Introducing a Zonal Based Natural Filtration System for Reef Aquariums

by Steve Tyree

Quite a few natural based filtration systems have been devised by reef aquarists and scientists in the past twenty years. Some systems utilized algae to remove organic and inorganic pollutants from the reef aquarium; others utilized sediment beds. The natural filtration system that I have been researching and designing is drastically different from both of these types. No external algae are used. I believe that all the algae a functional reef requires are already growing in the reef, even if they are not apparent. They include micro-algae, turf algae, coralline algae, single-cell algae within photosynthetic corals, and cyanobacteria with photosynthetic capabilities.

Most of the systems that I have set up to research this concept have not included sediment beds. All organic matter and pollutants are recycled and processed within the system by macro-organisms. Sediment beds have not been utilized to process excess organic debris, but that does not prevent other aquarists from adding them. The main concept behind my system is the use of living sponges, sea squirts, and filter feeders for filtration. Sponges consume bacteria, dissolved and colloidal organic material, micro-plankton, and fine particulate matter. Sea squirts consume large bacteria, micro-plankton, and small particulate matter. Filter feeders consume larger particulate matter. When utilized with live rock and modern lighting, the aquarist has a complete filtration system.

To set up this new system, the aquarist must establish separate zones having distinctly different environmental parameters. Nutrient exchanges occur between the zones. Before discussing these zones, we should discuss some details of basic nutrient cycling.

There has been much discussion about how much food should be added to a reef tank of photosynthetic corals. In the 1990’s, quite a few advanced reef aquarists maintained heavily stocked small polyp stony (SPS) coral reefs. It was believed that adding large amounts of external food was detrimental to the reef. Many of these reefs received only the minor amounts of food added to supplement the diet of the herbivores.

Surprisingly, stony corals in some of these reefs grew at phenomenal rates similar to natural growth rates. The theory behind this is that the photosynthetic corals are not able to supply from their symbiotic algae all the nitrogen necessary for growth, although they do fulfill 100% of the daily respiration requirements. There is speculation that corals that were not fed and still showed strong growth were consuming floating organic matter. There is nitrogen necessary for growth, although they do fulfill their daily respiration requirements. There is speculation that corals that were not fed and still showed strong growth were consuming floating organic matter.

The Coral Hind, Lapu Lapu, or Miniata Grouper, Cephalopholis miniata

by Robert Fenner

Cebu Island is a large island in the Philippines. We recently spent some time there with Dennis Mok and Marty Beals, owners of Tideline in Los Angeles. We toured Lapu Lapu City and did some diving and photography on Bohol Island, south of Cebu. We spent one evening at a fresh seafood restaurant eating, among other delicacies, the Hind, a bass of the genus Cephalopholis, commonly known as the Miniata Grouper. This fish is also called the Lapu Lapu, as is the large town. This is the name of the local hero who dispatched Ferdinand Magellan in 1521 and who has given his name to various other things. The Miniata or Lapu Lapu is a beautiful fish of typically shy bass-like behavior. It is tolerant of wide variations in water conditions, accepts most foods, and is very resistant to disease.

Range and Description

This grouper is common to many parts of the tropical Indo-Pacific, from the Red Sea to Durban, South Africa, and on most islands in the west-central Pacific. It is not found in Hawaii or the Persian Gulf. It can reach about twenty inches in length in the wild, and about half that in captivity. It is undoubtedly the most prized member of the genus for the aquarium trade. It is beautiful, intelligent, and capable of gulping up small fish and motile invertebrates. This species generally tolerates shipping well, recovering at the retail shop well enough in a few days to go to the home aquarium. Any torn fins that result from shipping will heal quickly. This fish is reclusive in nature, and will also be shy in a shop or home aquarium.

Environment and Behavior

A bigger aquarium is always better when considering housing the true basses of the family Serranidae, which includes the genus Cephalopholis. Even a small specimen should be in at least a sixty gallon tank, or even larger to encourage outgoing behavior. An aquarium double this size is necessary for more than one of the same or similar species. This species is undemanding in regards to water chemistry, requiring normal tropical sea temperature (low seventies to mid-eighties), specific gravity, and composition. Enhanced circulation, aeration, and filtration are beneficial in an aquarium containing such voracious fish, as you can imagine.

As is typical of basses, this species does not like to share its space with other fish. Yawning behavior and side-to-side alignment with tankmates are signs of aggression that should not be ignored. Negative interactions can be diminished by providing ample tank space, and keeping the water chemistry as close to its natural conditions as possible.
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material. A new study of the coral *Pocillopora damicornis* on natural reefs supports this speculation. Briefly, the study found that this coral was able to acquire nitrogen by taking ammonium from sea water, enough to support 100% of the growth demands of the coral and its symbiotic algae, even at normal ocean concentrations. Corals were also found capable of supplying 11% of their nitrogen demands from dissolved free amino acids. This indicates that aquarists do not need to feed SPS corals to insure adequate nitrogen supplies.

A traditional reef aquarium contains live rock and sand illuminated by very bright lights. Photosynthetic corals did very well here, as did coraline algae. Inorganic nitrate-nitrogen levels were slightly elevated, but well within the recommended range. To my amazement, a large community of cryptic organisms was able to thrive in the dark area, including numerous species of sponges and even a couple of sea squirts. What was the food for these organisms? Because I used no sediment beds I was able to observe how much organic matter was created. The light side, termed the exposed zone, generated a large amount of particulate matter, primarily wastes from the herbivorous fish, snails, and hermit crabs. What produced by stony corals may also be a significant factor of this matter. In this zone there exists an excess amount of organic carbon compounds that are consumed by the cryptic organisms in the dark zone.

An aquarist must reevaluate the traditional reef aquarium when he sets up this new zonal based system. A traditional reef aquarium contains live rock and sand illuminated by very bright lights. Photosynthetic corals are placed on top of the live rocks and sand. Such a set up reproduces the upper region of a tropical reef that is exposed to light. It does not reproduce the complete tropical reef platform. Researchers have found that at least half the surfaces of a reef platform are not significantly exposed to light, but are cryptic in nature, and many surveys have found that these cryptic areas can support just as much life as the exposed areas. Aquarists should think of the typical exposed captive reef as only a part of the whole zoned reef platform.

Although some aquarists have established caves in their reefs, such zones are small in size, and need to be expanded in scope. The exposed or illuminated part of a reef should be about equal in size to the cryptic zone. This would help to achieve a balance between the exposed zone where excess carbon based organic compounds are generated, and the cryptic zone where they are consumed, in part by bacterial and protozoan life forms.

The exposed zone can be set up the same way current brightly lit reef tanks are set up now. The use of herbivores to control algal growth will result in the creation of particulate organic matter and dissolved nitrogen wastes. The cryptic zone should be separated from the exposed zone where the excess particulate matter is produced. Large particulate matter is best processed by organisms in zones between exposed and cryptic. I call these semi-exposed and semi-cryptic. These zones are populated by non-photosynthetic organisms that capture plankton and particulate matter, such as the feather duster worm, *Bispira viola*. Animals in the cryptic zone primarily consume dissolved organic material, protozoans, and fine particulate matter. What current zones here should be very slow. Cryptic sponges can become clogged if large particulate matter is transported to their surfaces by strong currents. There are, however, many species of sponge that thrive in more exposed zones and can be placed in the semi-cryptic and semi-exposed zones.

The Coral Hind, Lapu Lapu, or Miniata Grouper, *Cephalopholis miniata*

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space, plenty of caves and cover, and species with different markings.

Reproduction of this species has not been observed in captivity, although other species of *Cephalopholis* have been successfully reared as food fish. The Hind is a prodigious excavator, moving sand and large pieces of rubble in its mouth. Place rock and other heavy pieces of decor very carefully so they won’t topple if disturbed from tunnelling underneath.

