

## **Marine Ornamental Aquaculture: Potential for Livelihood and Employment Generation**

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Marine and freshwater aquarium keeping is amongst the most popular of hobbies with millions of enthusiasts worldwide. As a result the trade of marine ornamentals has been expanding in recent years and has grown into a multimillion dollar enterprise mainly due to the emergence of modern aquarium gadgets and technologies for setting and maintenance of miniature reef aquaria. Since the marine ornamental trade is operated throughout the tropics, the global marine ornamental trade is estimated at US\$ 200-330 million. India is endowed with a vast resource potential of marine ornamentals distributed in the coral seas and rocky coasts with patchy coral formations. In the context of the expanding global scenario and the increasing demand in the domestic trade, it appears very much lucrative for India to venture into this industry. But it is a multi stakeholder industry ranging from specimen collectors, culturists, wholesalers, transshippers, retailers, hobbyists, researchers, government resource managers and conservators, and hence involves a series of issues to be addressed and policies to be formulated for developing and expanding a sustainable trade. In recent years it has been reported that nearly 1500 species of marine ornamental fishes are traded globally and most of these are associated with coral reefs. Nearly 98% of the marine ornamental fishes marketed are wild collected from coral reefs of tropical countries such as Philippines, Indonesia, Solomon Islands, Sri Lanka, Australia, Fiji, Maldives and Palau. This has been threatening the long term sustainability of the trade due to indiscriminate exploitation of coral reef areas. The three key words in the development of marine ornamental fish trade are – collection, culture and conservation. The development of technologies for hatchery production of selected marine ornamental fishes is the only option for evolving a long term sustainable trade without damaging the coral reef ecosystem. Even at an international level, the technologies for hatchery production of ornamental fishes are limited to a few species. The main steps in captive production of ornamental fishes are broodstock development, breeding, live feed culture, larviculture

protocols, growout methods, aquarium technology, diseases, packing and transportation, etc. The Central Marine Fisheries Research Institute (CMFRI) has been focusing on this vital aspect for the past few years. CMFRI is successful in developing hatchery technology for 21 species of marine ornamental fishes. The marine ornamental fish trade is low volume and high value industry in rural and urban areas, and hence it is very lucrative to initiate a trade purely based hatchery produced species. The setting up of a small-scale hatchery with details of economics are also included in this manuscript.

### **Captive breeding of marine ornamentals in India: Initiatives by CMFRI**

These investigations made CMFRI have resulted in the development of hatchery technology for 21 species of marine ornamental fishes such as clown fishes *Amphiprion percula* (True percula/ clown anemone fish); *A. ocellaris* (Common Clown/False clown anemonefish); *A. sandaracinos* (Yellow Skunk Clown); *A. frenatus* (Tomato clown), *A. clarkii* (Clark's anemone fish), *A. sebae* (Sebae clown) *A. periderarion* (Pink anemone fish ) *A. ephippium* (Red saddle back anemone fish), *A. nigripes* (Lakhadweep clownfish), *Premnas biaculeatus* (Maroon clown/ Spine cheek anemone fish. The species under damsels for which technology developed under captivity included *Dascyllus trimaculatus* (Three spot damsel); *D. aruanus* (Striped damsel); *Pomacentrus caeruleus* (Blue damsel); *P. pavo* (Sapphire or Peacock Damsel); *Neopomacentrus nemurus* (Yellow tail damsel); *N. filamentosus* (Filamentous tail damsel); *Chrysiptera cyanae* (Sapphire devil); *C. unimaculata* (One spot damsel), and *Chormisviridis* (Green chromis), and also dotty back *Pseudochromis dilectus* (Redhead Dottyback), purple fire goby *Nemateleotris decora* for the first time in the world (Madhu and Rema Madhu, 2002, 2006; Madhu *et al.*, 2006a,b,c; Gopakumare *et al.*, 2007; Rema Madhu, *et al.*, 2007; Madhu *et al.*, 2008, Madhu and Rema Madhu, 2014, Madhu *et al.*, 2016). It is well accepted that the trade developed from tank reared fish and other ornamentals is the final solution for a long term sustainable trade. The economic viability of ornamental fish production is more lucrative when compared to other mariculture species, due to their high unit value. The complete package of practices developed for their production can be taken up as an alternative livelihood option for small and large scale fish farmers. The transfer of technology to the public and private sector entrepreneurs who have approached for the technology is being planned by imparting hands on training through different modes

