Framework for participatory linkage of marine ornamentals germplasm conservation to livelihoods: Is community aquaculture an inclusive option?

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Periclimenella agattii, marine ornamental shrimp, species new to science,discovered from India.

Mainstreaming biodiversity is becoming the emerging thought globally, a way forward for conservation, management and the sustainable utilisation of genetic resources. Post Convention on Biological Diversity (CBD), the ownership of communities on their biological resources is guided by the Nagoya protocol during 2010, and this implies inclusive sharing of benefits arising out of trade in and utilisation of biological resources. In response to these international obligations, India has addressed the issues on its rich and diverse biological resources through a legal framework called the *Biological Diversity Act 2002*, implemented through an empowered agency, the National Biodiversity Authority. Sustainable Development Goals (SDG) established by the United Nations during 2015 also reflect working along these lines such as SDG 12 Responsible production & consumption; SDG 5 Gender equality and SDG 14 Life below water. In other words, the thrust of the future is on efforts that ensure the conservation of bioresources and at the same time harmonise with nutritional and livelihood securities. To fulfil these goals, programs are required that are science and technology driven and at the same time validated as working models for up-scaling to develop a value chain that has a direct community participation. The present article shares a framework in this direction at advanced stages of implementation for marine ornamental organisms, with researchers and community participation in Lakshadweep and coastal Maharashtra, India. The framework, during a short period since mid-2018, has stretched into a contribution to science, developed propagation techniques for new ornamental organisms, raised awareness and built capacity of communities at grassroots to adapt and produce these organisms. The perspective is of building of a value chain of market ready production and trade of high value ornamental fish and shellfish organisms by communities to supplement family income to vulnerable communities of coastal and island regions and reduce pressure on ecosystems through reduced exploitation, and available policy support and protection. This framework is an initiative of the ICAR-National Bureau of Fish Genetic Resources, Lucknow based on the concept of Live Germplasm Resource Centres. This article gives a brief overview of ornamental fish and shellfish trade in India

and the international level, their needs and how the present strategy is implemented with a synergy between research, policy and communities.

Scope for marine ornamental aquaculture in India and internationally

Ornamentals, the colourful organisms associated with the coral reefs, also play a vital role in sustaining the ecological balance of the marine ecosystem, in addition to increasing the value of the aquarium trade and providing livelihoods to coastal communities. Marine ornamental aquaculture and aquarium keeping is a multi-million dollar industry in both developed and developing countries. Marine ornamentals including fishes and invertebrates are widely collected from the coral reef habitats throughout the Indo-Pacific, as well as in the Red Sea and Caribbean. Fishes, corals, other invertebrates and live rock contribute to the bulk of the trade in terms of quantity and value. The demand for marine invertebrates such as soft corals, sea anemones, shrimps, crabs, and sea lilies are increasing, as a result of the growing interest in keeping home aquaria and technological developments.

The marine ornamental trade is worth US$ 362 million and its value is globally increasing with an average growth rate of 14% per year comprising both wholesale and retail business. Accurate ornamental fish industry data is difficult to obtain, as statistics vary between countries in terms of data collected, format and reliability. The Food & Agriculture Organization of the United nations (FAO) data indicate that, exports were worth approximately USD330 million in 2011 with approximately 1.5 billion fish traded per annum, although according to INFOFISH, the figure was USD364.9 million in 2011. FAO data also reveals the volume of live fish export increased in value from USD 21.5 million in 1976 to USD 315 million in 2007, so it is evident that, the sector is growing.

More than two million people in the world are involved in the ornamental trade as collectors to supply hobbyists including government agencies, airlines, associations and businesses. In general, the trade is dominated by freshwater species; however, the increasing popularity of reef aquaria has become a leading trend, since the late 1980s. Current global trade of marine ornamental organisms from wild sources reveals ecologically unsustainable practices that require immediate policy interventions. It is estimated that, around 90% of freshwater ornamental fishes are captive raised and the remaining 10% are wild caught. However, in marine ornamentals, about 95% are harvested from natural waters, while only 5% are hatchery produced and most of these belongs to the Pomacentridae family. The mortality of tropical organisms prior to reaching the aquarium market (25-80%) is associated with a range of factors, including poor or even destructive collection and husbandry practices, stress and poor shipping, which add to losses from marine ecosystems. It is difficult to estimate the long-term effects of this wild exploitation on vulnerable and fragile reef ecosystems, which already face serious challenges from climate change, ocean acidification and coral bleaching.

