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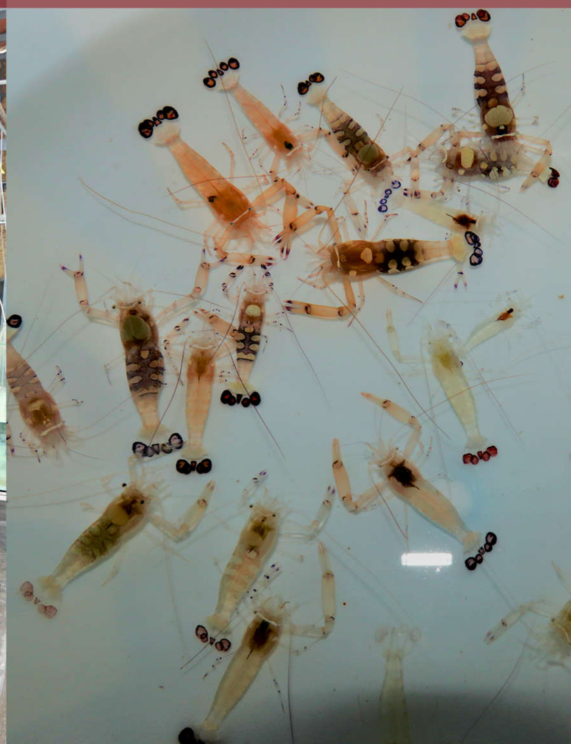
AQUACULTURE ASIA

Marine ornamentals and livelihoods, India

Utilisation of aquatic genetic resources in Asia-Pacific

Major carp model

Breeding endangered carp



AQUACULTURE ASIA

Aquaculture Asia

is an autonomous publication that gives people in developing countries a voice. The views and opinions expressed herein are those of the contributors and do not represent the policies or position of NACA.

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NACA

An intergovernmental organisation that promotes rural development through sustainable aquaculture. NACA seeks to improve rural income, increase food production and foreign exchange earnings and to diversify farm production. The ultimate beneficiaries of NACA activities are farmers and rural communities.

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More online offerings in 2021

Over the past few months NACA has collaborated with participating centres and FAO to offer (or contribute to) webinars and online training courses on mariculture technologies, aquatic animal health and biosecurity, the state of world aquaculture and genetics (details in the October and January newsletters).

These have proved to be wildly popular and we have been greatly encouraged by the number of people participating in our online offerings and by their enthusiasm. It seems that many people find the opportunity to attend free online events quite liberating, and we are pleased to have been able to share experiences with people from every corner of the world.

Although excellent COVID-19 vaccines are now ready to go, the reality is that its going to be a good while yet before they are widely deployed, and movement restrictions are going to be with us for a long time to come.

So, in 2021 we plan to increase our online offerings and create a regular programme of webinars and online training courses. Indeed, it is likely to be the major focus of the network in the year ahead, and probably permanently, given the limitations that travel costs place on physical participation in meetings.

Even if we do return to physical meetings at some point in future, we will continue to offer online participation in parallel to give everyone that opportunity to attend.

2021 will also see NACA experimenting with audio and video production (and let me tell you, its a lot more complicated than you might think!) to be delivered online. While opportunities to record field activities will remain limited, we will start with recordings of technical presentations made during our online webinars and training courses. This is intended to assist those living in different time zones and to serve as training materials on an ongoing basis.

Our flagship event – the Global Conference on Aquaculture – will also be held as a combined online/offline meeting. Since we can't predict what international travel arrangements will look like in September, online registration will be available and the whole event will be streamed live. Details will be announced shortly on the conference website, so please keep an eye on:

https://aquaculture2020.org

Have a great New Year and I look forward to seeing you on the internet.

Simon Wilkinson

AQUACULTURE ASIA

CONTENTS

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

T. T. Ajith Kumar[1], R. Charan[1], Teena Jayakumar[1], L. K. Tyagi[1], N. Saravanane[2], Vindhya Mohindra[1], T. Jaffer Hisham[3] and Kuldeep K. Lal[1*]

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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.

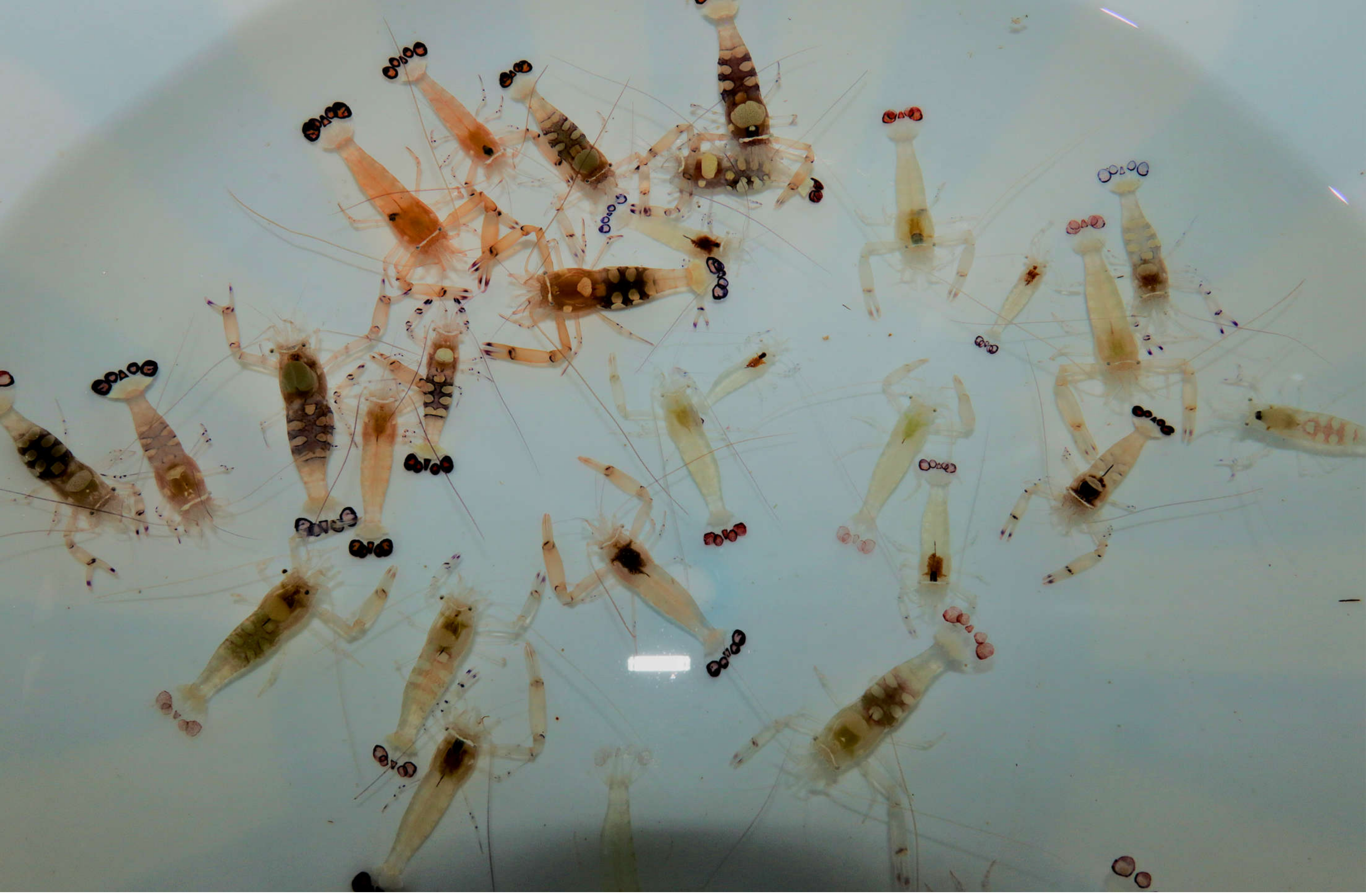
The rapid increase in the demand for fish and invertebrates of marine origin within the pet and hobbyist trade poses a threat of increased harvesting effort on natural resources. Recent developments in marine aquarium keeping has resulted in an over exploitation of natural stock and consequent destruction 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.