under the Consultancy Processing Cell (CPC) of the CMFRI and organized trainings. In addition, the hatchery produced seeds are also being sold to the farmers and aquarium hobbyists and traders through Single Window System and seed counters are in operation in marine hatcheries of CMFRI at Cochin and Mandapam. This has resulted in the emergence of several ornamental fish trade shops all over the country. Recently the National Fisheries Development Board (NFDB) has also developed schemes to fund for ornamental fish culture in the unutilized hatcheries of the prawn farmers in India.

### **Captive Breeding**

For the breeding of ornamental fishes under captive condition, the following few important steps are to be followed apart from maintenance of high water quality, provision of suitable environmental parameters, creating suitable condition for spawning and system for raising the larvae and juveniles.

The major aspects involved in ornamental fish culture are:

- Collection and transportation of broodstock
- In case active broodstocks are not available, pair formation and broodstock developments to be under taken in captive conditions
- Breeding system/ broodstock rearing setup and management
- Provision of Substrate for egg deposition
- Feed formulation and broodstock feeding and feeding schedule
- Incubation of eggs , parental care and management of parameters.
- Morphology and embryology of eggs
- Egg hatching and larvae handling techniques
- Larval rearing
- Nursery rearing
- Growout culture
- Quarantine
- Harvest of juveniles for trade
- Packing and transportation

### **Allied Section for Larval Rearing**

- Microalgae stock and mass culture (freshwater and marine )
- Zooplankton stock and mass culture (rotifers, copepod and cladoceran) for marine.
- Zooplankton stock and mass culture (rotifer, moina, daphnia and copepod ) for freshwater species
- Zooplankton harvesting and handling

- Artemia cyst hatching and harvesting
- Live zooplankton bio enrichments

### **Collection and transportation of fishes**

For the captive mass production of ornamental fishes, the basic requirement is to have a sufficient number of broodstocks or breeding pairs which can either be collected from the coral reef habitat or can be purchased from the pet shop depending upon the availability. In the wild, the clown fishes generally occupy in social groups centered in a host sea anemone with a sexually active pair of adults and one to three juvenile or sub adult fish. Invariably the female was somewhat larger than the male, and showed monogamous pair formation, and these pairs are need to be collected for broodstock development and breeding programme. During transportation, the fishes and sea anemones should be kept in separate plastic transportation bags.

### **Quarantine**

Fish newly obtained from the wild or from pet shops may carry pathogens that can infect healthy, valuable broodstock. Therefore, they are isolated in a separate tank or system for about three to four weeks, during which they are closely monitored and treated with medications if any disease symptoms appear. Similarly, before being sold, fish should also be properly screened and placed under quarantine.

### **Pair formation**

In the circumstance of non-availability of adult breeding pairs, individuals from different size groups are collected and encouraged to form pairs under captive conditions. This is achieved by stocking a minimum of five individuals of each sex, representing various size classes, together with a single host sea anemone in a 1000 L FRP tank equipped with a biological filtration system to reduce aggression. The rearing tanks in the hatchery are maintained under an incident light intensity of 2500–3000 lux, as sea anemones require adequate light for optimal survival under laboratory conditions. Feeding is provided at 10% of body weight per day, divided into three portions, using wet feeds such as shrimp, green mussel, and clam meat, along with live feeds including *Brachionus plicatilis*, *Artemia* nauplii, and adult *Artemia*. Successful pair formation depends on maintaining stable environmental conditions, including a temperature range of 26–29°C, salinity of

33–34 ppt, dissolved oxygen levels of 4.6–6.2 ml/L, and pH maintained between 8.1 and 8.8 in all rearing tanks.