Urocaridella arabianensis, marine ornamental shrimp, species new to science discovered from India.

Thor hainanensis, new distribution record to Indian waters.

New distributional and associational records to Indian waters, Argeiopsis inhacae as ectoparasite with Stenophus hispidus.

Captive raised Thor hainanensis, first attempt in India and internationally.

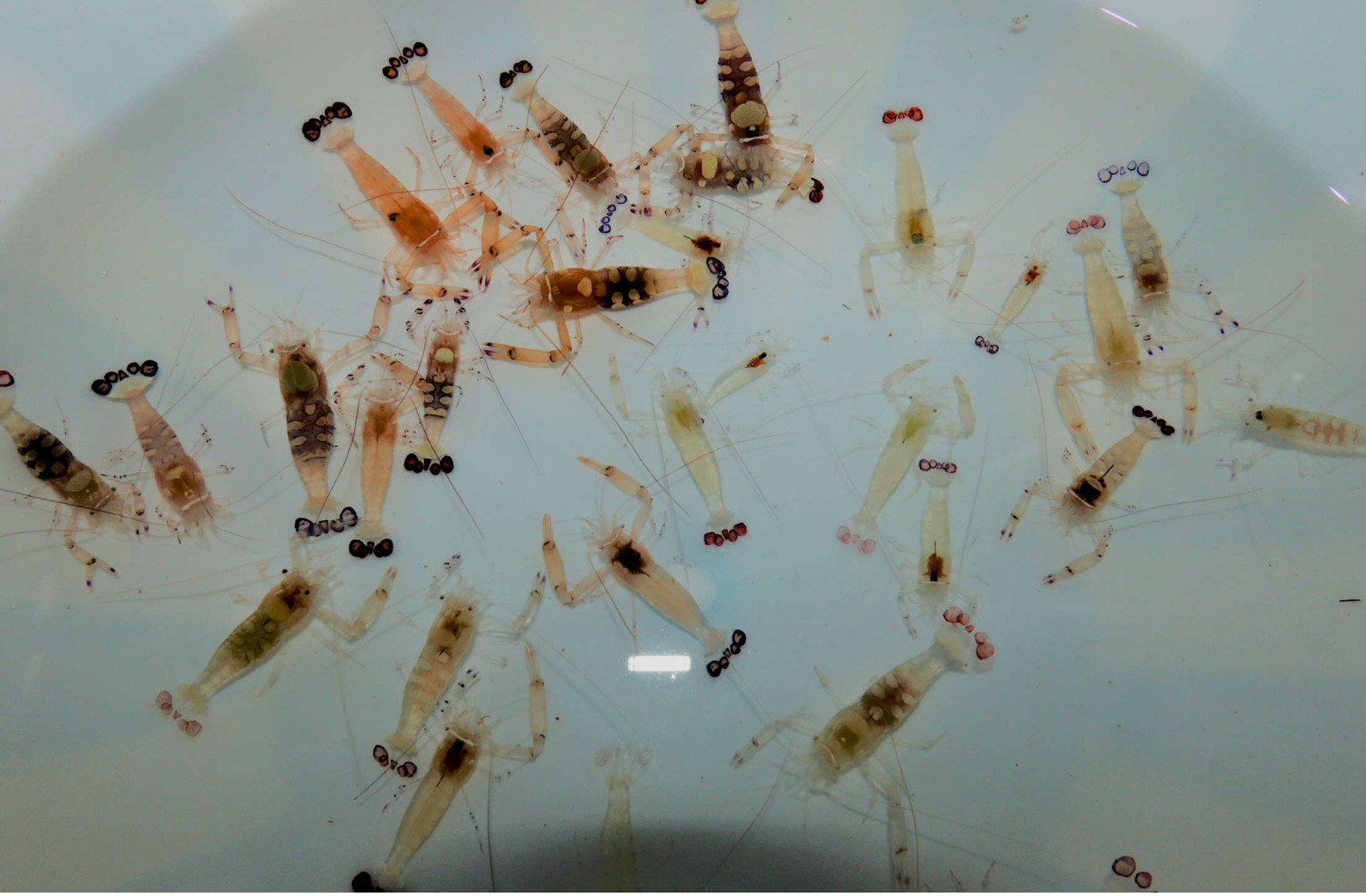
The rapid increase in the demand for fish and invertebrates of marine origin within the pet and hobbyist trade poses a threat of increased harvesting effort on natural resources. Recent developments in marine aquarium keeping has resulted in an over exploitation of natural stock and consequent destruction of reef area. There is a report pointing out that around 3,002 marine ornamental species (2278 fishes and 724 invertebrates) were imported into the US between the 2008-2011. However, there are no clear details about the species available / unavailable in the trade due to the unorganised, multifaceted and fragmented supply chain. The sustainability of this growing industry has been questioned because of controversies associated with its heavy reliance on wild collections.

