved to observe the spawning ritual of the shy Celestial Pearl Danio (*Celes-*

CONTAINER POND BASICS

- Choose the location carefully. Most aquatic plants will do best with at least several hours of full or filtered sunlight per day.
- Lightly stocked ponds can operate without filtration or heaters, but having access to electricity allows better water quality control and extended seasons in temperate climates.
- Add water to a new pond first, letting it age for several days or adding dechlorinator. Next add plants and substrate. Bioseeding with water or filter squeezings from an established aquarium will speed the development of populations of beneficial bacteria. After several days or longer, introduce fishes gradually.
- Smaller species do best in smaller water gardens. Goldfish and koi will die of oxygen starvation or fail to thrive in small ponds. Snails, bottom feeders such as Corydoras catfishes, and small shrimps will assist in natural maintenance.
- Feed lightly at least twice a day. Add and/or change water as needed. Be sure that lawn and garden chemicals are never allowed to contaminate the pond.
- Fishes should be able to keep a small pond from becoming a breeding ground for mosquitoes.
- Be prepared to take livestock and plants indoors for overwintering when temperatures drop in the fall.

Floating plants and water lily pads provide shade during the heat of the day and also discourage fishes from jumping during spawning frenzies.

tichthys margaritatus), I decided to set a jug on a bench among the conventional flowerpots that adorn our entryway. Filling a clean 4-inch clay flowerpot with aquarium gravel, I planted a single Madagascar Lace Plant (*Aponogeton madagascariensis*) bulb, tip showing, in the clay pot and placed the pot in the center of the clear jug. A shallow layer of aquarium gravel covered the bottom of the jug and helped to anchor the pot. I slowly filled the jug halfway with a combination of aquarium water and aged tap water.

Within days, the green tips of the Lace Plant could be seen emerging from the substrate. Several days later, I introduced a trio of two females and one male of the tiny danionins to the container. A little fresh water was added to the container every day or so, and I would remove some of the water to use in the flowerpots nearby. Over the course of the summer, the male could often be seen displaying for the females, and eventually fry did appear, but I never saw the fish spawn, only the evidence that they had done so.

Panda Cory, *Corydoras panda:* a candidate for a summer out-of-doors.

Summertime and the breeding is easy

The benefits of fresh air and sunshine are not limited to people. Fish that are kept in the aquarium year 'round are often pale and lethargic when compared to their brothers and sisters that have spent some time in one of the various homemade and portable ponds. If the water turns green, no problem; the glittering colors of the fishes more than make up for the slight murk. Besides, the fish grow fat and happy as live foods eventually appear like manna from heaven, the mosquitoes dutifully laying rafts of eggs that are the natural foods of so many small aquarium fishes. Other "no-see-ums" also appear to be good sport for the sharp-eyed fishes, who can be observed snapping at the waterline, especially at dawn and dusk.

With all the ready-made aquatic patio ponds coming on the scene, it is simple to create a little space for a water feature. Most garden centers now offer a range of virtually plug-and-play self-contained ponds, ranging from inexpensive black barrel liners and automatic animal waterers to

Below: *Jordanella floridae,* the American Flagfish, can show magnificent coloration and is an ideal candidate for small outdoor pools.

LEFT: AQUASCAPE INC., WWW.AQUASCAPEINC.COM. RIGHT TOP: AARON NORMAN. RIGHT BOTTOM: MATTHEW WITTENRICH/AQUATIC PIXELS

A classic pond species, the Goldfish, *Carassius auratus auratus*, demands a pond of 50 gallons or more and a place to spend the winter indoors. Neither goldfish nor koi are recommended for small water features.

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some very handsome and elaborate water features with cascades and multiple interconnected pools of water. Many of these pieces can be very attractively crafted, durable, and lightweight, and some have the durability of fiberglass/powdered stone composites.

In a very nice marriage of form and function, many have special integrated plant shelves and space for power cords, submersible filters, heaters, and water pumps in case you choose to add a small waterfall. When the inside is black, the interior of the pond has a nice, uniform color and the contrast makes the fishes practically glow in the dark. These patio pond containers and bowls commonly range in size from about 10 gallons to 50 gallons, although much larger systems are available.

If you plan to use a flowering water lily in your patio pond, remember that they require still water. Splashing from a fountain will allow water to settle on the surface of the leaves, causing them to break down and rot. This does not mean that you must forego the fish, however. Just keep the population down to two or three small fish, like Platies (*Xiphophorus maculatus*)—colorful, hardy little fellows that are not as inclined to take a flying suicide leap as Swordtails, which are notorious jumpers.

Species selection

In fact, in choosing fish species for small water gardens, it is good to know that certain groups are particularly prone to the outdoor version of carpet surfing—the tendency to fling themselves out of the water, usually during occasions of frenzied mating activity. Hatchetfish, most gouramis, Bettas, and Elephant Nose are all known leapers, as are the various loaches. None of this is carved in stone, and jumping is minimized if the surface has a goodly covering of plant life: water lily pads, Water Hyacinth, duckweed, and the like. (Banana plants do well in a small summer pond, quickly throwing up new shoots with miniature lily-like pads in green and red.)

Some people have good luck with guppies and love the sight of fry and juveniles in the pond in mid-summer, but frenzied males will sometimes overextend their drive to reproduce. The non-jumpers' list includes *Corydoras* spp., White Cloud Mountain Fish, *Otocinchlus* spp., small rasboras, tetras, and small danios. Any athletic, fast-swimming fish is probably not a good bet, especially those that move about in the upper layers of water.

In my own experience, the American Flag Fish (*Jordanella floridae*) is among the best fishes for the patio pond. Swimming among the plants, this hardy fish species flashes its tantalizing fins in the dim water. These small native American fishes are very curious, and feign shyness for a while, only to end up tame and hand-feeding in a very short time. Use primarily Java Moss (*Vesicularia* spp.) and Java Fern (*Microsorum pteropus*) with these fish, as they will make salad out of soft-leaved

plants like Water Wisteria (*Hygrophila difformis*). Let nature work its magic, and Flag Fish young will sooner or later be spotted hiding in the vegetation.

Koi are out, unless the pond has a minimum capacity of 300 gallons and a good water filtration system. And what about goldfish, those quintessential pond fish? If overstocked, they will quickly exhaust the oxygen and pollute a small pond. Plan on at least 50 gallons for one small pair of goldfish. And while they may seem perfect for summer, what happens in the fall, when the party moves back indoors? Few aquarium hobbyists have ever seen an adult goldfish, which are sometimes measured in pounds rather than length, as with most aquarium fishes. One of the most beautiful aquariums I've ever seen was about 70 gallons and home to three adult red and white Fantail Goldfish. Any more fish, and the tank would have been overcrowded. So this is what happens when goldfish grow up, which is what they do when we take good care of them. The adult size of goldfish isn't a problem in the traditional dug pond, where the fish remain year 'round, but if you plan to move the fish inside, be prepared to dedicate a substantial aquarium to their keeping.

Some aquarists like to use emersed growth plants to add height and interest and shade for the fishes. The rules sometimes get broken, but some of the plants we see as marginals, like Peace Lilies, *Spathiphyllum* spp., are quite willing to grow in a small container with inert media in the patio pond, raising their white flowers like flags of peace above the water. Irises, too, planted just before bloom, will surpass all expectations. Most serious garden centers now have a selection of aquatic plants that will grow emersed, while your local aquarium will have a mixture of those that stay submerged and those that reach toward the sun.

In the summertime, when the weather's fine and the days grow longer, the evening ritual moves to the outdoors. Regardless of accommodations—whether a cozy patio of stone or brick, a wooden deck, a high-rise urban balcony, or even the ubiquitous city fire escape—the lure of a long, relaxing evening ahead, in one's favorite company and among the fishes, is a suitable reward for a hard day's work.

Mary Sweeney *is the co-author of* A PocketExpert Guide: Tropical Fishes *(2009, Microcosm/TFH Professional Series).*

Ixinandria steinbachi:

A phantom puts in an appearance

The loricariid catfish species *Ixinandria steinbachi* was, until recently, no more than a phantom as far as aquarists were concerned: it existed only in photos of preserved specimens in museums. But some friends of mine managed to bring some back from South America, and I "babysat" for them for a month while their owners were on vacation. • *by Ingo Seidel*

The most fascinating thing about armored catfishes is their bizarre appearance, the threadlike fin extensions, and especially the spiny body. Some loricariids are real prickly monsters, and the males, in particular, have long bristles called odontodes around the edge of the snout. *Ixinandria steinbachi* males have broad, much flattened, heavily bristled heads and look really peculiar.

Because there is no collecting of aquarium fishes in the region where they live (southern Bolivia and northern Argentina), these fish are practically impossible to find in the trade. So-called *Ixinandria* that occasionally turn up in the aquarium trade have so far always turned out to be *Rineloricaria* species.

Found only in the Río Paraguay system

Ixinandria steinbachi is found only in the river system of the Río Paraguay in the border region between Bolivia and Argentina. These armored catfishes inhabit the drainages of the upper Río Juramento (northern Argentina), the upper Río Bermejo (Argentina and Bolivia), and the upper Río Pilcomayo (southern Bolivia). They are montane catfishes that are found only in the upper courses of rivers at an altitude of some 660–9,500 feet (200–2,900 m). The lowest confirmed occurrence to date was at an altitude of 700 feet (210 m) in the Río Rosario, about 30 miles (48 km) from the town of Salta in northern Argentina.

Habitat of *Ixinandria steinbachi*: a small stream around 12.5 miles (20 km) from Salta.

This region of South America is characterized by a rather cool, dry winter in the months from April to September; the air temperature drops to 50°F (10°C) on average and the precipitation to around .125 inch (2–3 mm). In January, the warmest and wettest month of the year, the temperature averages 71.5°F (22°C) and the precipitation is up to 7 inches (175.6 mm). (The data are for Salta, altitude 4,075 feet [1,238 m], source www.worldclimate.com).

According to Rodriguez et al. (2008), these fishes are found mainly in fast-flowing, very oxygen-rich, shallow sections of river with a depth of only 6–26 inches (15–65 cm), where they spend the day hidden beneath rocks. They are apparently especially common in waters with an abundance of thread algae.

The first in Germany

Because no imported *Ixinandria* had thus far been available in the aquarium trade, my only hope was that traveling aquarists would collect some of these fishes and bring them back. And in

LEFT: FAM. NORMANN; OPPOSITE PAGE: I. SEIDEL

Above: Male *Ixinandria steinbachi* from the area around Salta, Argentina. Note bristly snout and comical expression of eyes. Below: *Ixinandria* females look more like *Sturisomatichthys* than the closely related *Rineloricaria*.

Left: For comparison: male *Rineloricaria* sp. "Paraguay".

Middle: The belly of the *Rineloricaria* is covered in scutes.

Bottom: *Ixinandria* lacks the scutes seen on the belly of *Rineloricaria*.

flowing fast at the time and had an electrical conductivity of 236 µS/cm and a pH of 8.2. But they found only the syntopic species *Corydoras micracanthus*. When they visited the stream again in 2008 it contained a lot less water and was flowing only slightly, and there were lots of residual pools. The electrical conductivity was now 245 µS/cm, the pH 6.9, and the water temperature 73.5–77°F (23–25°C), which is supposedly the upper limit of the temperature range for *Ixinandria steinbachi* in the wild.

The Normanns cleared the rocks from one of the pools and caught three specimens, which they brought back alive to Germany: a large individual with a slightly broadened head and two smaller ones that did not yet show any indication of their sex. As luck would have it, a pair subsequently formed and spawned in the autumn of 2010.

In February 2011 I was lucky enough to be entrusted with this pair and some youngsters for around a month while their owners were on vacation. Because these individuals were thought to be the only *Ixinandria* in captivity in Germany, I treated them with great care. The following is a report on my observations of this species during the time I had them.

Copious water changes

Because these fishes originate from comparatively cool waters, I was aware that the maintenance conditions I was able to offer them during this one-month stay were not exactly optimal. To create their accommodations I vacated a 56-gallon (200-L) aquarium that was decorated with the obligatory sandy bottom and a number of rocks stacked up and equipped with powerful filtration and aeration. The room in which my aquariums are located is kept at a constant 75–79°F (24–26°C) year-round, so the water was the same temperature, even without a heater. Because such temperatures are thought to be too high for *Ixinandria* in the long term, I performed a copious water change every two days using significantly cooler water, which appeared to please the fishes. After each

October 2008, the Normanns, who have been traveling regularly to South America for many years, did precisely that. They had to visit the area around Salta in northern Argentina twice in order to find *Ixinandria* there. The couple had already looked for it in 2003, in a small stream about 12.5 miles (20 km) from Salta, which was

Left: Genital papilla of the male. The genital region of the female is shown at right.