**Nutrition and Disease Treatment**

In the wild this fish feeds principally on smaller fish and crustaceans. In captivity it will eat almost anything that will fit into its very large mouth. This includes any tankmates of appropriate size. It is best not to overfeed. Two or three meals a week should be sufficient. As with most basses, the Hind tolerates treatment for common diseases very well, including treatment by hyposalinity.

What more could an aquarist want in the way of a large specimen fish for the marine system? The Coral Hind, or Miniata Grouper, is strikingly beautiful, readily available, intelligent, hardy, and adaptable to captivity. It is an ideal addition to an aquarium that has larger-than-mouth-size tankmates. Please contact Aquarium Systems for a list of related references.

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**References**


Artificial Lighting in the Reef Aquarium

by Samuel H. Jones

All reef-building corals contain photosynthetic symbiotic dinoflagellates of the genus Symbiodinium. These unicellular algae, commonly referred to as zooxanthellae, play a critical role in calcification and contribute significantly to the overall energy budget of their coral hosts (Goreau and Goreau, 1959; Muscatine et al, 1984). Coral reefs are found in tropical latitudes where the intensity of light is high, and includes the ultraviolet UV-A (320-400nm) and UV-B (280-320nm) regions of the spectrum, as well as infrared (IR) radiation (>700nm). Light intensity is often measured in photon flux density, the number of incident photons per second per unit surface area.

In general, Symbiodinium require light of a particular spectral quality for net photosynthetic gain. Proper light enhances coral photosynthetic production, calcification rate, reproduction (Falkowski et al, 1990), and promotes skeletal growth. Too much light, especially in the harmful UV region of the spectrum, may increase coral mortality, inhibit skeletal growth, decrease carbon fixation, reduce photosynthetic irradiance (Coles and Jokiel, 1978), induce coral bleaching, and promote the growth of unwanted filamentous algae.

Because reef corals are so dependent on light for their continued survival and growth, anyone attempting to maintain corals in artificial environments must give serious consideration to lighting requirements. Two of the most important variables to be evaluated when choosing artificial lighting are spectral quality (wavelength, nm) and quantity (photon flux density per wavelength interval). Symbiodinium require light in the 400-700nm waveband, called photosynthetically active radiation or PAR. The ideal choice of lighting for coral culture would include PAR irradiance, with a broad photon flux density peak between 400nm and 550nm, and a narrower peak between 650nm and 700nm, the characteristic absorption spectrum for Symbiodinium (Falkowski et al, 1990).

As many coral culturists are aware, choosing the right lighting from the array of available products can be bewildering. Venture®, German®, Iwasaki®, Ushio®, Coralife®, Radium®, Osram®, Duratest®, and Hamilton® all offer bulbs designed for aquarium use, with varying wattages and color temperatures. Moreover, manufacturers publish very little accurate technical information about their bulbs.

The variability of natural light adds to the challenge of comparing natural and artificial light. It has long been recognized that the availability of light is a primary influence on the vertical distribution of corals of tropical reefs (Vaughn, 1916). Incident light at the surface of a colony is a function of the angle of the sun, the atmospheric attenuation of the light, and the attenuation of the light through the water column, a function of water clarity and depth (Kleypas et al, 1999). Artificial lighting is usually fixed in position, so only the other two variables need be considered when designing a coral system.

A recent unpublished study at the Wildlife Conservation Society’s New York Aquarium compared the spectral quality and quantity produced by several metal halide bulbs of various wattages and color temperatures. The aim of the study was to compare light from artificial sources to the natural solar irradiance experienced by corals in shallow reef environments. Attenuation of light through the atmosphere and the water column was taken into account by taking spectroradiometric scans for each bulb at various water depths and light heights. Results obtained from these scans, generated by a Li-Core underwater spectroradiometer (LI-1800UW) showed that the Iwasaki bulbs were among the few artificial lighting sources in the study that provided light that was close to natural sunlight. These bulbs are ideal for culturing reef-building corals because they produce little UV light, which is harmful to corals and other forms of life (Giese, 1964; Halldal and Taube, 1972). The light from the Iwasaki bulbs also includes a high percentage of PAR, and little IR, which can add to heat production.

Coral mariculturists recognize that, once an artificial lighting source is installed, it should be used correctly. First, it is recommended that metal halide bulbs be illuminated for at least 100 hours before they are installed near the coral system. It takes this long for the halide gases within the bulbs to stabilize and the intensity of the light to stop fluctuating. Also, the quality and quantity of artificial light degrades over time, so bulbs should be changed every six to nine months, assuming that the bulbs are run for half-day periods during this time. To acclimate corals to the more intense light from new bulbs, the light hood should be raised one to three feet when bulbs are changed, and lowered a few inches every other week. Most importantly, corals should be observed closely for changes that may be related to the lighting. Raising the light hood a few inches may reverse any bleaching noted around the time a new bulb is installed. The hood may be lowered a few inches if no bleaching is observed and the corals seem to be healthy.

It is important to match the current lighting conditions of each coral to the previous lighting environment experienced before introduction into your system. It may be possible to gather information about the quantity and quality of artificial light used if a coral has just come from some coral culture facility. However, this information may not be available if the coral came from a commercial operator. In any case, there are still a few ways to approximate the lighting required by any particular coral. Observation of coral morphology will give clues for this. Deep-water corals receive less light and less wave action, and often have delicate, branching, plate-like forms. Shallow-water
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New Successes in Angelfish Breeding
by Thomas Frakes

While attending the 2nd International Conference on Marine Ornamentals in November, 2001, I heard of advances in the breeding of dwarf angelfish. Frank Baensch of Reef Culture Technologies announced success in spawning and larval rearing of Fisher's angelfish (Centropyge fisheri). His work was in collaboration with Malia Chow of the Hawaii Institute of Marine Biology. Also, Dr. Charles Ladley and Dr. Robin Shields of the O ceanic Institute reported spawning and rearing of the flame angelfish (C. loriculus) entirely in captivity. They isolated plankton from the local waters for the first larval food.

On January 17, 2002, the W aikiki Aquarium announced the first successful spawning and rearing of the Hawaiian masked angelfish (Genicanthus personatus). This rare and highly sought after species has sold for as much as $5,000. A key to the breeding success was the discovery by Karen Brittain of a new, living food source.

Artificial Lighting in the Reef Aquarium

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corals receive plenty of light and rough currents, and usually have more solid, stunted, solidly constructed forms (Veron, 1993). Creating both lightly shaded and intense lighting regions in a single mariculture system will provide positions for a variety of coral species.

Choosing and utilizing appropriate artificial light is a hallmark of a successful reef aquarium. Take time to decide which artificial lighting sources to use, and gather as much information as possible about the native lighting environment of each coral in your collection. Create a variety of well-lit and shaded areas, and above all, observe your corals closely and respond immediately to even the slightest signs of light-induced stress.

References


The ABC's of Coral Bleaching
by Paul L. Sieswerda, The New York Aquarium

Dried coral pieces seen in curio shops are undeniably beautiful. Even though they are only the bleached white skeletons of the living animals, they possess intricate form and delicate structure. But it is the living corals that are truly stunning. Each coral polyp is brilliant with iridescent color. By the millions they build reefs of spectacular color and size. Living corals actively building reefs of multi-hued brilliance can be rivaled by only the most brilliant flower garden. In fact, early zoologists classified corals in the plant kingdom because of their similarity to flowers.

Corals are animals, but tiny algal cells also live in the coral polyps. Aquarists are no doubt familiar with these symbiotic algae, zooxanthellae. It is these algae that contribute to the beautiful and varied colors of living corals. When corals lose the zooxanthellae, they lose their color and are termed “bleached.” This is considered to be an injurious condition, often a precursor of death. It is generally believed that corals expel zooxanthellae because of stressful environmental conditions. Recently bleached corals cover wide areas of reefs around the world, and have become a concern for scientists and aquarists alike around the world. In a recent issue of Nature, Dr. Andrew Baker of The New York Aquarium presented findings that may give some insight on the troubling problem of coral bleaching.