### **Sex change and pairing**

Clownfishes are protandrous sequential hermaphrodites, meaning they first mature as males. A clear dominance hierarchy is formed in which the female is the most dominant, followed by the male, while all juveniles remain subordinate to the breeding pair. In general, all individuals begin life as males and later transition into females when they attain larger size or when a mate is lost. The male and female maintain a monogamous pair bond that typically persists until one of them dies. If the female dies first, the largest male undergoes a rapid sex change to become female, while the second-largest or dominant juvenile assumes the role of male and pairs with the newly transformed female. This natural adaptation can be used to develop breeding pairs in captivity by establishing appropriate social structures.

After 3 to 4 months of rearing during pair formation, one pair in each tank usually outgrows and establishes itself as the spawning pair. Since newly formed pairs tend to be highly aggressive and often spend more time defending territory and evading subordinates rather than engaging in reproduction, it is essential to transfer each breeding pair into separate broodstock tanks.

### **Broodstock development and maintenance**

Formed pairs are subsequently transferred to separate glass aquaria for broodstock development, with the number of pairs maintained according to production capacity and seed demand in commercial hatcheries. Broodstock are fed wet feeds such as green mussel, shrimp, clam meat, and fish egg mass, along with formulated diets enriched with vitamins, minerals, and algal powder at 10% of body weight, given in split doses at 3-hour intervals during the daytime. In addition, enriched live feeds are provided daily, including rotifers, *Artemia* nauplii, and adult *Artemia*. The incorporation of enriched live feeds has been shown to significantly enhance egg quality and hatchability compared to non-enriched diets.

### **Water quality maintenance**

The maintenance of optimal water quality is likely the most critical factor for successful breeding of marine fishes under controlled conditions. As a precautionary measure,

seawater should be passed through a series of sand filtration units before being supplied to the rearing tanks. In all breeding tanks, temperature should be maintained between 26 and 30°C, while dissolved oxygen levels (4.8–6.3 mL/L), pH (8.0–8.9), and salinity (32–36 ppt) must be carefully regulated. Continuous water recirculation is required to ensure proper water movement and to maintain good water quality, supported by a specially designed filtration system throughout the rearing period. Additionally, 25% of the water should be replaced weekly to prevent stress responses such as elevated plasma cortisol levels, which may lead to Cushing-like conditions, suppression of gonadal steroidogenesis, and eventual development of gonadal atresia.

### **Substrate for egg deposition**

Clownfish produce capsule-shaped eggs that are firmly affixed to a suitable substrate inside the tank. The eggs are usually deposited in dense clusters and adhere strongly to rough surfaces due to a sticky coating secreted during spawning. This attachment helps maintain stability, prevents egg dispersal, and ensures adequate aeration throughout development. Since the eggs are substrate-bound, a rough surface is required, typically placed close to the host sea anemone or within the rearing tank. In captive breeding systems, materials such as tiles, earthen pots, oyster shells, or PVC pipes are commonly used to promote egg laying. These substrates also allow the eggs to be transferred safely and without damage to hatching tanks when necessary.

### **Breeding and spawning**

Clownfish broodstock maintained under captive conditions may begin breeding within 4–6 months when provided with adequate nutrition and favorable environmental parameters. Prior to spawning, the male selects an appropriate nesting site near the sea anemone and cleans it by removing algae and other debris. On the day of spawning, both parents spend considerable time preparing the site, which serves as a clear indication that spawning is imminent.

In laboratory conditions, spawning generally takes place during daylight hours, typically between 05:00 and 15:30, and lasts for about 1–1.5 hours. Females lay around 300–1,000 capsule-shaped eggs at intervals of 12–15 days, depending on species, body size, and prior spawning history. These eggs measure approximately 1.5–3.0 mm in length and 0.8–1.84 mm in width and are firmly attached to the substrate via a stalk (Fig.). Under

controlled conditions, a breeding pair usually spawns twice within a lunar month, yielding an estimated annual fecundity of 7,200–24,000 eggs per pair.