Frontal view of the *Ixinandria* male.
Below: Female swollen with eggs in frontal view.

Left: Pair preparing to spawn beneath a rock.

Bottom: The male guarding the large eggs, eight days after spawning.

Right: Male with newly hatched fry 0.375 inch (12 mm) long.

water change the water temperature fell to 64.5–68°F (18–20°C) and then slowly rose again to around 77°F (25°C).

The water was a mixture of reverse-osmosis and tap water, and the electrical conductivity varied between 200 and 400 µS/cm; the pH was in the 7.0–7.5 range. The aquarium was filtered using filter foam. Two airlifts ensured good oxygenation and provided a fairly strong current. The two *Ixinandria* mostly remained hidden among the rocks.

On a diet of live *Tubifex* and glassworms, frozen *Cyclops*, and food tablets, the girth of the female increased enormously within just a few days. She was incredibly distended, so I had reason to hope that the fishes would breed during their stay.

Cave brooders

Even at first glance, the sexes are very easy to distinguish in adult specimens. The male has a very broad, flat head region. The sides of the male's head is set with numerous odontodes, and there are also bristles on the upper side of the branched pectoral fin rays. In addition, males have significantly more papillae in the mouth opening than females, and the form of the teeth also differs in sexually mature males. The teeth are bicuspid in both sexes, but the outer cusp is rounded in males, straight in females.

As far as is known at present, the catfishes of the subtribe Rineloricariina are practically all cave brooders, and *Ixinandria* appears to be no exception. But they completely ignored the clay pipes and bamboo tubes I provided for them, and which I have always used successfully for my *Rineloricaria*.

Ixinandria apparently prefer to spawn on the undersides of rocks, and I had the great good luck to be able to witness and photograph the event. When I saw two tails protruding side by side from beneath a flat rock, I slowly moved the rock closer to the front glass, turned it around a little, and fixed it in this position. Now I could not only watch but also photograph the spawning.

The fishes didn't seem to be much bothered by this. Only the sudden collapse of the spawning rock, which certainly frightened me, led to a brief interruption in the spawning. I fixed the rock back into its former position and the spawning continued as before.

The female had a noticeably protruding and swollen genital papilla, and laid one approximately 3.5-mm-long yellowish egg after another. She broke off from this procedure from time to time and then the male crept over the eggs, apparently in order to fertilize them. The entire process lasted for many hours. After around four or five hours I eventually stopped watching and put the rock back in its original position.

The next morning I could see only one tail protruding from beneath the rock. The female, now noticeably slimmer, had taken up residence in another part of the aquarium. When I lifted the rock I saw that she had

THE GENUS *IXINANDRIA*

The loricariid catfish genus *Ixinandria* was erected in 1979 by two Dutch ichthyologists, Isbrücker & Nijssen, for the two taxa *Loricaria steinbachi* Regan, 1906 and *Canthopomus montebelloi* Fowler, 1940. According to Isbrücker at that time (1979), *Ixinandria* belongs in the subtribe Rineloricariina of the armored catfish subfamily Loricariinae and is very closely related to the genus *Rineloricaria*, the males of which can look rather similar. However, *Ixinandria* can be distinguished from *Rineloricaria* by the complete absence of scutes on the belly, the even more robust nature of the spinous structures known as odontodes on the anterior body, and the more pointed head in sexually mature males.

Isbrücker (1981) noted early on that the differences between the two species *Ixinandria steinbachi* and *Ixinandria montebelloi* were so slight that regarding them as distinct was probably not justified. Rodriguez et al. (2008) performed a morphometric analysis and a molecular comparison of the Cytochrome-Oxydase-I gene for various populations from the distribution regions of *Ixinandria montebelloi* in Bolivia and *Ixinandria steinbachi* in Argentina, which confirmed Isbrücker's supposition. Accordingly, they declared *Ixinandria montebelloi* to be a synonym of *Ixinandria steinbachi*.

The body form of *Ixinandria* (right) is very different from that of a young *Rineloricaria*.

produced an impressive clutch consisting of around 70 eggs, which were now being tended in exemplary fashion by the male.

The color of the eggs changed from day to day. Initially they altered from yellow to pink. After six or seven days the first embryonal pigments could be clearly seen through the egg membrane. On the 10th day the first fry began to hatch, and at this stage only a small yolk sac remained. By the 11th day all the fry had hatched. Some of them remained under the male's care for a few more hours, but then they scattered all over the aquarium.

Amazingly, by the time the fry hatched the female was already exhibiting a noticeable spawning papilla, and the fishes did, in fact, spawn again a few days later. It thus appears that these fishes can spawn repeatedly at very short intervals during the breeding season.

Rearing challenges

The fry were already 0.5 inch (12 mm) long on hatching, and, like young *Rineloricaria*, sported bands and similar brown fins. But the base color of young *Ixinandria* is light gray, while young *Rineloricaria* are usually light brown. The most obvious differences are in the body form: young *Ixinandria* have noticeably broader anterior bodies and rounded heads. At the same age, *Rineloricaria* are slimmer and their heads are more pointed.

I fed the young *Ixinandria* with brine shrimp nauplii and crushed food tablets sprinkled on the surface of the water. Later on I gave them an additional feed of frozen *Cyclops* once a day. They accepted this food very well. Unfortunately, I lost a number of the fry, perhaps through feeding inferior quality *Artemia* nauplii.

Anyone who can't offer these fishes permanent low temperatures of around 61–75°F (16–24°C) would do better not to keep them at all. But if you have a chiller or a cool room with a steady year-round temperature, *Ixinandria steinbachi* is not difficult to maintain in the aquarium and is even easy to breed. Still, I doubt that it will become commonplace in the trade. Like me, many aquarists will be unable to offer suitable conditions. I am very happy that I managed to breed these rare catfishes despite less than optimal conditions, but I was also relieved to be able to return them unscathed to their owners, along with their offspring, after the month was up.

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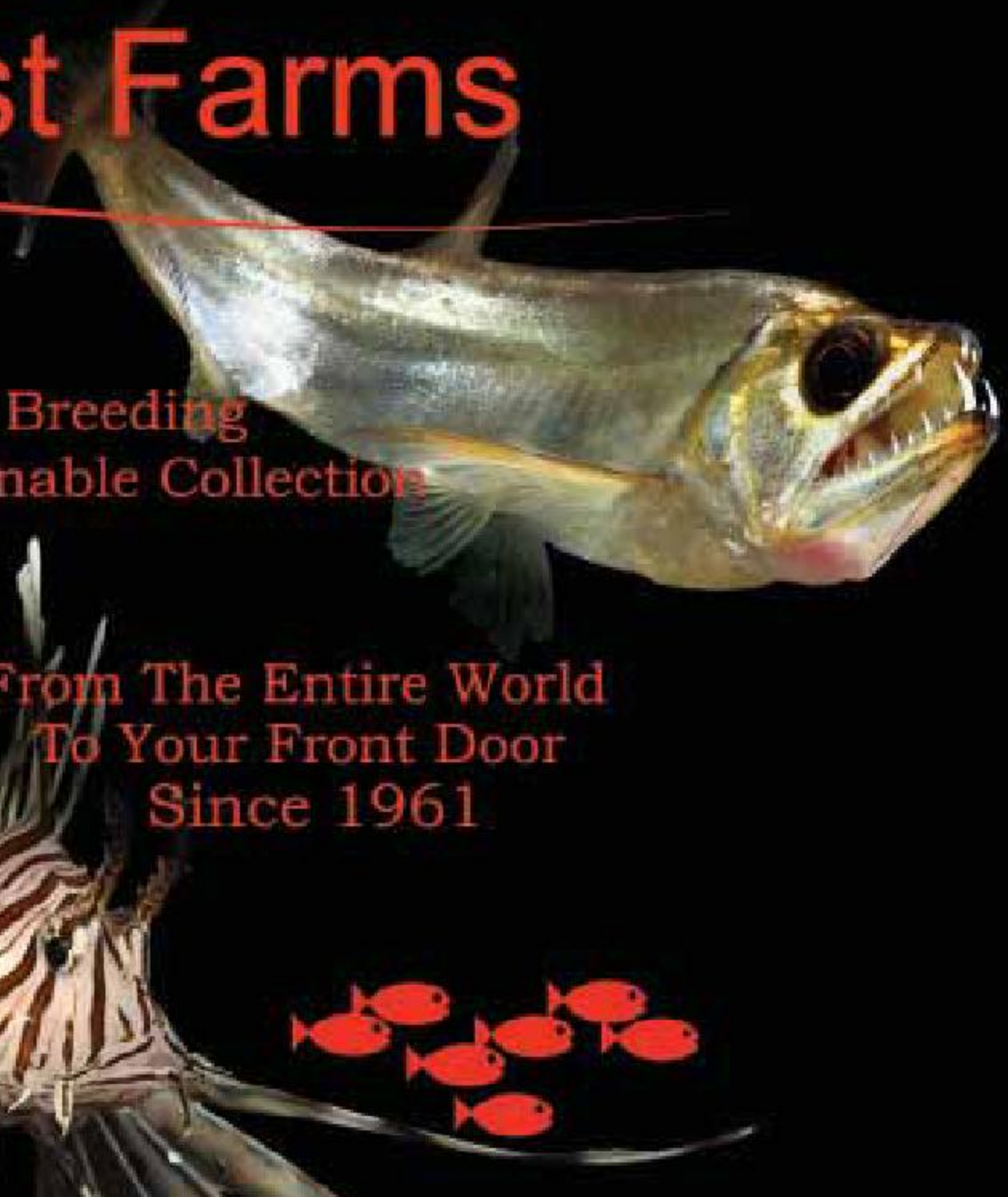

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The coloration of the live *Denticeps clupeoides* is here revealed for the first time.

Denticeps clupeoides is a surface-dwelling fish that swims in small groups and maintains contact with its fellows.

Denticeps clupeoides:

the Denticle Herring from West Africa

The Clupeomorpha (herring-like fishes) comprise some 390 species distributed worldwide, predominantly in the sea, although a number of species, for example the European Allis Shad (*Alosa alosa*), migrate to spawn in fresh water. Some species from different groups among the clupeomorphs have succeeded in adapting completely to life in fresh water. These freshwater herrings occur in many of the large lakes and rivers of the world, and include the West African species *Denticeps clupeoides*. • *article and images by Ralf Britz*

Clupeomorphs differ from all other fishes in having paired, balloon-like extensions (diverticula) of the swim bladder, which are directly connected to the inner ear. A very long, narrow canal extends posteriorly from each diverticulum, linking it with the rest of the swim bladder. This connection between the swim bladder and the ear provides better hearing, and some species can even detect frequencies in the ultrasound range. Another striking character of the clupeomorphs are the so-called keeled scutes, a row of unpaired scales covering the underside of the ventral keel.

