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Utilization of fish bycatch in live ornamental fish trade from Kerala, South India

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Abstract

Marine ornamental fish industry is dominated by wild caught reef fishes. In India many potentially ornamental fish species are discarded as bycatches of trawling. A study was planned to investigate the degree of physical damages caused due to trawling and subsequent survivability in a captive environment. About 57 species of fishes belonging to 32 families and 38 genera were recorded in trawl by-catch, of which 8 species had a uniform distribution throughout the study period. The death on arrival (DOA) was high for most species. However, *Epinephelus diacanthus*, *Sufflamen capistratus*, *Scatophagus argus* and *Therapon jarbua* were found to be more sturdy fishes. The major cause of mortality in these fishes was damages especially to body and fins. It was estimated that 36% of fishes entering Ponnani harbour has one or the other form of physical injury. The present study demonstrates a simple technique which enables easy rearing and transport of fishes in live condition from sea to harbour and rearing them under captivity till they are marketed. The study also studies the possibility for developing effective marketing channels based on consumer preference for these fishes ensuring better returns to the fishermen as well as conserving the valuable marine resource.

Keywords: Ornamental fishes, Survivability, Market channel, Recirculation system, Ponnani

1. Introduction

The marine ornamental fish industry has been dominated by wild caught species (98%) especially from coral reefs [13]. Due to restrictions on collection of ornamental fishes from coral reef ecosystems imposed of late, there has been an increasing demand for ornamental fish. A portion of this demand can be met by diversification of fish species. According to data held in Global Marine Aquarium Database a total of 1,471 species of marine ornamental fishes are traded globally [5, 13]. Most of these species are associated with coral reefs although a relatively high number of species are associated with other habitats such as seagrass beds, mangroves and mudflats. The marine ornamental fish trades are directly netted from coral reefs. The use of clandestine methods for wild collection, over harvesting of targeted organisms, high level of post-harvest mortality is in turn causing damage to the reef ecosystem. Although marine ornamental fish trade is very lucrative, the problems involved continue to be complex & requires appropriate management strategies.

The increase in commercial fish production all over the world in the last five decades has been accompanied by an increase in the landings of by-catch and discards. The trawl net is the most destructive type of mobile fishing gear as it is dragged through the sea bottom, gathering a wide array of organisms as by-catch [1]. While in the Western countries almost all the by-catch is discarded, in countries like India by-catch is brought back to the landing centres because of its economic utilities. Recent publications, particularly by the experts associated with the FAO, unambiguously admit to the lack of scientific information on the issue of by-catch and its utilization [3]. In tropical waters, trawl nets can catch over 400 species in their nets [2]. The diversity of species discarded due to trawling in tropical waters would be considerably higher than that in the temperate waters. Most of the fishes landing in as by-catch have potentials to be ornamentals. In India many potentially ornamental fish species are discarded as by-catches of trawling [12, 10]. Hence, not only for sustenance of marine ornamental fish trade, but also for fisheries management definitive solutions to the problem of by catch and discard are elusive. Better utilization of the incidental catch can reduce discards and move them in to ornamental fish trade yields additional income to the fishermen. In some cases, discard rates can be significantly reduced by modifying gear and fishing methods. However,

there is still considerable debate on the effectiveness of many of these devices and gear modifications, especially as it relates to the potential loss of target catch. If the gear modifications have high impact on fishery profits, the implementation of their use becomes very challenging.

Under the above backdrop, a study was designed to develop a strategy to collect, rear and transport potential marine ornamental fishes encountered in trawl catches off Ponnani, a traditional fish landing centre in North Kerala. Efforts were also taken to study the physical damages occurring to these fishes during post-harvest handling and their survivability in captivity. Development of any system for keeping these fishes alive onboard and maintaining them in healthy condition in harbor till they are marketed would substantially improve the income of fishermen. Ultimately the study focuses on developing a steady marketing channel for ornamental fishes caught as by-catch and developing a system for its holding and continuous supply in aquarium fish trade. The project was carried out with active support of fishermen of Ponnani thereby percolating the benefits to the local community by creating awareness and providing training to fishermen on aspects of fish handling, rearing and marketing.