### **Parental care and egg morphology during incubation period.**

Parental care is essential for successful larval hatching; therefore, the breeding pair should be kept in the spawning tank until around 4 pm on the anticipated hatching day. The incubation period is approximately 168 hours for *Amphiprion* species and 144 hours for *Premnas* at a water temperature of 27–29°C. During incubation, both parents continuously tend to the egg clutch, primarily by fanning the eggs with rapid movements of their pectoral fins to improve water circulation and by mouthing the eggs to remove dead or weak embryos as well as accumulated debris. The eggs are initially white to bright orange during the first two days after spawning. As development proceeds, they gradually darken, appearing black between the third and fifth day of incubation. By the fifth day, a faint silvery sheen begins to appear, which becomes more pronounced, and by the seventh day the eggs turn fully silvery due to the development of the larvae's large eyes. At this stage, the embryos' reflective eyes are clearly visible through the egg capsule even from a short distance, indicating that hatching is imminent and will typically occur in the evening after sunset.

Although both parents participate in brood care, the male performs the majority of parental duties and spends significantly more time at the nest site than the female. His nest attendance increases steadily as hatching approaches, reaching nearly 70% of the total time. Under a temperature range of 27–29°C, hatching generally occurs on the seventh day of incubation (168 hours), shortly after sunset.

### **Hatching and larval transfer**

The incubation period of clownfish eggs typically varies from 6 to 15 days, largely influenced by water temperature. At temperatures ranging between 26 and 30°C, hatching usually occurs within 6–7 days. About one day prior to hatching, the embryos develop a distinct silvery appearance, and their reflective eyes become clearly visible through the egg capsule, providing a reliable sign that hatching is approaching.

On the expected day of hatching, the egg-bearing substrate is generally moved from the parental tank to a 100-L hatching tank approximately two hours before sunset. The hatching tank is kept in complete darkness to encourage and synchronize the hatching

process. Larvae emerge by breaking the egg capsule tail-first, with hatching beginning shortly after sunset. Peak hatching activity is usually observed between 19:00 and 20:30 hours under dark conditions.

Newly hatched larvae are about 3–4 mm in length and are transparent, with large eyes, a visible mouth, and a small yolk sac (Fig.). After briefly resting at the bottom of the tank, they become free-swimming. Larval rearing is commonly carried out using a green-water system enriched with *Nannochloropsis oculata* and *Chlorella salina*, along with very small rotifers (*Brachionus rotundiformis*) as the initial live microzooplankton feed.

The larval period generally lasts up to 20 days, after which most fry undergo metamorphosis and begin to resemble juvenile fish. During this transition, they shift from a partially pelagic phase to an epibenthic lifestyle and readily accept feeds such as minced shrimp, fish flesh, mussel meat, clam meat, and formulated diets.

### **Methods for larval rearing**

The larval rearing of clown fishes can also be carried out in three ways (i) Same tank or parental tank method, (ii) Transferring of eggs to hatching tank and subsequent larval rearing, (iii) Transferring of larvae to the larval rearing tank.

### **Larval feeding**

The success of the first feeding strike in clownfish larvae is initially low but improves quickly during early development. Survival at this stage depends on providing high densities of appropriately sized, nutrient-enriched live feed. Because larvae have a very small mouth gape (about 80–123  $\mu\text{m}$ ), they can only ingest extremely small prey; therefore, failure to locate and capture sufficient food before energy reserves are depleted can lead to starvation and mortality. Since yolk reserves are limited, exogenous feeding begins within a few hours after hatching depending on the species. To enhance feeding efficiency, rearing tanks are maintained under continuous light (24 h) up to 20 days post-hatch (DPH). Good hygiene is also essential, with daily siphoning of dead larvae, feces, and debris, along with at least 25% daily water exchange. Larval feeding is divided into three phases. From 1–5 DPH, larvae are fed super-small rotifers (*Brachionus rotundiformis*, 60–100  $\mu\text{m}$ ) and copepodites under a green-water system at densities of 30–50  $\text{mL}^{-1}$  after enrichment with vitamins and fatty acids. From 6–10 DPH, diets shift to

pre-adult copepods, nauplii of *Diaphanosoma celebensis*, and S-type rotifers (*Brachionus plicatilis*) enriched with microalgae at 5–10 mL<sup>-1</sup> to meet increasing nutritional demands. From 11–20 DPH, larvae are fed larger prey including adult copepods, adult *D. celebensis*, and L-type rotifers (*Brachionus plicatilis*), matching their increased mouth size and improving growth and metamorphosis success.