The most ancient clupeomorph

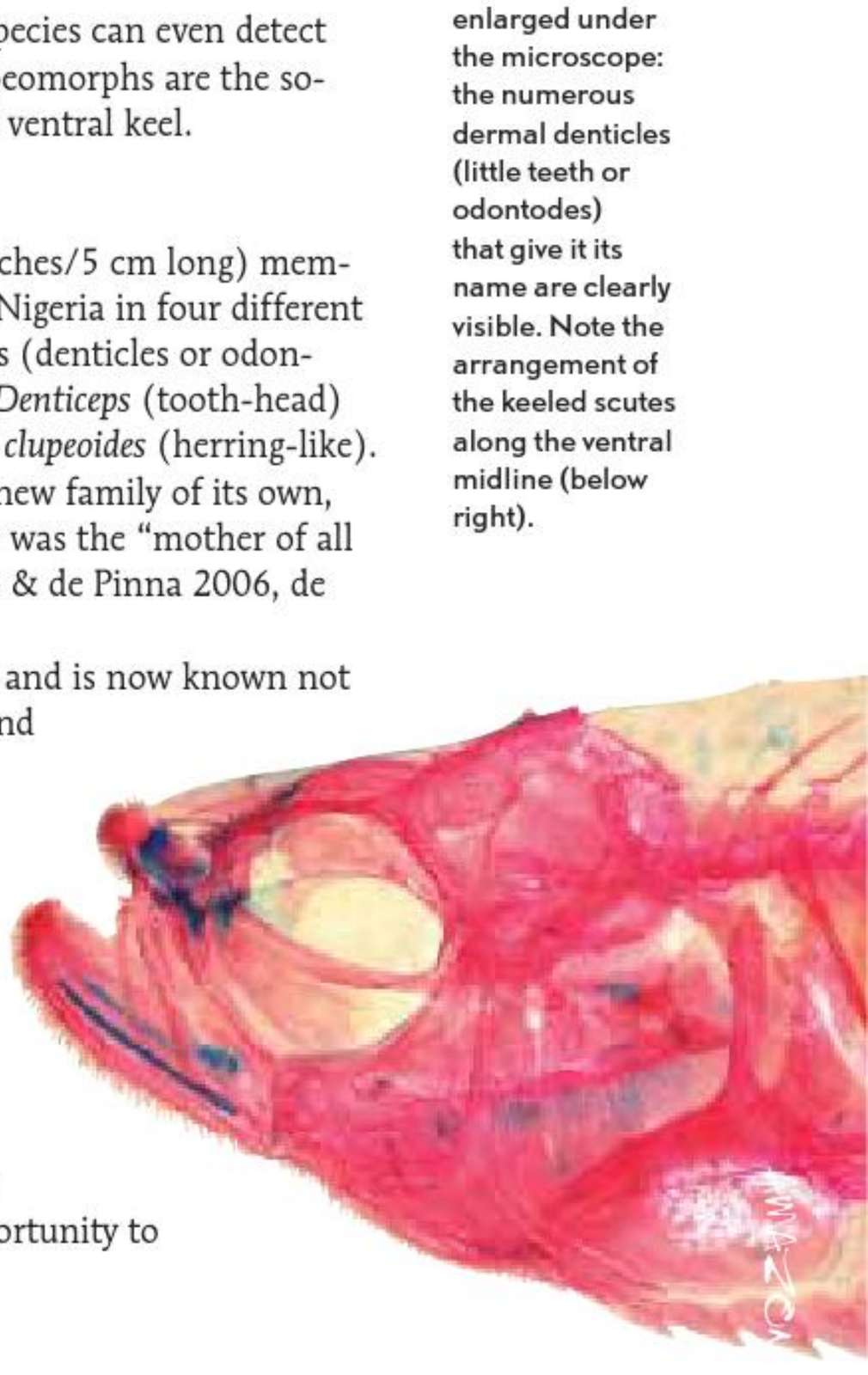
In 1959 the Danish ichthyologist Stenholt Clausen described a small (2 inches/5 cm long) member of the Clupeomorpha that had been collected during an expedition to Nigeria in four different rivers in the southwest of that country. Because of the tooth-like structures (denticles or odontodes) present all over the head, the author gave this fish the genus name *Denticeps* (tooth-head) and indicated its similarity to the herrings (*Clupea*) with the species name *clupeoides* (herring-like).

Based on its unique characteristics, Clausen also placed *Denticeps* in a new family of its own, the Denticipitidae. Further research on its anatomy revealed that *Denticeps* was the "mother of all herrings"—the oldest of all the clupeomorphs (Greenwood 1968, Di Dario & de Pinna 2006, de Pinna & Di Dario 2010).

Denticeps has subsequently been recorded in other parts of West Africa and is now known not only from the drainage of the Niger in Nigeria but also from the Ouémé and Iguidi Rivers in Benin and the Mungo River in Cameroon (Teugels 2003). Its unusual anatomy and systematic position have continued to fascinate ichthyologists, and additional scientific work on the species has recently been published (de Pinna & Di Dario 2010).

Rarely imported

To date *Denticeps* appears to have been rarely seen in the aquarium hobby, if at all, and one can search in vain for reports on its maintenance or even just an illustration showing the color of a live specimen. Because I have a considerable interest in unusual fishes and, as a scientist, am also professionally interested in this little fish, I have always jumped at the opportunity to visit an importer of West African fishes.



Head of *D. clupeoides* enlarged under the microscope: the numerous dermal denticles (little teeth or odontodes) that give it its name are clearly visible. Note the arrangement of the keeled scutes along the ventral midline (below right).

When, sometime in the 1990s, I mentioned to Frank Schäfer of Aquarium Glaser in Rodgau, Germany, that I was particularly interested in the Denticle Herring, he told me that the species was being imported, albeit rarely, from Nigeria. I asked him to let me know the next time this occurred, but as luck would have it, soon afterward new importations of *Denticeps* ceased. One day some time later, while I was wandering around a very well-stocked aquarium store in London, the manager drew my attention to the fact that he had a few *Denticeps* in one of his tanks. He had ordered them from Aquarium Glaser, but so far nobody had shown any interest in buying them. I was over the moon! Immediately, I had him bag up all five fishes for me. But when I arrived back in my fish room and unpacked the bags containing the *Denticeps*, I realized with horror that only four of them had survived the two hours of transportation—and one of these appeared to be unwell.

These rapid swimmers are difficult to photograph.

Always on the move

I put the fishes in a tank of their own, set up with a layer of fine gravel, lots of Java Moss, and water with a pH slightly below 7 and a conductivity of somewhat more than 100 µS/cm. Unfortunately, I found the sick fish dead in the tank the next day, but the remaining three appeared to be doing well. They were soon taking a wide variety of foods ranging from flake to frozen foods of various kinds, and were particularly fond of bloodworms and glassworms.

When I released the fish into the tank I was immediately struck by their almost compulsive liveliness. Denticle Herrings are constantly on the move, indefatigably performing their rounds in the tank. This makes it particularly difficult to photograph them, and getting them in sharp focus in a side view is a real challenge. They also react to the flash by changing direction extremely quickly, so I had to take several hundred photos in order to put together a few usable ones for this article.

Denticeps has a fairly transparent body with a yellowish-beige sheen. A dark longitudinal band runs from the posterior edge of the operculum to the caudal peduncle, where it widens to form a spot. Above and below this band there are iridescent metallic golden stripes that broaden to cover a wide area in the region of the body cavity and cover its entire upper half. Another particularly striking feature of the coloration is the iridescent color of the upper half of the eyeball. The individual scales have dark margins, giving the body a reticulated appearance.

A narrow black stripe runs the entire length of the anal-fin base. The tip of the dorsal fin, the lower edge of the anal fin, and the extreme tips of the caudal lobes are whitish, while the base of the last-named fin is yellowish in appearance. The rest of these fins, as well as the pectorals and ventrals, are transparent. The keeled scutes, which number around 20 in *Denticeps* and cover the ventral midline from the breast region to the anal opening, can be seen quite well in the photos of live fishes, but even better in the skeletal preparation on page 75.

Sensitive to transportation

In the aquarium, Denticle Herrings move around in a loose shoal and appear to be repeatedly following the same circuits. When alarmed they shoot rapidly across the tank. I maintained my three fishes for a period of almost two years, until they died one after another. It remains unclear whether they had reached their natural maximum age or fallen victim to some disease that I didn't recognize. Be that as it may, after the demise of my three Denticle Herrings I tried to obtain more, my desire being to maintain as many of these interesting fishes as I could get my hands on. A new inquiry to Aquarium Glaser confirmed that the species was essentially unobtainable.

Again I waited for around a year, and then the same store in London called to tell me that a few *Denticeps* had come in. I knew from personal experience in the field, as well as reports from other ichthyologists, that clupeomorphs in general react extremely badly to removal from the water, and die almost as soon as they are lifted out in the net. This is probably because the balloon-like swim bladder diverticula in the skull are damaged in the process. *Denticeps* are somewhat less delicate, but I still thought it would be better if the fishes were transferred from net to bag underwater. This proved possible, and none of the five fishes died during transportation. Those five are still swimming in one of my tanks, and four of

When the fish is illuminated from the side, the flanks have a metallic shimmer. The abdominal scutes are clearly visible in this photo.

them seem to be slowly coming into breeding condition. The gonads, which lie between the swim bladder and the stomach region, have become fairly large and cover the anterior third of the swim bladder laterally. There is, however, no real external sexual dimorphism in *Denticeps clupeoides*.

Reproduction unknown

To date nothing is known about reproduction in the Denticle Herring, and it remains to be seen whether breeding in the aquarium is possible. On the basis of current knowledge, the size of the eggs, as well as their form and structure, varies considerably within the Clupeomorpha. Depending on the species, they can be between 0.6 and 3.8 mm in size and either round or highly elliptical. They either float in the open water with the aid of a globule of oil or sink to the bottom after spawning. What first foods will be required for the newly hatched fry is another area where we remain in the dark.

I continue to dream of one day being able to keep a large group—perhaps dozens—of *Denticeps* in a big tank, so that I can study their behavior further and perhaps even crack the challenge of breeding them. Unfortunately, exportations of aquarium fishes from Nigeria have greatly decreased because of the current political problems, and my dream is unlikely to be fulfilled in the foreseeable future.

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The upper surface of the head and the upper part of the ocular ring are yellow in color. Under the correct lighting the Denticle Herring is a rather attractive fish.

Tetraodon suvattii – the Arrowhead Puffer

Puffers have always been my favorite fishes. Their intelligence never ceases to amaze me, and I like the way they move. Most of them also have very appealing faces. A notable exception is *Tetraodon suvattii*, which has a face only a mother (or maybe an eccentric aquarist) could love. The V-shaped marking (see top image on facing page) on top of the head has led to its common name, the Arrowhead Puffer. • *by Kurt A. Zahringer*

Tetraodon suvattii is a lurking predator. The arrowhead marking on the top of the head makes the species unmistakable.

Because of its provenance and physiognomy, the Arrowhead Puffer is also known as the Mekong or Pignose Puffer. *Tetraodon suvattii* originates from the Mekong drainage in Southeast Asia, and these fishes spend their entire lives in fresh water. The species was first described as recently as 1989 and named in honor of Dr. Chote Suvatti, a fisheries professor at the University of Kasetsart in Thailand. The type series originated from northern Thailand, although the species supposedly has a much larger distribution and also occurs in Laos and Cambodia (Sontirat 1989).

Unlike many better-known species, the Arrowhead Puffer is a lurking predator that often hides buried up to its eyes in the substrate, waiting for incautious prey to swim by. While many puffers specialize in eating snails, this species normally prefers to catch fishes and shrimps. Nevertheless, it has a powerful bite. *Tetraodon suvattii* often grabs a fish by its middle, folds it in half, and sucks it in, sending scales and innards flying across the aquarium.

This freshwater puffer grows to a maximum length of 4.75–6.0 inches (12–15 cm). Its skin is

Arrowhead Puffers spend the whole day lying almost motionless in the aquarium and watching every movement outside it. They very quickly become active when food arrives in the tank.

predominantly gray-brown with assorted dark spots, and it has a characteristic black, arrow-shaped marking between the eyes. According to Sontirat, specimens can occur in almost any color, from cream to completely black or red. The large caudal fin is usually carried folded, sometimes with the caudal peduncle laid to one side. These fishes move forward by using their pectoral fins in the puffer-typical manner. When frightened they can also manage a brief sprint.

Maintenance in a species aquarium

Because *Tetraodon suvattii* is a confirmed predator with a fierce disposition, it can only be kept in a species aquarium. I wouldn't risk keeping it with other fishes apart from conspecifics, which is possible in a spacious aquarium as long as each individual has a place of its own to retire to, out of sight of all the others.

Arrowhead Puffers don't harm plants (at least not as long as they are well rooted or attached to wood), so they can be maintained in a planted aquarium. To

During courtship the male and female circle one another above the spawning site. Below: The male fertilizes the eggs just laid by the female.

Brood-caring male above the spawn (note clear eggs on driftwood).

make them feel secure you must provide hiding places—caves or overhangs—and a substrate of sand in which they can bury themselves. After a while they will get to know their owner and will constantly beg for food whenever he or she appears.

When two individuals are in dispute, one swims head down, inflates its body, and attacks its opponent. The other puffer then turns around and presents its belly in a gesture of submission. The confrontation usually ends there, although the fishes may also bite one another, leaving circular wounds. Luckily, these are usually superficial and heal without problems as long as the water quality is good.

Being a puffer, *Tetraodon suvattii* has no scales and reacts particularly strongly to poor water quality. Because of their eating habits, regular large water changes are very important for their long-term health. One way of reducing pollution in the water is to offer small morsels of food that can be swallowed whole by the fishes. Although some people may find it interesting to watch a puffer dismember another fish of its own size (which they can and will do), this rapidly pollutes the water and makes maintenance harder work.