2. Materials and Methods

The study was conducted in Ponnani Fishing Harbour, one of the important fish landing centre in Kerala. Five trawl boats were continuously engaged on a monthly basis to collect fishes on a fortnightly basis during August 2010 to February 2011. The fishermen engaged were trained on matters related to using suitable harvest techniques, onboard handling, assessing of health of fish and steps to be taken for stress free transport of fish to the harbor. For this purpose each boat was provided with a plastic tank of 300 litre capacity and a battery operated aerator for transporting fishes in live conditions. These fishermen were also provided with colour prints of major available ornamental fish species of the region for easy identification after each haul. Once the fishes landed in Ponnani harbor they were immediately transported in aerated containers to the fish holding facility of the MES Ponnani College. In the laboratory, fishes were enumerated, quarantined by giving a quarantine dip in 5% Acriflavine for 10 minutes for removing ectoparasites and other epidermal pathogens. The fishes were then identified up to species level^[9, 6], and stocked in separate tanks based on their compatibility to other species. The data on the area and depth of collection were also recorded. The specimens were observed for fin and body damages, if any. In order to assess the adaptability of these fishes to aquarium environment, Aquarium Suitability Index (ASI) was used^[8]. ASI is a rating from 1 to 5 that gives information on how hardy and how adaptable each species is under captivity. The more the value the better the fish adapts to aquarium condition. Once acclimatized the fishes were transferred to a recirculation system for holding the fishes for a period of six months.

2.1 Recirculation System: Fish holding facilities included a reservoir tank of 3000 litre capacity, ten cylindro-conical rearing tanks of 750 litre and five filter tanks of 300 litre. Separate power heads and aerators were also provided in each rearing tanks. Hence for every two rearing tanks one sand filter was provided. Sea water collected from shore region of salinity above 28 ppt was stored in the reservoir tank for removing silt. After sedimentation of suspended materials, water was filled in to each rearing tanks and aerated

continuously for 24 hrs. The whole system of tanks was kept covered with semitransparent tarpaulin roofing.

2.1.1. Filter: To ensure good quality of water 300 litre fiber plastic tank were used as sand filters. For this purpose a bottom perforated PVC pipe (4") was vertically erected at the centre of the tank. About 1/5th part of the tank was filled with metal rocks, after that sea sand of large particle size added. Remaining half of the tank was then filled with metal and sand. Charcoal was added underneath of the surface layer as it reduces chemical toxicants in water. Plastic pipes of 1/2" diameter was used to ensure continuous inflow of water from culture tank to the filter. A power head (600 litre/hr) erected in to the vertical PVC column, connected with a 1/4" PVC pipe provided regular outflow of filtered water.

2.1.2. Stocking: After the quarantine dip, fishes were sorted based on their size and species and transferred to larger holding tanks. The stocking density was maintained at a rate of 15-20 nos. for larger fishes, 25-30 for medium sized fishes and 35-40 for small fishes. During the point of stocking the types of fishes, their number and external damages, if any, were recorded. Under high stocking density each tanks were provided with additional aerators and power heads. Care was taken to stock fishes based on their compatibility. Hence highly predatory fishes were kept in a single tank. Separate nets are used for each operation in order to avoid disease transmission.

2.1.3. Feeding: Feeding was resumed from the second day. Fishes were initially fed with minced squid and fish twice daily @ 10% of their body mass. Later they were weaned to artificial pellet feeds (prawn grower feeds of Higashimaru Feeds). Water quality parameters were monitored regularly and maintained at optimal levels i.e., temperature at 27-29 °C, dissolved oxygen at 5-6 ml/l, and pH ranging from 7.5 - 8.5. Accumulation of ammonia and nitrite in the tanks were curtailed with routine water exchange (20% weekly) and maintained below 0.001 ppm. During excessive frothing a protein skimmer was operated to remove excess protein formation and bring down total suspended solids. Periodical checking of water was made by using water quality analysis kits.

2.2. Data Analysis: Regular observation on the availability, survivability, and rate of acclimatization to artificial system were taken. The fish health, feed intake and compatibility with other species were monitored during the process. The data so recorded were statistically analyzed using SPSS 17.0 ver. for Windows. Comparisons of mean survival rate for different species and under different periods were done following Duncan's Multiple Range test (DMRT). Based on the results the most appropriate species that had good demand in marine ornamental fish trade and which landed in good quantity in Ponnani and showed better survival in aquarium conditions were selected and their market testing was carried out. For this five marine ornamental fish exporters in Cochin were provided with a regular supply (20 nos) of these fishes under three size groups (Small, Medium and Large). Based on the feedback from these traders the most preferred species and size group was ascertained, thus creating a marketing channel for live ornamental fish trade.

