# Ocean Life
# Food & Medicine
# Expo 2004

## PROCEEDINGS

International Conference & Exposition on
Marine Living Resources of India
for Food and Medicine

27-29 February 2004,
Image Hall, MRC Nagar, Chennai, India.

### Organisers

Tamilnadu Veterinary and Animal Sciences University, Chennai

University of Madras, Chennai

Annamalai University, Chidambaram

Manonmaniam Sundaranar University, Tirunelveli

Aquaculture Foundation of India, Chennai

*Published by*

**Aquaculture Foundation of India**

4/40, Kapaleeswarar Nagar, Neelankarai, Chennai - 600 041.

**2005**

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4/40, Kapaleeswarar Nagar,
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Printed by :

Antony Enterprises
15, Hawker Jesson Lane,
Seven Wells, Chennai - 600 001.
Tel. : +91-44-55475307
H/P : 94441 85977

**2005**

# MARINE ORNAMENTAL FISH CULTURE STATUS, CONSTRAINTS AND POTENTIAL

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## ABSTRACT

Culture technologies on marine ornamentals available at present are mainly confined to anemone fishes, damsel fishes (Pomacentridae), gobies (Gobiidae), cardinal fish (Apogonidae), sea horses (Sygnathidae), angelfishes (Pomacanthidae) and dotty backs (Pseudochromidae). The major constraints that limit the expansion of marine ornamental fish aquaculture are (i) control of patterns of sex reversal, broodstock development and spawning, (ii) identification of appropriate live feed items and their mass culture for larval feeding, and (iii) suitable larval rearing systems with emphasis on water quality parameters. With the current status of technology available, costs of culture, limitations with first feeds and limited number of species, it is not possible for tank-reared fish to complete with wild caught ornamental fish. Hence more concerted, multidisciplinary research efforts which can lead to advancements in methods of controlling maturation, spawning and larval feeding are required to evolve cost-effective commercial level hatchery production technologies for different species. Due to the restrictions on collection of ornamental fishes from coral reef ecosystems, increasing demand from the ornamental fish trade can be met only by production of hatchery-reared fish in significant quantities. Hence the future of marine ornamental fish trade has to be directed towards tank reared fish, which is sustainable, ecofriendly and can generate new economic opportunities.

## INTRODUCTION

The expanding marine aquarium industry in recent years has been threatening the long term sustainability of marine ornamental fishes collected from the wild due to the indiscriminate exploitation in the coral reef areas by the use of explosives, electro fishing devices, chemical poisons or intoxicants. Even if ecofriendly collection methods, which do not destroy the reef environment, are employed for the capture of fishes, the increasing demand for marine tropical fish can lead to over-exploitation and consequent depletion of stocks. Hence, there is a compelling need to practice resource conservation through the development of culture technologies for marine ornamental fishes. Research and development in marine ornamental fish aquaculture is still in its infancy. Even though more than 800 species of fish and invertebrates are traded now, only about 25 species can be listed as commercially cultured. The marine ornamental fish trade is a global multi million-dollar industry worth an estimated US$ 200-330 million annually and operated throughout the tropics (Larkin and Degner, 2001). The aquarium industry in general is a low volume and very high value enterprise (Balboa, 2003). Between 1.5 to 2 million people world-wide keep marine aquaria with 600,000 households in the United States alone (Green, 2003). Ornamental marine species including fish, corals and other invertebrates are collected and transported mainly from Southeast Asia, but also increasingly from several island nations in the Indian and Pacific Oceans. The major destination markets are United States, the European Union and to a lesser extent, Japan.