Because these fishes spend most of their time at rest, they don't need a lot of swimming space. A 20-gallon (75-L) aquarium should be regarded as the minimum size for a single individual; a pair would need one twice that size. Of course, the larger the tank, the easier it is to maintain good water quality. These fishes prefer to linger on the bottom, so a large bottom area is more important than tank depth.

Arrowhead Puffers are very greedy feeders, and will eat until they burst if given the opportunity. I restrict the amount of food to three pieces of krill per day or one large fish roughly every third day. Although newly imported specimens can initially be very shy of feeding, I have no problem getting them to accept frozen foods quickly. I feed my puffers frozen foods such as krill, fish, mussels, and squid, and they remain in good health on this diet.

A driftwood spawning site

It wasn't until I read Klaus Ebert's book *The Puffers of Fresh and Brackish Waters* (2001), which I can heartily recommend, that I first learned that it is possible to breed *Tetraodon suvattii* in the aquarium. The relevant section contains a very detailed description of breeding the species. Ebert was of the opinion that it shouldn't be difficult to breed this species commercially as well. That inspired me to try, and eventually I was successful.

Because pair formation can be a violent process (male versus male battles can be fierce), some breeders search for a known mated pair, while others prefer to acquire five or six young juveniles and let them pair off.

Spawning is preceded by a long courtship ritual, during which the male and female circle above a particular spot. During this process the female noticeably alters her color pattern. The base color becomes light brown and the arrow turns white. For my fishes, the first spawning was triggered by the massive water changes with which I was trying to control a green water problem, and they subsequently spawned whenever I put them together.

My puffer pair selected the flat surface of a piece of driftwood as their spawning site, although they may also spawn on flat stones or beneath overhangs. They circled each other with caudal fins outspread, repeatedly inflated themselves, and rubbed against each other. Now and then one of them would incline itself downward toward

the chosen spot, inflate itself, and apparently clean the spot with a jet of water.

This courtship behavior can last for three days, day and night. During this period the fishes even ignore food. Eventually the female lays more than 300 colorless eggs, about 3 mm in diameter, on the chosen spot. The male immediately chases the female away and begins to guard the eggs. He hovers above the spawn, turns slowly on the spot, and attacks immediately if another fish comes near.

Once courtship has begun, it is very important to check the fishes regularly and remove the female immediately after spawning so she won't be seriously injured. Or you can provide a hiding place that can't be seen from the spawning site, so the female can retire to safety following the spawning.

Miniature versions of the parents

During the development of the eggs the male occasionally checks the spawn and removes any fungused eggs. It is astonishing how carefully this fish, whose jaws can cause serious damage to a finger, can remove a single egg, leaving the rest unharmed. The development period is temperature-dependent, and 70°F (21°C) seems to be optimal. At this temperature the development of the eggs takes around 16 days, after which the larvae hatch almost explosively and swim away rapidly. At higher temperatures the fry hatch earlier, are smaller, and continue to exhibit a yolk sac for a number of days.

After the hatch, the male stops taking care of them. The larvae, which look like miniature versions of their parents—right down to the arrow-shaped mark on the head—can take food immediately; in fact, a good food supply is the main prerequisite for their successful rearing. Live, freshly hatched *Artemia* are a suitable food during the first weeks of life.

I had a quite atrocious survival rate with my first broods of young. I later discovered that I had not given them enough to eat. Even in youngsters the stomach is extremely distensible and can expand until it fills almost the entire body. By the time I raised my third brood, I virtually flooded the aquarium with *Artemia* twice daily and achieved better success.

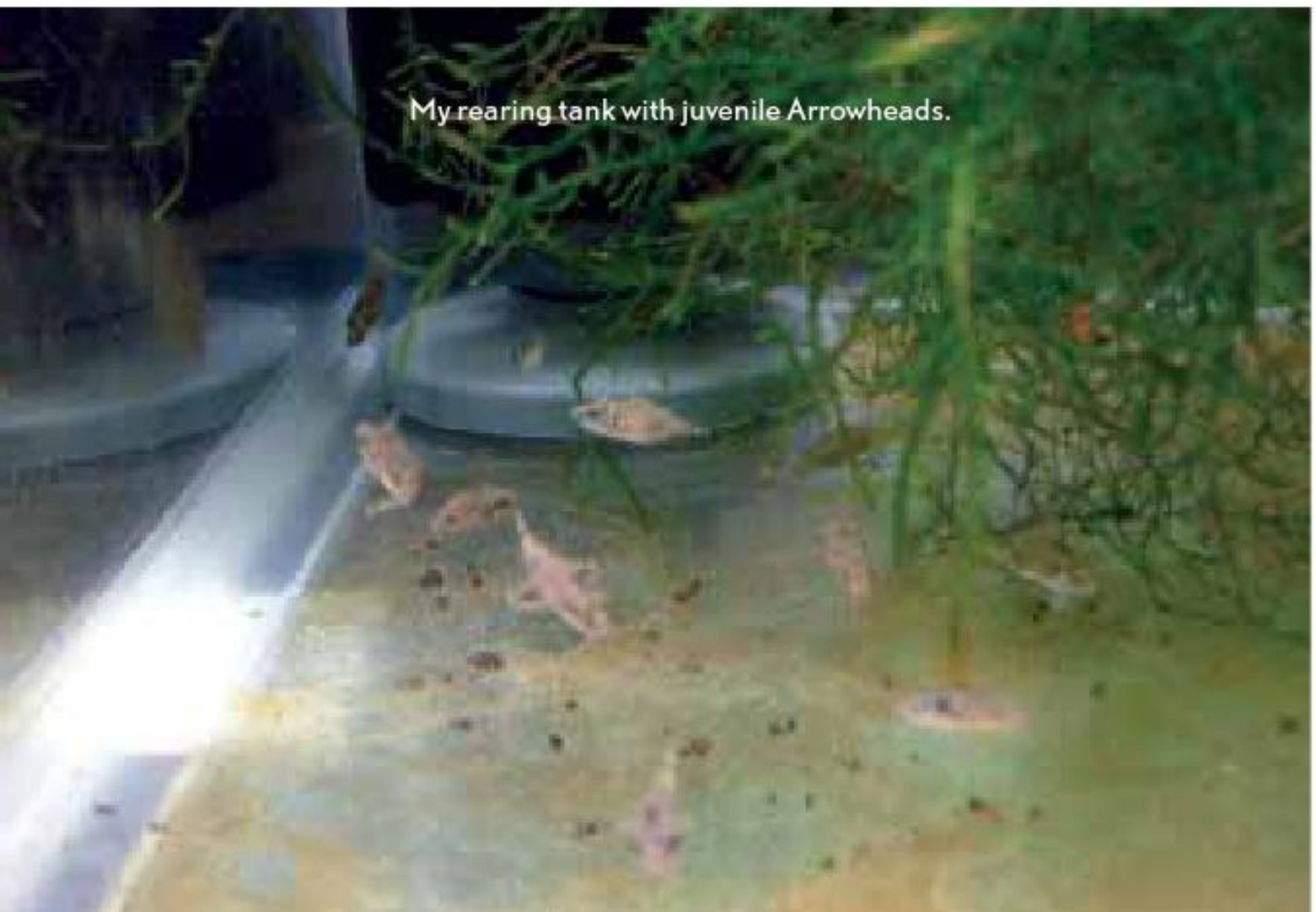
As soon as the young attained a length of around 0.375 inch (1 cm) I also fed them mosquito larvae, which they enjoyed very much. With good feeding they grew on rapidly and reached a length of around an inch (2.5 cm) at an age of 60 days. I now supplement their diet with live blackworms and frozen bloodworms, feeding them these foods until they are large enough to manage the same food as the adults.

Don't rear too many fry

When they were 90 days old, I found a number of youngsters disemboweled on the bottom of the rearing tank. Apparently they begin to behave like adults at this age and become less tolerant of one another. I divided them between several aquariums and provided lots of hiding places to avoid further deaths.

This brings me to another lesson I learned in rearing this species. At first I was proud to have bred my puffers and have a few hundred little ones. But it soon became clear that I couldn't feed them all and didn't have enough aquariums to rear them. So I recommend culling 80 percent of the larvae after hatching. I find this very difficult to do, but it is better to rear a handful of healthy fishes than a few hundred poor-quality ones that subsequently start to shred one another.

I was lucky that my first two fishes turned out to be a pair. Unfortunately, the sparse literature on the species provides no information on the differences between the sexes. After my puffers had spawned several times I photographed their undersides in the hope of finding a few clues. It turns out that the tissue around the vent is convex in females and concave in males. Of course I can't say for certain that this is a reliable characteristic on the basis of just two individuals, but I hope that my observation can be confirmed if more aquarists breed these fishes.



My rearing tank with juvenile Arrowheads.

This species is a very interesting aquarium occupant, both as a "pet fish" and as the basis for a new breeding project for the ambitious aquarist. Arrowhead Puffers require only attention to their simple needs and a bit of enthusiasm. Even if you have no previous experience with puffers, you will soon discover that maintaining *Tetraodon suvattii* isn't all that difficult.

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In pursuit of the disappearing Ogilby's Rainbowfish

—*Melanotaenia ogilbyi*

Indonesia, West Papua Province, south of the Great Dividing Range: the little town of Timika is the focus of a huge mining company, P.T. Freeport Indonesia, and coincidentally also the only known locality for a practically unknown rainbowfish species that has supposedly been virtually impossible to find for some years. I thought *Melanotaenia ogilbyi* was worth a trip. • *article and images by Hans-Georg Evers*

Two friends, Jeffrey Christian (Maju Aquarium, Java) and Mikael Hakånsson (Imazo, Sweden), and I set out at the beginning of June 2011 to try and rediscover the elusive *Melanotaenia ogilbyi* and attempt to make it available in the aquarium hobby. The very limited amount of literature available (Allen et al., 2000; Wilson, 2005, cited at www.rainbowfish.angfaqld.org.au) included a few pictures of the species, but they all showed gray fishes with a few reddish longitudinal bands. All the known photos had apparently been taken immediately after capture in a photo cuvette/box or later in a tank specially set up for photography. But anyone who is familiar with rainbowfishes knows that these fishes only color up properly when they are feeling good—so we had reason to hope that Ogilby's Rainbowfish would have more to offer than the pictures promised. Because the species attains a maximum length of 2.75 inches (7 cm), which is relatively small, we thought it would make an interesting aquarium fish.

We investigated all the waters in the immediate vicinity during the days that followed our arrival in Timika, but didn't find our quarry. We did find other rainbowfishes (the Goldie River Rainbowfish, *Melanotaenia goldiei*, and the Red-Striped Rainbowfish, *M. rubrostriata*), but the phantom *ogilbyi* was nowhere to be seen. Large parts of the area that can be reached on the few roads are inaccessible, however, because they belong to Freeport Indonesia. Our attempts to reach the Kopi and the Aikwa Rivers foundered on the frowns of the company police. Strangers, especially white strangers, are never allowed access to places where gold is being sought. Even the short stroll we attempted in the prohibited region resulted in a sharp request to make ourselves scarce.

Nor were we allowed to travel along the old road to Tembagapura, shown on the map in Allen et al. (2000), so we were unable to head toward the mountains and then further east, as planned. But we were told that a new road to Nabire was being constructed and would probably be finished in a few years. That sounded promising, so we decided to try our luck.

This little river flows out of the rainforest. *Melanotaenia ogilbyi*, a rainforest fish, is becoming increasingly rare as the forest disappears. It's no wonder that in recent years the species has vanished from its original habitat around Timika.

Black water

Only a few kilometers from Timika we came to the Iwaka River. After crossing the bridge we came across a border post manned by a number of Papuan men. When traveling in West Papua or Papua New Guinea, it is absolutely essential to respect such boundaries and politely ask for permission to enter a tribal region. Ignoring this code of behavior can have dire consequences, as the Papuans constantly carry bows and arrows around with them and know how to use them. The presence of our native guide and driver, Eko, a polite, friendly approach, and a few small gifts generally made it possible for us to locate the rivers and fish in them without incident.

We passed the barrier and found ourselves back on the 165-foot-wide (50 m) swath cut through the dense rainforest. The road continued for around 25 miles (40 km) before it reached the Wataikwa River. Here our journey came to an end,

Opposite page:
The broad Wataikwa River can be reached via the new road. In a few years there will be a bridge over the river here—and a route to the mountains of the Great Dividing Range, visible on the horizon.