3. Results

During the present study a total of 57 species of fishes

belonging to 32 families and 38 genera (Table 1) were identified from trawl by-catches.

Table 1: Classification of Marine ornamental fishes caught in the trawl by-catch off Ponnani

| Sl. No | Family | Fish species | Common Name | ASI |
|--------|------------------|--------------------------------------|----------------------------|-----|
| 1 | Acanthuridae | <i>Acanthurus mata</i> | Lined surgeon fish | II |
| 2 | Ariidae | <i>Arius seemani</i> | Tete Sea Catfish | III |
| 3 | Balistidae | <i>Odonus niger</i> | Red toothed file fish | V |
| | | <i>Sufflamen capistratus</i> | Masked file fish | V |
| 4 | Carangidae | <i>Caranx melampygus</i> | Bluefin trevally | II |
| | | <i>Pampus argenteus</i> | Silver pomfret | I |
| | | <i>Parastromateus niger</i> | Black pomfret | I |
| 5 | Chaetodontidae | <i>Heniochus acuminatus</i> | Pennant coral fish | I |
| | | <i>Heniochus diphreutus</i> | Longfin Ribbonfish | I |
| | | <i>Parachaetodon ocellatus</i> | Ocellated butterfly fish | I |
| 6 | Dactylopteridae | <i>Dactyloptena orientalis</i> | Flying gurnard | I |
| 7 | Diodontidae | <i>Diodon holocanthus</i> | Long Spined porcupine fish | IV |
| | | <i>Diodon maculifer</i> | Blotched porcupine fish | III |
| | | <i>Diodon hystrix</i> | Spotted porcupine fish | III |
| 8 | Gerridae | <i>Gerres filamentosus</i> | Long rayed silver biddy | II |
| | | <i>Gerres abbreviates</i> | Blue black silver biddy | II |
| 9 | Holocentridae | <i>Holocentrus rubrum</i> | Red soldier fish | III |
| | | <i>Holocentrus ittodai</i> | Japanese soldier fish | III |
| 10 | Lagocephalidae | <i>Lagocephalus inermis</i> | Smooth backed blowfish | III |
| 11 | Lutjanidae | <i>Lutjanus fulviflamma</i> | One spot golden snapper | III |
| | | <i>Lutjanus johnii</i> | Moses perch | II |
| | | <i>Lutjanus ruselli</i> | One spot snapper | II |
| | | <i>Lutjanus kasmira</i> | Blue and yellow snapper | II |
| | | <i>Lutjanus sebae</i> | Emperor bream | II |
| 12 | Menidae | <i>Mene maculata</i> | Moonfish | II |
| 13 | Monodactylidae | <i>Monodactylus argenteus</i> | Silver bat fish | II |
| 14 | Mullidae | <i>Upeneus sundaicus</i> | Ochreband goatfish | II |
| | | <i>Upeneus sulphurus</i> | Yellow goatfish | II |
| 15 | Muraenidae | <i>Gymnothoax rupelli</i> | Ruppell's moray | V |
| 16 | Nemipteridae | <i>Nemipterus japonicus</i> | Japanese threadfin bream | III |
| 17 | Platacidae | <i>Platax teira</i> | Long finned bat fish | III |
| | | <i>Platax orbicularis</i> | Orbiculate bat fish | II |
| 18 | Plectorhynchidae | <i>Plectorhinchus diagrammus</i> | Silver banded sweet lip | III |
| | | <i>Plectorhinchus griseus</i> | Grey sweetlip | III |
| 19 | Plotosidae | <i>Plotosus lineatus</i> | Striped catfish eel | III |
| 20 | Pomadasyidae | <i>Pomadasyus maculatus</i> | Spotted grunter | III |
| 21 | Pomacentridae | <i>Apolemichthys xanthurus</i> | Yellow brown angel fish | II |
| 22 | Priacanthidae | <i>Priacanthus hamrur</i> | Crescent tail bigeye | I |
| 23 | Scatophagidae | <i>Scatophagus argus</i> | Spotted Scat | III |
| 24 | Scolopsidae | <i>Scolopsis vosmeri</i> | White cheeked bream | II |
| | | <i>Pterois volitans</i> | Ornate butterfly cod | III |
| 25 | Scorpaenidae | <i>Pterois ruselli</i> | Russel's fire fish | III |
| | | <i>Epinephelus caeruleopunctatus</i> | White spotted reef cod | V |
| | | <i>Epinephelus fario</i> | Trout reef cod | III |
| | | <i>Epinephelus tauvina</i> | Greasy reef cod | III |
| | | <i>Epinephelus diacanthus</i> | Six barred reef cod | V |
| | | <i>Epinephelus malabaricus</i> | Malabar reef cod | III |
| | | <i>Grammistes sexlineatus</i> | Golden stripped grouper | III |
| 27 | Siganidae | <i>Siganus oramin</i> | White spotted spine foot | III |
| 28 | Sillaginidae | <i>Sillago sihama</i> | Silver whiting | II |
| 29 | Synanceiidae | <i>Synanceia verrucosa</i> | Poison scorpion fish | II |
| 30 | Syngnathidae | <i>Hippocampus kuda</i> | Common seahorse | III |
| 31 | Tetraodontidae | <i>Arothron aerostaticus</i> | Black line blow fish | III |
| | | <i>Arothron leopardus</i> | | III |
| | | <i>Arothron reticularis</i> | Reticulated blow fish | III |
| 32 | Theraponidae | <i>Eutherapon theraps</i> | Banded grunter | III |
| | | <i>Therapon jarbua</i> | Crescent perch | IV |