Unlike freshwater ornamental fishes, where 90% of the fish species are currently farmed, the marine ornamental fishes are obtained from wild collections (Andrews, 1990). With almost all the tropical marine aquarium fish and invertebrates in trade are directly exploited from coral reefs, the long-term sustainability of the aquarium industry is a controversial aspect (Inskipp, 2003). The damaging techniques such as the use of sodium cyanide are non-selective methods used to capture fish and it adversely affects the health of the fish and also kills the non-target organisms (Erdmann *et al.,* 2000). The over-harvesting of the target organisms is another aspect of concern (Moore and Best, 2001). In addition, there are high levels of mortality associated with insensitive shipping and poor husbandry practices (Balboa, 2003; Oliver, 2003). But if managed properly, the aquarium industry could support long-term conservation and sustainable use of coral reefs. In addition, the development of mariculture technologies for the different species involved in the trade can reduce the pressure on the wild populations.

## CURRENT GLOBAL SCENARIO OF THE TRADE

Based on the Global Marine Aquarium Database (GMAD) the annual global trade is between 20 million and 24 million numbers for marine ornamental fish, 11-12 million numbers for corals and 9-10 million for other ornamental invertebrates. A total of 1471 species of fish are traded globally. Most of these species are associated with coral reefs although a relatively high number of species are associated with other habitats such as sea grass beds, mangroves and mud flats. According to the data provided by exporters, the Phillippines, Indonesia, the Solomon Islands, Sri Lanka, Australia, Fiji, the Maldives and Palau, together supplied more than 98% of the total number of fish exported. GMAD trade records from importers for the years 1997-2002 showed that the United States, the United Kingdom, the Netherlands, France and Germany were the most important countries of destination, comprising 99% of all imports of marine ornamental fish. Exporters data revealed Taiwan, Japan and Hong Kong to be important importing areas (Collette *et al.*, 2003).

Among the most commonly traded families of fish Pomacentridae dominate accounting for 43% of all fish traded. They are followed by species belonging to Pomacanthidae (8%), Acanthuridae (8%), Labridae (6%), Gobiidae (5%), Chaetodontidae (4%), Callionymidae (3%), Microdesmidae (2%), Serranidae (2%) and Blennidae (2%).

During 1997-2002, *Amphiprion ocellaris, Chromis viridis, Labroides dimidiatus, Chrysiptera cyanea, Paracanthus hepatus, Pseudanthias squamipinnis* are the most commonly imported species into the EU. Together the top ten species make up 37% of all fish imported into the EU between 1997 and 2002 Similarly, the top ten species including *Dascyllus aruanus, Chrysiptera cyanea, Dascyllus trimaculatus* and *Labroides dimidiatus* accounted for 39% of all the species exported to the US (Collette *et al.*, 2003).

## CONSERVATION ISSUES ASSOCIATED WITH WILD COLLECTION

Destructive collection practices, the introduction of alien species, overexploitation, the lack of scientific information on many species collected and threat of extinction of target species are the major problems of the marine ornamental fish trade. Destructive fishing techniques include the use of sodium cyanide and other chemicals to stun and catch fish. Eventhough cyanide only stuns the fishes; high post capture mortality is recorded. It may destroy the coral reef habitat by poisoning and killing non-target animals, including corals. During collection of coral pieces for the coral trade, many more colonies may be damaged or broken than are actually harvested. Corals are also broken for easy access to capture fish. This is more common with branching species in which small species such as *Dascyllus* and *Chromis* often refuge (Edwards and Shepherd, 1992). Collection of live rock has been considered as potentially destructive as it may lead to increased erosion and loss of important fisheries habitat.

Although no marine species collected for the aquarium trade have been driven to global extinction, studies carried out in Sri Lanka, Kenya, the Phillippines, Indonseia, Hawaii and Australia have reported localized depletion of a number of target aquarium species of fish like butterflyfish and angelfish due to heavy collection pressure (Collette *et al.*, 2003).

The effects of fishing are significantly different for species that are hermaphroditic compared with species that do not change sex. A fishery selectively removing larger animals first will mean that animals will have to start changing sex at smaller sizes, possibly reducing the fitness of individuals and thus making hermaphroditic stocks more vulnerable to over fishing.

Trade in ornamental marine fishes is characterised by extreme selective harvesting. For many species, juveniles are preferred by aquarium fish collectors due to their distinctive colouration and ease of maintenance. Consistent harvesting of juveniles may leave only limited number of young ones to reach adult size and replenish the adult stock.

