

Marine Ornamental Fish Production for Economic Empowerment

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Keeping an aquarium at home and watching the nature's beauty in the comforts of our living room can help to improve mental well-being and overall health of an individual. The history of fish keeping as a hobby can be traced back to ancient civilizations such as Sumerians, Ancient Egyptians, Assyrians and also in ancient China and Rome. The earliest reports of keeping fish in glass containers dates back to mid 1700s in England where gold fish was kept in glass containers. Presently aquarium keeping is a favourite pastime hobby which is the second most popular hobby after photography. A report by American Pet Products Association showed that in 2019/2020, fish occupied third position after dogs and cats in the number of households keeping pets. The global ornamental fish trade is a multibillion dollar industry worth around \$ 15-30 billion which covers retail sales, accessories, wages and non-exported products (INFOFISH, 2021). The ornamental fish trade is supported by supply from developing countries in the tropical and subtropical regions where it offers avenues for employment and livelihood opportunities for rural population. The major source countries of ornamental fish in the global trade are from South East Asia (Singapore, Thailand, Hong Kong and Indonesia) followed by China, Amazon region, and regions of the African Great Lakes. The countries in SE Asia have developed large scale commercial breeding units and farms of ornamental fish wherein more than 95% of freshwater ornamental fish traded are produced in captivity. After the Second World War the trade showed a significant increase, perhaps due to the introduction of civil aviation (Tissera, 2010; Monticini, 2010).

The global ornamental fish trade comprises of both freshwater and marine ornamental species in which the freshwater forms dominate in terms of quantity with more than 60% of the volume being traded. The marine ornamentals, on the other hand are superior in terms of unit value. Although captive bred species dominate the global freshwater ornamental fish trade, it also includes fishes and invertebrates collected from the wild. However, the lion's share of marine ornamental fish trade is contributed by wild caught fishes with contribution from captive bred species falling below 10% of the volume.

The trade in Marine Ornamentals

The marine ornamentals can be defined as those fishes, shell fishes, invertebrates, corals and live rocks which can be used for setting up of a marine aquarium. It is estimated that around 2 million people keep marine aquaria worldwide. The marine ornamental trade is

a multimillion-dollar industry which started in the 1930's in Sri Lanka and has expanded tremendously during the last few decades. It is estimated that over 46 million organisms representing 2500 species are traded annually with a value exceeding US \$ 300,000,000. Hence there is immense scope for expansion and growth of the global marine ornamental fish trade in future. The marine ornamental fishes belonging to family Pomacentridae are the most popular group accounting for 43% of all fish traded, followed by species belonging to Pomacanthidae (8%), Acanthuridae (8%), Labridae (6%) Gobiidae (5%), Chaetodontidae (4%), Callionymidae (3%), Microdesmidae (2%), Serranidae (2%) and Blennidae (2%).

Wild Collection of marine ornamentals

The supply of fishes to the marine ornamental trade is from wild collection as well as hatchery production, wherein the wild collection dominates with more than 90% of the volume being traded. The common collection practices employed for harvesting of marine ornamentals from the wild are briefly described below:

a. Hand picking/Catching by hand

Catching wild fish by hand, using a minimum of equipment is the best approach as this allows fishermen to carefully select which fish to be caught as per their requirement thus avoiding any by catch or discards. This also doesn't cause much damage to the habitat. Some fishes like catfish and cichlids hide in submerged rocks, shells, or wooden pieces, which can be lifted out of water and shaken over nets to catch the fish. Also certain sedentary fishes, starfish etc can be caught by hand picking.

b. Chasing and netting

The fishes are carefully shepherded into a bag net or enclosure and can be collected. This type of collection can be done in reef areas without causing much disturbance to the reef ecosystem.

c. Traps

This is a passive method of collection without causing much disturbance to the reef ecosystem. Traps are set either with baits or without bait where the fish normal behaviour itself makes it get trapped in the trap.

d. Diving

Fish capture by diving or snorkelling is also adopted by wild fish collectors, but fishing is restricted to hand picking or hand nets. At slightly greater depths, hookah and scuba diving are the main ways to catch fish, again with hand-held or larger nets, or to collect corals by hand.

Hatchery production of marine ornamentals

The ultimate solution for sustainable development of the sector will be a gradual shift from capture to culture for sourcing of marine ornamentals for the trade. The significance of captive breeding of marine ornamental fishes for the sustainable development the trade has been very well recognised. However, successful commercial rearing has been scientifically

reported for only a few species. The contribution of hatchery produced fishes in the global trade of marine ornamentals is very minimal which is less than 10% is. There are currently 338 marine ornamental fish species belonging to 37 families reported as Captive bred (CB) species, but from this only 24 species are regularly available in the trade (Pouil *et al*, 2020).