Left: A broad swath has been cut through the ancient rainforest by loggers who are harvesting the valuable timber. Within a few years the idyllic scenery will be a thing of the past.

Ivantsoff's Blueyes, *Pseudomugil ivantsoffi*, have a yellow base color when freshly collected from blackwater streams.

Fewpored Gudgeon, *Oxyeleotris paucipora*, lives in the same biotope as another dwarf goby, *O. nullipora*, below.

Poreless Gudgeon attains a length of less than 1.25 inches (3 cm).

as no bridge had as yet been built. However, this area in the drainage of the Wataikwa River was still very unspoiled, and along the road we found not only a number of clearwater rivers that harbored already-familiar fish species, but also various small streams that flowed out of the rainforest and contained tea-colored water—blackwater streams. There must be other fishes here!

Pay dirt!

Measurements taken in various small streams and rivers along the road from the Wataikwa to the watershed with the Iwaka indicated rather acid pH values between 4.7 and 5.0 and a conductivity of 20 to 50 µS/cm. The water temperature in June, at the height of the dry season, varied between 79.2 and 81.7°F (26.2 and 27.6°C). We were traveling at an altitude of around 330–660 feet (100–200 m) above sea level in the foothills of the mountains.

The logged areas in the rainforest looked freshly cut. Everywhere we could hear saws at work, and we saw planks being sawn from fallen forest giants right next to the road. Large numbers of hornbills, lories, and cockatoos were a welcome change from fishes, which were difficult to find here. Sometimes there were only shallow trickles of water flowing among the fallen tree trunks. By poking our hand nets into the leaf litter we caught a total of three very attractive dwarf goby species, *Oxyeleotris nullipora*, *O. paucipora*, and *Mogurnda cingulata*—this last species was common everywhere in the blackwater

Left: The attractive Banded Mogurnda, *Mogurnda cingulata*, is the commonest goby species in the blackwaters of the Wataikwa drainage.

Opposite page: Female Ogilby's Rainbowfish are rarely this drab in color. They are usually more colorful and are difficult to distinguish from half-grown males.

A group of *Melanotaenia ogilbyi* in the aquarium. The fish at front right is a female.

streams here—which were soon swimming around in our bags. We also caught Ivantsoff's Blue-Eye, *Pseudomugil ivantsoffi*, mainly in the marginal vegetation where the streams were wider, but also in the 4-inch-deep (10 cm) water of the bank region. Although they had a bright yellow base color when captured, in the aquarium they changed fairly rapidly to the familiar gray coloration with yellow fins and blood-red tail.

I had already seen a number of rainbowfishes flitting away and was in a state of high excitement. Since we couldn't use our seine net in the normal manner in this uneven terrain, we needed to outsmart them, so we stretched the seine across the entire width of the stream. The two men handling the net had by far the easier job, as the "chaser" had to battle through knee-deep mud in order to drive the elusive fishes into the net. But we were successful, and when the mud fight was over we had finally achieved our goal: an adequate number of *Melanotaenia ogilbyi*, carefully packed in large plastic bags!

Excitement back home

Following a rather difficult acclimatization period, I have now had two groups of Ogilby's Rainbowfish swimming in my tanks back home for some time. It was obvious to us immediately after their capture that these fishes had some color surprises in store for us. Dominant males exhibited not only a variable red coloration with rows of blue scales on the flanks, but also a red underside to the belly and shimmering metallic blue on the back, as seen above in one of my aquariums.

The females displayed a somewhat paler version of this coloration, and initially, when the fishes were emaciated, it wasn't at all easy to tell the sexes apart. But now that the fishes are properly acclimatized, they are displaying their full potential. Courting males become bright red and exhibit a light "blaze" on the head, as is usual in *Melanotaenia* species.

These gorgeous little rainbowfishes are a real sight for sore eyes, and I am delighted every time I pass their aquarium and see them in action. The first breeding attempts are now in progress, and with any luck, *Melanotaenia ogilbyi* will soon be available to other aquarists as well.

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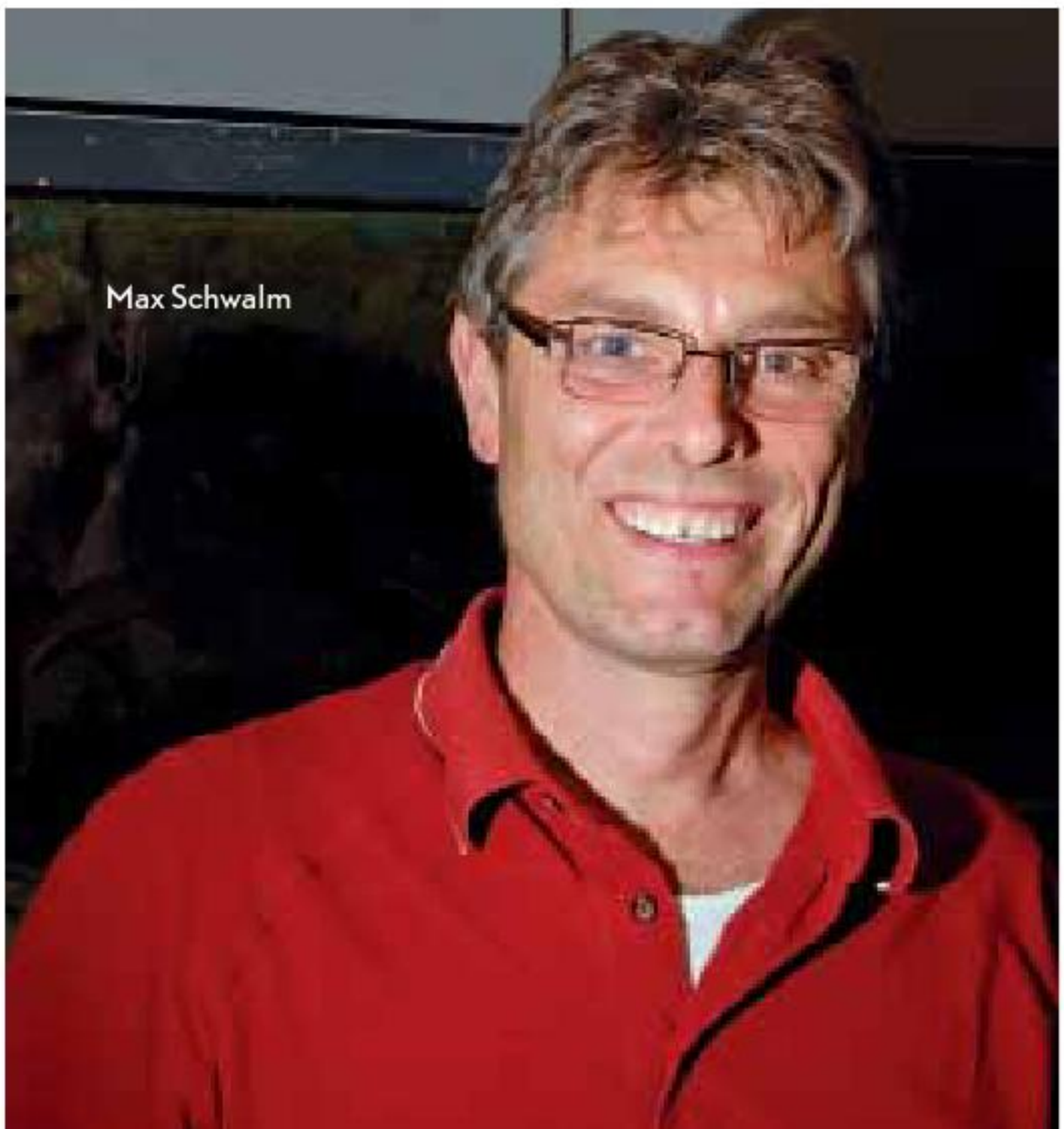
• *article and images by Hans-Georg Evers*

Switzerland is home to a number of very keen aquarium enthusiasts. Following a lecture evening in St. Gallen, the *AMAZONAS* team had the opportunity to visit a few of them and admire their setups.

Aquarists (Max Schwalm, Barbara Nicca, Hans Metzler, Patrick Pellin) in Switzerland

Visiting Max Schwalm's fish room is almost like being in South America.

Max Schwalm, a member of the St. Gallen Aquarium Club in eastern Switzerland and my host for the night, looks fit as a fiddle. A wiry man in his mid-fifties, Max has been keeping fishes all his life, but has only recently achieved his long-term aquarium goals. His current setup includes 40 tanks, some of them very large, which have a total volume of some 2,110 gallons (8,000 L) of water.


Max Schwalm

Some pretty expensive equipment is used to run the aquariums. They are linked in blocks to a central filtration system, but each can be isolated and run with its own mat filter. The water quality in the tanks is monitored electronically and maintained at a very high level by means of an automatic daily water change of around 15 percent of the total volume, using reverse-osmosis water mixed with tap water to achieve a carbonate hardness of around 2°KH and a conductivity of 150 µS/cm. Due to the low carbonate hardness, the small tanks contain limestone and crushed coral to buffer the water against pH collapse.

Max is a technology freak and takes a "belt and suspenders" approach. Two electrical pumps and three air-driven systems keep the water circulating; there is also an emergency power supply. The crystal-clear water, well-kept setup, and fishes in robust good health—fed mainly on live food that Max collects himself—add up to an excellent advertisement for the aquarium hobby.

Max tries to maintain his fishes in truly optimal conditions that are as close as possible to nature. His aquariums feature spacious bottom areas—in the large tanks approximately 75 to 150 gallons (284–568-L)—in order to house his South American geophagine cichlids and numerous mailed catfishes in really good condition. He keeps only a small number of fishes in

Satanoperca species, plus armored and mailed catfishes.

each aquarium, and every tank is decorated with a sand substrate, bogwood, and a number of aquatic plants. The high-tech equipment minimizes upkeep, and Max likes to spend his spare time observing his fishes. The secret of his success is simple: good water hygiene, good food, and plenty of room for the fishes.

Some like it warm

Max keeps his favorite fishes, the large cichlids of the genera *Satanoperca* and *Geophagus*, in very large aquariums. These fishes really do need a lot of space to feel at home and exhibit their full beauty. The equipment automatically maintains the water temperature at a rather high 80.5–84°F (27–29°C) and the pH is kept low, as some species, for example *Satanoperca daemon* (the Three-spot Eartheater), will spawn only at pH 5 or lower. Max has succeeded in breeding *Retroculus xinguensis* in his huge 8-foot (2.5 m) tank, a rare achievement of which he is justifiably proud.

A set of three large, linked tanks house *Gymnogeophagus* and catfishes from Uruguay. The system has a cooling unit, but is fed mainly from a large container outside so as to achieve a steady water temperature of less than 68°F (20°C). All the species in these aquariums spawn

High-tech equipment provides a constant supply of good quality water with the desired temperature and pH.

Large bottom area with sand, rocks, and wood. The cool temperature accommodates splendid fishes from subtropical South America.

regularly, and the *Gymnogeophagus* are constantly shepherding fry.

Future plans

Max Schwalm loves mailed catfish. He usually maintains his breeding groups separately in smaller species aquariums, where there are always a number of young. But I also saw various shrimp species and even platies in his tanks; he sells their young to help finance his hobby. He also has a new project in the works: a large outdoor setup that will hold 3,166 gallons (12,000 L)—not quite a lake, but a well-insulated aquarium that will be heated during the harsh Swiss winter so that he can continue to observe his fishes!