Corals have been observed around the world after so-called “bleaching events.” While it is clear that some environmental change must be associated with such an occurrence, debate has raged over specific causes. Pollution is of course one suspect. Temperature increase from global warming, El Nino, and lethal irradiation from ultraviolet light have also been considered as direct or contributing causes of the widespread destruction. Curiously, destruction is neither uniform nor universal. Of two heads of the same species of coral, side by side, one may be bleached and the other not. If caused by a universal parameter such as increased temperature, why aren't all corals affected?

Dr. Baker's work gives some insight into this apparent incongruity and also shows how bleaching may be an adaptation that actually helps fish for its relatively poor sighted partner. Some crustacean experts have suggested that these shrimp actually see quite well, but their visual acuity is still not as good as the goby. As the shrimp keeps house or feeds just outside the burrow, the goby sits near the burrow's entrance and stands guard while it feeds or interacts with other gobies. The tidy little crustacean moves freely in and out of its refuge, but when it leaves the burrow it keeps in contact with the vigilant goby by placing one of its antennae on the fish. This antenna contact is the critical line of communication between the two animals.

When a predatory fish approaches, the goby will flick its tail rapidly, warning the shrimp of impending danger. If the goby flicks its tail once the shrimp may not respond, but it will quickly back into its burrow if the goby executes a series of flicks. If the predator comes within a critical distance, the goby will also dart headfirst into the burrow.

The marine aquarium opens an amazing world to amateur naturalists. Not only do aquarists have an opportunity to observe a wide array of interesting invertebrates and fish, they can also witness some of the relationships that occur between these animals on the coral reef. For example, we are all familiar with the association between sea anemones and anemonefish. Many marine aquarists were drawn into the aquarium hobby as a result of their fascination with this relationship. But there is another pairing of invertebrate and fish that I think is even more unusual than this. It involves several goby genera and certain snapping shrimps of the family Alpheidae.

The shrimp goby (genus Stonogobiops)
by Scott Michael

Highfin Shrimpgobies (genus Stonogobiops)
by Scott Michael

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The shrimp goby and snapping shrimp relationship is a mutualistic one where both members benefit. The primary benefit for the goby is the shrimp's burrow that provides sanctuary for an otherwise vulnerable fish. In exchange for refuge, the goby acts as a seeing-eye fish for its relatively poor sighted partner. Some crustacean experts have suggested that these shrimp actually see quite well, but their visual acuity is still not as good as the goby. As the shrimp keeps house or feeds just outside the burrow, the goby sits near the burrow's entrance and stands guard while it feeds or interacts with other gobies. The tidy little crustacean moves freely in and out of its refuge, but when it leaves the burrow it keeps in contact with the vigilant goby by placing one of its antennae on the fish. This antenna contact is the critical line of communication between the two animals.

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Genus Stonogobiops
The members of the genus Stonogobiops are some of the most attractive gobies available to marine aquarists. There are six species in the genus, one of which has yet to be formally
Stonogobiops species are usually found at moderate depths, 45 to 140 feet, on sloping, sandy bottoms at the base of fringing reefs. Unlike other gobies that spend most of their time resting on the substrate, these gobies scull in the water from one-half to fourteen inches over the burrow entrance. Most cases these fish associate with Randall’s shrimp (Alpheus randalli). However, in the Seychelles S. dracula also lives in association with a shrimp tentatively identified as A. djiboutensis, and in Japan S. xanthorhina will associate with A. bellulus. In an aquarium these fish will pair up with any of the commensal snapping shrimp.

These gobies are far from aggressive with tankmates, and are often dominated by other gobies, sand perches, dottybacks, hawkfish, blennies, and wrasses. Thus they are best kept with more docile species including placid Opistognathus jawfish, smaller Cirrhilabrus fairy wrasses, Parachellinus flasher wrasses, Macropharyngodon leopard wrasses, Gobiodon clown gobies, Amblygobius gobies, Nemateleotris fire gobies, Ptereleotris dart gobies, assessor fish, and dragonets.

Stonogobiops will occasionally threaten other fish at feeding time by charging them with open mouths, but it is just a bluff. They may not get enough to eat if they are kept with larger or more aggressive fish. A pair can share an aquarium, but it is highly likely that individuals of the same sex will fight, especially if in an aquarium smaller than 55 gallons. Fighting consists of mouth gaping displays, chasing, and biting. W hen biting, I have known individuals to hold on to even larger fish tenaciously, so long that I had to separate them. If startled, these gobies may bury under fine sand or leap out of an open tank.

Sexing is difficult with these species. S. xanthorhina males are reported to have higher dorsal fins than females. In all species, females have swollen abdomens during the reproductive period as a result of hydrated eggs. These gobies will accept finely chopped fresh sea food and small pieces of frozen and flake food. In the wild they feed exclusively on planktonic crustaceans, and are not very likely to take food off the substrate. Therefore it is best to place food in the outflow current of a pump so it moves through the water as it does in nature.

**Stonogobiops Species**

The black ray goby (S. nematodes) is the most commonly encountered shrimpgoby. It is easily identified by the elongate first dorsal spine, which is lacking in similarly colored members of the genus. This fish is found in Indonesia and the Philippines, usually on black sand flats and slopes adjacent to coastal reefs at depths from 16 to 130 feet, but most commonly below 65 feet. It is most often found in pairs, and rarely has been found paired with S. xanthorhina. The yellow snout goby (S. xanthorhina) differs from S. nematodes in that it has a triangular first dorsal fin rather than elongate. However, I have occasionally seen S. nematodes in the aquarium trade that could have been mistaken for S. xanthorhina. The long fin rays had been chewed off in a fight. S. xanthorhina is most similar to S. dracula, a species that is seldom seen in the aquarium trade. Coloration is slightly different, and S. dracula’s dorsal fin is rounded. The natural range of S. xanthorhina is from eastern Indonesia to the Solomon Islands, north to southern Japan and south to the northern Great Barrier Reef. Curiously, the average size in the cooler waters off Japan is about half an inch larger than elsewhere. Specimens are usually found on sand, or sand and rubble slopes at depths of 9 to 146 feet, most commonly in the tropics at more than 65 feet. In Japan it is common at depths of 10 to 33 feet. They are usually found in pairs, and normally form pairs even before sexual maturity. In the northern portions of its range it will retire to the burrow when ambient water temperature drops below 59 degrees F until the temperature rises. In Japan, egglaying occurs from late June to mid-August, and small juveniles appear on the substrate from late July to October. It has been suggested that males have a slightly higher dorsal fin than females.

The white ray goby (Stonogobiops sp.) is spectacular, with a long white first dorsal spine and orange longitudinal lines on the flanks that break into elongate spots on the head and opercula. Its natural range has not been defined, but it has been collected from southern Japan south to the Great Barrier Reef, and in Sri Lanka. Even though it has a wide range and is well known to ichthyologists, it has yet to be scientifically described and named. It inhabits sand and mixed sand and rubble slopes at depths of more than 98 feet.

This goby has been observed singly and in pairs, and, as with others of the genus, is usually found with Randall’s snapping shrimp (A. randalli). Fortunately for the aquarist, this goby is often available with its shrimp partner, which makes for a remarkable display in an aquarium. It is slow to acclimate to new surroundings, and will remain undercover if intimidated by aggressive tankmates. Keeping the aquarium in a low traffic area is advised.