Males of many coral reef fishes tend to be preferred due to their distinctive colouration. Selective harvesting for males of particular populations on a regular basis may lead to reproductive failure and ultimate population collapse due to heavily biased sex ratios in remaining population.

There are many factors that lead to post harvesting mortality, such as physical damage and use of chemicals during collection, poor handling practice and disease. Even when collected in an environmentally sound manner, aquarium organisms often suffer from poor handling and transport practices resulting in stress and poor health of fishes.

**Culture of marine ornamental fishes**

From the foregoing it is evident that the ultimate answer to a long-term sustainable trade of marine ornamental fishes can be achieved only through the development of culture technologies. At present almost all the marine ornamentals are wild caught and tank reared species contribute only 1-2 % of the trade. However, there is an increasing trend to reliable and commercially viable captive breeding techniques for the long-term sustenance of the trade.

The list of marine ornamental fishes reared in captivity today the world over contains more than 84 species. The major species bred for marine aquarium trade is given in Table1.

In India, till recently much attention was not focused on the culture of marine ornamental fishes. During the past few years the Central Marine Fisheries Research Institute has intensified its research on breeding, seed production and culture technologies for marine ornamental fishes

One of the milestones in this programme is the recent success in the hatchery production technology of clownfish (Gopakumar *et al.*, 2001; Ignatius, 2001; Madhu, 2002). Another significant achievement is in the seed production of sea horse. Experimental success was also obtained on the broodstock development and larval rearing of three species of damselfishes (Gopakumar *et al.*, 2002).

**Table 1. Main species bred for the marine aquarium trade**

| Commercially available | Production and marketing difficult |
|---|---|
| *Amblyeleotris randalli* | *Amphiprion bicinctus* |
| *Amblygobius phalaena* | *A.chrysopterus* |
| *A.rainfordi* | *Gobiosoma xanthipora* |
| *Amphiprion akallopisos* | **Subject of research** |
| *A.akindynos* | *Abudefduf abdominalis* |
| *A.allardi* | *Anisotremus virginicus* |
| *A.biaculeatus* | *Apogon spp.* |
| *A.clarkii* | *Bodianus rufus* |
| *A.ephippium* | *Calloplesiops altivelis* |
| *A.frenatus* | *Centropyge potteri* |
| *A.melanopus* | *Chaetodon lunula* |
| *A.ocellaris* | *C.miliaris* |
| *A.percula* | *Chromis cyanea* |
| *A.sebae* | *Chrysiptera parasema* |
| *A.perideraion* | *Dascyllus albisella* |
| *A.polymnus* | *Dascyllus aruanus* |
| *A.rubrocinctus* | *Diodon spp.* |
| *A.sandaracinos* | *Equetus acuminatus* |
| *Cypho purpurascens* | *E.lanceolatus* |
| *Dascyllus trimaculatus* | *E.punctatus* |
| *Doryrhamphus excisus* | *Forcipiger flavissimus* |
| *Elacatinus puncticulatus* | *Gramma loreto* |
| *Gobiodon citrinus* | *Hippocampus erectus* |
| *Gobiodon okinawae* | *Hypoplectrus unicolor* |
| *Gobiosoma evelynae* | *Hypsypops rubicundus* |
| *G.louisae* | *Microspathodon chrysurus* |
| *Gobiosoma multifasciatum* | *Opisthognathus aurifrons* |
| *G.oceanops* | *Pomacanthus arcuatus* |
| *G.randalli* | *Pomacanthus paru* |
| *Lythrypnus dalli* | *Synchiropus splendidus* |
| *Hippocampus barbouri* | *Zebrasoma flavescens* |
| *Pseudochromis aldabraensis* | *Pomacentrus pavo* |
| *P.dutoiti* | *Chrysiptera unimaculata* |
| *P.flavivertex* | *Pomacentrus caeruleus* |
| *P.fridmani* | *Neopomacentrus cyanomos* |
| *P.sankeyi* | *N.nemurus* |
| *P.splendens* | |
| *P.steeni* | |
| *Pterapogon kauderni* | |