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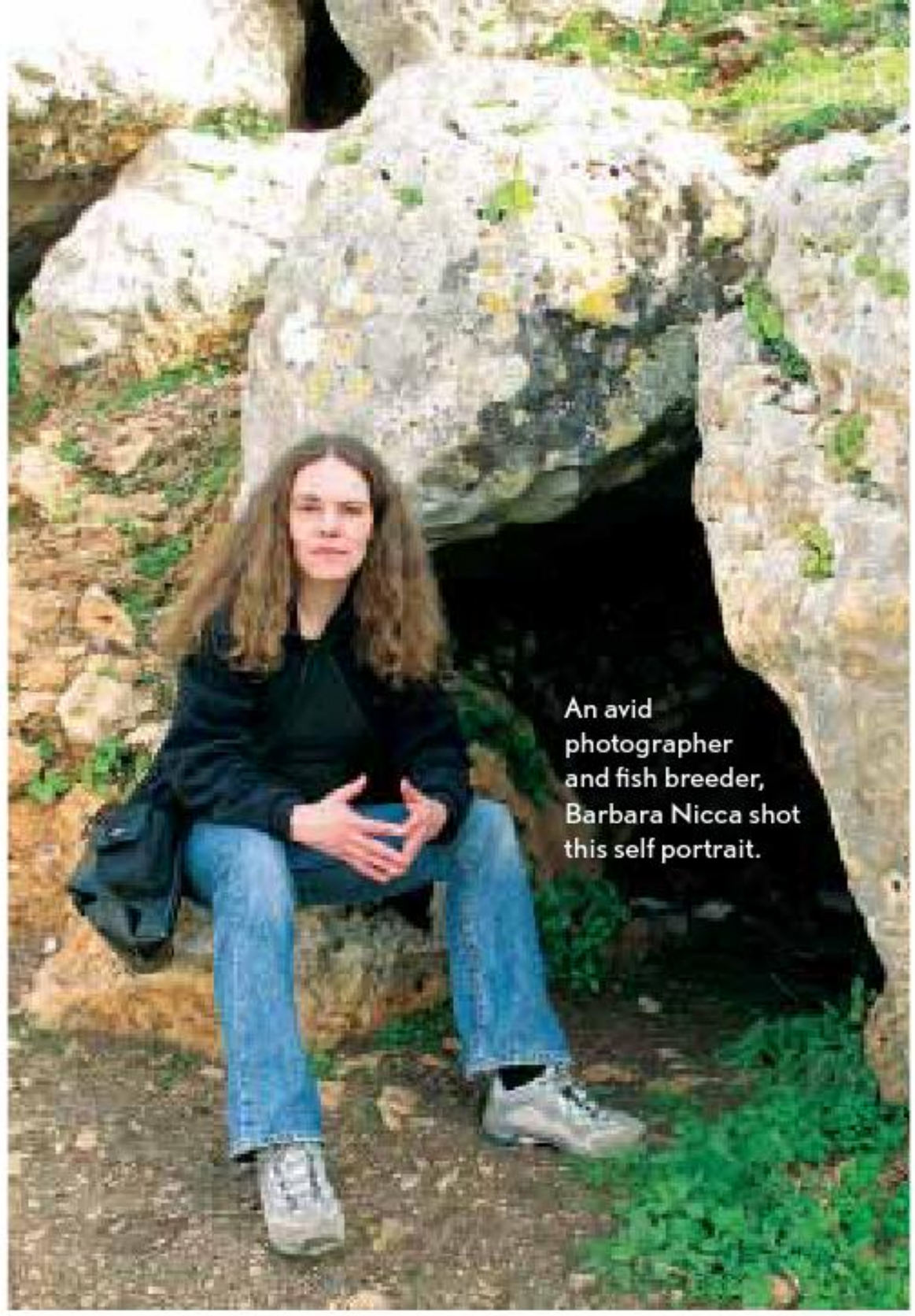
FISH ROOM TOUR

From rare killifishes to fancy guppies, Barbara Nicca fills her house with fishes.

Barbara Nicca lives in a small terraced house with her sons. Her aquarium hobby is evident throughout the house. On the ground floor it was the splendidly planted tanks, populated by fancy strains of guppies, that caught my eye. Barbara said that the guppies finance her hobby and confided that she really likes some of them, such as the wild form of Endler's Guppy (*Poecilia wingei*) from Campoma (Venezuela).

I also spotted a brackish aquarium containing large numbers of Blueback Blue-Eyes (*Pseudomugil cyanodorsalis*) swimming around among the algae. In the workroom there was a large aquarium housing a cichlid species I had never seen before: *Astatotilapia flaviijosephi* from Lake Gennesaret (better known as the Sea of Galilee) in Israel. There were even tanks in the bathroom; some of these contained spawning mops full of the eggs, and others the fry, of *Aphanius* species. I was beginning to realize that Barbara Nicca has a preference for unusual fishes from brackish water.



An avid photographer and fish breeder, Barbara Nicca shot this self portrait.

Below: All the freshwater aquariums in the Niccas' home are splendidly planted.

Getting started

Barbara lived in Israel for many years. She didn't get interested in the aquarium hobby until after her return to Switzerland, when one of her sons decided he wanted an aquarium. After the first years of "normal" fishkeeping she developed an interest in fish species from the Middle East, and during her regular visits to Israel she has also

Above: Part of the basement setup. Even the brackish aquariums, which have no tall aquatic plants, are appropriately decorated.

Below: The huge aquarium for the rare *Astatotilapia flaviijosephi* from Israel stands in the workroom. Even cichlid tanks can be attractively decorated!

The guest bathroom doubles as a fish room.

made the acquaintance of biologists and conservationists familiar with the native waters and their inhabitants.

Barbara now operates 40 aquariums (including a number of concrete vats set into the ground in her garden). Each species is kept and bred in a large group in a capacious aquarium decorated with rocks and algae. It is easy to photograph her fishes in these aquariums, and Barbara is a passionate and successful photographer who takes pictures whenever she has a minute to spare. Her tap water has a hardness of 14°dGH, and she adds salt from the Dead Sea or other sea salt to create water of suitable salinity for the species she keeps.

Project *Aphanius*

Within the German Killifish Community (known in Germany as the DKG) there is a small group of enthusiasts who focus on *Aphanius* and other brackish water species. Barbara's particular interest is the conservation breeding of killifishes of the genus *Aphanius*, especially those that originate from completely fresh water, as well as some that like salty or very salty conditions. She maintains, breeds, and photographs these fishes and has a special interest in those from Israel, which are all extremely difficult to obtain.

Barbara is already working with Vienna's Schönbrunn Zoo and would like to extend this collaboration to include other institutions.

I had a lot of fun reporting on these enthusiastic Swiss aquarists. I am grateful to my hosts, Max Schwalm and Nora Brede, to the aquarists I visited, and to everyone else who made this an unforgettable fishkeeping weekend.

Aphanius dispar "Abu Dhabi" is just one of the numerous brackish water killifishes that are almost unknown, but very attractive and interesting.

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Hans Metzler—the all-round breeder extraordinaire

Hans Metzler is an aquarist through and through. The aquarium hobby has been his great passion since 1958, one he indulges year-round and shares with his wife. Breeding his fishes is important to him, and during his long career as a fishkeeper he has bred them all: cichlids (Malawi, Tanganyika, South America), characins, barbs, labyrinthfishes, catfishes, and many more. The Metzlers used to supply pet shops and specialized fish auctions, until one day they decided to open their own store.

Hans is an offset printer by profession—even today he still puts his own books together and has them printed. The fish store, which the Metzlers ran as a sideline from 1976 to 2006 (at 70 they wanted to take things a bit easier), became a popular meeting place for numerous aquarists from St. Gallen and the surrounding area.

Water, water everywhere!

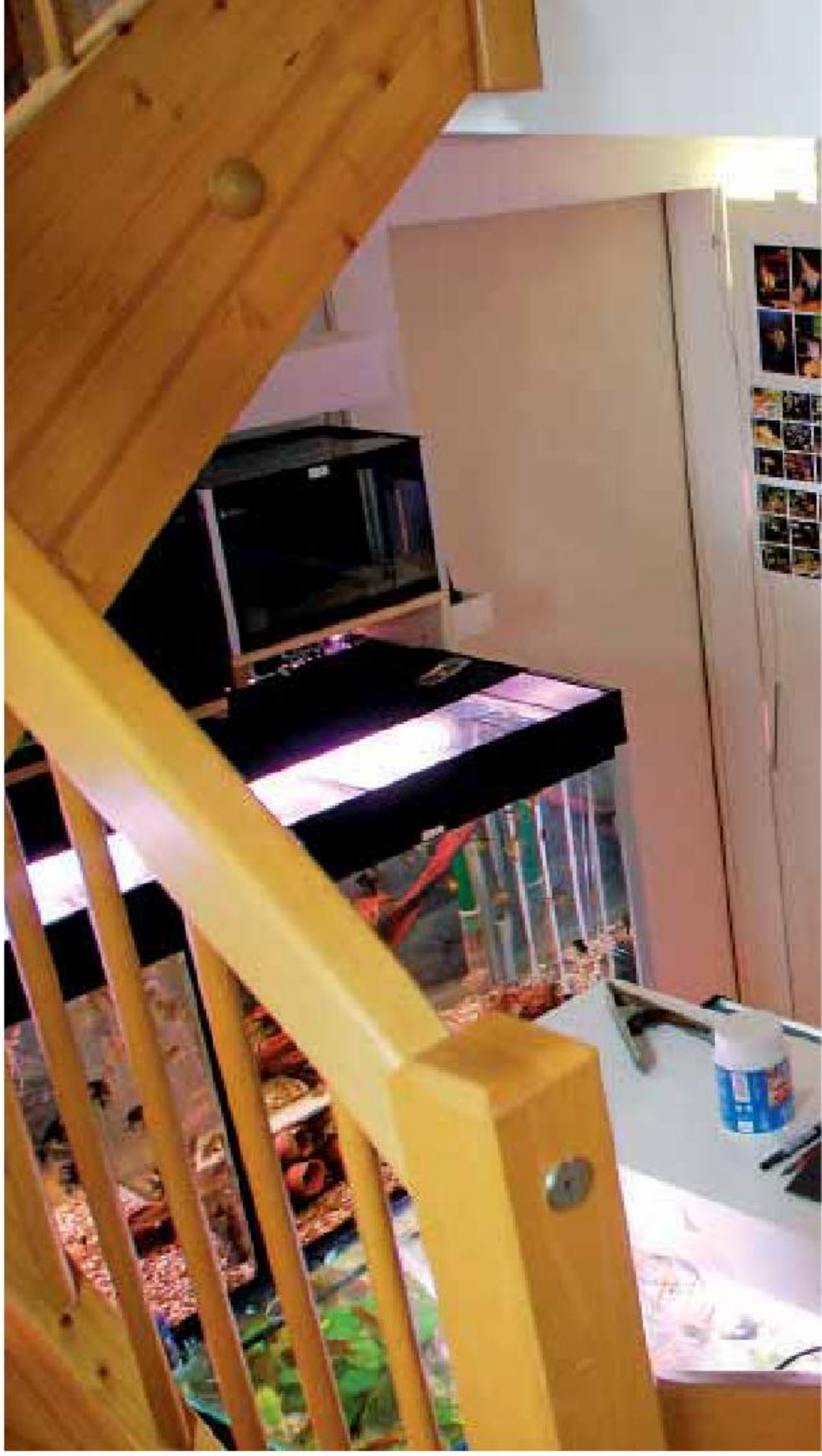
Since 2006 Hans has been breeding fish purely as a hobby—he can't bear to sit around doing nothing, so he still has innumerable aquariums filled mainly with dwarf cichlids and catfishes, but all sorts of other things as well. Hans has always liked diversity in his tanks.

A huge aquarium dominates the Metzlers' living room. It used to contain rays, but has recently been set up anew as an aquarium for Tanganyika cichlids, which are very popular among Swiss aquarists.

The view from the stairway to the cellar is enough to make any aquarist's heart skip a beat: row after row of attractively masked, spick-and-span tanks full to the brim with home-bred fishes. But keeping 62 tanks holding a total of 1,600 gallons (6,000 L) takes a lot of work.

In his loricariid catfish tanks Hans changes up to a third of the water twice a week, using tap water for one and 100-percent reverse-osmosis water for the other. These water changes ensure that *Hypancistrus* & Co. breed exceptionally well; he has bred all of them successfully except *Panaqolus* sp. L 204.

The rearing tanks for dwarf cichlids and angelfishes are packed full of youngsters, and Hans, whose reputation is excellent in the area, has no problem finding homes for them. This enables him to offset the high cost of electricity, water, and food.



Wonderland

Every square inch of the fairly small cellar room is put to use. I even crawled beneath the steps down to the cellar to admire his angelfishes. There are custom-made aquariums, some with angled sides, and every wall is covered with tanks or equipment. Hans Metzler's fish room is a real wonderland.