All these fishes were either ornamental fishes or had potential to be categorized under ornamentals fishes. Most of the families (56%) were represented by a single species. Serranidae represented the family with maximum species

representation (6 nos.). The results of the present study show a rich diversity of ornamental fishes off Ponnani coast. One important observation made during the study was that out of the 57 species encountered, 27 species of fishes succumbed to

the trauma of trawling and subsequent handling and died within 24 hrs of landing in Ponnani harbor. The percentage occurrence of live species that survived beyond 24 hrs in

captivity during the study period and their rate of survival at Ponnani harbor are depicted in Figure 1.

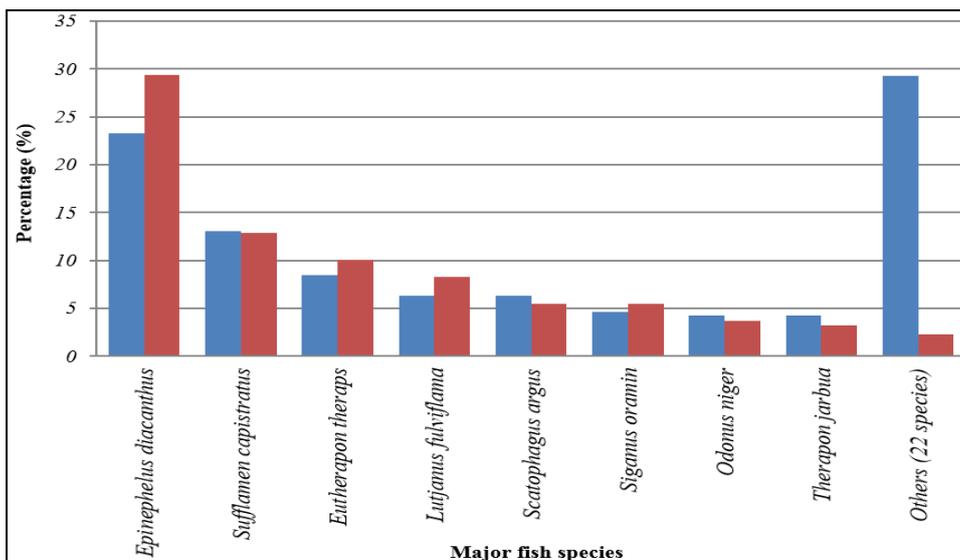


Fig 1: Percentage occurrence and survivability of ornamental fishes landing in Ponnani harbour