This ends our examination of the fascinating genus Stonogobiops. I hope that those of you with a passive community tank will seek out these fish and their shrimp associates and give them a try. They make great pets. Happy fish watching!
Reef Tank Water Testing
by Mike Paletta

As a marine reef aquarist becomes more sophisticated in the hobby he also often becomes more technical. Many experienced aquarists rely on electronic monitors and computers, and on simple observation, for monitoring the health of a reef tank. Although careful observation of a reef is important, it cannot take the place of water testing to accurately judge the exact conditions existing in an aquarium. Water testing is not very popular. Testing water samples does not add to the beauty of a tank in the same way the addition of a new fish or coral specimen does. Also, some aquarists have the misconception that water testing is difficult and complicated. Fortunately, testing kits are now available that are easy to use and require little in terms of time and experience. Many kits also suggest recommended levels for the tested parameters, along with adjustment procedures.

The number of tests to be performed weekly is not overwhelming, and each test should take only ten to fifteen minutes per week. Regular weekly tests should include pH, salinity, alkalinity, calcium, phosphate, and nitrate. Water temperature and general tank appearance should also be noted. Testing should be done at approximately the same time of day each week to insure consistency. Some values, such as pH, vary throughout the day in a regular pattern. Results should be kept in a log book. Examining the log will show the trend of a gradual change, as well as highlight a sudden dramatic anomaly that may require retesting for verification. It is important to know about gradual increases or decreases, as corrective measures may be necessary. If the level of nitrate or phosphate is gradually increasing, it may be an indication that the protein skimmer needs cleaning or adjustment, that feeding should be reduced, or that larger or more frequent water exchanges should be made. Similarly, a falling level of calcium or alkalinity suggests the need for increasing the addition of supplements. The effect of such adjustments on an observed trend can readily be noticed in log book entries.

The test for salinity is the simplest to perform. Salinity is the measure of the amount of salt dissolved in a kilogram of sea water. The average salinity of natural sea water is 34.7 parts per thousand (ppt). Measuring salinity is somewhat difficult, so an indirect method indicates salinity by measuring the density of the water. The earliest device for home aquarists for measuring density was the sealed glass tube hydrometer with an elongated tip. This type of hydrometer usually requires a correction for current water temperature to determine standard density accurately. A glass hydrometer is very fragile, so the more durable plastic box type hydrometer has become more common. In this instrument, a plastic indicator swirls inside the water-filled box to show the density. The recommended range for density in an aquarium is between 1.022 and 1.026. The density of natural sea water varies in different locations. The Red Sea ranges from 1.027 to 1.028, and the Indo-Pacific ranges from 1.022 to 1.026. Low salinity may be indicated by blooms of blue-green algae or other slime algae, or by the sudden failure of corals. High salinity may be indicated by deflated coral polyps.

Testing for pH should also be performed regularly. The pH of a substance is the expression of the relation of acid to base in that substance. When they are present in equal proportions the solution is considered to be neutral and the pH is 7. When more base is present than acid the solution is alkaline. When more acid is present than base the solution is acidic. The recommended pH for a saltwater tank is between 8.0 and 8.4.

The pH of aquarium water will generally be lowest one hour before the lights come on, and highest one hour before the lights go off. This is a function of the respiration of the animals and plants and the resulting amount of carbon dioxide that is released into the water. The fluctuation should not be cause for concern unless it is more than 0.4 during the course of a day. A greater fluctuation may indicate the presence of too much algae or of insufficient water movement to dissipate carbon dioxide. Gradually declining pH over time is more serious. Low pH has been shown to reduce a coral’s ability to deposit calcium carbonate. It can also result in the freeing of bound organic phosphate that can encourage algae blooms. Declining pH usually indicates a build-up of acids. This can be alleviated by removing detritus and other decomposing material by means of water exchanges, more frequent changes of mechanical filtration media, and improving the efficiency of the protein skimmer.

Declining pH usually indicates declining alkalinity, as well. Testing for alkalinity, also known as buffer or carbonate hardness, should also be done on a regular basis. Alkalinity is, simply, the measure of saltwater’s ability to maintain a certain pH when a given amount of acid is introduced. In a marine system it gives an approximation of how many carbonate ions are present and is expressed in mEq/l or dKH. The value for natural sea water is 2.5 to 3.5 mEq/l (7 to 10 dKH), but it may be slightly higher in a closed system. Alkalinity will tend to decrease over time as corals utilize carbonate during calcification, or when carbonate interacts with organic acids during mineralization. It can be replenished through the addition of commercial alkalinity builders or buffers. They should be added slowly over several days to raise alkalinity when the level is unusually low, as the buffers can react with the calcium present in the tank and precipitate as insoluble calcium carbonate. Too rapid addition of buffer to low-alkalinity water can cause precipitation that looks like snow in the tank.

As with alkalinity, calcium levels should be regularly monitored. Usually if one is above normal the other will be low. The calcium level of natural sea water is between 380 and 480 mg/l. Aquarium water should be in this range or slightly higher. Calcium is necessary for soft and hard coral growth, is rapidly consumed, and thus must be replenished. Replenishment can be done in several ways, but even when done there is usually still a need for regular supplements. Over time, as corals grow, the amount of calcium consumed will increase. For this reason, regular testing is critical to maintain adequate levels of calcium.

The foregoing tests assess additions necessary for a reef aquarium. There are two additional tests to perform regularly that assess levels of compounds to be removed from a closed system. Nitrate is the end product of biological filtration and nitrification. When fish and corals eat and respire they produce waste that is converted by bacteria into nitrate. Fortunately, this is the least toxic form of nitrogen that can occur in a marine tank, but, unfortunately, it is still a very good fertilizer for algae. Corals live in areas where nitrate levels are less than 0.125 mg/l. While fish and corals have been successfully maintained in tanks with nitrate levels as high as 40 ppm, the optimal level is between 1 and 2 ppm. There are several ways to lower the level of nitrate. They include frequent water changes and removal of detritus, with strong protein skimming. There is some evidence that sand beds more than 4 inches deep may allow nitrate to be converted to nitrogen gas. External denitrators and separate refugia tanks containing Caulerpa algae have also been shown to be useful. Regardless of the method, the goal should be to keep the nitrate level low and to keep algae to a minimum. The other regular test that should be performed is for phosphate. On most natural reefs the phosphate level is under 0.02 mg/l. As with nitrate, phosphate is a fertilizer for algae and the level should be kept as low as possible. High levels have also been shown to inhibit growth in corals by reducing calcification. Phosphate is also an end product of respiration and metabolic processes, supplied in food for fish and corals, usually a secondary contributor, often being tap water. Most test kits measure only inorganic phosphate, although more complicated kits that
The ABC’s of Coral Bleaching

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corals survive environmental change. Recent work has shown that corals host a varied population of symbiotic algae that inhabit tissues in patterns that relate directly to depth of the coral in water. The zooxanthellae are grouped into four clades of the genus Symbiodinium called A, B, C, and D, and they populate the corals according to depth, and sometimes shading, of each coral head. The established population of a clade dominates, but may not exclude other clades. For example, clade A may be dominant, but some B’s may also be present. The relative stability of the reef environment ensures continual growth of the coral head and its clade, as long as conditions remain optimal for that particular combination.

To test his theory, Dr. Baker transplanted coral heads of the same species to different depths ranging in opposite directions from shallow water (2 to 4 meters) to deep water (20 to 23 meters). He did this with eight different species of corals. He then assessed their general condition after eight weeks, surveying the zooxanthellae population and coral mortality. He found that five of the eight species exhibited a strong pattern relating zooxanthellae population to light intensity. For example, clade A was abundant either as an initial or an increasing population in those heads brought up from deeper positions. Corals brought from deep water to shallow water experienced significant bleaching after the eight week observation period. Corals moved in the opposite direction did not show bleaching. Surprisingly, after twelve months, the unbleached corals had higher mortality. The bleached corals changed the zooxanthellae population significantly more than the unbleached corals. Dr. Baker infers from this that the acute stress of heightened irradiation in shallow water causing bleaching, as the move to deeper water did not elicit this response. He suspects that shading a population adapted for one condition maximizes opportunity for expansion of another population that is more adapted to the new condition. Hence, bleaching is not necessarily a bad thing.