The marine ornamental fishes that are most commonly bred in captivity include clown fishes and damsel fishes. The captive breeding and seed production techniques of clown fishes and damsel fishes are described below:

Captive breeding of Clown Fishes

Clown fishes are distributed throughout the Indo-West Pacific Region. Clown fishes continue to be the most demanded marine tropical fish and the technologies available at present on marine ornamental fish breeding are mainly centred around clown fishes. They are distinguished and taxonomically separated from damselfish by their dependence on anemones for protection. They are further distinguished from damsels by their large capsule shaped eggs and large larvae at hatch.

Species of clownfish for which hatchery technologies are developed and standardized in India is given in Table.1. Recently seed production of designer clown fishes (such as Picasso, Platinum, snowflake etc) which are the most sought-after varieties among clown fishes, have also been achieved at Mandapam Regional Centre of ICAR CMFRI.

Species of clownfish for which hatchery technologies have been developed

Sl.No.	Species name	Common name
1	<i>Amphiprion sebae</i>	Sebae clownfish
2	<i>A.clarkii</i>	Clark’s anemonefish /yellowtail clownfish
3	<i>A.percula</i>	Orange clownfish
4	<i>A.ocellaris</i>	Ocellaris clownfish/false percula clownfish
5	<i>A.frenatus</i>	Tomato clownfish
6	<i>A.perideraion</i>	Pink skunk clownfish
7	<i>A.nigripes</i>	Maldive anemonefish /black finned anemonefish
8	<i>A.ephippeum</i>	Red saddle anemonefish/Fire clown
9	<i>A.akallopsisos</i>	Skunk clownfish
10	<i>Premnas biaculeatus</i>	Spine cheeked anemone fish/ maroon clownfish

The hatchery protocols for seed production of all clown fishes are more or less similar. The clown fishes are protandrous hermaphrodites. The major components in the seed production are Brood stock development, Pair formation, Egg laying, Larval rearing and Live feed culture.

The broodstock development and pair formation is a major component for successful hatchery operation. The brood stock of the fishes has to be maintained at optimum water quality conditions (Table) free from pathogenic organisms in order to condition them for breeding. This is possible by providing a Recirculatory Aquaculture System (RAS) in the hatchery. The basic components include a common sump, biofilter, UV filter, Chiller, Protein skimmer, Blower, water inlet and outlet assembly for the fish tanks and lighting arrangement for the fish tanks.

Optimum water quality parameters for marine ornamental fish brood stock development

Sl. No	Parameter	Values
1	Temperature	27-28 °C
2	Salinity	30 – 35 ppt
3	pH	7.5 - 8.5
4	Dissolved Oxygen	> 5ppm
5	Ammonia	0 ppm
6	Nitrite	0 ppm
7	Nitrate	< 25 ppm

The clown fishes are monogamous in nature and pair formation is a tricky part of the captive breeding technique. The clown fishes are born as males and according to social conditions prevailing in the clownfish colony they reverse the sex. There will be only one functional pair (male and female) in a colony. All the other members of the colony remain as sub-adults. In a colony, one pair of fish will grow ahead of other fish – the larger of the two will become the female and the other one will be the male. Hence in a clownfish colony, the larger fish will be the female and the next large fish will be the male. Compatible pairs have to be identified by trial and error methods and once the pair formation is complete, they can be introduced into the brood stock holding tank, such that, only one pair is kept in a tank with a host anemone for better results. Age of the fish is the most important factor determining sexual maturity. Sexually matured adult clownfish are usually 9-18 months old. Conditioning the fish is a prerequisite for spawning any fish. Conditioning is a term used to describe the utilization and manipulation of a combination of environmental factors to induce gonadal maturation and spawning. The factors may include light intensity, light duration and possibly wave length, temperature, water current, water quality, nitrogen, phosphate, ammonia, p^H, type of food, tank size and shape, aeration and habitat. All fish do not respond to the same environmental cues which trigger spawning. Under natural conditions, wild clownfish spawn most of the year, but usually not more than one spawn per month. Under optimum conditions and proper feeding, they can be induced to spawn atleast twice a month.

The quality of broodstock diets greatly influence a successful spawning. Hence suitable diets at satiation levels must be fed to the broodstock fish. Boiled and chopped mussel/clam meat and fish roe can be fed *ad libitum* twice a day. Live feeds like *Artemia* nauplii, adult *Artemia* and *Moina micrura* can also be supplemented. If brood stock fish are not properly fed, the results are directly reflected in the number of eggs laid, pigmentation of the eggs, 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.