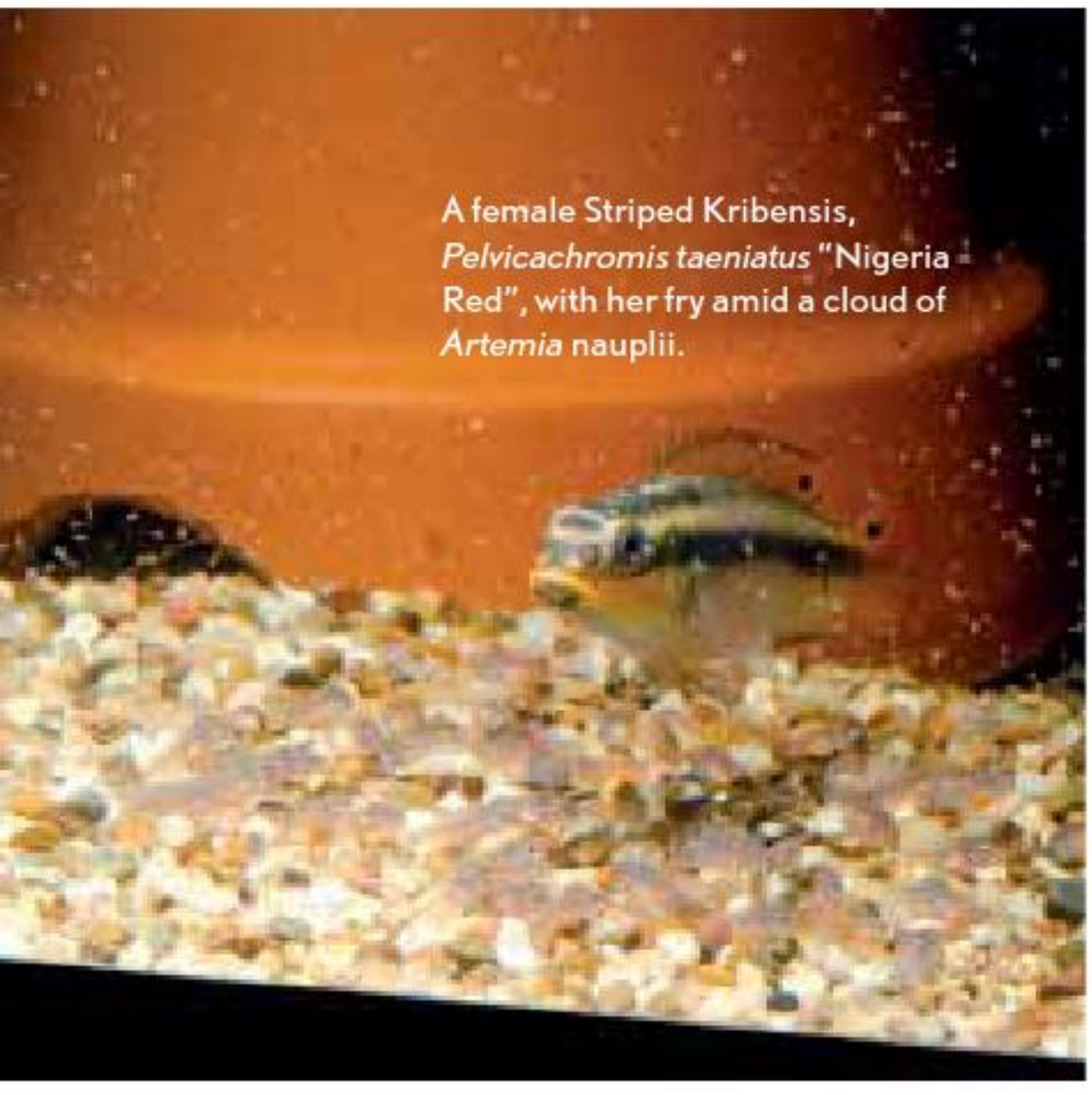
The filtration is via foam filters powered by a ring-main air system. The small tanks use practical Chinese foam mini-filters, and each of the larger aquariums has an Eheim external filter. In addition to a container for reverse-osmosis water, there are the inevitable *Artemia* hatcheries, and, of course, microworm cultures for feed-

Above: View of part of the set-up from the cellar stairs – a wonderland of a fish room. At right is Hans with some of his tanks.

The huge Tanganyika cichlid tank in the Metzler living room had just been set up.

ing the numerous fish fry. Hans uses quality flake food and granulate in addition to live and frozen foods.

At the end of our chat in the winter garden, where Hans and his wife enjoy their second-favorite hobby, orchids, he revealed yet another of his miracles to me. He swears by 10-percent Lugol's iodine solution (one drop per 2.5 gallons /10 L of water) for the disinfection of wounds on fishes, the artificial hatching of eggs, and even for characin breeding tanks. This prevents any wound from becoming infected and combats fungal attack—it's a real pharmaceutical miracle cure. And the best thing about it is that it's completely colorless—unlike my visit to Hans Metzler, which was a colorful journey through 50 years of passion for fishkeeping!



A female Striped Kribensis, *Pelvicachromis taeniatus* "Nigeria Red", with her fry amid a cloud of *Artemia* nauplii.

Hans Metzler breeds several angelfish color variants.

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Patrick Pellin —a cellar full of catfishes and much more

Patrick Pellin has been an aquarist since childhood, but the hobby really took over around 15 to 20 years ago when his increasing enthusiasm for loricariid catfishes outgrew the small number of aquariums in his apartment. So when I visited him, the two of us went down into the basement of the apartment building where the Pellin family lives on the ground floor. Into this basement space, Patrick has crammed 30 aquariums with a combined volume of around 1,320 gallons (5,000 L). The tanks, which sit on wooden stands, are clad in light-colored wood and use air-driven filtration. Water changes are performed manually using a bucket and muscle power—his way of exercising, Patrick told me with a smile. The new water is first put through a germ filter, as he regards water with a low bacteria count as a very important prerequisite for the successful breeding and rearing of L-number catfishes and other fishes. To rear species from extremely soft water, he also uses reverse-osmosis water.

Below left: View of part of Patrick's set-up. The tanks in the bottom rows contain catfishes from cooler, subtropical regions. Below, right: All packed into a very small area: UV-filter, reverse-osmosis, sink, and even the *Artemia* cultures.

Catfish breeder par excellence

Patrick Pellin keeps mainly armored and mailed catfishes. But in addition to the colorful L-number catfishes popular everywhere, he is particularly fond of the members of the subfamily Loricariinae and has already had considerable success with them. I saw several broods of *Pseudohemiodon cf. apithanos* youngsters, the relatively new form from the upper Rio Tigre, which exhibits areas of red-brown as well as black and white pigmentation.

Patrick's finest achievement to date, however, is the successful breeding of *Rineloricaria cf. latirostris*, a fish from the cool waters of the Rio de Janeiro area. As far as I know, this was a first. I've been trying to breed this fish myself for many years. Patrick keeps the species that originate from cool waters at low temperatures in the lower aquariums, and the tropical species are housed in the upper tanks—to save money, the room is heated rather than the tanks themselves.

But Patrick Pellin doesn't just keep and breed catfishes. I saw Daisy's Ricefish, *Oryzias woworae*, blue-eyes (family Pseudomugilidae), and even Endler's Guppies (*Poecilia wingei*).

Display aquarium or breeding tank?

Later, as we sat in Patrick's kitchen eating chocolate cake, he told me about an unusual chance breeding success with an undescribed *Hypostomus* species that his friend and fellow club member, Robert Guggenbühl, had brought back from Bolivia.

Patrick had intended to use the display tank in the living room for an attractive growth of plants, but since the first young of the *Hypostomus* species put in an appearance there, the tank has slowly become overgrown. It is, after all, very unusual for a *Hypostomus* species to breed in the aquarium at all, and therefore best not to risk disturbing them. When I looked into the large aquarium after a few food tablets had been dropped in as bait, I could indeed make out a large number of *Hypostomus*, large and small, behind the wall of Giant Vals (*Vallisneria gigantea*) growing along the front glass.

I could have carried on talking shop with Patrick for hours, as his taste in fishes is just the same as mine. But I had to leave—I had a date with yet another aquarist!

Top: *Pseudohemiodon cf. apithanos* is just one of the tricky species that Patrick Pellin has succeeded in breeding.

Middle: This *Loricaria* sp. from Colombia is constantly producing eggs and young.

Below: Juveniles in the show tank: *Hypostomus* sp.

CALENDAR

compiled by Mary E. Sweeney

MAY

18–20 **Convention**, Tropical Fish Club of Erie County, 25th Anniversary, Buffalo, NY
Tfcprez2@aol.com

25–27 **Convention**, American Killifish Association/Missouri Aquarium Society, St. Louis, MO
www.aka.org

17–20 **Interzoo 2012 International Trade Fair**
Nuremberg, Germany
www.interzoo.com/en

JUNE

1–3 **Lilyfest**, Genesee Valley Aquarium Society, Rochester, NY
www.gvpakc.org

22–24 **Show & Auction**, Niagara Frontier Koi & Pond Club, Tonawanda, NY
www.nfkpc.org

22–24 **Convention**, North American Discus Association, Atlanta Aquarium Association, Atlanta, GA
www.discusnada.org

23–24 **Show & Auction**, New England Fancy Guppy Association
Contact: etjane100@comcast.net

Contact: **mary.sweeney@reef2rainforest.com**

JULY

11-15 **Convention**, American Cichlid Association, hosted by Circle City Aquarium Club, Indianapolis, IN
www.cichlid.org

SEPTEMBER

15–16 **Convention**, Aquarium Club of Lancaster County, Lancaster, PA
www.aclcpa.org

29–30 **Convention**, 1st European Discus Championship, Dortmund, Germany
www.european-discus-championship.eu/

OCTOBER

18–21 **Convention**, All Catfish Convention, Potomac Valley Aquarium Society, Hyatt Dulles, Herndon, VA
www.catfishcon.com

NOVEMBER

1–4 **Convention**, Aquatic Gardener's Association hosted by Missouri Aquarium Society, St. Louis, MO
www.aquatic-gardeners.org

16–18 **Extravaganza!** Ohio Cichlid Association, Strongsville, OH
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❹ CHINESE FIREBELLY GOBY ❺ CORYDORAS FOWLERI "MILAGROS"
❻ TABAKI TILAPIA ❼ STRAWBERRY RASBORA


Puntius cf. tetrazona "Flower"

Flower Tiger Barb, *Puntius tetrazona*

1 | *Puntius tetrazona* (Zarske 2008), alias the "Flower" Sumatra or Tiger Barb, is a relatively new cultivated form from Asia. There is nothing fundamentally wrong with breeders fiddling with virtually domesticated species, as long as it doesn't cause the animals in question to suffer. However, in this case, as with many other cultivated forms of the Sumatra Barb, the question must be asked: is the modification actually an improvement? The flattering name "Flower" made me laugh. These colorful little fishes look as if they've finished flowering, don't you think? Aside from that, they behave just like the original Tiger Barb—quarreling, fin-nipping, and belly-ramming. They're typical healthy Sumatra Barbs, just slightly disfigured!

—Hans-Georg Evers

REFERENCES

Zarske, A. 2008. Zur Identität der Sumatra—oder Viergürtelbarbe. ***Aquaristik Fachmagazin*** **39 (6): 4–12.**

Fireback Snakehead

2 | The new snakehead pictured here is a member of the *Channa gachua* group and was recently imported by Aquarium Glaser in Germany under the name *Channa* sp. "Fireback". These fishes originate from northern Thailand near its border with Laos. The dorsal and caudal fins have a wide red margin, while the edge of the anal fin is broad and white.

It is amazing how many new forms are regularly being discovered in this genus, and the Fireback will certainly be a welcome newcomer for snakehead enthusiasts.

—Hans-Georg Evers

Cruzeiro Pleco, *Panaqolus* sp.

3 | Many aquarists are familiar with the Striped Sock Pleco, *Panaqolus* sp. L 204, from Peru's Río San Alejandro, and many have already kept these fishes. It is also well known that specimens of L 204 with aberrant patterning sometimes occur—for example, the lines on the body or the head might be incomplete.

On the other hand, there is a group of forms that are usually assigned to *Panaqolus albomaculatus*. It isn't important whether these are similar species or simply local variants of a single species, so we just call them *P. albomaculatus*. They are characterized by a dark background overlain with light dots that sometimes merge with one another. In practice, this variability of the two forms makes it difficult to classify borderline cases accurately. And to make matters even more complicated, German importer Oliver Frank recently imported a new *Panaqolus* that is being sold under the name *Panaqolus* sp. "Cruzeiro" and purportedly comes from the Rio Jurua in Brazil—a claim that seems doubtful, to say the least, as these catfishes exhibit all the characteristics of *Panaqolus* from the Ucayali basin in Peru.