This work holds promise for a better understanding of coral reef ecology and the potential impact of the global conditions that may accelerate change. It is also of interest to hobbyists who may find bleached corals in their tanks and who have no clear explanation for this. A change in condition from the collection site may have as much to do with this as conditions in a tank where other corals thrive. Bleaching may simply be nature’s way of clearing the field to allow change.

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Six inch Z. desjardini, in captivity

Breeding Lysmata rathbunae Shrimp; Metamorphosis in 19 Days
by Matthew L. Wittenrich

The marine ornamental industry has for long been accused of being responsible for habitat destruction and the degradation of wild populations of fish and other animals. There have been threats of collection moratoriums and bans, making it increasingly important to expand the range and availability of captive raised marine ornamentals.

Much of the technology for aquaculture of marine ornamental species is proprietary information, and this has impeded the growth of the industry. Such research and development takes place behind the closed doors of private corporations, and is extremely valuable to the corporations. The unfortunate result is that many hobbyists are left in the dark about new advances, and are unaware of most existing protocols for raising marine species.

As might be expected, culture research for marine ornamentals is geared toward reducing the time necessary for grow out to saleable size. The larval stage before metamorphosis is generally exceptionally delicate, and species with longer larval stages usually have higher mortality than other species. Fewer animals reaching metamorphosis makes commercial culture of the species economically unfeasible.

The peppermint shrimp Lysmata wurdemanni has been commercially raised by many companies, and rearing protocols for it and other related species, including L. debelius, are available (Crompton 1992, 1994, Riley 1994, Fletcher et al. 1995, Zhang 1997). Several months ago I began spawning and raising what I thought were peppermint shrimp. I had many established broodstock pairs that proved to be extremely prolific, and rearing the larvae seemed easy. Before long I had thousands of shrimp at various stages of development. When larvae began to settle from the water column at day 19 of my first trial runs, which is large for Zebrasomas. Both species have similar characteristics relative to food, disease susceptibility, etc., and they exhibit typical surgeonfish traits: rather aggressive temperament, generally hardy, beautiful, and interesting. Following are notes on their biology and captive care.

Selection of Specimens
Zebrasoma specimens should be evaluated carefully before purchase. I have found the following categories to be useful:

1. **Body Conformation**: Healthy specimens will have fresh color and a rounded body shape. The upper body above and behind the eyes should not be sunken. Occasionally collectors will snap the caudal peduncle spines of surgeonfish to prevent net fouling and damage to other surgeons during shipping. These will grow back. Do be careful when netting these fish. The best method is to use submerged double plastic bags, not nets.

## The Sailfin Tangs: Zebrasoma desjardinii and Zebrasoma veliferum

by Bob Fenner; e-mail BobFenner@WetWebMedia.com

As far back as 1973, Warren Burgess introduced the theory that the Indian Ocean or Red Sea sailfin tang, Zebrasoma desjardinii, was a different species from the Pacific sailfin tang, Z. veliferum. They are classified today as two separate species of the seven composing this genus, although some still believe they are only one. In the aquarium trade usually one or the other is available, depending on location. In the wild they can grow to as much as 16 inches long, which is large for Zebrasomas. Both species have gorgeous flowing fins, particularly in young specimens. The most obvious difference is the tail color. The tail of Z. desjardinii is dark with whitish yellow spots. The tail of Z. veliferum has bands of whitish yellow and gray. Because of the very small differences in appearance, some still consider Z. desjardinii to be a junior synonym of Z. veliferum.

**Breeding Lysmata rathbunae Shrimp; Metamorphosis in 19 Days**

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After digging through old and dusty books, and purchasing wild-collected batches of...
The Sailfin Tangs: Zebrasoma desjardinii and Zebrasoma veliferum

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2. **Size:** Fish should be between 2 and 5 inches, with 3 inches being ideal length.

3. **Color:** Color should be intense and uniform. Sailfin tangs have varying normal color patterns depending on stress, time of day, and aggression. Avoid purchasing specimens that are obviously stressed, or that have red, blotchy, or eroded markings.

4. **Behavior:** Sailfin tangs that have been handled properly are active and curious about their environment. Avoid individuals that hide, or that are solitary at the top or bottom of the aquarium. Ask to see the fish eat before purchasing it.

5. **Time in captivity:** Observe the fish for a week or two at the shop before purchasing it. Survival may indicate the fish is free of parasites, has acclimated to aquarium conditions, and has recovered from capture and transport trauma.

**Aggression**

Individual sailfin tangs can be very aggressive, but most are generally easygoing. They should be added to an aquarium when young, under 3 inches in length, and kept in uncrowded aquariums of at least 60 gallons, with plenty of live rock for foraging and hiding places. Other species of the genus have been known to damage large polyp stony corals, feather duster worms, and giant clams, but not these. The biggest problems with these fish in reef aquariums are their large food requirement and copious waste production.

**Reproduction**

Zebrasoma tangs are sexually dimorphic, and in these two species the male is larger than the female. In the wild they have been observed spawning in pairs and in schools. There have been attempts to spawn and rear various members of the Acanthurid family in captivity, but without success, mainly because of the long pelagic larval period and difficulties in providing proper food. Zebrasoma tangs are all wild caught.

**Nutrition**

Analysis of gut contents has revealed that in the wild, Z. veliferum consumes mostly microalgae and Z. desjardinii consumes mostly macroalgae. In captivity they will both eat almost all types of algae encountered, brown, red, green, blue-green Cyanobacteria, and even diatoms. They may consume Valonia and Bryopsis, but also desirable species such as Caulerpa. They should be given green leafy food daily. Additionally, these two species consume bits of hard sand to aid in grinding ingested food. Provide some in a small area even if you do not use it as a substrate. Also, extended exposure to copper compounds is not beneficial. Tangs have microbes in their guts that can suffer from such exposure.

**Disease**

Tangs have been appropriately labeled “ich magnets.” All are prone to marine white spot and velvet disease, and should be quarantined before introduction to a display tank. Striped Zebrasoma are less likely to develop these problems, but will certainly do so if the quality of the water or nutrition slides.

The purple tang, Z. xanthurum, is most noted for developing the environmental and nutritional disorder called head and lateral line erosion, or HLLE, but all Zebrasoma species are susceptible to some extent. This condition is easily prevented and often cured by careful attention to improving water quality and augmenting the diet. In the wild, Z. veliferum consumes mostly microalgae and Z. desjardinii consumes mostly macroalgae. In captivity they will both eat almost all types of algae encountered, brown, red, green, blue-green Cyanobacteria, and even diatoms. They may consume Valonia and Bryopsis, but also desirable species such as Caulerpa. They should be given green leafy food daily. Additionally, these two species consume bits of hard sand to aid in grinding ingested food. Provide some in a small area even if you do not use it as a substrate. Also, extended exposure to copper compounds is not beneficial. Tangs have microbes in their guts that can suffer from such exposure.

**Conclusion**

Both species of sailfin tangs are hardy aquarium specimens that will consume both micro- and macro-algae, but have a capacity to become very large in an aquarium. If the aquarium is small, a better choice would be smaller members of the Zebrasoma genus, or the bristlemouth tangs, genus Ctenochaetus.