The clown fish spawns by attaching the eggs to any substratum available in the tank. Hence, suitable substratum such as tiles or earthen pots can be placed inside the brood stock tanks. The clownfish normally spawn during forenoon. Once spawning commences, females

press their body towards the substrate and slowly move in a rowing fashion using their pectoral fins. She moves in a circular path depositing a continuous spiral of eggs from the central outward. The male swims behind the female, releasing sperm over the newly deposited eggs. Spawning occurs during day time and it lasts for about one to one and half hours. Each female lays 300 to 1000 capsule shaped eggs. Generally the egg size ranges between 1.5 to 3mm in length and 0.8 to 1.8mm in width. Each egg is attached to the substratum by a stalk. During the incubation period both the parents carefully look after the eggs by fanning the eggs by their fins and removing the dead and infected eggs by mouth. After spawning the males assume a more dominant role. He intermittently fans the nest with his caudal or pectoral fins. He also cleans the eggs by gently mouthing them without removing them. Dead and fungal infected eggs are routinely removed and eaten. Substrate around the nest is also often cleaned. The male spends an average of 30-60% of its time during the day for tending the nest. Fanning the eggs is frequent on the day after spawning and diminishes considerably about mid-way in the incubation period. On the day of hatch, fanning increases again. In captivity most pairs spawn a minimum of 11 months a year, regardless of the species.

The colour of the eggs will be bright orange initially which will change to black and finally to silvery colour with prominent eyes of the embryo on the 7th day. The eggs hatch on the seventh day shortly after sunset at a water temperature range of 27 – 29 °C. On the expected day of hatching, 2 hours before sunset the eggs along with the substratum are transferred to hatching tanks. The larvae break their capsules and hatchlings emerge soon after sunset and peak hatching takes place between 1900 – 2000 hrs in darkness.

The newly hatched larvae measures 3-4 mm in length and each has transparent body, large eyes, visible mouth and a small yolk sac. Soon after hatching the larvae are free swimming. The initial nourishment to the developing fish larvae is obtained from the egg yolk. When the yolk reserves have been completely utilized, the larval feeding capabilities are developed and hence at this stage the larval survival is entirely dependent on the availability and quality of food in sufficient quantities. The phase when yolk has just been depleted and the larvae turn to exogenous feeding for further development is the most critical stage. At this stage, suitable live feed should be available in the larval rearing tanks. For this larval rearing has to be carried out in green water (using microalgae such as *Nannochloropsis oculata*, *N.salina* etc) and feeding with rotifers (*Broachionus plicatilis* & *B rotundiformis*) initially (upto 8th day after hatching) and then with *Artemia* nauplii from 9th day onwards. A minimum 8-10 nos of rotifers per ml is required during rotifer feeding period and 2-3 nos nauplii per ml during *Artemia* feeding stage. The larvae metamorphose between 15-20 days. After metamorphosis the larvae can be transferred to grow out tanks. Mild aeration can be provided during larval rearing. The larviculture period from 3-8 dph is critical due to the change in feeding from endogenous to exogenous. After 8 dph there will not be any further mortality if proper feeding and water quality parameters are maintained. The tank bottom should be cleaned daily with atleast 25% water exchange. Sufficient green water should be

added daily. Weaning with pellet feed can be started after metamorphosis. Start with suitable sized pellets along with the live feeds and slowly wean them to the pellet feed. The ICAR CMFRI has developed a marine ornamental fish feed “Cadalmin™ Varna” which gives very good colour enhancement for the fishes. Boiled and chopped mussel meat can also be used as feed. Two to three times feeding at satiation level is sufficient to rear them to marketable size.

Captive breeding of Damsel fishes

The damsel fishes which also belong to the Family Pomacentridae are very popular among aquarists due to their small size, bright colours, quick acclimation to captivity and interesting behaviour. The majority of species inhabit the Indo-Pacific region and about 100 species and 18 genera have been recorded from the Indian Ocean. More than 30 species belonging to the genera *Pomacentrus*, *Neopomacentrus*, *Chromis*, *Abudefduf* and *Chrysiptera* are commonly available from Indian coral seas. Broodstock development and larval rearing were achieved in India for nine species of damselfishes (Table)

Damselfishes for which hatchery production have been achieved.

Sl.No	Common name	Scientific name
1	Three spot damsel	<i>Dascyllus trimaculatus</i>
2	Striped damsel	<i>D. aruanus</i>
3	Cloudy damsel	<i>D. carneus</i>
4	Blue damsel	<i>Pomacentrus caeruleus</i>
5	Peacock damsel	<i>P. pavo</i>
6	Bluegreen damsel	<i>Chromis viridis</i>
7	Filamentous tail damsel	<i>Neopomacentrus cyanomos</i>
8	Yellowtail damsel	<i>Neopomacentrus nemurus</i>
9	Sapphire devil damsel	<i>Chrysiptera cyanea</i>