Conservation of biodiversity in coastal ecosystems depends on the successful resolution of developmental challenges. In general, the coastal and island communities are committed in fishing practices to generate their income with a large number of dependants in each family. Subsequently, there are fishing communities that find themselves in a downward spiral of resource degradation and increasing poverty as overfishing develops. So, some communities lying in the coastal and island belts have turned to exploiting reefs for the aquarium industry as their livelihood.

India is rich in marine biodiversity and ornamental resources, which are abundant in the Gulf of Mannar and Palk Bay in Tamil Nadu, Gulf of Kutch in Gujarat, Malvan coast, in between Maharashtra and Goa, Andaman and Nicobar and the Lakshadweep islands. Our waters contain 400 species of ornamental fishes belonging to 175 genera and 50 families however, only around one hundred species are found in the trade. The exploitation and trade of wild-caught ornamentals are contributing to the national economy, so, it has been considered as a major conservation challenge in biodiversity rich regions of the country. About 500 species of invertebrates other than coral are popular and roughly ten million individuals are traded each year. These include molluscs (gastropods, bivalves and cephalopods), echinoderms (starfish, urchins), actinarians (sea anemones), crustaceans (shrimp, crabs and lobsters) and polychaeta (feather dusters and Christmas tree worms). Of this group, cleaner shrimp of the genus *Lysmata*, boxing shrimp of the genus *Stenopus* and sea anemones of the genus Heteractis compose most of the high value trade among non-coral invertebrates. Still there is no continuous breeding technology for the highly traded groups. Continuous exploitation of these resources from reef regions should be restricted and captive propagated organisms have to be introduced in the trade.

Ornamental aquaculture is usually conducted in closed production systems at a relatively small scale. Breeding of marine ornamentals not only provides an alternative supply for the market, but also provides new information on the reproductive biology and life history of the species. Marine ornamental aquaculture can be an environmentally friendly way to increase supply and reduce pressure on wild populations. Recent advances in hatchery production technology, including improvements in feeding for different life cycle stages will enable more species to be cultured under controlled conditions. However, to date, successful rearing has been scientifically reported for only with few species and less than 1% of marine aquarium fishes are commercially produced.

Since coastal and island community are often financially weak they may depend on seasonal jobs and live around coral and mangrove ecosystems. Therefore, there is an urgent need to develop long-term management strategies for regular employment and routine income generation, with the additional goal of conserving marine living resources. Inadequate alternate livelihood opportunities and insufficient entrepreneurship capacity is one of the causes of development stagnation in rural communities.



Captive raised Ancylocaris brevicarpalis, first attempt in India and internationally.

ICAR - NBFGR initiatives on conservation and livelihood promotion

As a measure towards marine biodiversity conservation and promoting livelihoods to coastal and island communities of the country, the ICAR - National Bureau of Fish Genetic Resources (NBFGR), Lucknow has taken initiatives and designed concepts to validate a replicatable working model for harmonising biodiversity conservation and promotion of livelihoods in the coastal Maharashtra and Lakshadweep islands. Since marine ornamental aquaculture is a source of employment, livelihoods and high foreign exchange earnings; this will be an option to them. Culture of marine ornamental fishes, dissemination of the relevant technologies through training, demonstration and hands-on learning will encourage coastal and island communities to take up this venture. Running a successful ornamental business unit calls for relatively easier skills, which can be learned within few weeks. When there is a major shift in technology and associated process or policy matters, periodic hands-on learning will improve their professional competency. The very nature of industry is well suited for low-income groups, particularly women. A few hours spent every day can earn them an upright livelihood. A well-managed rearing unit can produce quality fishes and shrimps, which fetch higher market prices and India can cater to the burgeoning global demand for marine ornamental fishes.