### **Rearing conditions**

Maintaining excellent water quality is a key requirement for successful larval rearing of clownfish and other marine fishes under controlled conditions. During larval culture, the period between the 3rd and 8th day post-hatch (DPH) was identified as particularly critical, likely due to the transition to exogenous feeding. However, once larvae successfully completed 8 DPH, no further mortality was observed. Given the fragile nature of the larvae, gentle aeration was supplied using PVC columns fitted with 20- $\mu$ m mesh screens placed at all four corners of the rearing tanks to maintain adequate dissolved oxygen levels. These columns were arranged to promote continuous water circulation, ensuring uniform oxygen distribution and optimal rearing conditions. Throughout the larval rearing period, water quality parameters were carefully maintained at optimal levels: pH 8.0–8.2, temperature 26–30°C, dissolved oxygen 5.5–7.8 mg/L, salinity 33–35 ppt, with ammonia (NH<sub>4</sub><sup>+</sup>/NH<sub>3</sub>) and nitrite (NO<sub>2</sub>) maintained at 0 mg/L, and nitrate (NO<sub>3</sub>) kept below 0.2 mg/L. Tanks were cleaned daily using cotton and magnetic scrapers to remove debris and biofilm, and one-fourth of the water was replaced each day with equal volumes of filtered seawater.

### **Light intensity**

Head-butting syndrome was another major challenge during larval rearing, primarily caused by the underdeveloped retina, which led larvae to repeatedly strike the tank walls. To minimize this problem, two key measures were implemented. First, all four sides of the rearing tanks were covered with black cloth or painted black to eliminate light reflection. Second, low-intensity lighting was maintained by suspending two 60-watt bulbs or night lamps 15–20 cm above the water surface, operated continuously from day 0 to day 20. This lighting helped larvae locate and capture feed more effectively and

encouraged them to remain near the water surface at night instead of sinking to the bottom, thereby reducing overnight mortality.

### **Juvenile rearing**

As the larvae reach 19–20 DPH, clownfish larvae transform into juveniles, transitioning from a pelagic to an epibenthic lifestyle and resembling miniature adults. Growth rate at this stage is influenced by rearing tank size, stocking density, feed quality and quantity, and water temperature. Because clownfish exhibit a social hierarchy, dominant individuals tend to grow faster and suppress the growth of subordinates. This can be minimized by either rearing juveniles together in larger tanks with adequate host anemones or by segregating them into smaller groups across multiple juvenile rearing tanks of 250–1000 L capacity equipped with biological filtration.

At the early juvenile stage, stocking density is maintained at about 90–100 individuals (8–10 mm size) with a single host sea anemone in a 100-L glass or Perspex tank for the first 1–2 months. During this period, variations in banding patterns and growth rates become evident. Once fish reach 24–35 mm total length, stocking density is further reduced to 30–50 individuals per 100-L tank with one sea anemone and 80 L of biofiltered seawater until they reach market size. In larger 500-L FRP tanks, approximately 130–150 juveniles can be maintained with 1–3 sea anemones.

### **Juvenile feeding**

During juvenile rearing, a 100% survival rate was achieved by feeding wet diets such as mussel meat, prawn muscle, fish eggs, and minced trash fish at 15–20% of body weight. In addition, *Artemia* nauplii (10–15 individuals/mL) and rotifers (*Brachionus plicatilis*, 50–55 individuals/mL) were provided after enrichment with brown algae ( $10^4$  cells/mL) and green algae ( $10^6$  cells/mL), along with cod liver oil and fat-soluble vitamins A, D, E, and K. These were administered twice daily, helping to maintain fish coloration and supporting the inclusion of adult *Artemia* (2–4 individuals/mL) as part of the diet.