**Culture of clownfishes**

Clown fishes are among the easy to breed category and the technologies of clownfish hatchery production has been standardized (Hoff,1996). There are 27 known clownfish species. Clownfishes are distributed throughout the Indo-West pacific region. The major species of clownfishes are given in Table 2. Anemone fish as their name defines, live in a mutualistic relationship with anemones. In nature, selection of preferred anemones is species specific. Primary benefits to clownfish from anemone association are protection of the pair, their nests and a portion of their progeny from predation. The fish achieves protection from stinging of anemones by means of the development of a special external mucus layer. Clownfish appear to be monogamous, pairing for life. There is also a possibility that some species may be polygamous.

**Table 2. Major species of clownfishes**

| Species | Common Name |
|---|---|
| *Amphiprion alkallopisos* | Skunk clownfish |
| *A.alkindynos* | Barrier reef anemonefish |
| *A.allardi* | Two bar anemonefish |
| *A.perideraion* | Pink anemonefish |
| *A.melanopus* | Fire clownfish |
| *A.bicinctus* | Two band anemonefish |
| *A.ocellaris* | Clown anemonefish |
| *A.polymnus* | Saddleback clownfish |
| *A.clarkii* | Yellowtail clownfish |
| *A.ephippium* | Saddle anemonefish |
| *A.chagoensis* | Chagos anemonefish |
| *A.chrysogaster* | Mauritian anemonefish |
| *A.chrysopterus* | Orange anemonefish |
| *A.frenatus* | Tomato clownfish |
| *A.nigripes* | Maldive anemonefish |
| *A.percula* | Orange clownfish |
| *A.rubrocinctus* | Red anemonefish |
| *A.sebae* | Sebae anemonefish |
| *A.tricinctus* | Maroon clownfish |
| *A.omanensis* | Oman anemonefish |
| *A.sandaracinos* | Yellow clownfish |

Sexually matured adult clownfish are usually 9-18 months old. While selecting possible pairs or purchasing fish for pairing, it is best to buy sub-adults. Sub-adults do not form immediate pairs or fully display adult colouration, but they will quickly adjust and mature in good environmental conditions. Eventhough they are younger than adult pairs, they will only take about 3-6 months for initial spawning. A distinct advantage when pairing clownfish is their ability to change sex. The best and easiest approach in pairing clownfish is purchasing 3 or 4 fish of equal size, 2.5 to

5cm in total length. Put all the fish in one established aquarium with no other fish. Since sex reversal is prevalent in clownfish, they simply decide which will become the male and which will become the female. Eventually, two fish will tend to stay together, chase others from specific areas, and attempt to destroy others. Sometimes a pair will accept and allow a few smaller individuals to remain in a reserve situation. Utilization of reserve fish is an unique adaptation in clownfish. When the female of a pair dies, the original male will become female and one of the reserve fishes will become the new male. Within a pair, the female is usually the first to die. Colouration can be used for sexing many species of clownfish. *A. polymnus* females have bright yellow coloured face, where as most males have a dull brownish coloured face. *A. melanopus* females have a dull whitish red face, while the males have bright reddish face and fins. *A. ephippium* females have an overall dull red body colour and whitish red faces, while the males have bright red bodies and faces. *A. akallopisos* females are usually a bright yellow orange than the males. *A. perideraion* males have a narrow orange trim on the edge of the soft dorsal and upper and lower margin of the caudal fin. Colour differences are found only on sexually matured adults.