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Angelfish Culture Update
by Frank Baensch; e-mail centropyge@hawaii.rr.com

Three research groups from Hawaii have succeeded in breeding marine angelfish in the last twelve months. In January 2002 Karen Brittain of the Waikiki Aquarium raised the masked angelfish, Genicanthus personatus, through metamorphosis. At the same time the Oceanic Institute announced the successful rearing of the flame angelfish, Centropyge loriculus. My first rearing success occurred in November 2001 with Fisher’s angelfish, Centropyge fisheri. Employing similar techniques, I have since raised two other Centropyge species, the lemonpeel angelfish, C. flavissimus, and the and the flame angelfish, C. loriculus. I am presently working on rearing a fourth species, the multicolor angelfish, C. multicolor. My research was done at my 700 square foot home-based facility, Reef Culture Technologies LLC. Following are some interesting observations on the larval development of these four Centropyge species.

The ontogeny of C. fisheri, C. flavissimus, C. loriculus, and C. multicolor is very similar. As with most pelagic spawners, the eggs are tiny and positively buoyant, containing a single oil globule. Size differs only slightly, from 0.7 mm for C. fisheri to 0.75 mm for C. flavissimus. Hatching occurs in 16 to 18 hours at a temperature between 27 and 28 degrees Celsius. At this time the larvae are about 2 mm long, and primitive, lacking eyes, mouth, digestive tract, and functional fins. The yolk sac is depleted as these develop. Larvae of C. flavissimus can start feeding after 3 days, but the others need 4 days. With the proper food and environment, all four species will undergo noticeable vascularization during the first 2 weeks of development, but only if the larvae are healthy and growing. Between days 15 and 25 the larval compress laterally, and then take on silver coloration and develop dorsal pigmentation. Centropyge larvae go through a period of extended metamorphosis that can last for several weeks. A darkening of the soft dorsal and anal fins marks the beginning of this transition. Larvae become more stationary and behave less erratically as the juvenile coloration gradually fills in. Then they can be transferred to the grow out tank.

The larvae of C. fisheri start metamorphosis near day 45, when about 10 mm long. They finish by day 60, having the characteristic brown color of an adult. C. flavissimus start to change at the same age, but are 20 mm long. They develop a black dot on the body center. A bright blue ring encircles this dot as they become yellow, and they fully resemble a juvenile by day 70. C. loriculus larvae also develop pigmentation on the soft dorsal and anal fins about day 45, but do not acquire juvenile form and behavior until day 80, when they are 15 mm long. As I write this, my C. multicolor larvae are 70 days old. Fin pigmentation began about 3 weeks ago, and I believe they will be ready for grow out in 7 to 10 days.

It has taken me many years to achieve success at rearing Centropyge. I plan to make my technique available to others once I have developed it more, and explored more fully its potential application to other difficult to rear pelagic spawners.

A ten day old flame angelfish larva, 3.3 mm in length

The seventy day old lemonpeel juvenile, 25 mm in length

A 102 day old flame angelfish juvenile, 20 mm in length

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Breeding Lysmata rathbunae Shrimp

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peppermint shrimp, it became apparent that my spawning shrimp were not L. wurdemanni, and that I wasn’t such a great culturist as to cut the larval stage in half. Although there are some obvious differences, Lysmata rathbunae looks enough like L. wurdemanni that they are collected and sold together under the name of peppermint shrimp. To my knowledge, there is only one other report of breeding L. rathbunae, but the information in it differs greatly from my observations.

System Design

Broodstock pairs were isolated in 2.5 gallon tanks that were fitted with standpipes and connected through a central filtration system. This minimizes exposure when broodstock are transferred to hatching and rearing tanks. Eight pairs were in individual tanks, each tank with a refuge area provided by ceramic tiles tilted against the standpipe. Reproduction for L. rathbunae is more predictable and reliable when pairs are isolated, in contrast with the groups recommended for L. wurdemanni. A mixed diet of fresh squid, shrimp, and commercially prepared flake food was offered several times a day. Water temperature in the system was maintained at 81 degrees F, specific gravity at 1.026, and pH at 8.2. Aeration was performed on a biweekly basis, allowing nitrate levels to reach 20 ppm. Ammonia and nitrite never reached measurable levels. Photoperiod was maintained on a 16 hour light cycle.

Breeding and Rearing

The gonads of these shrimp are visible through the carapace, so it is obvious when spawning has occurred, by the absence of ripe gonads and by the presence of eggs stuck to the pleopods. Newly laid eggs are tan in color, and number from 50 to over 700, depending on the size of the adults. As are most other known members of the genus Lysmata, L. rathbunae is a simultaneous hermaphrodite. Any two individuals are capable of producing a fertile clutch of eggs. Reproduction occurs year round on a 9 to 12 day cycle, corresponding to the molt cycle. Eggs mature in about 9 days, at which time they take on a characteristic silver sheen caused by the eyes of the developing larvae. Aults displaying eggs with mature characteristics are moved to a hatching container in the rearing vessel. A coarse plastic grid, used for needlework, is shaped into a cone. Larval shrimp pass through the grid, but not the broodstock shrimp. The eggs hatch about 2 hours after dark, after which the broodstock are returned to the breeding tanks. If not removed, the adult shrimp will eat the larvae.

The larvae are about 2.4 mm in length at hatching, and are poor swimmers. We raise them in black sided 20 gallon tubs with rounded corners. The first day after hatching we add a single air stone producing a slow stream of bubbles. By day 2 the larvae have pronounced eyestalks and benefit from an increase in air flow. Larvae will quickly settle to the bottom of shallow vessels if the air flow is restricted. The larvae undergo a series of molts and developmental stages similar to those of L. wurdemanni (Crompton 1992).

Rotifers at a density of 5 per ml are the first food offered. In the late afternoon we offer newly hatched Artemia at a density of 1 to 2 per ml. The Artemia cysts are decapsulated with household bleach and hatched in Plexiglas cones, and are enriched with HUFA. Rotifers are added only once, and newly hatched Artemia, less than 6 hours old, are used for the first 3 days. Enriched Artemia are the major part of the diet throughout the larval cycle, increasing in size as the larval increase. At day 6 we also add grated shrimp and squid to the diet 3 times a day by moving a block of frozen shrimp and squid around in the rearing vessel. Strong air flow keeps most of the food suspended in the water column. It is remarkable to observe a dozen tiny larval shrimp clustered around a single piece of food.

Any uneaten food will pollute the water very quickly and should be siphoned out soon after feeding. Water from the central system is dripped into the rearing tank slowly to prevent deterioration of water quality. We then feed the newly hatched second batch of Artemia, which are offered at a density of 1 to 2 per ml. By day 15 the larvae are almost 10 mm in length, and begin to spread out around the sides of the rearing tank, rather than clustering in the middle. By day 19 they begin to settle on the bottom and scavenge through detritus. Metamorphosed larvae become very active at night, and move rapidly through the water and at the surface, searching for food. This can be observed by means of a flashlight in a dark room. Each day a significant number of larvae settle to the bottom. In later trials, most larvae settled in 23 days, with some taking as long as 29 days.

The most common peppermint shrimp, L. wurdemanni, takes 40 to 65 days to reach metamorphosis, and fire shrimp take 75 to 158 days (Palmtag & Holt 2001). This is 2 to 3 times the duration necessary for L. rathbunae. Both species of peppermint shrimp prey on Aiptasia, and both are equally prolific, but L. rathbunae reaches saleable size in half the time. Choosing appropriate food for broodstock and larvae is essential for successful propagation, and may decrease the duration of the larval period.

Literature Cited


Pygmy Angelfishes in the Marine Aquarium

by Scott W. Michael

Angelfishes are considered by many to be the most beautiful fishes associated with coral reefs. But many of the members of this family, known scientifically as the Pomacanthidae, grow too large for small and medium-sized home aquaria. For example, most members of the genus Pomacanthus reach lengths in excess of 30 cm (12 in) and require plenty of swimming room if they are going to thrive in captivity. There are two genera comprised of smaller species that are better suited for smaller aquaria. These are the members of the genera Centropyge and Paracentropyge, which are known as the pygmy or dwarf angelfishes.