Only eight species recorded considerable landings during the study period. Among them *Epinephelus diacanthus* showed better percentage of occurrence and survivability during landing (23.3 and 29.3% respectively). A noteworthy observation was that 22 species that had meager representation in trawl by-catch also had least survivability (2.3%). These observation clearly indicate that only very few ornamental fish species have the capacity to survive the harvesting and post-harvest process of trawling. Results of Aquarium Suitability Index (ASI) indicates that 11% of fishes that landed as by-catches in Ponnani have the potential to be reared as aquarium

fishes. The species diversity observed in the present study is more than that reported by Sureshkumar *et al.* (2004) [12] who recorded a total of 40 species belonging to 22 families and 26 genera. In concurrence to their report there was perceptible difference in the species diversity with depth. Most of the fishes encountered in the present study were from shallow waters similar to report of Sureshkumar *et al.* (2004) [12] who observed maximum occurrence of fishes from a depth of 33-35 m. The trend in the survival rate of different fish species under captive condition in depicted in Figure 2.

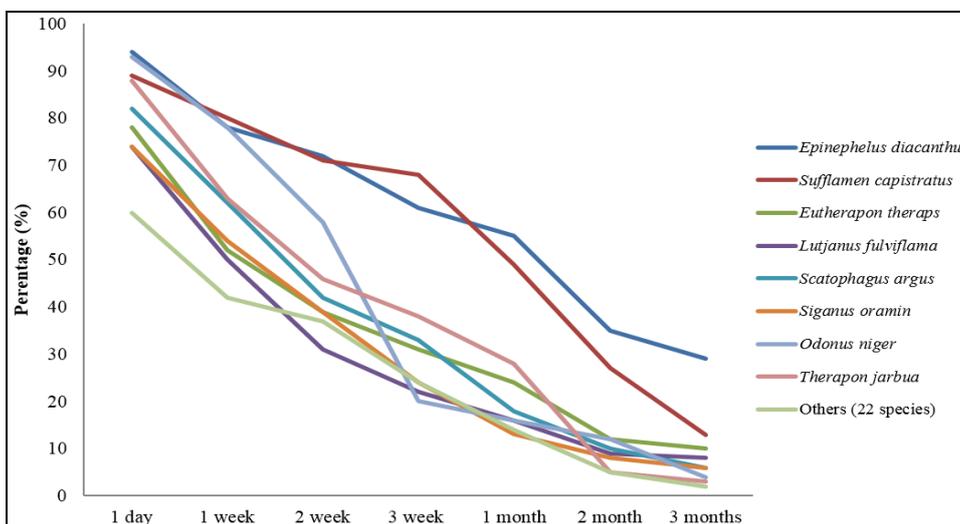


Fig 2: Progression of mean survival rate of major fishes in captivity

The progression pattern shows that for all the species studied there was a significant ($P < 0.001$) decline in the survival rate at the end of three months of rearing. Among the different species a majority were vulnerable to changed environments from the first day onwards, which was noticed by a reduction of survival rate by 60% among these species. Four species i.e., *E. diacanthus*, *S. capistratus*, *S. argus* and *T. jarbua* showed better survivability at different stages of observation. On

further analysis following Duncan’s Multiple Range Test (DMRT) it was observed that except for *E. diacanthus* and *S. capistratus* the mortality rate of all other species increased from first week itself (Table 2). However, there are species that shrank in numbers beyond second week (*L. fulviflamma*), third week (*O.niger*), one month (*S. oramin*) and two months (*T. jarbua*).

Table 2: Results of DMRT analysis on mean survival rate for major fishes during the study