Acknowledgements

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Induced breeding of farm-bred and pond-raised critically endangered peninsular carp, *Hypselobarbus pulchellus*

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Adult Hypselobarbus pulchellus.

Puntius pulchellus also called *Hypselobarbus pulchellus* is endemic to the peninsular rivers of India, mainly the Krishna, Godavari, Tungabhadra, Sita and Tunga. It once formed a major fishery of the Tungabhadra reservoir but has declined to the status of a critically endangered fish species. *H. pulchellus* is a bentho-pelagic species which inhabits the deeper part of large streams and rivers along the base of ghats. Pulchellus is considered to be the only indigenous fish consuming aquatic weeds and submerged grasses and this fish could be used in controlling aquatic vegetation in reservoirs, tanks and irrigation canals. Though herbivorous, pulchellus is known to change its feeding habits depending on the availability of food. This fish, which is capable of attaining 8 kg could become a welcome addition to pond culture practices of India, especially for composite fish culture.

The need for diversification of farmed fish species in recent years has resulted in renewed interest in the breeding, propagation and culture of *H. pulchellus*. This has resulted in successful induced breeding of wild stock of this species by the ICAR-Central Institute of Freshwater Aquaculture, paving the way for its introduction to aquaculture systems of the country (Sridhar et al., 2014). In natural waters, the breeding of *H. pulchellusis* reported to commence soon after the monsoon months from September which continued until April with a peak in September and January. However, under pond culture conditions, we obtained first maturity of both the sexes during June-July and breeding of this fish continued till October of the same year. This article gives an overview of the breeding and seed production technologies developed by ICAR-CIFA for farm bred and pond raised *H. pulchellllus*.

Brood stock management

Brood stock was raised from the F1 generation of this fish produced at our research centre through induced breeding of pulchellus collected from the wild and reared under pond conditions. Broodstock ponds of 0.01 ha area were stocked with males and females weighing around 800-1200 g, three months prior to breeding season @ 2000 /ha (10 of each). The ponds were manured initially with cow dung @ 3-4t/ha, 7-10 days prior to stocking. This fish prefers clear waters and a minimum water depth of 1 meter was maintained. Pulchellus has a shoaling tendency and swims in groups and as such it is easy to observe the fish and record any abnormal behaviour/swimming pattern. The fish were fed diet with a formulated diet containing fishmeal (22%), groundnut oil cake (30%), rice bran (38%), finger millet (7%) and vitamin and mineral mixture 92%) having crude protein content of 35%. Feed was prepared as follows. All the ingredients were sieved through a fine meshed screen (0.5 mm) and mixed with hot water to make dough. The dough was cooled, vitamin-mineral mixture added and pressed through a pelletizer to get uniform sized pellets (3 mm). The pellets were sun-dried and packed in air-tight plastic bags till further use.

Selection of brooders

The fish were observed regularly for maturity through periodic sampling. Farm bred fish attained first maturity at 1.5-2 years of age. It was easy to select brooders for induced breeding as sexual dimorphism was exhibited very distinctly by mature males and females. Males during breeding season were distinguished by a dark colour, especially at the abdominal region and a pink snout with prominent tubercles between the eyes spreading to the snout, in contrast to the white and swollen belly, plain and smooth snout and swollen pinkish vent of females. Male maturity was also judged by the production of milt, which got expressed on application of slight pressure on the lateral sides of the abdomen near the vent. The appearance of tubercles in males was seasonal and disappeared after 3–4 months of its onset. Out of the 10 females stocked, 7 attained maturity and were used for breeding.

Spawning

The fish was successfully bred using a preparation consisting of salmon gonadotropin releasing hormone analogue and domperidone (Ovatide). The first injection of the hormone preparation was given to both sexes at a dosage of 0.5 ml/kg body weight. All injections were given intramuscularly between the base of the dorsal fin and lateral line by lifting the fish scale to insert the needle. After injection and withdrawal of the needle the area was gently massaged to aid distribution of the hormone into the musculature and prevent any backflow. The injected brooders were released to the breeding pool of a Chinese hatchery and were allowed to remain there with circulating water and overhead shower running throughout. After 8–12 hours when the belly of the females became soft and swollen the second dose of hormone preparation was administered to both males and females at the same dose given earlier. After 12 hours of the second hormone administration, the fish were anaesthetized by submersing in 25 ppm solution of clove oil. The dry method of stripping was followed. First, the female fish were wiped gently with a dry and clean cloth and held in an inclined position with the head up and the ventral portion over the basin. A slight pressure was applied gently with the thumb and index finger on the swollen belly, slowly descending towards the lower end of the body down to the vent. The fully mature females released a stream of ripe eggs. Immediately after stripping the eggs, the procedure was repeated with the males and the milt directly stripped on to the eggs. The milt was allowed to fertilize the eggs by slow orbital rotation of the basin for a period of 10 min. The eggs were then washed with freshwater, till the washings become clear of the milt. The fertilized eggs appeared bright orange in colour. Since the fish is a batch spawner, the number of ova released per spawning was less (relative fecundity 8,029 + 3,539/kg female) compared to other carps. Further, the fecundity recorded in the present study was lower compared to that reported by Sridhar et al. (2014) for the same species. The difference in the two studies was that Sridhar et al. (2014) used wild collected specimens for developing brooders, while in the present study, the brooders were developed from the fingerlings produced at the Centre. Kulkarni (2000) and Keshavanath et al. (2006) observed that in pond-raised mahseer the fecundity is comparatively low.