Size can be another criterion determining males and females of many species of clownfish. In general females are largest individuals. Eventhough the tropics have a 12 : 12 light and night period, a 14 : 10 light / dark period is ideal for clownfish spawning. Lights should not be located directly on top of the tanks but should be elevated 12 inch or more above the tank. The salinity of around 28ppt is better while conditioning the fish. Lower salinity basically helps to reduce osmotic stress and may reduce disease problems associated with parasites that demand higher salinities to survive. It also allows a large variance in salinity due to evaporation of tank water in the hatchery. A nitrate level of 20-30ppm, nitrite and ammonia level of less than 0.1ppm, pH around 8-8.3 are ideal in conditioning tanks. Normally the clownfish utilize the live anemone as their protective habitat and the hard surface beneath the anemone as their spawning substrate. For best results, the pair should be kept in individual tanks with opaque sides.

Suitable diet for the brood stock is the key to successful spawning. Eggs contain considerable lipids, which are high, and long lasting energy resources needed for the protracted development of the embryos within the eggs. These deposits are reserves to be incorporated within the eggs and provide energy to the female during her fasting period. Hence suitable diets and enough food must be fed to the broodstock fish. If brood stockfish are not properly fed, the results are directly reflected in the number of eggs layed, fertilization rate, hatch rate and the quality of hatched larvae. Poor quality eggs develop slowly, hatch late and often result in significant early larval mortalities. Conditioning food should be administered routinely to the brood stock clownfish three times a day - early in the morning, noon and around 5 o'clock.

Use of *Artemia* for conditioning and spawning should only be supplemental and not a steady diet. Live food imparts certain attributes not found in non-living diets. Live foods are excellent carriers of nutritionally specific fats, oils and amino acids if they are programmed prior to feeding. A starving live animal is not a nutritionally balanced food. Essential fatty acids, micro algae, etc. can be administered to adult brine shrimp prior to feeding, to boost their food value. The enriched food must be utilized within 3 hours or less to realize the potential of nutritional enhancement. Minimal disturbance of the pairs in the broodstock tank results in more consistent spawning and fecundity. Disruption during the spawning of clownfish often results in scattered, not fully fertilized eggs. Sightseeing, just walking through broodstock areas, can have an effect on more sensitive species. Any movement can cause the pair to temporarily stop spawning and move away from the new nest. It is better that every effort should be made to keep the pair isolated from external distractions. Routine daily procedures of broodstock maintenance include feeding, checking for new spawns, checking the general health of the pairs and nest and adjusting air and water flows. Weekly routine maintenance includes siphoning of detritus buildup and uneaten food. Bi-weekly maintenance includes removal of dirty spawning substrates and replacing them immediately with clean ones and general bottom siphoning if needed. Every 12-18 months, the entire tank should be thoroughly cleaned, gravel removed and new or reclaimed gravel replaced. Disruption by moving of a mated pair usually results in no spawns for several months. Average recovery back to the spawning state was around 30 days.

Periodically adult clownfish consume their eggs only hours after laying them. If this practice continues, it indicates a specific problem that must be corrected. There are several possibilities including being a newly formed pair, the pair was scared or nervous, too many tank inhabitants, diet deficiencies, parasitic destruction of eggs, poor water quality resulting in poor fertilization or the male is non functional. Diet is the most common problem. At times two females will reside together and spawn, obviously resulting in non-fertilized nests, which are usually consumed. Poor water quality can cause poor quality or unfertilized eggs. Low pH reduced sperm activity thus resulting in poor fertilization.

