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Culture of coral reef fishes

by Suresh Job, Michael Arvedlund & Michael Marnane

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Over the past couple of years, a number of different coral reef fish species have been successfully spawned and reared at James Cook University, with relatively high rates of survival. A list of these species is shown in Table 1 (see next page). Some of the species listed have been spawned, but the larvae have not yet been reared.

Breeding set-up

The University's Research Aquarium Facility comprises two recirculating seawater systems. The main system has a holding tank of 150 000 litres (l) and a smaller system of 50 000 l. Together, these systems service a total of 40 satellite tanks of 1000 l and approximately 80 smaller tanks in covered areas, and five temperature controlled laboratories. High quality water is maintained using algal scrubbers, biological trickle filter towers, protein skimmers and high-pressure sand filters. A heater/chiller unit ensures that critical outside areas and the five laboratories receive temperature controlled water (26°C – 28°C), allowing the coral reef fish breeding programme to continue throughout most of the year.

In all the breeding tanks, good water movement is maintained using submersible pumps to ensure high levels of oxygenation. With the exception of the anemonefish (Family Pomacentridae) species, all the breeding fish are maintained outdoors with a 50 per cent shade cloth roof over them. Outdoors, the fish spawn consistently for about 10 months of the year. The anemonefish are maintained in pairs in indoor tanks and breed consistently throughout the year. The temperature in all the breeding tanks is maintained between 26°C and 28°C, with the exception of those containing *Premnas biaculeatus*, which is most successfully bred at a water temperature of 28°C – 30°C.

The most important considerations when trying to breed reef fishes are to provide an appropriate environment and to feed broodstock adequate levels of nutritious food. The tank sizes recommended in Table 2 (see page 45) are a rough guide to the sizes required for breeding. Breeding fish are territorial and extremely aggressive toward members of their own sex. The underlying rule is that group spawners require enough space so that smaller individuals can form territories of their own and avoid aggression from their tank mates. Pair spawners can usually be bred in much smaller tanks. As far as food goes, our preference is to mix high cholesterol foods such as shrimp (which apparently improves egg quality) with vitamin-enriched flake foods.

Table 1: Species reared at James Cook University

Species	Spawned	Reared
Damselfish		
Amphiprion melanopus (Red and black anemonefish)[a,b]	X	X
Amphiprion percula (Clown anemonefish)[a,b]	X	X
Premnas biaculeatus (Spinecheek anemonefish)[a,b]	X	X
Neopomacentrus bankieri (Chinese demoiselle)[a]	X	X
Pomacentrus amboinensis (Ambon damselfish)[a,c]	X	X
Pomacentrus coelestis (Neon damselfish)[a]	X	
Cardinalfish		
Cheilodipterus quinquilineatus (Five-lined cardinalfish)[a]	X	X
Apogon cyanosoma (Yellow-striped cardinalfish)[a]	X	X
Apogon compressus (Split-banded cardinalfish)[a]	X	X
Archamia fucuta (Narrow-lined cardinalfish)[a]	X	
Sphaeramia nematoptera (Pyjama cardinalfish)[a]	X	
Angelfish		
Centropyge bicolor (Bicolour angelfish)[a]	X	

Reared is defined as rearing the larvae to adulthood.
a: S. Job; b: M. Arvedlund; c: M. Marnane

Larval rearing

Larvae are reared in tanks as small as 70 l for some of the anemonefish, up to 150 l for some of the other species. The most commonly used and versatile tank sizes are 150 l glass aquaria and 100 l circular plastic tanks. The temperature in the rearing tanks is generally maintained between 28°C and 30°C. Water in the larval tanks is gently aerated during the day, and changed gradually each night from the main aquarium via a gentle flow-through which returns the water to the aquarium. A 'standpipe', constructed from 50 mm PVC pipe with numerous holes covered in very fine mesh, prevents the larvae from being siphoned out of the tank during water changes.

The most critical requirement for larval rearing tanks is to prevent 'head-butting syndrome'. This is the phenomenon in which the larvae will swim towards any light reflected off the sides or bottom of the tank and will continue to 'head-butt' the sides of the tank until they eventually die. This occurs in the early larval stages of many species of coral reef fish and, in the damselfishes, may continue until a few days before settlement. In order to reduce this behaviour, three measures are taken: First, the insides of the plastic tanks are painted with a food grade, black fibreglass resin or black epoxy paint. The outsides of glass tanks are painted black or completely covered with black plastic sheets. This reduces the reflection of light from the sides and base of the tank and prevents outside light from shining in. Second, dark tank covers, with the middle section cut out, are used to reduce light reflecting off the sides of the tanks. Third, all rearing is conducted using 'green-water' techniques, which essentially means that phytoplankton (*Nannochloropsis* sp.) is used to 'green-up' the tanks during the day until the bottom of the tank can no longer be seen. This generally stops headbutting syndrome and also improves the water quality since the algae also improve water quality. The green water also improves the quality of the food (rotifers and *Artemia*) and is reported to improve prey contrast and visibility. Several species of algae are available from commercial hatcheries and are easily cultured, given sufficient light and nutrient enrichment (most water soluble plant fertilisers will suffice).

Light intensity is another critical factor for larval rearing, not only during the day, but also at night.

The light intensity during the day has to be sufficient for the larvae to easily detect and capture food. We use between two and four fluorescent tubes (depending on the tank size) suspended well above the tank. The photoperiod used is 14 light : 10 dark. We suggest that a minimum 'daylight' duration would be about 10–12 h, especially for younger larvae.