Above, male (note prominent turbercles across upper lip); below, female.

Incubation

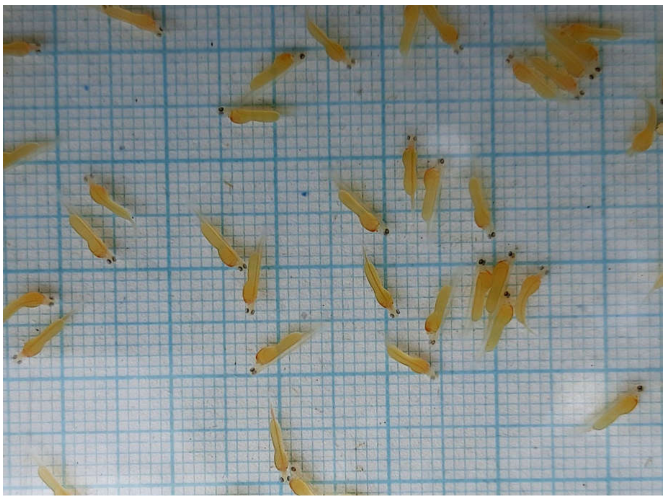
After fertilisation, the bright orange eggs were transferred to a hatching unit specially designed for heavy yolk laden eggs. The unit consisted of a series of rectangular FRP tanks with plastic trays having a synthetic net bottom (1 mm mesh) with continuous flow of water on a re-circulatory mode with necessary bio filters to ensure good water quality. The fertilised eggs were spread uniformly on the trays and a water level of 2 inches was maintained over the eggs. The bad (white) eggs were removed daily. A fertilisation rate of 70.80% was recorded. The eggs attained a size of about 3mm in 48 hours. At this stage


Stripping female.

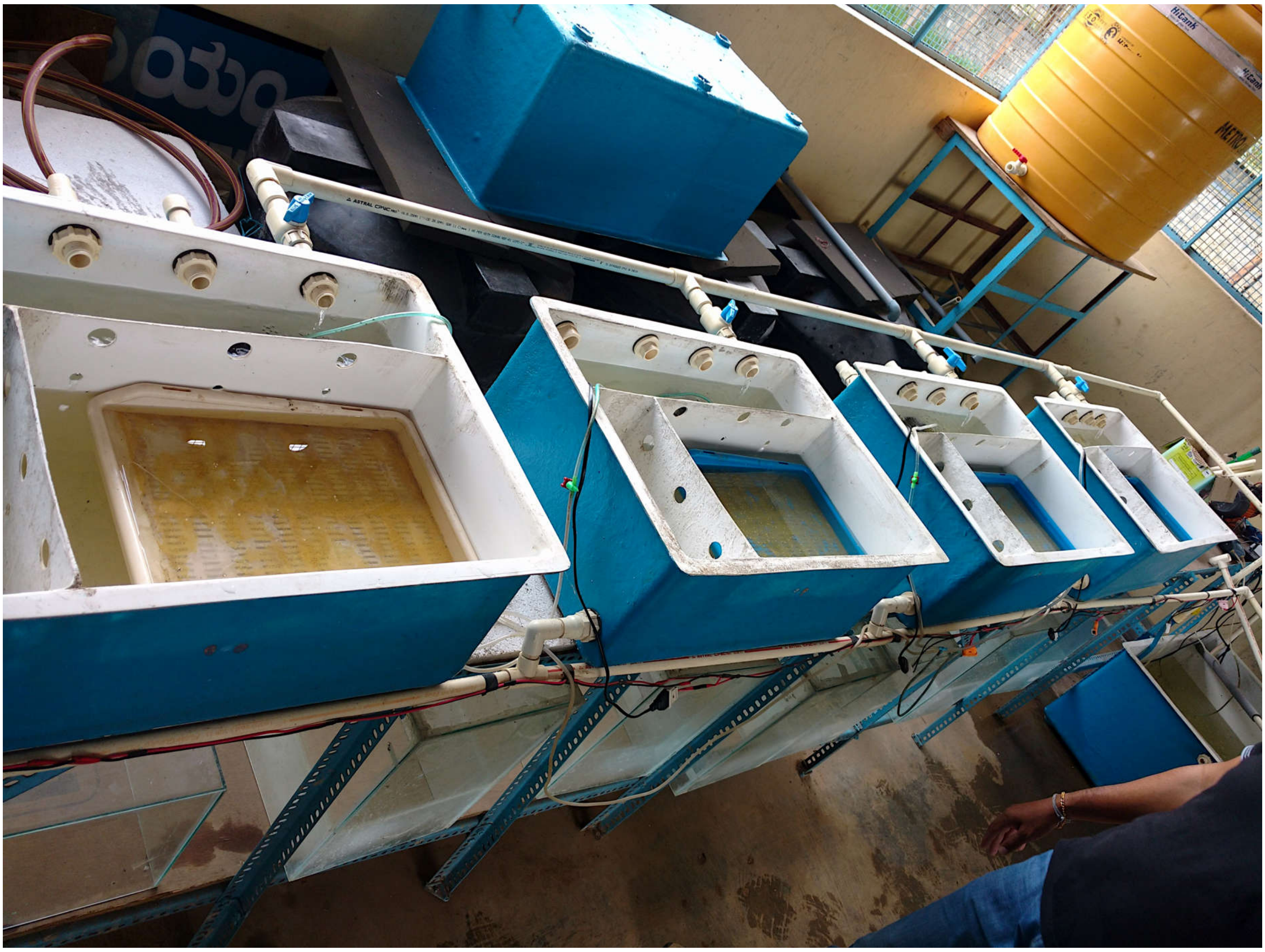

Stripping male.


Fertilised eggs.


Hatching.


Spawn.


Fry.



Recirculatory hatchery unit, note the hatching trays with eggs.

the eggs became translucent and the twitching larvae could be clearly seen inside when examined under an inverted microscope.