Pairs should be routinely checked externally for skin disorders, swelling and behavioural changes. Usually within spawning pairs of clownfish, the female is the most susceptible to diseases. Initial indicators of possible disease or stress include paleness or darkening of colour, excessive mucous or white surface film, dry looking skin especially around head region, exposed mucous pores around head region, rapid breathing, gills flared outwards, gulping air at the surface, hiding in the corners of the tank, resting on the bottom, swimming on the surface, erratic swimming or apparent loss of equilibrium, sunken abdomen, forehead or dorsal crest, sores which do not heal quickly, bloated abdomen or raised scales, excessive scratching, white spots on surface of fins and body and disinterest in mate, usual habitat or feeding. The most common seasonal diseases of clownfish broodstock are white spot or saltwater itch and velvet disease. The white spot is caused by the ciliate *Cryptocaryon irritans.* This ciliate is very susceptible to hyper (>55 ppt) or hypo saline conditions (<16 ppt). Use of high salinity dips for five to ten minutes will help to remove attached tomites. During treatment the tank should be drained, cleaned and refilled. Several dips may be required. Freshwater dips may also be used, provided the pH is adjusted to 8.0 to 8.2. The velvet disease is caused by the dinoflagellate *Amyloodinium ocellatum* . In adult fish it manifests itself in high concentrations within the gill cavities and gill filaments. In later stages the fish characteristically have a dull velvet film on the skin with very small sparkling dots. Other symptoms include excessive scratching and laboured breathing. Quinine hydrochloride at 15 ppm is found to be very effective as a quick treatment followed by copper sulphate treatment for a long period.

From larvae to sexual maturity and spawning takes from 9-15 months (normally 12) for clownfish. Some species like *A. ocellaris* reach maturity earlier. Sub adults generally take about 6 months to reach sexual maturity. Full size adults obtained from the wild usually take 2 3 months to begin spawning again. Often the female takes the initial lead role in forming a new pair and in spawning. Excessive digging in the bottom substrate for cleaning of many areas usually occurs. As the pair matures, the male becomes more aggressive. Eventually the male assumes most of the nest cleaning and tending of the eggs.

A key factor to success and failure of the spawn is nest pigmentation. Healthy, well fed clownfish pairs produce orange to bright red nests depending on the species. The degree of intensity of colour is directly proportional to the amount of pigments within their diet. Overall nest size depends more on the species, size and age of the female. Eggs range in size from 2.0-2.4mm and 0.9mmwide. The newly hatched larvae measure around 4mm in total length.

The clownfishes live for longer periods. The age of captive *A. frenatus* is recorded as 17 years, *A. clarkii and A. ocellaris* as 14 years and *A. perideraion* as 21years. Clownfish are protracted spawners and produce one nest per month or less in the wild. Under controlled conditions and ideal consistent diets, they can be easily induced to spawn an average of 2.1 times per month. In captivity most pairs spawn a minimum of 11 months a year, regardless of the species. Individual pairs of clownfish seem to reach a typical reproductive pattern that remains fairly consistent for an extended period of time.

Eventhough adult clownfish pair for life, this does not mean that they will remain good commercial pairs throughout their lives. When a pair is no longer productive, it should be replaced or separated for repairing. The criteria that can be adopted for culling pairs include pairs producing less than two spawns a month over the last four months, old pairs with greater than 50% of the nest gone over the last four months and pairs that continuously spawn on the side of the tank.

The duration of hatching of clownfish eggs from the day of egg laying for the common species generally ranges from 6[th] day evening to 9[th] day evening, at a temperature range of 26-28°C. Hatching of clownfish eggs normally commences from 1-2 hours after dark. Hatching takes between 15-20 minutes.

When hatched, the larvae were trapped in the compartment containing the spawning substrate. This method works but allowing the larvae to remain in hatchers overnight resulted in high mortalities. Physically removing intact nests just prior to hatch and placing them directly in larval rearing tanks is found to yield successful hatching.

Larval rearing is the most critical, time-consuming phase of marine fish culture. Success or failure in larval rearing is closely associated with water quality and availability of quantity and quality of live feeds and how they are administered. To rear clownfish larvae, about 300-600 rotifers per larvae per day for a period of 5-10 days are required.

Tank colouration can play an important part in the survival of larvae. Yellow, green and black coloured tanks are closer to natural environmental colours and showed better survival than darker red and brown coloured tanks.

Clownfish larvae are highly sensitive to light. High light intensities or sudden lighting induces stress to the larvae. The light intensity just sufficient to see the live feeds is preferred. In 14-16 hours light period is advantageous to the larvae. Healthy clownfish larvae are clear yellowish in colour, with dark pigmentation around the stomach and eye region. Stressed larvae remain dark along the entire body.