| Fish Species | 1 day | 1 week | 2 week | 3 week | 1 month | 2 month | 3 months |
|-------------------------------|---------------------|---------------------|-------------------|---------------------|-------------------|-----------------|-------------------|
| <i>Epinephelus diacanthus</i> | 94 ^a | 78 ^a | 72 ^a | 61 ^a | 55 ^a | 35 ^a | 29 ^a |
| <i>Sufflamen capistratus</i> | 89 ^{a,b} | 80 ^a | 71 ^a | 68 ^a | 49 ^a | 27 ^a | 13 ^b |
| <i>Eutheron tharaps</i> | 78 ^{b,c} | 52 ^{b,c,d} | 39 ^{c,d} | 31 ^{b,c,d} | 24 ^{b,c} | 12 ^b | 10 ^{b,c} |
| <i>Lutjanus fulviflamma</i> | 74 ^c | 50 ^{c,d} | 31 ^d | 22 ^{c,d} | 16 ^{b,c} | 9 ^b | 8 ^{b,c} |
| <i>Scatophagus argus</i> | 82 ^{a,b,c} | 62 ^{b,c} | 42 ^c | 33 ^{b,c} | 18 ^{b,c} | 10 ^b | 6 ^{b,c} |
| <i>Siganus oramin</i> | 74 ^c | 54 ^{b,c,d} | 39 ^{c,d} | 24 ^{c,d} | 13 ^c | 8 ^b | 6 ^{b,c} |
| <i>Odonus niger</i> | 93 ^a | 78 ^a | 58 ^b | 20 ^d | 16 ^{b,c} | 12 ^b | 4 ^{b,c} |
| <i>Therapon jarbua</i> | 88 ^{a,b} | 63 ^b | 46 ^c | 38 ^b | 28 ^b | 5 ^b | 3 ^c |
| Others | 60 ^d | 42 ^d | 37 ^{c,d} | 24 ^{c,d} | 14 ^c | 5 ^b | 2 ^c |

Means with same letter as superscript are homogeneous

An analysis of the extent of physical damage to fishes due to trawling and post-harvest handling showed that nearly 36% of the ornamental fishes that land as by catch in Ponnani harbour have one type of damage or other. On further analysis, it was noted that majority of injury occurs to the body proper (47%) followed by damages to the caudal and pectoral fins (22 and 15%) respectively (Fig 3).

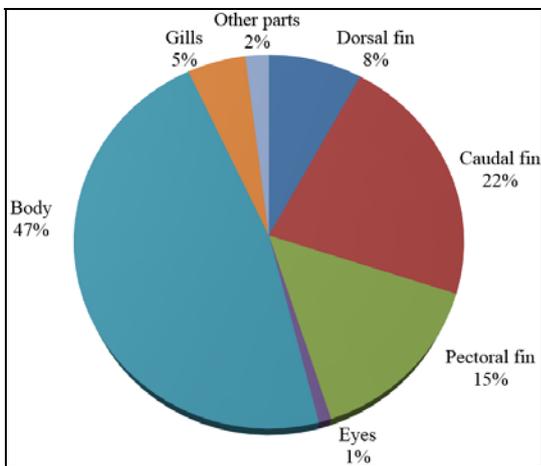


Fig 3: Physical damages witnessed among fishes landing at Ponnani harbour

The reduction of post-harvest mortality therefore plays a central role in the management of the trade. Because tropical fish are transported great distances to overseas destinations, and because many people are involved in their processing, there are a number of possible causes of post-harvest mortality. Schmidt and Kunzmann (2005) [11] have reported

that onboard fish handling results in 10-40% of mortality among ornamentals reef fishes. Injured fish made up a considerable part of the losses. In the present study also a similar value was attained since 36% of fishes have some kind or other type of physical injury resulting in death. This indicates that transport time was not the only factor influencing death on arrival (DOA). Treatment and handling of fish in the period from catch to arrival at the harbor played an important role too. Unlike earlier observations on the percentage of fin damage in the present study a three-fold increase in the occurrence of physical injury was noticed among the bycatch fishes. Marine fish were reported to be inadequately handled and stored in most cases (Gasparini *et al.*, 2005) [4] and mortality immediately after collection and in holding tanks was estimated to be at least 30-40%. The survivability of fishes are different according to the species. The six month trial run of the newly developed fish holding recirculating system proved that it is an effective technology for long term holding of marine ornamental fishes. Generally, it was obvious that a combination of physical injuries were responsible for mortality at the time of arrival, subsequent death were however contributed by other factors. The longer the duration of stay in the rearing system, the stronger the influence of disease-causing bacteria and parasites. This explains the peaks of mortality that were frequently observed to occur after three weeks to three months. The results emerging from the present study indicate the vulnerable period that each fish faces beyond which the survival rate of these fish fall drastically. Hence, through timely interventions if these fishes could be transported to better rearing environment they have a potential to survive well in captivity.