The development of the embryos was slow with the elongation of the yolk mass taking about 24 hours at water temperature of 22-24°C. As the embryo advanced in its development, the movements became more vigorous. The first larva hatched out after a period of 48 hours with a heavily laden yolk sac. A hatching rate of 68.06% was recorded. The yolk was completely absorbed at 5-6 days post hatching.

Rearing of hatchlings

After yolk absorption on day 6 post hatching the larvae were shifted to glass aquaria maintained at 26°C with constant aeration @ a stocking rate of 1,000/m3 of water volume and fed with filtered zooplankton for a period of 5 days followed by a combination of filtered zooplankton and finely ground pelleted feed containing 35% crude protein explained earlier, as additional supplementary feed for another 10 days. The dead larvae, if any, along with other uneaten feed and faecal matter at the tank bottom were removed daily before feeding. On every third day one third of the water from the tank was removed and replenished with fresh water. The fry thus obtained, 15 days post hatching, were transferred to nursery tanks for rearing to fingerlings.

Successful breeding of the farm bred and pond raised *H. pulchellus* will have implications on conservation of this endangered species as well as a providing a new candidate species for freshwater aquaculture.

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A way forward for utilisation of aquatic genetic resources in Asia-Pacific: Synthesis from deliberations during the Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration 2019

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The world is facing multiple interlinked problems with cascading impacts. The world population is rising and likely to reach 9.8 billion mouths to feed by 2050. The need for more job opportunities, livelihoods, nutritional security, quality of life and of environment demands an innovative sustainable growth pathway, to check the risk from societal inequalities. In this context, genetic resources are poised to play a significant role in the future and considerable attention must also be given in the various global treaties and actions not only to conserve resources, but to sustainably utilise them, also. This is reflected through the developments after the Convention on Biological Diversity (CBD) and many other instruments, such as Nagoya Protocol, Sustainable Development Goals (SDGs), and Aichi's Biodiversity Targets. The majority of the countries including from the Asia-Pacific region are committed to fulfill these international obligations.

Aquatic genetic resources, unambiguously, are important for enhancing food production and their diversity is important for future food security, especially in view of climate change. These resources are the outcome of natural forces and evolution of biological systems and represent the adaptations to the changing environment happening through millions of years.

Aquatic genetic resources can be propagated to meet human needs. The carbon-based economy, which has been driving economic growth in the industrial era, is dependent upon finite resources, therefore the bioeconomy is now been looked upon as a future source of intensified growth. Hence, it is an important perspective that countries in Asia-Pacific, with rich and diverse biodiversity, need to consider genetic resources for their economic growth and nutritional security. Going forward, technology and knowledge can be major drivers in this movement of enhancing the utilisation of diversity and with minimum risk to the environment.

Utilisation of aquatic genetic resources is a concern

Fish genetic resources have an important place in meeting future food production demands, however, as capture fisheries are stagnant and to meet the additional expected requirement of 40 million tonnes of fish after 2030, intensification of aquaculture production is important. Among all the food production sectors, aquaculture is growing among the fastest at a pace of over 6% globally since 1970, and now contributes nearly 50% to global fish production. Asia contributes over 70% to global fish production and 38% is traded mostly from developing countries to developed countries. This trade is a source of livelihoods in the small-scale farming context, which makes up the bulk of Asian aquaculture. In many Asian countries, per capita fish consumption has reached over 40 kg against the global average of around 20 kg. Aquatic genetic resources are also products of commercial importance.

FAO's Commission on Genetic Resources for Food and Agriculture (CGRFA) has published the Report on the Status of World Genetic Resources Aquatic Genetic Resources with input from 92 nations, including 21 countries from Asia. This report covers all the major fish producing countries. The report emphasises the vast untapped potential which should be a joint concern for all nations. Globally, out of the known 163,588 species, only 554 species (0.003%) are in farming and 1,839 (0.011%) are used through capture. The group-wise details are given in table 1, which shows that the current utilisation of genetic resources is a tiny fraction of the total available potential.

Table 1. Global utilisation of aquatic genetic resources through aquaculture and capture as proportion of total species diversity available.

	Aquaculture	Capture
Finfish	1.09	4.59
Molluscs	0.17	0.28
Crustaceans	0.09	0.28
Other aquatic animals		
Aquatic plants	0.27	0.20

In aquaculture, the species used are still mainly wild types in contrast to other livestock and crop industries where cultivation is based on domesticated and improved varieties developed through human intervention. Genetic improvement is an important issue fundamental to farming. This practice is still very low in aquaculture, as the genetic diversity below the level of species is still inadequately documented and utilised for most of the important aquatic species, particularly in the Asia-Pacific region. The discoveries of species which are new to science is still happening with the increased use of integrated taxonomy. Moreover, some nations are also developing advanced research capabilities for management of aquatic genetic resources. Countries that are rich in aquatic genetic diversity, both at inter and intra-species levels have potential to harness improved benefits from the bioeconomy. In this scenario, knowledge, technological developments, inclusive strategies to manage aquatic genetic resources, enabling environment and policy support can be the key drivers. There will be enormous significance of cross learning and mutual support for technological capacity building. Some of the important perspective elements of bioeconomy with respect to aquatic genetic resources are given in table 2.

Table 2. Elements of bioeconomy based on utilisation of aquatic genetic resources.

Element	Utilisation
Technological innovations & scientific findings from life forms	AqGR as model in medical science Genomic selections for improvement Genome editing Genes & alleles discovered for traits Transgenics
Production, processing & use of aquatic genetic resources	Aquaculture Capture fisheries Processing & trade Commercial & pharmaceutical products Disease diagnostics & management Ornamental fish trade Material & infrastructure manufacturing Services & consultancies

Information and databases to support utilisation of aquatic genetic resources

Aquaculture is remarkably diverse compared to terrestrial livestock industries, involving hundreds of species cultured across a wide range of taxonomic groups, and with constant exploration of new species. However, outside a small handful of mainstays, little is known about most aquatic species in terms of their biology, health, precise nutritional needs, behaviour, ecology and environmental requirements.

As we document and build our knowledge of aquatic genetic resources it is increasingly important to capture data in information systems where it may be searched, accessed, and archived online in perpetuity. There are several ways that information systems can contribute to the sustainable utilisation of aquatic genetic resources:

Documenting biodiversity: Identifying new species with high potential to be farmed; or that would make useful alternative species under some circumstances (eg. due to an environmental tolerance or resistance to a pathogen); or that can fill vacant/underutilised niches in our farming systems and provide supplementary crops.