### **Packing and Transportation**

Fish are typically starved for 2–3 days prior to export or transport to reduce waste production during transit. A small quantity of fresh water is added to the packing water, and in some cases, sedatives are used to calm the fish during long-distance journeys.

Packing is carried out immediately before transportation. Fish are placed in double-layered polythene bags filled with oxygen and a small amount of water, either individually or in groups, to ensure they remain fully submerged. For short-distance transport, these bags are placed in cardboard boxes, whereas for long-distance shipment they are packed in Styrofoam boxes with ice to maintain a low temperature. Paper layers may be inserted between bags to prevent visual contact and reduce stress, particularly in aggressive species. Packaging techniques have improved significantly over time due to customer feedback, and many exporters now report near 100% survival rates to most destinations, provided reliable connecting flights are available.

### **Setting up of a small-scale hatchery**

Small-scale hatcheries for marine ornamental fish are those where the capital costs and technologies are accessible for relatively low cost which focuses on broodstock development, larviculture, nursery rearing and grow-out to marketable size. The small scale hatcheries can be easily adapted to culture a range of different species. A typical small-scale hatchery for marine ornamental fish consists of the following units and facilities .

1. Broodstock tanks
2. Larviculture tanks
3. Live feed unit
- Nursery rearing and grow-out tanks
4. One sand filter
5. Outdoor live feed (Phyto and zooplankton) production tanks
6. Seawater and freshwater supply system.

### **Hatchery equipment and accessories**

- (i) Water Pump: Two types of pumps are required for the small-scale hatchery operation. A pump of 5HP is required to pump seawater to the hatchery's sand filter tank. A separate submersible pump is required to distribute water within the hatchery system.
- (ii) Generator: A generator of 1 KVA is essential as backup electricity supply for the hatchery.
- (iii) Aeration system: Small 100 watt air pump with at least one backup is needed.
- (iv) Other hatchery equipments

- a. An ordinary microscope.
- b. Thermometer
- c. Salinometer
- d. pH meter
- e. Water analysis kit
- f. Hand nets
- g. Plastic wares like buckets, bins, hoses etc.

(v) Manpower: The small scale hatchery can be managed by two full time staff – One technician and two workers. Basic training on technical aspects is needed for day to-day hatchery operation. Daily routine works include cleaning broodstock and larval tanks, feeding broodstock and larval tanks, harvesting microalgae, rotifers, *Artemia* etc.

### **Advantages of small-scale hatcheries**

- 1. Low capital inputs
- 2. Simple construction
- 3. Ease of operation and management
- 4. Flexibility
- 5. Quick economic returns.

### **Economic Assessment**

The candidate speeis selected for economic analysis is the true clown *Amphiprion percula*.

### **Capital Investment**

This component involves all the expenditure on the infrastructure and establishment of the hatchery. The items included in this component generally have a life span larger than one year and they are used to generate the future income from the hatchery. The items include

| <b>Capital Investment items</b> | <b>Quantum</b>               | <b>Cost in Rupees</b> |
|---------------------------------|------------------------------|-----------------------|
| Temporary Shed                  | 144m <sup>2</sup> (12 X 12m) | 1,10,000              |
| Tanks                           |                              | 6,40,000              |
| i. Broodstock                   | <b>12</b>                    |                       |
| ii. Larval rearing              | 12                           |                       |
| iii. Nursery and grow out       | 18                           |                       |

|                                                            |   |                 |
|------------------------------------------------------------|---|-----------------|
| iv. Microalgae (outdoor)                                   | 4 |                 |
| v. Rotifer (outdoor)                                       | 3 |                 |
| vi. Sand filter /Over head tank                            | 1 |                 |
| Artemia hatching tanks (Transparent Perspex)               | 3 | 10,000          |
| Power installation                                         |   | 10,000          |
| 4 HP diesel pump                                           | 1 | 19,000          |
| 1/2 HP submersible pump                                    | 1 | 6,000           |
| Generator 2 KVA                                            | 1 | 30,000          |
| Air pumps                                                  | 2 | 40,000          |
| PVC piping, plastic wares (water supply/aeration/drainage) |   | 45,000          |
| Netting, miscellaneous etc.                                |   | 40,000          |
| <b>TOTAL COST</b>                                          |   | <b>9,50,000</b> |