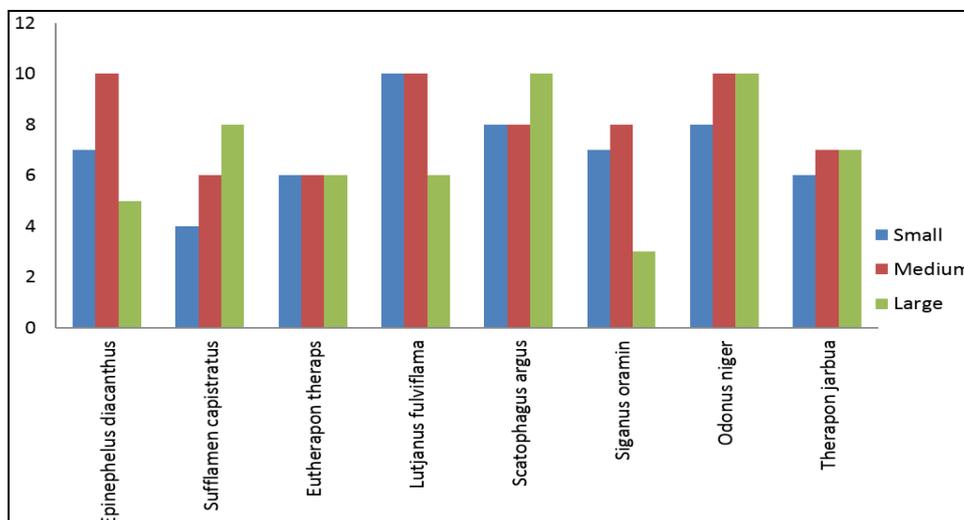


Fig 4: Consumer preference for different marine ornamental fishes

The results of the market survey suggested that the consumer preference varied significantly among the different fishes and their size groups. The consumer preference for each species on a ten-point scale is shown in Figure 4. Results clearly indicate that *L. fulviflamma*, *S. argus* and *O. niger* were the most preferred species. Among size groups preference for small or medium sized *L. fulviflamma*, larger *S. argus* and medium or large sized *O. niger* was high. In terms of return, although all the species were widely accepted among the aquarists the above three species provided maximum price compared to other fishes. Hence the study shows a new possibility for converting the otherwise invaluable bycatch to a more remunerative source for fishermen. Lobo *et al.* (2010) had documented that fishing operation along Coromandel Coast like rest in the country is becoming less profitable and more and more bycatch is now being used to sustain livelihood of fisherfolks. Their study suggests that while reducing waste and improving livelihoods, the increasing reliance on bycatch to sustain the trawl fisheries has the potential to exploit marketable species to the point beyond economic extinction and from which recovery may be difficult. Hence encouraging fishermen to transport fishes in live condition to the harbor and thereby reducing the percentage of fish discards would not only provide an additional source of better income for fishermen, but also help is restoration of more commercially important fish stock on a longer perspective.

The present study showed that *E. diacanthus* and *S. capistratus* are probably hardy fishes, which shows high survival rates and supports farming, whether the fish shows slight damages during the catch. However, there are other species such as *O. niger*, *L. fulviflamma*, *S. argus*, *T. jarbua* and *S. oramin* have great potential to qualify as aquarium fishes. This can be made possible only by intensive rearing of these species under sophisticated recirculating systems and providing a near perfect environment, especially at the end of two weeks of rearing. Development of simple management systems such as these would maintain potential ornamentals fishes in the trawl bycatch alive and in healthy condition in harbor till they are marketed would improve the survivability. Though domestic trade of marine ornamental fishes is still at infancy there is a huge potential to grow. Nevertheless, it is still highly unorganized and unregulated in Kerala. Hence by developing a strong marketing channel a renewed interest among aquarium hobbyist to rear marine fishes can be seen as a reality. The improvement in fish marketing system and distribution would not only reduce the demand-supply gap of aquarium fishes across the state, but would also contribute substantially to the livelihood of over a million fishermen. Development of harbor based retail outlets operated by women self-help groups can drastically cut down the infringement of middle men in the trade. Government can also take steps to develop such centres in every landing centre and harbor of the state through public-private partnership. This would not only help a regular supply of marine ornamentals to both domestic and international trade, but also ensure steady remunerative prices to the fishers.

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