The damsel fish exhibits protogynous hermaphroditism and they are group/harem spawners. One male can fertilise the eggs deposited by more than one female. The eggs are deposited on any hard substratum as in the case of clown fishes. Earthen pots or PVC pipes can be used as substratum for egg deposition in case of damsel fishes. The egg hatches out on 4th day. The egg size and larval size is comparatively smaller than clown fishes due to which the live feed also have to be smaller to suit the mouth size of the larvae. Hence copepod nauplii/copepodite of suitable size range and nutritional value has to be provided for first feeding of the damsel fish larvae. This is the major difference in seed production between clown fishes and damsel fishes. The mass production of suitable copepod species was a major bottleneck in the seed production of damsel fishes till very recently. However, techniques for culture of copepod species with suitable size and nutritional value have been developed by Vizhinjam Research Centre of ICAR CMFRI, which is being adopted for the seed production of damsel fishes. After the initial feeding stage with copepod nauplii or copepodites, rotifers

can also be used as live feed along with green water technique. The rest of the larval rearing techniques are similar to that of clown fishes.

Live Feed Culture

Live feed culture is an integral part of marine ornamental fish seed production technique because the initial feeding of the larvae is purely on live feeds such as rotifers, copepods and artemia nauplii. To culture these zooplankton like rotifer and copepods, micro algae (phytoplankton) is necessary. Hence live feed comprises of micro algae and zooplanktons (such as rotifers, copepods and Artemia nauplii). Micro algae such as *Nannochloropsis occulata*, *N salina*, *Isochrysis galbana* etc are commonly cultured for rearing the rotifers or copepods. Rotifer species commonly used in hatcheries include *Brachionus rotundiformis* and *B plicatilis*. Copepods species widely used include *Parvocalanus*, *Pseudodiaptomus*, *Oithona*, *Temora turbinata* etc. Artemia cysts are readily available in the market, which can be hatched in the hatchery as per the requirement and given to the larvae when their mouth size is big enough to capture artemia nauplii. Detailed description on all the live feed culture techniques are given in separate chapters in this book. The readers are advised to refer these chapters for more information.

Marine Ornamentals for Economic empowerment

Empowerment is a process through which individuals or organised groups increase their power and autonomy to achieve certain outcomes they need and desire. There are different types of empowerments such as Social, Economic, Political, Gender, Educational etc. Economic empowerment allows poor people to think beyond immediate daily survival and to exercise greater control over both their resources and life choices. For example, it enables households to make their own decisions around making investments in health and education, and taking risks in order to increase their income (Combaz & Mcloughlin, 2014).

The primary stakeholders in the value chain of the marine ornamental fish trade are the coastal fisherfolk engaged in wild collection since major part of the trade comes from wild collection. These fisherfolk in the source countries, depend on this activity as a livelihood option which clearly shows the influence of marine ornamental fish trade in their economic empowerment. The wild collection, in the long run can raise sustainability concerns and hence captive breeding for production of marine ornamentals would be the best solution to address this issue. The production of marine ornamentals through captive breeding can also be taken up by the coastal fisherfolk owing to the proximity /accessibility to sea, which again can lead to their economic empowerment.

The ICAR-CMFRI, under the SCSP (Scheduled Caste Sub Plan) programme funded by Government of India, has established marine ornamental fish production units operated by beneficiaries belonging to the Scheduled Caste community. This has helped in creating alternate livelihood options for them and employment generation which ultimately leads to their economic empowerment.

Conclusion

The marine ornamental fish sector all over the world is dominated by fishes/shell fishes/invertebrates caught from the wild and the share of hatchery produced fishes still continues to be at a very minimal level. The ever increasing demand for ornamental fish has necessitated the development of captive breeding techniques of these fishes. Captive breeding techniques of marine ornamentals comprise of broodstock development, breeding, larval rearing, live feed culture, health management, water quality management and suitable husbandry practices. The reproductive biology of the fish (viz; hermaphrodite or gonochoristic) and feeding habits of the adult as well as larvae/juveniles of the fish need to be understood thoroughly before undertaking the breeding programmes. The total number of captive bred species available in the marine ornamental fish trade are around 340 belonging to 37 families. However, this forms nearly 19% of the total number of species being traded and from this, only very few are commonly available in the trade, which points to the fact that, dependence on wild collection for sourcing of fishes will continue. Hence responsible and eco-friendly collection methods need to be promoted by the regulatory agencies for ensuring a sustainable growth of the sector. Promoting hatchery production of marine ornamental fishes would be the best option to ensure sustainable development of the sector. Even though collection from the wild continues to be the major contributor in the trade, it is imperative to shift gradually from the wild collection to captive breeding and seed production of marine ornamental fishes in order to ensure a sustainable development of the sector. Hence the marine ornamental fish production can thus help in the economic empowerment of the coastal fisherfolk in the source countries by providing avenues for employment and income generation.

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