The clownfish reach the juvenile stage, which can be transferred to growout tanks when they are around 13mm size and about 30 days old. Generally it takes a total of 4 months to rear to a marketable size of around 38mm. Juvenile growth and development are strongly influenced by water quality, food quality and the amount of food fed. A significant portion of juvenile culture facilities should be dedicated towards filtration. It is advantageous to use a bare tank with a single large airlift sponge filter. Juveniles should be fed a minimum of 3 times a day to obtain maximum growth. Uneaten food and fecal matter should be removed each morning by siphoning. It has been proved that astaxantin is the key pigment in clownfish. Products containing significant amounts of astaxanthin are most effective in enhancing pigmentation in clownfish. Frozen, freeze dried and meals of the planktonic krill are some of the best food sources for astaxanthin.

**Culture of cardinalfish**

The Banggai cardinalfish (BC) *Pterapogon kauderni* and silver high fin cardinal is an attractively patterned black and silver cardinalfish. Breeding and rearing of Banggai cardinal fish *Pterapogon kauderni* is reported recently. Typically males of cardinal fish incubate the eggs orally until they hatch, at which point the fry swim away and enter the water column. The fry are quiet large about ¼th of an inch. They feed immediately after release and they can accept newly hatch nauplii of brine shrimp (*Artemia).* The fry require large amounts of living food and at two and a half months, can eat adult brine shrimp. (Moe, 1995)

**Culture of neon goby**

The neon goby, *Gobiosoma oceanops,* is one of the largest species of the genus and probably the most common goby in marine aquariums. It is a cleaner species and even though of small size (2 to 3 inches as adults) the neon goby does well in a community tank. As the neon gobies mature, they begin to pair for mating. Spawning usually takes place in the early morning hours. There seems to be several periods of egg deposition by the female followed by fertilization by the male.

The male cares for the eggs throughout the incubation period, which, depending upon the temperature may be between 6 to 8 days.

A large female at the height of reproductive activity may lay 500 to 600 eggs, but the usual spawn size is about 250 eggs. The egg capsule is about 2 mm long and 1 mm in diameter and is completely transparent. The entire development of the embryo, from the first division of the blastodisc through to hatching, can be observed through the transparent chorion, or egg "shell" casing. The attachment of the egg consists of a mass of fiberous threads extending from the base of the egg capsule to a sticky pad that adheres to the substrate. The eggs are placed very close to each other and the newly laid spawn has the appearance of, an undulating patch of clear globules. The embryo turns around in the egg capsule on about the third day of development and completes incubation.

The larvae are quite small (4 mm long) upon hatching and usually carry a residual yolk. Feeding usually begins after the early juveniles take up a benthic mode of life. Sub-adult size is reached within 3 months. Small living organisms are required as a first food. The larval stage of the neon goby is rather prolonged. First metamorphosis into the adult colouration and behavior pattern occurs at about 18 to 20 days.

**Culture of marine angelfish**

All angelfish species so far studied are protogynous i.e., all individuals begin life as females, with mature larger individuals becoming male. Spawning occurs at sunset, and the microscopic larvae that hatch out the next evening swim as plankton for about a month. Members of the genus *Centropyge*, which are the best choices for aquarium fish, routinely form pairs and spawn often daily in captivity. Maintaining 2-3 females with a single male or rearing 3 small fish together is sufficient for obtaining spawning. The first case of artificial breeding of angelfish was achieved in bluemoon angelfish *Pomacanthus maculocus* in China. Very recently, the Hawaiian masked angelfish *Genicanthus personatus* and flame angelfish *Centropyge loriculus* were successfully bred and reared in captivity. Recently Frank Baensch achieved a breakthrough in breeding marine angels which is detailed in the articles published in Freshwater and Marine Aquarium Magazine (FAMA), Baensch (2002) and Baensch (2003).