Documentation of improved varieties: Selecting the best performing genetic resources to develop high performance lines or improve overall performance. In terrestrial agriculture, selective breeding is taken for granted; genetic profiling of dairy cattle and exchange of genetic materials to improve the herd productivity is widely practiced in Australia and elsewhere, using online information systems to share data and select appropriate material.

Documentation of molecular genetics: Markers, sequences, genomes and related data can inform breeding programmes for improved productivity or conservation purposes.

Development and maintenance of such information systems is a large and expensive undertaking, and one that requires an ongoing commitment. However, it is also an endeavour that rewards collaboration and is ideally suited to an international effort, with economies of scale easily realised.

Way forward

To tread on the path of bioeconomy, there is urgent need of strategies, policies and capabilities to enhance the utilisation of species diversity. One of the important aspects of such strategies is prioritisation of resources for use and development of appropriate processes and practices to derive sustainable production and revenues from genetic resources. In this context, the successful Regional Workshop on Underutilized Fish and Marine Genetic Resources and their Amelioration organised by the Asia-Pacific Association of Agricultural Research Institutions (APAARI) is an important milestone. The workshop was organised on July 10-12, 2019, in collaboration with the Sri Lanka Council of Agricultural Research and Policy (SLCARP) and National Aquatic Resources Agency (NARA) in Sri Lanka. About 95 participants from thirteen countries of Asia-Pacific region participated in the workshop. The perspective emerging from this workshop holds immense significance to Asia for two very important reasons: These nations are virtually endowed with diverse genetic resources. Hence, on one side while this genetic diversity between and within species, is an opportunity for diversification and productivity improvement, on the other side the required knowledge generation and technology development for utilisation and conservation is a challenge.

The workshop proved an excellent opportunity to take a birds-eye view of the current status of aquatic genetic resources utilisation in the region, R&D status of priority species, knowledge gaps and most importantly, to identify the opportunities and capacities that are available. The perspectives gained will be instrumental in increasing awareness of the importance of underutilised aquatic genetic resources and to formulate strategies for strengthening their sustainable use at the regional level. This event also emphasised the importance of sharing knowledge, resources, and experience for capacity building, developing research programs on areas of common interests, harmonised policy frameworks on the introduction of alien species, checking biopiracy, access-benefit sharing, implementing international treaties, transboundary disease management and common infrastructures wherever possible for conservation, characterisation and evaluation of resources.

Existing regional networks such as APAARI and NACA, which have played significant role in the past in improving production and income for rural farmers, have a greater role to play in the changing scenario, where productivity and sustainability is the aim. These networks can play a greater role than before in systematic exchange of resources including knowledge and germplasm, sharing experience and capacity so that countries can build on each other's strengths and resolve each other's weaknesses. It is significant to note that some of the countries in the region have developed good capacity and research infrastructure on conservation and management of aquatic genetic resources. This gives an opportunity of horizontal expansion of such capacities through linkages among countries. Active networks can develop linkages such as hub and spoke models for capacity development, where the capacity developed by one nation serves as hub of learning, knowledge sharing and developing research programs with others in areas of common interest. Such programs will help nations to imbibe new technologies and carry out research in a cost-effective manner. Conservation programs, when taken up jointly by nations, will permit conservation of the genetic diversity of species over their complete native distribution, and across political boundaries. Such joint programs are likely to bring opportunities for funding from international donor agencies, which might be attracted to the possible multiple benefits to large populations and ecosystems. It is important to mention that countries with shared water resources also have shared gene pools which are linked by evolution and history.

Epilogue

The strength of the Asia-Pacific region, its rich and diverse biological wealth, is a potential pathway to transform the bioeconomy leading to regional growth supporting the livelihoods and income of farmers, producing safe and certified food, increased revenues through new products and opportunities of trade and social equitability. This transformation will need investments in capacity development of nations, mutual understanding on policy frameworks for sharing knowledge and resources, responsive institutional frameworks, research, and new technologies and opportunities for effective linkages between researchers and industry within the region and to global planning and development processes.

Cast nets: The dominant active fishing gear in the Kashmir Valley

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The State of Jammu and Kashmir falls in the great north-western, complex of the Himalayan ranges with marked relief variation, snow- capped summits, antecedent drainage, complex geological structures and rich temperate flora and fauna. Kashmir or the Jhelum Valley is situated between the Pir Panjal range and the Zanskar range. The average height of the valley is 1,850 metres above sea level but the surrounding mountains, which are always snow-clad, rise from three to four thousand metres above sea level. The surface of the valley is plains and abounds with springs, lakes and health resorts.

Kashmir Valley is bestowed with abundant water resources in the form of high altitude lakes, wetlands, rivers and springs and the geophysical conditions offer a great scope for fish to thrive. There are about 1,248 water bodies in the valley, of which lakes cover about 32,765 hectares (Raina, 2002; Sodhi et al., 2013). These harbour diverse species of fish both endemic and exotic in nature of which the predominant ones are snow trout, Chinese carps, and introduced trout. Although the fisheries sector in the Kashmir valley has enormous potential, which could ineluctably contribute to the GDP of the valley, it is yet to gain the required pace. While fishing is limited to harvesting and selling, aquaculture is in its infancy stage (Malik et al., 2018).

The huge water resources of the area play a compelling role in the socio-economic and cultural development of a large section of the population in the valley (Malik et al., 2018). At the national level fisheries form an important instrument of livelihood for a large section of the economically disadvantaged population of the country. More than seven million fishers in the country depend on capture fisheries and aquaculture for their livelihood. The story of Kashmir valley is no different as around 70% of the total population has adopted agriculture as a primary source of occupation, of

which 15% substantially has fisheries as a principal source of income (Qureshi et al., 2013). The existing fish production from Jammu and Kashmir is around 20.7 thousand metric tonnes, and the volume of fish production over a decade has varied between 19-20 thousand metric tonnes (Statista, 2019). The fisheries sector contributes around 0.48% of India's total freshwater fish production and 31% of total cold-water fishes produced in the country (Qureshi et al. 2016). The major share is from capture fishery wherein fishes are harvested from natural or open water bodies employing different types of harvesting crafts and gears. The different types of fishing gears employed in Kashmiri waters are gill net, long line, cast net, pole and line, scoop net, spears, and bag nets. The major and most commonly used is the cast net.