As an initiative on establishment of a marine ornamental fish village in coastal Maharashtra, a demonstration ornamental fish hatchery has been established by this institute on the premises of the Coastal and Marine Biodiversity Centre of the Mangrove Foundation and Mangrove Cell, Government of Maharashtra, who funded this programme. Ten different Amphiprion species were collected from various reef regions of India, broodstock developed and juvenile production is in progress. The rearing technologies have been simplified with low-cost techniques for the adaptation of community based clownfish aquaculture by the coastal community of Maharashtra. Beneficiaries from Thane, Palghar, Raighat, Ratnagiri and Sindhudurgh districts were selected by the Mangrove Foundation and hands-on training on clownfish aquaculture is being extended to the beneficiaries of three districts. Community based and cluster mode clownfish rearing units were established by the Mangrove Cell with the technical expertise of ICAR-NBFGR and one of the units at Dive Kevani coastal village of Thane district has been stocked with hatchery bred clowns, recently and the villagers are operating the unit nicely. A market linkage / supply chain will be established for selling the clownfish being reared by the beneficiaries.

The ICAR-NBFGR and DBT Germplasm Resource Centre for Marine Ornamental Invertebrates has been established on Agatti Island, Lakshadweep, funded by the Department of Biotechnology, Govt. of India, which is a new approach in the country. The exploratory surveys conducted in different pristine reef islands revealed hidden diversity with discovery of two shrimp species new to science, *Periclimenella agattii* and *Urocaridella arabianensis* and new distributional and associational records, *Thor hainanensis* and *Argeiopsis*

inhacae with *Stenophus hispidus* and the same were published. Over 500 individuals of fifteen species of ornamental shrimps were collected from the wild for germplasm conservation and captive propagation. These fascinating ornamental shrimps exhibit myriad colours, semiotic association with other groups, behaviours and body forms, which make them attractive to the hobbyists, suggesting potential avenues for promoting marine ornamental trade in India, besides supporting the livelihood of the coastal and island communities.

Three species of marine ornamental shrimps namely *Thor hainanensis*, *Ancylocaris brevicarpalis* and *Gnathophyllum americanum* were acclimatised as broodstock and juveniles were raised in captivity for the first time in India and internationally. The rearing technology for marine ornamental shrimps will be transferred to the islanders, once the package of practice is developed. Moreover, the beneficiaries will be motivated to establish backyard rearing units and marketing channels can be directly linked with them to sell the captive reared ornamental shrimps and anemones.

Captive propagation of some of the most collected and traded species would contribute to reliving the current pressure on coral reefs and also for ex-situ conservation of the selected species. This is important to avoid over harvesting of species that potentially disturb the ecosystem due to unauthorised anthropogenic activities. The marine aquarium trade is an excellent opportunity for community-based, conservation-focused aquaculture initiatives in the coastal and island regions. Reducing the exploitation of vulnerable marine ornamental species, aquaculture could relieve much of the conservation concern over their status in the wild. Thus, the way forward can be bio-based interventions and capacity building to the coastal and island people about community based, cluster mode ornamental culture. The present information is outcome of the ICAR-NBFGR initiative taken at Lakshadweep islands and coastal Maharashtra, which is an attempt to develop a working model, which can be replicated for future adaption in other similar places in India or neighbouring countries.

As an awareness creation and hands-on training for marine ornamental shrimps rearing, a campaign was organised at Agatti Island, Lakshadweep during March, 2020 and more than one hundred beneficiaries were actively participated. Currently a batch of twenty women native of Agatti Island are undergoing hands on learning of 30 days duration. In the next four months, a target of over 100 trainees is expected to be achieved, to develop as core mass of entrepreneurs to participate in community aquaculture.