**Breeding of orchid dottybacks (Pseudochromids)**

For development of broodstock, get several of the smallest individuals you can find and place them in a covered tank with a lot of structure. As they age, one will grow faster and become the male. Within a few months, breeding "pair" (a male and female that tolerate each other) will form. The male selects a den area; they court; the female enters the den; spawning occurs; an egg mass results; the male tends the eggs; the eggs hatch in four days; they spawn again two days later. 400 to 800 eggs are usually produced. Transfer them to the larval tank that is already set up with water and air stone.

Add algae (if possible), not a lot, just make the water a very light green, the day before hatch. Add rotifers, about 3 to 5 per ml to the tank the morning of the day after hatch. Dottybacks feed on rotifers and rotifers should be added as often as required (depending on the number of larvae and the size of the tank).

The juveniles require a bottom environment. In home hatchery situations it is best to transform the larva tank into an intermediate grow out tank by adding live rock and PVC structure to the larva tank. Within a couple of weeks, the juveniles should be transferred to a larger grow out tank, 30 to 50 gallons depending on numbers, set up with live sand and PVC structure.

## CONSTRAINTS

The absence of sexual dimorphism, the complex patterns of sex change in certain groups and the problems of larval rearing can be considered as the major reasons for the slow progress in the culture of marine ornamental fishes. The most important aspect is the lack of understanding and the difficulties of creating the pelagic environment essential for larval survival. The concepts of breeding and larval rearing of freshwater ornamental fishes are mostly not applicable in the case of marine ornamental fishes. Marine fish in general do not care their young after they have hatched. Since most fish spend their larval period as part of the plankton, plankton-feeding fish quickly eat their own young, if they happened to drift nearby.

**Two key bottlenecks currently limit the expansion of marine ornamental fish aquaculture. First is the control of maturation and spawning and the second is the identification of the appropriate live food items for larval first feeding.**

The common approach in marine fish hatchery is to find an appropriate mix of food organisms, develop methods to mass culture them and device a feeding schedule. Until these methods are developed for marine ornamentals, alternative means may be required. Wild zooplankton sieved to appropriate size has been used successfully to culture several marine ornamental species. The disadvantages are inconsistency of supply and possibility of introducing planktonic predators and parasites.

Once an acceptable first food organism has been found for a particular species, then one can develop a larval feeding regimen for that species. The first food organism typically will take the larval fish through the first five to eight days after feeding begins. They can usually take a lager food organism within three to four days. But after six to eight days, if there are no larger organisms present, feeding problems will emerge. The next organism after rotifers or copepods is usually brine shrimp nauplii. The nutritional requirements of most marine fish larvae are not completely fulfilled by the nutritional profile of brine shrimp. This is resolved by enriching the brine shrimp with highly unsaturated fatty acids and by supplementing the diet with other foods as soon as possible. Each species or group of related species has its own nutritional requirements at this early stage and dietary adjustments must be made to obtain good survival.

## POTENTIAL

It is generally accepted that the wild collection of ornamental animals from coral reef habitat can lead to overexploitation of these resources and deterioration of the coral reef habitat and hence long term sustainable marine ornamental trade can be developed only through tank reared fishes. In addition, hatchery production and culture of marine tropical ornamental fish can prove to be more economically feasible than that of marine food fish culture. This is because, eventhough the market for ornamental fish is much smaller than that of food fish, the price per unit is far higher in the case of aquarium fish. Hence in future, hatchery reared fish will become a significant part of marine ornamental fish trade. The clownfishes and damselfishes of the family offer immediate scope for hatchery production due to the availability of methodologies for broodstock development and larval rearing for a few species. Intensive research in broodstock development, breeding and larval rearing can result in the successful hatchery production of many more species belonging to the genera *Amphiprion, Pomacentrus, Neopoamcentrus, Chromis, Dascyllus* and *Abudefduf*. These species along with a few gobies, sea horses, cardinal fishes, pseudochromids and angelfishes for which also hatchery technologies are available can provide the technology background for the development of hatcheries for marine ornamental fishes which can pave the way for a sustainable marine ornamental fish trade in the near future.

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