Cast nets

Cast nets are conical shaped; falling gear with weights attached at regular intervals on a lead rope with lengths varying from 4.20- 7.11m (Azeez, 1997). Such nets are narrow at the top and wider at the bottom to cover a large area of water. The weights on the net typically weigh around 5-7 kg. However, their weight can exceed 10-15 kilograms when loaded with squirming fish (Syed, 2018). The cast net typically has four panels and is usually made of monofilament nylon, polyethene (PE) and polyester (PES). PA twine with specifications 210 × 2 × 2 are used for the construction of cast nets in Trandava Reservoir, Andhra Pradesh (Rajeswari et al., 2015). The use of a cast net requires great skill to deploy the net efficiently, covering a large area. The durability of cast nets ranges from three months to three years with good care (Emmanuel et al., 2008). These nets are ideal for collecting fish in shallow habitats and for supplementing impoundment collection (Meador and Kelso, 1990; Stevens, 2006). They are cast from boat or shore and catch fish by falling and closing on them (Nedelec, 1982). The catch per fisher on each fishing operation can be 5-8 kg (Udolisa and Solarin, 1979). However, this gear has certain limitations such as being difficult to deploy, small area coverage and having a low catch efficiency (Leber, 1995; Emmanuel et al.2008).

In Kashmir, cast net is locally known as zaal, and cast nets are one of the dominant active fishing gear types in Dal, Wular, and Manasbal lakes of the valley. They are also known by names such as *gol zal*, *naushath zal* or *bahshath zal* (Syed et al., 2016). The nets here are circular and made of nylon and cotton thread; generally, the fishermen use nylon cast nets. The size range used is typically between 1.0 to 2.0 m in diameter, varying from 1.2 to 3.0 cm bar to bar. The nets are equipped with iron or lead sinkers of about 5.0 kg weight around the periphery (Dar et al. 2014). In Dal Lake, two types of cast nets are operational based on mesh size, i.e., large mesh (4.55±0.21m total length) and small mesh (4.13±0.31m total length) for capturing different size groups of the fish (Syed et al., 2016). In Wular Lake cast nets in use are known by different vernacular names such as *guran thap jal*, *yhap thap jal*, *naushuth jal*, *naskhul jal*, *pouch kul*, and *nor* (Dar et al.,2014). The dimensions, period of operation, species of fish caught by this net in different water bodies of Kashmir valley are given in the tables.

Conclusion

The fisheries sector of Kashmir valley is contributing to a great extent to the economy of the valley. It provides valuable foreign exchange and employment to thousands of people. At the same time it is an instrument of livelihood for a certain section of population of the valley. More than 10% of population in the valley depend on capture fisheries and aquaculture for their livelihood. Kashmir fisheries form an important component of the national fisheries with valley being the largest producer of coldwater fish in the country. The share of valley fish production to the national fish production has increased to a great extent. Since the major chunk of production is from capture fisheries a change of mindset is the need of hour as the resources, being limited, will exhaust soon if the pace of fishing is not capped. More aquaculture operations should be brought into practice to keep fish production growing at the required pace to meet the demands of the growing population. The use of technologically sound and environmentally friendly gears along with modern scientific, energy efficient farming methods will suffice the same. At the same the use of traditional fishing gears must not be side-lined. The most promising traditional gear in this direction is the cast net owing to its easy operation, size selectivity and affordability as well as durability.

Table 1: Typical specification of cast net used in Wular Lake.

Local name of the gear	Gol zal
No. of fishermen	1
Total length of net (m)	5.01 ± 0.22
Material of webbing	PA Multifilament
Specification of webbing	210D×2×2/210D×6×3
Colour of webbing	White
Mesh size of webbing (mm)	43 ± 1
Selvedge mesh no.	21.87 ± 5.82
Selvedge mesh size (mm)	64 ± 7
No. of pockets	91 ± 114
Length of pockets (m)	0.36 ± 0.03
Sinker per pocket	3.9 ± 0.1
Length of sinker line (m)	5-8
No. of sinkers	3.9 ± 0.1
Distance between sinkers (mm)	38 ± 3

Table 3: Typical cast net specifications used in Dal Lake.

Local name of the gear	Gol zal, naushath zal and bhahshath zal
Total length of net	4.55±0.21
Material of webbing	PA multifilament
Specification of webbing	210D × 6 × 3/210D × 2 × 2
Selvedge mesh size (mm	46.25 ± 2.39
Sinkers per pocket	3 ± 0
Material of sinker line	Polyethylene
Diameter of sinkers (mm)	5-8
Length of sinkers (m)	23.65 ± 0.50
Number of sinkers	337 ± 3.32
Material of sinkers	Lead/iron
Weight of sinkers (g)	32.5 ± 5.95
Diameter of sinkers (mm)	13.75 ± 1.25

Table 2: Typical specifications of different local types of cast nets operated along the Wular Lake, Jammu & Kashmir.

Local name	Length (m)	No.	Mesh size (mm)	Operation	Species of fish caught
Guran thap Jal	3.20	9	10	May-August	Latus-latus, *Puntius*, *Chonchonius*
Thap thap jal	4.5	9	10	August-Nov	Latus-latus, *Puntius*, *Chonchonius*
Naushuth jal	4.0	6	15-30	Whole year	*Schizothorax* and *Cyprinus carpio*
Naskhul jal	5.79	7	30	June-Sep	Fish weighing more than 100 g
Pouch kul	7.62	8	50	April-June	Fish weighing more than 500 g
Nor	3.66	7	25	Running water	*Schizothorax* species

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Moyna model of major carp farming in Purba Medinipur District, West Bengal, India

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Major carp farming in West Bengal and Andhra Pradesh

Major carp culture accounts for 80-85% of total inland fish production. West Bengal is the second largest producer of table-sized fish in India, next to Andhra Pradesh; with production amounting to 1.773 million tonnes in 2018-2019. West Bengal leads in hatchery-oriented fish seed production, which amounted to 22,691 million fry in the same year. In Andhra Pradesh, Krishna, West Godavari and Nellore districts are primary carp culture areas and the predominant centre is in and around Kolleru Lake. Grow-out ponds are often 0.4-4 ha in area but may extend up to 40 ha[1]. 'Bigger is better' for grow-out ponds, with an average of about 8.1 ha, and the optimum range considered to be around 10-20 ha[2]. The Kolleru system is the dominant production model for Indian major carp culture in India, termed 'yearling-based culture' which has proved highly profitable for Andhra Pradesh farmers. Large, stunted yearlings/stunted carps of 50-150 g are stocked in grow-out systems.

In West Bengal, progressive fish farmers mostly practice commercial carp farming in leased ponds. They prefer to produce sub-adult fishes that are harvested and transported live to market. In 254 treated domestic wastewater-fed fish culture ponds i.e., the East Kolkata Wetlands covering 3,944 ha, fish are harvested in 3-4 months to avoid bioaccumulation risk. The majority of Andhra Pradesh farmers harvest major carps at table size, whereas in West Bengal, major carps are mostly harvested as advanced fingerlings and juvenile fish because of high demand.