### Operating expenses

This component is for the expenses that are spent during each production cycle and are essential for the routine operation of the hatchery. The items included are:

|   | Items                            | 1st year | 2nd year | 3rd year |
|---|----------------------------------|----------|----------|----------|
| 1 | Broodstock fishes/Anemone        | 25,000   | 5,000    | 5,000    |
| 2 | Feeds                            | 12,000   | 12,000   | 12,000   |
| 3 | Artemia                          | 4,000    | 12,000   | 12,000   |
| 4 | Chemicals for microalgal culture | 6,000    | 6,000    | 6,000    |
| 5 | Electricity                      | 36,000   | 36,000   | 36,000   |
| 6 | Diesel                           | 24,000   | 24,000   | 24,000   |
| 7 | Maintenance                      | 12,000   | 18,000   | 18,000   |

|   |                                            |                 |                 |                 |
|---|--------------------------------------------|-----------------|-----------------|-----------------|
| 8 | Workers salaries(1xRs. 8000;<br>2xRs.5000) | 2,16,000        | 2,16,000        | 2,16,000        |
| 9 | Miscellaneous expenditures                 | 12,000          | 12,000          | 12,000          |
|   | <b>TOTAL</b>                               | <b>3,47,000</b> | <b>3,41,000</b> | <b>3,41,000</b> |

### Non-operational expenses

These are related to the capital cost and investment write off. There are two items under this component for small-scale hatcheries.

i) Depreciation

ii) Interest on capital investment

### Technical assumptions for production

It is assumed to be an indoor system located in a coastal area with access to both salt and freshwater and easy transportation access to market. There are 12 broodstock pairs. At any time there are 10 active spawning pairs. Each pair will spawn 2 times per month. An average of 400 larvae are produced during each spawn. The survival rate of the larvae to the grow out phase is 50%. The period from larvae to juvenile is 30 days. There is a 60% survival rate for juveniles to market size, which are saleable. The period from nursery to market size is 120 days. In a month, 240 saleable sized fishes can be produced from one pair of clown fish. Each fish can be sold at a rate of Rs.100. The sale of the fishes will start from second year onwards. The first year of operation will be construction and set up of the building, procurement of equipment and collection and maintenance of brooders. The first spawning is expected in eighth month of first year. The first harvest and sale will occur at the first month of second year.

| Amount in Rs.                                                                                             |        |           |           |
|-----------------------------------------------------------------------------------------------------------|--------|-----------|-----------|
|                                                                                                           | Year 1 | Year 2    | Year 3    |
| <b>Revenue</b>                                                                                            |        |           |           |
| Sale of clownfish fingerlings @<br>s.100/fingerlings(240 juveniles x 10 pair x12<br>month =28,800 numbers |        | 28,80,000 | 28,80,000 |

|                                          |                 |                  |                  |
|------------------------------------------|-----------------|------------------|------------------|
| 28800 x Rs 100 = Rs. 2880000)            |                 |                  |                  |
| <b>Non operating expenses</b>            |                 |                  |                  |
| a. Depreciation (20%)                    | 1,90,000        | 1,90,000         | 1,90,000         |
| Interest rate on capital investment @12% | 78,000          | 78,000           | 78,000           |
| <b>Operating cost :TOTAL EXPENSES</b>    | 2,63,000        | 2,57,000         | 2,57,000         |
|                                          | <b>5,31,000</b> | <b>5,25,000</b>  | <b>5,25,000</b>  |
| <b>Profit</b>                            | <b>————</b>     | <b>23,55,000</b> | <b>23,55,000</b> |

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