The newly imported, half-grown specimens—there isn't just one—are almost reminiscent of a photo montage. The body exhibits the pattern of dots typical for *P. albomaculatus*, while the head and all the fins have the markings seen in L 204. The fact that the color of


Channa sp. "Fireback"

Cruzeiro Pleco, *Panaqolus* sp.

the lines on the fins is similar to that seen in L 425 doesn't make identification any easier.

I cannot even guess whether the new imports are an aberrantly patterned form of L 204, *P. albomaculatus*, an intermediate form between the two "species," or a new, related form. To determine that, it will be necessary to breed the fishes and see whether the color form breeds true.

It is clear that the unequivocal classification of wood-eaters from the *P. albomaculatus* assemblage hasn't just become easier. But regardless of the phylogenetic classification of these fishes, in all probability they are no different in their husbandry requirements, so anyone who has already successfully kept L 204 shouldn't have any problems with this form, either.

—Sandor Tüllmann

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Chinese Firebelly Goby, *Micropercops swinhonis*

4 | Members of the small family Odontobutidae (freshwater sleeper gobies) are rarely seen in the aquarium hobby. There are 21 species in 6 genera, and of these the Chinese Firebelly Goby, *Micropercops swinhonis* (Günther 1873), turns up in the trade now and then. The species is also known under its former name of *Hypseleotris swinhonis*, because until relatively recently the family was still regarded as part of the family Eleotridae (sleeper gobies).

Micropercops swinhonis is a subtropical species that occurs in China, Korea, and Japan, which means that these gobies should be kept at room temperature in the aquarium, without additional heating. The species is relatively easy to breed in the aquarium. Like most gobies, they spawn in a cave and the male guards the clutch.

My specimens grew to just 2 inches (5 cm) long and proved rather fussy about food. They happily took live food, but ate frozen food reluctantly and wouldn't touch dry food.

Males are splendidly colored, with a brilliant yellowish to orange belly, especially during courtship. Females don't exhibit these "signal colors" and are somewhat smaller. Firebelly Gobies are fairly peaceful fishes with a bottom-oriented, secretive way of life, but they are very worthwhile aquarium occupants.

—Michael Taxacher

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Armitage, D. 2000. Charme, Chaos und Charisma. China: Impressionen eines reisenden Aquarianers. *Das Aquarium* 370: 2–6.

Iwata, A., H. Sakai, K. Shibukawa, and S.-R. Jeon. 2001. Developmental Characteristics of a Freshwater Goby, *Micropercops swinhonis*, from Korea. *Zool Sci* 18: 91–7.

TOP LEFT: H.-G. EVERS; BOTTOM LEFT: F. STROZYK; TOP: S. TÜLLMANN; BOTTOM: M. TAXACHER

Male Chinese Firebelly Goby, *Micropercops swinhonis*

Corydoras fowleri "Milagros"

5 | In the summer of 2011, the German company Aqua-Global imported a suspected variant of *Corydoras fowleri* (Fowler's Cory) that had previously appeared on stock lists as "Milagros" from the vicinity of Pevas in Peru. This form is characterized by its particularly contrast-rich coloration. The shiny black wedge marking on the flank is particularly slender and the base color is a light beige.

It appears that there are variants of *Corydoras fowleri* in numerous clearwater river systems in central and northern Peru, where they inhabit the many small streams in the rainforest between the central Ucayali and the Río Ampiyacu. The species *Corydoras coriatae*, first described by Burgess (1997), also belongs to this assemblage, and I am now fairly sure that it, too, is just a variant of *Corydoras fowleri*. I have also discussed a form from the Brazilian-Peruvian border region (Evers 2010), thereby significantly increasing the known distribution region of the species.

Corydoras fowleri is a very unusual species: variable, difficult to keep, territorial, and a challenge to breed. To some of us, that's an inducement to keep it!

—Hans-Georg Evers

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Burgess, W.E. 1997. *Corydoras coriatae*, a new species of callichthyid catfish related to *Corydoras fowleri*. *Tropical Fish Hobbyist* 45 (8): 138–47.

Evers, H.-G. 2010. Kurz vorgestellt: *Corydoras fowleri*. *Amazonas* 32, 6 (6): 77.

Sabaki Tilapia, *Oreochromis spilurus spilurus*

6 | "A face that only a mother could love" might be the first thought that comes to mind on encountering this fish, but it isn't often that we get to see a fish smiling!

Oreochromis spilurus spilurus (Günther 1894), the Sabaki Tilapia, comes from coastal fresh waters in Kenya, where males attain a length of around 8 inches (20 cm). Females are somewhat smaller. These maternal mouthbrooders have all the attributes required to make them interesting to keep: they are content to eat the usual dry foods, breeding them holds no major secrets, and they can usually be kept with other African cichlids of similar character.

But every silver lining is surrounded by a cloud. Because all *Oreochromis* species were until recently assigned to the genus *Tilapia*, it is practically impossible even to give away the young. Still, they will always have a place in my tanks, at least.

—Norbert Knaak

Strawberry or Eyespot Rasbora, *Boraras naevus*

7 | At last the long-awaited description of this little jewel from Thailand has been published (Conway & Kottelat 2011), and the species has been given the scientific name *Boraras naevus*. I have known this fish as *Boraras* sp. "South", Roland Numrich of Mimbon Aquarium obtained the species under the name *Boraras* sp. "Pech Noi", and some aquarists know it as

Female *Corydoras fowleri* "Milagros"

Oreochromis spilurus spilurus, male

Boraras sp. "Micros" (naevus means spot).

Just a day after I caught large numbers of these fishes during a collecting day-trip, I opened my mailbox to find no fewer than three communications, each accompanied by the original description, from friends and aquarium-hobby colleagues who were aware of my passion for *Boraras* species. With the possible exception of *Boraras micros*, they are all gorgeous fishes with especially attractive shades of blue and red.

The red is particularly intense in *B. naevus*, and freshly caught fishes appear blood-red in the net; the pattern of spots is initially unnoticeable to the collector. Because of this, *B. naevus* is sometimes confused with small *Boraras maculatus*, but the two species clearly differ in various details. Kottelat divides *Boraras* into species with a spot pattern, namely *B. maculatus*, *B. micros*, and now *B. naevus*, and species with a longitudinal stripe pattern, such as *B. brigittae*, *B. urophthalmoides*, and *B. merah*.

The distribution of *Boraras naevus*, which is mainly in the flood plain of the Tapi River in southern Thailand, is well separated biogeographically from that of the related species *B. maculatus*, whose habitat begins around 124 miles (200 km) further south, near Hat Yai. Only *B. urophthalmoides* shares the distribution of *B. naevus*. Interestingly, the type material was collected in an area further to the north and not directly in contact with the Tapi River system. However, these systems were linked in the geological past.

Boraras species are ideal aquarium fishes, and *B. naevus* is no exception. Attractive coloration, lively behavior, and ease of breeding make *B. naevus* ideal for a small, nicely planted aquarium. One important point: these fishes like the water warm, with a temperature range of 75–82.5°F (24–28°C). I am a great fan of *Boraras* species in general, and *B. naevus* in particular.

—Jens Kühne

LEFT: H.-G. EVERS; TOP: N. KNAAK; BOTTOM RIGHT: J. KÜHNE

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Conway, K.W. and M. Kottelat. 2011. *Boraras naevus*, a new species of miniature and sexually dichromatic freshwater fish from peninsular Thailand (Ostariophysi: Cyprinidae). Zootaxa 3002: 45–51.

Strawberry or Eyespot Rasbora, *Boraras naevus*, male

Boraras naevus, female

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Niagara Frontier Koi & Pond Club
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www.NFKPC.org

Tropical Fish Club of Erie County
Hamburg
www.Tropical-Fish-Club-of-Erie-County.com

NORTH CAROLINA

North Carolina Aquarium Society
Raleigh
www.NCAquariums.com/society

Raleigh Aquarium Society, Raleigh
www.RaleighAquariumSociety.org

OHIO

American Cichlid Association, Hamilton
www.cichlid.org

Cleveland Aquarium Society, Cleveland
www.ClevelandAquariumSociety.org

Columbus Area Fish Enthusiasts
Plain City
www.ColumbusFishClub.org

Greater Akron Aquarium Society, Akron
www.GAAS-FISH.net

Great Lakes Cichlid Society, Euclid
www.GreatLakesCichlidSociety.net

Medina County Aquarium Society
Medina
www.geocities.com/MCASfish/index

Ohio Cichlid Association, Brunswick
www.OhioCichlid.com

Stark County Aqua Life Enthusiasts Society, Canton
www.ClubScales.com

Youngstown Area Tropical Fish Society
Youngstown
www.YATFS.com

OREGON

Greater Portland Aquarium Society
Clackamas
www.GPAS.org

PENNSYLVANIA

Aquarium Club of Lancaster County
Lancaster
www.ACLCPA.com

Bucks County Aquarium Society
Chalfont
www.BCASOnline.com

Greater Pittsburgh Aquarium Society
Pittsburgh
www.GPASI.org

TEXAS

Houston Aquarium Society, Houston
www.HoustonAquariumSociety.org

VERMONT

Tropical Fish Club of Burlington
Burlington
www.tfcb.org/

VIRGINIA

Potomac Valley Aquarium Society, Fairfax
www.PVAS.com

WASHINGTON

Greater Seattle Aquarium Society
Seattle
www.GSAS.org

Puget Sound Aquarium Society
Federal Way
www.thePSAS.org

WISCONSIN

Milwaukee Aquarium Society, Milwaukee
www.MilwaukeeAquariumSociety.com

INTERNATIONAL AQUARIUM SOCIETIES

AUSTRALIA

New South Wales Cichlid Society
Moorebank, NSW
www.NSWCS.org.au

Victorian Cichlid Society Inc.
Mitcham, VIC
home.vicnet.net.au/~cichlid

Queensland Cichlid Group Inc.
Clayfield, QLD
www.qcichlid.org

BELGIUM

Belgian Cichlid Association
www.cichlidae.be/

CANADA

Saskatoon Aquarium Society
Saskatoon, SK
www.SaskatoonAquarium.com

Montreal Aquarium Society, Montreal, QC
www.theMontrealAquariumSociety.com

Hamilton & District Aquarium Society
Hamilton, ON
www.HDAS.ca

Durham Region Aquarium Society
Oshawa, ON
www.DRAS.ca

Association Regionale des Aquariophiles de Quebec, Ste-Foy, QC
www.ARAQ.org

Aquarium Society of Winnipeg
Winnipeg, MB
www.ASW.ca

FINLAND

Finnish Cichlid Association, CIKLIDISTIT RY,
Vantaa, FI
www.aquahoito.info/cichlids/index.html

FRANCE

Association France Cichlid, Hoenheim, FR
www.FranceCichlid.com

GERMANY

Deutsche Cichliden-Gesellschaft
(German Cichlid Society)
Frankfurt am Main, DE
www.DCGonline.de

SINGAPORE

Discus Club Singapore
www.DiscusClubSG.com/

UNITED KINGDOM

Anabantoid Association of Great Britain
Doncaster, UK
www.AAGB.org

Bristol Aquarists' Society, Bristol, UK
www.bristol-aquarists.org.uk

The Federation of British Aquatic Societies, Sussex, UK
www.FBAS.co.uk

Greater Manchester Cichlid Society
www.nekrosoft.co.uk/GMCS

Middlesex & Surrey Border Section, British Koi Keepers Society
www.MSBsection.co.uk

The Calypso Fish and Aquaria Club
London, UK
www.calypso.org.uk

GET LISTED!

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www.kingfishservices.net

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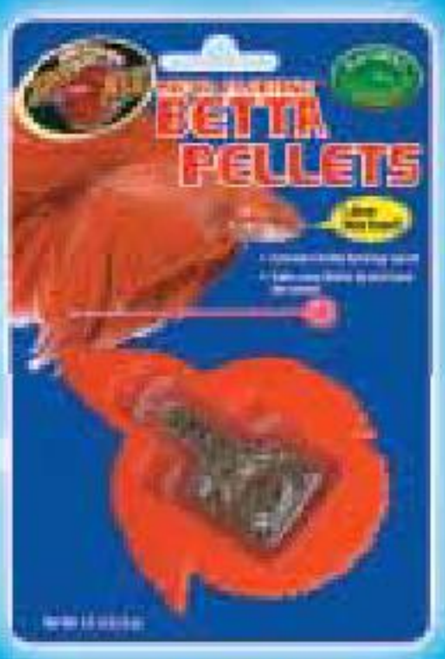

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