The genus Centropyge is the largest in the family Pomacanthidae. It is comprised of two subgenera and 30 described species. In contrast, the genus Paracentropyge is quite small with only three species. The largest of the Centropyge species attains a maximum length of 18 cm (7 in) with the average adult size for the genus falling around 10 cm (4 in).

Pygmy Angels in the Aquarium

Pygmy angelfishes will thrive in aquariums as small as 15 gallons but are best kept in larger tanks unless they are being housed on their own (more on this later). An aquarium that contains one or more of these fish should be replete with hiding places that can be created by loosely stacking artificial corals or live rock. It is also a good idea to place a layer of medium to large sized pieces of coral rubble on the bottom. Arrange the more sizable chunks to form holes and passageways that the fish can disappear into if threatened. For those species that are usually found in caves or overhangs create a microhabitat that mimics these geologic formations in the aquarium.

Pygmy angelfish usually do not have to be fed as frequently as other angelfishes because the algae and detritus present in the aquarium provides them with a natural food source. In fact, an occasional individual may never take introduced food but sustain itself solely on algae and detritus. Feeding fresh greens (e.g., steamed spinach, broccoli), dried seaweed (Nori), and flake or pelletized foods that contains Spirulina will ensure their nutritional needs are met, especially in a tank devoid of algae growth.
Aggression and Compatibility

When it comes to aggression and their compatibility with other fish, there is considerable interspecific variation in the genus Centropyge. Some species tend to be quite aggressive, while others are not. For example, all the members of the ‘Argi’ complex, which includes the cherubfish (C. argi), African flameback (C. acanthops), Caribbean flameback (C. aurantonota) and resplendent angelfish (C. resplendens), are usually very belligerent, not only to related species but to any fish and especially those introduced to the aquarium after them. Because the members of this group are diminutive in size they are often housed in small aquarium. This is the worst thing you could possibly do if you plan on keeping them with less pugnacious tankmates. ‘Argi’ complex angelfish are best kept in larger aquarium with lots of hiding places and should not be housed with passive fish (e.g., seahorses, pipefishes, batfishes, leopard wrasses, flasher wrasses, highfin shrimp gobies, fire gobies and dart gobies, to name a few). If you keep ‘Argi’ complex angelfish with less aggressive species, introduce ‘Argi’ angelfish after the other fish have been added and acclimated to the aquarium. Some other species that also have a propensity for aggression are the flame (C. loricula), lemonpeel (C. flavissima), halfblack (C. vroliki), Potter’s (C. potteri) and the multicolor angelfish (C. multicolor).

If you want to keep more than one pygmy angelfish in the same aquarium you will have greater success if your aquarium is larger (70 gallons or more) and is packed with hiding places. I will repeat that - PACKED with hiding places! When arranging the decor, a series of coral heads is better for dispersing individuals throughout the tank than a long contiguous reef. Add all the individuals you intend to keep together (of course, after they have been quarantined) or add the smallest individuals first, followed by the larger fish. Your goal is to have only one male per aquarium. In those species that display permanent sexual dichromatism this should not be difficult but in those species where the sexes are indistinguishable it can be a guessing game. One clue to an individual’s gender is its size. Males are usually larger than females, at least the females in its harem. Therefore, the greater the size discrepancy between two individuals the more likely you are in acquiring a male and one, or more, females. Also remember that in the absence of a male, females may change sex. Therefore, females held in retail, quarantine or display tanks too long before being exposed to a male may change sex (note – sex change in some species will not occur unless a conspecific is present). Although it was once thought that sex reversal was not possible, recent observations suggest that in some angelfishes a transforming female or male may be able to revert back to the feminine sex. However, a dominant male may kill a subordinate male or transforming female before they can complete this process.

Another way to possibly curb the aggressive tendencies of your pygmy angelfishes is to house them with larger fishes. They are less likely to engage in frequent bouts of aggression if potential predators are present. No, I would not recommend keeping them with fishes that could actually eat them! Instead include some fish tankmates that are three to five times larger than they are (large angels, some butterflyfishes, large wrasses, large anemonefishes, surgeonfishes) and your Centropype spp. will be less likely to attack similarly sized fishes with reckless abandon. Note that some of the more timid pygmy angelfishes may be deleteriously affected if intimidated by larger tankmates. They may refuse to feed and hide all the time. So be careful employing this aggression reducing strategy.

Selection and Health

As far as durability is concerned most pygmy angelfishes are great aquarium fishes. However, there are species that are more difficult to keep including Colin’s (C. coli), the golden (C. aurantia), Herald’s (C. heraldi), peppermint (P. boylei), multibarred (P. multifasciata) and the purplemask angelfish (P. venusta). The survival of some of these pygmy angelfishes in the aquarium may be mostly a function of how they were collected or the condition of the fish when it gets to your aquarium. For example, the golden angelfish, which is a cryptic, crevice-dweller may have been captured with cyanide. Colin’s angelfish occurs in deepwater and thus is more likely to suffer from decompression related maladies. One secret to keeping many of the more finicky pygmy angelfishes is to add them to a tank with lush filamentous algae growth. Many of these fish will readily browse on this material.

Before purchasing a pygmy angelfish examine the sides of the fish very carefully for raised scales or red areas. Some species, especially those taken from deeper water (e.g., Colin’s and the multicolor angelfish), may be injured when they are brought to the surface. This can lead to internal infections that cause the side of the fish to swell and then burst. This malady is often referred to as pygmy angelfish blond. Pygmy angelfishes may also suffer from parasitic infections like saltwater ich (Cryptocaryon irritans), anemonefish disease (Brooklynella hostilis) and coral fish disease (Ampharylum ocellatum). Some pygmy angelfish species (e.g., C. loricula, C. flavissima, C. multicolor, C. interrupta and C. joculator) are thought to be hypersensitive to copper-based medications. Therefore, it is best to administer an alternative treatment for these fish. Formalin is an effective treatment for some of the protozoan and dinoflagellate parasites. A freshwater dip can be an effective treatment for the eradication of Cryptocaryon.

Pygmy Angelfishes in a Reef Tank

Are pygmy angelfishes suitable for the reef aquarium? First of all, I should point out that a reef tank is a perfect environment for keeping more than one species of pygmy angelfish because this type of aquarium is usually replete with hiding places (a must when trying to house multiple Centropyge spp.). But these fishes can be a threat to sessile invertebrates.

If one examines the natural diets of the Centropyge spp. it would appear the threat to invertebrates would be minimal. But most of these angelfishes do feed on detritus and coral slime falls into this category. While pygmy angelfishes usually do not feed directly on coral polyps, they will graze on the slime they exude. The coral species that are often used as a feeding substrate are the larger-polyped hard corals like the elegance coral (Catalaphyllia jardinei), open brain (Trachyphyllia geofroyi), tooth corals (Lobophyllia spp.) and crator corals (Cynarina spp.), as well as zoanthids. The slime on tridacnid clam mantles is also a food source for pygmy angelfish. If you put one of these angels in an aquarium with corals or clams and the invertebrate is constantly closed-up there is a good chance that the angelfish is bothering it. Some pygmy angelfishes will also nip at the oral disc of anemones, feed on their feces, or even eat dying corals or anemones. Some angelfishes may also pester feather duster and Christmas tree worms by nipping at their feathery feeding appendages.