Purba Medinipur is the largest (in quantity) table-size major carp producing district out of 23 in West Bengal and uses large-scale production systems as followed in Moyna Community Development Block. In Moyna, suitable fish farming plots are taken on lease by fish farmers and the area of a single water body is comparable to conventional fish ponds with typical sizes in the ranges 6-8 ha, 20-21 ha or even 48-56 ha, although they may be less deep than a typical pond. State-of-the-art of carp farming at Moyna is the same as in Andhra Pradesh, aiming to produce large sized major carps from big, shallow water bodies in a modified extensive system.

Moyna fish production system as model

Moyna town is 90 km from Kolkata city via road. This block was declared as a fishery hub in West Bengal by the State Government and the 'Moyna Model' accepted as an example for freshwater fish culture throughout West Bengal. Moyna is a great example of the freshwater fish culture revolution in West Bengal and a new horizon for culture of the major carps. Moyna fish farmers have adapted the procedures of Andhra farmers incorporating their own blend of experience,

Larger Indian major carp fingerlings (80-100 g).

skill and technology. Its repute has spread to different parts of West Bengal and neighbouring states. The unique kind of pisciculture in vast tracts of water bodies is practiced in 55-60 villages out of 81 in 11 Gram Panchayats in Moyna and some neighbouring blocks. Many commercial carp culturists at Moyna produce major carps of 1.2-2 kg in seven to eight months.

As considerable success has been achieved, the Hon'ble Chief Minister, West Bengal, dignified state-of-art of carp farming at Moyna as an official Fishery Model. The State Fisheries Department adopted it as a flagship model and pilot project in September 2017 to boost production of farmed table size major carps in other districts of West Bengal and reduce imports. About 150,000 tonnes of table fish are brought to West Bengal annually from Andhra Pradesh, Madhya Pradesh and Odisha, mostly major carps with 80,000 tonnes supplied from Andhra Pradesh (Srikakulam, East Godavari). Every day not less than 15-20 trucks loaded with approximately 100 tonnes of major carps are sent to Kolkata market from Andhra Pradesh and other places[3]. Emphasis is now being given to achieving self-sufficiency, increasing local production and meeting consumer demand for table size carp within West Bengal; hopefully farmers here will be able to meet demand following this model. Fish farmer beneficiaries in West Bengal will receive technical assistance and input support aiming for a production target of 8,000-10,000 kg/ha/year. With reference to the Moyna Model, there is good scope for cultivating large carps; 150 g fingerlings will weigh about or more than 1.5 kg after 6 months. This practice will contribute to rural socio-economic upliftment and nutritional and livelihood security.

Rainwater stagnation in fields

Moyna is bordered by the Kansai/Kansabati rivers in the north and east, the Chandiya River in the west, the Keleghai River in the south and the Baksi canal in the north. Out of 26 community development blocks in Purba Medinipur, Moyna first gets inundated during incessant rain and flood. As a basin, water accumulates here during rain in the surrounding blocks. River water flows into Moyna from the end of May and remains 8until January[4]. Villages highly-affected by water stagnation (between 0.9-1.0 m depth) are Mathurichak, Harakhulibhandarchak, Balbhadrachak, Kalagechia, Panchpukuria, Gourangachak, Mathurapur, Baitalchak, Kripanandapur, Dakshin Ankha, Uttar Ankha, Laluageria, Dakshin Moyna, Chrandaschak and a few others. Extended low-lying fields unsuitable for Aman and Boro paddy cultivation have proven to also be conducive environments for carp farming. Jute, paddy and betel leaf are traditionally grown at Moyna, but the increasing commercial importance and popularity of farmed major carps, a more profitable venture,

Carp farming water body at Bhagabanpur Block.

have exceeded others. Flood water from Khirai River enters paddy plots every year but increasing annual losses in paddy due to floods have led to leasing out of the majority of lands to commercial fish farmers.

Beginning of fish farming at Moyna

Once farming of paddy varieties such as raktapani kalas, sadapani kalas, gadahuta, aamol, kalamocha, banshkaati, bhuto were well-known in Moyna, and propagation of naturally-grown fish such as *Clarias batrachus*, *Mystus* sp., *Channa* sp, *Anabas testudineus*, *Tilapia* sp was done simultaneously with paddy farming, with fish harvested at the onset of winter. Paddy was produced 2-3 times a year. However, in 1995 commercial major carp farming started in conjunction with deepwater paddy in standing water fields during mid-June to December. In agricultural fields taken on lease for carp farming, fishes under culture didn't harm growing paddy and fields were dewatered during their harvest. Both paddy and fish farmers benefitted. Over time, due to the fast growth rate and success of organised paddy-cum-fish farming with fingerling stocking and feeding, the practice has also flourished outside Purba Medinipur.

Individual plots are in production at villages including Gopalchak (505 ha), Dakshin Changrachak (50.5 ha), Janakichak (8 ha), Mathurichak (65.5 ha), Charandaschak (40.4 ha) and Baitalchak (60.7 ha), traditionally used for rice culture by some 1,100 farmers. Simultaneous kharif paddy and major carp farming is conducted after flooding by the monsoon rain, beginning in June/July[5]. From 2002 onwards, paddy plots in Annapurna Village started to be leased out solely for carp farming to highest bidders for 3-5 years. Many farmers paid 3,000-4,000 INR as a yearly lease for every 64 m^2 land, started this vocation, dug out earth in paddy fields to increase depth and hold more fish. It spread to almost all villages in Moyna; presently about 200 fish farms exist covering about 7,000 ha. Vast fish farming plots are densely located at villages Gojina, Ramchak, Bakcha, Tilkhoja, Paramanandapur, Noichonpur and others. Around 2005 and earlier, the flood-affected people of Moyna sought shelter in other districts. Since the recent past, the majority of flood-affected villagers have found a new source of livelihood via fish culture in such areas, i.e., large lowlands with continuing rainwater stagnation. Owing to high profitability in carp culture, most paddy fields in Moyna have turned to 'fish ghery' (a vernacular term for big freshwater bodies). It started on large scale in 2011-12. Paddy-cum-fish farming continued at Janakichak until 2008.