On the concept of harmonising conservation and livelihood, another initiative has established a live germplasm resource centre for clown fish species. Indian waters, east and west coast, harbour 16 species of clown fishes, mostly in coral reefs. This centre at Airoli, Mumbai, established in collaboration with the Mangrove Foundation, Government of Maharashtra, has ten species of clown fish conserved in captivity. This facility also serves as a master breeding facility to produce seed which can be given to trained beneficiaries to establish the value chain of production to trade. This hatchery facility works on recirculatory seawater. Currently, *Amphiprion ocellaris*, is under mass production for use in this community aquaculture program. To achieve the livelihood objective of this program, 150 beneficiaries from the Thane, Palghar and

Below and overleaf: Group of native women participants in the training at the hatchery at Agatti, Laksahdweep Island.

Raighat districts of coastal Maharashtra were given clownfish rearing techniques during different periods in 2019-2020 and cluster mode rearing units in their backyards are ready for stocking the hatchery bred clownfish for further rearing and marketing.

In both programs, the functional target is to conserve wild collected parents in captivity and utilise F2 generation for supplementary income for the families. Mostly, such coastal communities and island dwellers are close to fragile ecosystems, have limited livelihood options and skills and are more prone to adverse impacts of changing climates. The diversified livelihood options and supplementary income can help such communities to remain resilient and at the same time reducing pressure on sensitive ecosystems.

The technological interventions and innovations, validated through direct capacity building involving native communities will help in building a value chain that will enhance family incomes and provide other social tangible benefits such as empowering women, and improving family health and nutrition. The interventions of mainstreaming biological resources with an enabling policy environment will lead to scaled-up production, procedural tools for certification and traceability of the produce, as a part of a framework to protect the interests of native communities. Functional models of mainstreaming biodiversity and the lessons learnt can be shared to establish such programs with an aim of enhancing livelihood options for island and coastal communities, not only in other parts of India but other interested NACA member states.

NBFGR marine ornamental hatchery facility at Airoli, Mumbai.

Beneficiaries stocking hatchery bred clown fishes in their backyard rearing unit at Dive Kevani Village, Thane District, Maharashtra.

Clown fish (Amphiprion ocellaris) raised in captivity at ICAR-NBFGR hatchery at Airoli, Maharashtra, stocked at the beneficiaries unit (previous page).

Conclusion

Germplasm conservation is a potential way to contribute to the documentation of marine ornamentals in coral reef regions. Breeding and rearing of marine ornamentals is a way to mitigate the destruction of marine bio-resources and maintain the ecological balance. Furthermore, hatchery production, adaptation, and supply of marine ornamentals by coastal and island communities will create more employment opportunities in this region and raise the hope of the people and their living standard. The small-scale cluster mode rearing setup requires only a marginal investment, diminutive working area, limited water volume and very minimal personnel.

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References

Compendium of Biological Diversity Act 2002, Rules 2004 and Notifications 2015, 214pp. http://nbaindia.org/uploaded/pdf/Compendium_Book.pdf.

ICAR - National Bureau of Fish Genetic Resources, Annual Report, 2016. 145pp.

FAO. Fisheries and aquaculture statistics and information branch. Global production and trade 1976-2011. 2014. (Available at: http://www.fao.org/fishery/statistics/en).

Ajith Kumar, T. T. and Balasubramanian, T, Broodstock development, spawning and larval rearing of the false clown fish, *Amphiprion ocellaris* in captivity using estuarine water, Curr. Sci., 2009, 97(10), 1483-1486.

Job, S., Integrating marine conservation and sustainable development: Community-based aquaculture of marine aquarium fish, SPC Live Reef Fish Information Bulletin #13., 2005, 24-29.

R. Calado and M. T. Dinis, Collection of marine invertebrates for the aquarium trade in European waters: is anyone surveying? Aquat. Conserv. 2008, 18, 335-338.

Calado, R., Olivotto, I., Oliver, M. P., & Holt, G. J. (Eds.). Marine ornamental species aquaculture. John Wiley & Sons. 2017. 677pp.

Tlusty, M., The benefits and risks of aquacultural production for the aquarium trade. Aquacul., 2002, 205, 203-219.

FAO, State of World Fisheries and Aquaculture 2006, Food and Agriculture Organization of the United Nations, FAO Newsletters: Rome. 2007.