As far as their predilection to damage sessile invertebrates there seem to be trends within the various pygmy angelfish species but there is also a considerable degree of individual variation. For example, the cherubfish (C. argi) can often be kept with most stony and soft corals without inflicting damage. However, an occasional individual will begin picking at the tissue of elegance or open brain corals or the polyps of Xenia or Anthelia. On the other hand, although most lemonpeel angelfish are a real threat to corals and should not be placed in the reef aquarium, an occasional individual will not develop this bad habit. The
Treatment of Cryptocaryon irritans in Aquaria

by Dr. Harry W. Dickerson

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Cryptocaryon irritans (white spot disease) is a common ciliated protozoan parasite that can be inadvertently introduced into marine aquaria through infected fish or contaminated inorganic material. Most marine fish are susceptible to infection, visible as white spots on the skin, and will succumb to infection unless the parasites are aggressively treated.

Survival of the aquarium population requires the elimination of virtually all parasites, and treatments will not work unless carried through to completion. When treatments are applied with an understanding of the parasite's life cycle, the chances of success increase significantly.

**Life Cycle**

The life cycle of Cryptocaryon is relatively simple. Cryptocaryon is an obligate parasite, one that cannot survive without a period of growth on a fish. It spends five to seven days (at 24 to 27°C) feeding and growing in the skin and gills. The parasite at this stage is called a trophont, and ranges from 60 to 370 microns in size. When the parasite reaches maturity it leaves the fish and enters the water as a single large cell called a tomites. The parasite swims for 12 to 18 hours until it attaches to the fish and begins to secrete a cyst wall and emerge into the water. These free-swimming parasites are killed as they pass through the UV light until the entire population is eliminated. Success depends on using an adequate UV dosage and the correct water flow rate. Gratzek et al. (1983) reported success in treating Ichthyophthirius multifiliis (Ich) using a sterilizer rated at 91,900 micro-watts/second/centimeter2. The advantage of this method is that it effectively eliminates the establishment of future Cryptocaryon infections.

**Chemical Treatment**

Aqua can usually be freed of Cryptocaryon by using a combination of water changes and chemical treatment. Multiple application is the key to success. Formalin used at a concentration of 25 parts per million (ppm) every other day for two weeks with a complete water change on alternate days has been successful for us. To treat at this level, use 1 milliliter (mL) formalin in approximately 10 gallons of water. Formalin should be handled carefully. If the aquarium contains invertebrates that could be injured by treatment, the fish should be removed and treated in a conditioned hospital aquarium for the duration of the medication schedule.

Repeated water changes in the original infected aquarium will remove parasites that emerge from cysts. A study recently completed in my laboratory at the University of Georgia found that Cryptocaryon develops inside cysts at different rates, but theronts are always released in the morning, regardless of the day they appear. Assuming that morning release is a common phenomenon in all occurrences of Cryptocaryon, one should be able to exploit this for treatment by adding formalin to the water at the time infective parasites are released.

**Prevention**

The best way to eliminate problems with Cryptocaryon is to prevent its introduction into your aquarium in the first place. Steps to avoid outbreaks include buying fish from a reputable supplier; placing fish, coral, and any other live material that could act as a source of contamination into quarantine for two to three weeks before introduction into the aquarium; disinfecting inanimate material such as gravel or coral, or glass. They die to prevent the release of parasites into the aquarium.

**Water Changes**

Free-swimming parasites are eliminated from an aquarium each time the water is changed, but water changes alone are not completely effective because some parasites will attach to fish before they can be removed. Once parasites attach to a fish they penetrate the skin in five minutes. Cysts attached to sand, gravel, and other material will also remain in the aquarium. Complete water changes diligently repeated every day for three to four weeks can eliminate the parasite in bare aquariums. One could also move fish to clean aquaria every other day for three weeks. A simpler, although initially more expensive, alternative is to recirculate aquarium water through ultraviolet (UV) sterilizer. Free-swimming parasites are killed as they pass through the UV light until the entire population is eliminated. Success depends on using an adequate UV dosage and the correct water flow rate. Gratzek et al. (1983) reported success in treating Ichthyophthirius multifiliis (Ich) using a sterilizer rated at 91,900 micro-watts/second/centimeter2. The advantage of this method is that it effectively eliminates the establishment of future Cryptocaryon infections.

**Treatment**

The objective of treatment is to break the cycle of infection, and treatment must be started as soon as parasites are detected. Heavily infected fish will often die from severe gill damage despite treatment. Cryptocaryon is inaccessible inside the skin and gills, becoming vulnerable to treatment only after it leaves the fish. The parasite is difficult to treat because its rate of development is extremely variable, even in the same population. This means that when you treat the aquarium some parasites will inevitably remain on the fish and survive.

The key to success, then, is multiple treatments. In my opinion, this is the most important aspect of controlling Cryptocaryon, even more than the method used. Multiple treatments ensure that Cryptocaryon is killed or removed as it comes off the fish and before it gets a chance to re-infest. Heavily parasitized fish may not survive the stress of infection and treatment. They should be removed as soon as they die to prevent the release of parasites into the aquarium.

**Life Cycle of Cryptocaryon irritans**

[Diagram by Becci Velasquez]

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Cryptocaryon irritans in Aquaria

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sand before adding it to the aquarium; and disinfecting nets.

References available upon request

Editor’s Note: Low salinity is another approach to controlling Cryptocaryon. Colorni (1985, 1987) reported various methods for treating fish using hyposalinity. One approach was to lower salinity in fish aquariums to 10 parts per thousand (ppt), or a specific gravity of 1.007, for 3 hours every third day to kill tomonts in the aquarium before they could hatch. He also found that tomonts exposed to salinity of 20 to 25 ppt (specific gravity of 1.0145 to 1.018) produced tomonts, but their hatching was delayed up to 28 days. Thus reducing salinity to 23 ppt (specific gravity of 1.017) for 48 hours or more did not produce any live tomonts. Cysts kept at 15 ppt (specific gravity of 1.011) for 48 hours or more did not produce any live tomonts. We have used low salinity to treat fish with Cryptocaryon here in our lab. We remove half the water in the aquarium and replace it over a 1 hour period with dechlorinated fresh water. The resulting salinity (approximately 15 ppt or specific gravity of 1.011) is maintained for 7 to 10 days. This treatment should not be used for invertebrates or especially sensitive fish, but most marine fish will tolerate it well.

Pygmy Angelfishes in the Marine Aquarium

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species that are less likely to cause damage to your invertebrates include the members of the 'Argi' complex. Other species that are reported to be less dangerous to sessile invertebrates include Fisher’s (C. fisheri), the whitetailed (C. flavicauda) and the multibarred angelfish. The pygmy angelfishes that appear to pose the most risk to your corals include the bicolor (C. bicolor), Colini’s, lemonpeel and keyhole angelfish (C. bicen). The coral beauty (C. bispinosa), rusty (C. ferrugata), Herald’s, flame, halfblack, golden, multiclor and the purplemask angelfish fall somewhere in-between the two extremes when it comes to sessile invertebrate compatibility or incompatibility.

No matter what species you are thinking of adding remember: introducing any angelfish to your reef aquarium always entails some degree of risk. Therefore, if you are going to “blow a casket” if your corals get picked on, you better look for safer piscine alternatives. The corals that are least likely to be bothered by your pygmy angelfishes are those soft corals that are highly ichthyotoxic and distasteful. These species, which are avoided by generalized predators, include some, but not all, members of the following genera: Lepnalia, Sinularia, Sarcophyton, Cladiella, Paralemnalia and Eflittouaria.

Pygmy angelfishes are also less likely to cause problems if the tank is larger and they are fed more frequently. Another technique that can reduce “bad behavior” is to regularly introduce pieces of romaine lettuce or sheets of freeze dried algae to the aquarium. This gives the angels something to pick at other than the corals.

If provided with the right conditions pygmy angelfishes should live for years in the home aquarium. Longevity records of six years have been reported for Centropyge bicen in the wild, while the lemonpeel, keyhole and coral beauty pygmy angelfish have been kept in captivity for over 10 years. Happy fish-watching!