Table 2: **Suggested breeding tank size**

Species	Breeding tank size
*Amphiprion melanopus**	70 l glass aquaria
*Amphiprion percula**	70 l glass aquaria
*Premnas biaculeatus**	70 l glass aquaria
Neopomoacentrus bankieri +	1000 l oval plastic tanks
*Pomacentrus amboinensis**	100 l circular tank, 350 l circular plastic tanks
Pomacentrus coelestis +	1000 l circular plastic tanks
Cheilodipterus quinquilineatus +	1000 l oval plastic tanks
Apogon cyanosoma +	1000 l plastic tanks, 350 l circular plastic tanks
Apogon compressus +	1000 l oval plastic tanks
Archamia fucata +	1000 l oval plastic tanks
*Centropyge bicolor** +	1000 l circular plastic tanks

* indicates breeding pairs, + indicates breeding groups

We also provide low intensity diffuse lighting during the night. This is especially important in the earlier stages as it helps to keep the larvae swimming towards the surface at night rather than sinking to the bottom. While overnight lighting is preferable with damselfishes and anemonefishes, it is essential for young cardinalfish larvae, which otherwise show high overnight mortality. A common, low intensity 'night light' of around 10 watts works well if suspended above and well away from the rearing tank.

Feeding

Most larval fish are driven by an instinctive need to feed and will do so if live prey of the right size are provided. We have achieved reasonably high survival in most species using a diet of rotifers (*Brachionus* sp.) for the first half of the larval period followed by newly-hatched *Artemia* nauplii when the larvae are large enough to take them.

Rotifer 'starter kits' are available from many commercial hatcheries and are easily cultured using either algae or brewers yeast. Several strains of rotifers of different sizes are available, and the larvae may require a smaller strain for the first few days before switching to a larger strain.

As an example, *P. amboinensis* larvae show better survival if fed with a small strain of rotifer for the first three days before being weaned onto a larger strain. These foods will suffice for most of the species listed above. However, species with very small larvae may require copepod nauplii for the first few days until they are large enough to be weaned onto rotifers.

Rotifers are fed to the fish larvae at densities of approximately 2–8 per ml, while *Artemia* nauplii are fed at densities of 1–2 per ml. Both rotifers and *Artemia* nauplii are rinsed thoroughly before adding them to the rearing tanks to remove any waste nutrients from the culture tanks. In the case of the larval anemonefish, rotifers are used as the first food for about 6 days for *Premnas biaculeatus* and for about 2–3 days for the *Amphiprion* spp. The larvae are then weaned onto newly hatched *Artemia* over a 2-day period. The damselfish larvae are fed rotifers for approximately 9–10 days before weaning them onto *Artemia* nauplii over 3–4 days. *Apogon cyanosoma* larvae have been relatively tricky to rear with high survival rates, and do better if wild-caught plankton are used for the earlier part of the larval period, followed by *Artemia* nauplii.

Water quality

Maintaining high water quality is possibly the most critical factor when rearing larval reef fish. Poor water-quality management results in extremely high mortality.

As the mortality is often very sudden (a whole batch of larvae can be lost in just one night due to poor water quality!), efforts must be taken to ensure consistently high water quality. This is especially true in situations such as ours, where relatively high numbers of larvae (about 500–1000) are reared in relatively small tanks (100 l and 150 l).

Three main steps should be taken to maintain high water quality. First, the addition of too much food can rapidly reduce the water quality (even when using live foods). Reef fish larvae can survive at relatively low food densities (although it does effect growth rates). Therefore, it is better to add too little food initially and have to top-up later in the day than to add too much initially. Secondly, a bacterial build-up on the sides and bottom of the tanks, present as a slimy layer, can also effect water quality by producing compounds which may be toxic to the larvae. The bottom of the tank should be cleaned regularly (daily if possible) and any dead larvae removed. Third, regular water changes must be carried out. An adequate rule of thumb seems to be a one-third water change every day. We use a very gentle flow-through of water overnight which results in about a 100 per cent water change.

Growout tanks

Post-settlement juveniles are reared in 350 l circular plastic tanks at high densities to reduce aggression. The use of UV sterilisers to reduce the incidence of disease is often useful, especially when juvenile fish densities are high. The juveniles are generally switched from *Artemia* nauplii to finely-chopped fish or shrimp within 1–2 weeks. Due to their relatively high growth rates, they need to be fed at least twice a day to satiation.

Survival rates

Using the rearing method described, we have generally achieved about 70 per cent survival for damselfish and up to 90 per cent survival for most species of cardinalfish and all species of anemonefish through to settlement. It is likely that these methods will prove to be effective for a wider range of species, with the possible exception of those with extremely small larvae.

Future directions

There is currently no regular commercial-scale breeding of any coral reef fish species in Australia for the aquarium trade. Conversations we've had with both marine aquarium fish collectors and retailers strongly suggest that the current demand for some species by the aquarium trade, is far greater than supply. Of the species successfully cultured at James Cook University this is probably most true of anemonefish as a group, and of *A. percula*, in particular. Considering that wild-caught anemonefish retail in aquarium shops at about A$ 30 a pair, and that captive-bred fish reach marketable size in approximately 3–6 months, the potential for the commercial breeding of these fishes seems obvious.

Another important consideration is that the commercial breeding of coral reef fish would reduce the need to exploit wild populations from coral reefs. It seems a shame that species still be collected from the Great Barrier Reef and other reefs in the Indo-Pacific. However, with the current trend towards greater protection of coral reefs worldwide, it appears likely that there will be greater restrictions on their exploitation in the near future, and more emphasis will be on the captive breeding of coral reef species.

Suggested further reading

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Further information

Further information can be obtained from the authors at:

Department of Marine Biology
James Cook University of North Queensland
Qld, 4811
Australia.

Phone +61 77 814200.
E-mail: Suresh.Job@jcu.edu.au
Michael.Arvedlund@jcu.edu.au
Michael.Marnane@jcu.edu.au