At Moyna, embankments are strengthened on all sides of ghery to prevent the entry of flood water within. After two successive crops, black bottom mud is removed to avoid dissolved oxygen depletion in the next one and ploughed to oxidise material that will cause harmful gases. Freshwater is channelled into gherys from river/canals via sluice gates up to depths suitable for fish farming. After liming, 50-150 g carp fingerlings are stocked @ 15,000-30,000/ha. Harvest begins once fishes reach 500 g and above on 100-120th day of stocking (Courtesy: FEO, Moyna Block). Banks and the slope of some gherys are covered with large plastic sheets all around extending into the water column to prevent erosion.

Case studies at Moyna

State-level awardee progressive farmer Sri Jhantucharan Middya, Village Bakibhandar Chak possesses two farming plots of 81 ha and 69 ha respectively at Bakibhandar Chak and Ramtarak in adjacent Sahid Matangini Block. Earlier, paddy was cultivated here but it was spoilt by medium to heavy rainfall in most years and was not profitable even during good production. Landowners now earn from people like Sri Middya who ventured into pisciculture in 2001-2002 making Rs 1,000,000/- annually as income after subtracting the amount invested. He determined to elevate himself to the standards of Andhra farmers in table fish production and proceeded ahead[6].

His Indian major carp fingerlings are stocked twice a year and reach 500-600 g in four months with proper feed and medicines (at times of need). Such fishes are in good demand. He explained that the profit margin will reduce if the fish are raised to 900-1000 g. Fish growth is retarded during winter months in West Bengal unlike Andhra Pradesh, where it is consistent throughout year with higher winter temperature (warmer winter), favouring growth. Many fish farmers in Moyna produce carp yearlings (90-100 g) and earn a good profit by selling to grow-out farmers, who in turn are benefited as yearlings have an almost 100% survivability, exhibiting fast growth in large water bodies once stocked. Sri Chandan Bera at Paramanandapur has two fish farming water bodies of 26.7 ha and 29.9 ha respectively, taken on lease and makes a profit of Rs 3,800,000/- from the first plot alone in a year6. In October 2016, author had an on-site conversation with three fish farmers namely Sri Debtosh Moni at Purushottampur, Sri Dipankar Barman at Putputir Math and Sri Dibakar Mal at Charandaschak villages[7]; growth of their fish as obtained is mentioned in Table 1.

Groundwater exploitation for fish farming - an issue

At Moyna, many fish farming water bodies/ghery(s) have been established near rivers and wide canals to intake fresh-water when in need and maintain depth during post-winter, pre-summer and summer months. But a lack of adequate

Harvested carps from D. Barman's ghery under oxygenation, before transportation.

Medium-sized carp culture pond.

Stunted IMC fingerlings (yearlings 150-200 g).

Pelleted floating major carp feed (3mm diameter).

Sri D. Barman, Sri D. Moni and author at Moyna.

Tin-built boat for aquaculture works on bank of a ghery.

An extended fish farming water body at Moyna.

Fish farmers from Jharkhand on bank of large ghery at Moyna.

Table 1: Growth of Indian major carps in water bodies of D. Barman, D. Moni and D. Mal, Moyna Block.

Farmer	Village	Water area	Size and time of stocking	Size and time of harvest	Fish feed used	Crops / year
Dipankar Barman	Puthputia	6.87 ha	*Labeo rohita* and *Cirrhinus mrigala* 100-150 g each *Catla catla* 200-250 g March	*C. mrigala* and *L. rohita* 600-650 g *C. catla* 1.5 kg End of July	Commercial pellets Farm-made formulated feed	2
Debtosh Moni	Purusottampur	5.27 ha	*C. mrigala* 50 g *L. rohita* 60 g *C. catla* 100-120 g June	*L. rohita* 450-500 g *C. catla* 1.2-1.5 kg *C. mrigala* 400 g November	Farm made formulated feed	2
Dibakar Mal	Manuakhali	56.6 ha	*C. mrigala* *L. rohita* *C. catla* 125-140 g each	*C. mrigala*, *L. rohita* and *C. catla* 500-600 g each; 60th-75th day of stocking	Farm-made Commercial floating pellets	4

water supply is felt. Gherys have been newly formed in villages Radhaballavchak, Kanchichak, Mathurichak, Jagirchak, etc in Gokulnagar Gram Panchayat of Moyna, quite far away from rivers and canals. Here, submersible pumps are set up and groundwater extraction is indispensible to sustain carp farming. Groundwater intake into gherys is practiced in villages Mathurapur, Donachak, Sudampur, Uttar Chengrachak, Dakshin Chengrachak and others and loaded in trucks during live major carp transportation from Moyna. Questions have been raised against incessant groundwater extraction and ongoing carp culture activity in certain villages. Fish farmers possessing gherys located far from the river face water shortages and year-round carp farming is prevented.

Water replacement during live table fish transportation.

If fish farming done all year round, instead of for 7-8 months and water requirement met, 60-70 tonnes of table fish will be produced annually from gherys in Moyna. Use of submersible pumps for drawing groundwater for pisciculture will be prohibited. To supply water into these vast fish farming plots regularly throughout the year, the West Bengal Government is examining ways to bring freshwater in, particularly from the lower 87 km stretch of the Rupnarayan River (about 10 km east from Moyna) through connecting canals/pipelines at Moyna when required.

Other issues and way forward for sustainability

Economic analysis of fish culture for carp farmers Sri Moni, Sri Barman and Sri Mal in monetary terms and estimating the strengths, weaknesses and deficits in detail have led to some measures, suggested to make the activity more effective8. Farmers should get more production and income in terms of money invested for inputs (production cost); production is high but not at par to investment. Many are producing carps @ 3,500-6,500kg/ha/year, which must be improved. Farmers must increase planktonic food production in water bodies in addition to the use of commercial pelleted fish feed. Stocking of Indian major carp fry together with larger fingerlings, heavy stocking (that will retard fish growth), application of raw poultry droppings, left over chicken viscera and animal skin by-products in fish farming water bodies, use of anti-parasite agents in water and antibiotics with carp feed - such activities must be completely debarred. After determining the real valuation of all inputs used by Moyna pisciculturists, fish farmers will be benefitted if a project for 1 ha water area is formulated considering expenditure. A special loan strategy can be introduced with some facilities (also financial support from Government).

Fish markets at Moyna

Annapurna fish market at Moyna is one of the biggest in West Bengal, where the auction of fishes is conducted at 9.00 pm, midnight and 3.00 am every night. About 50 tonnes of fish is bought and sold here each day in a season, which commences after the Durga Puja festival[6]. Fish are transported via wholesalers. About 36,000 tonnes of table size carps is supplied from Moyna every year to different districts of West Bengal, to Bihar, Jharkhand and Chhattisgarh (Courtesy: FEO, Moyna Block), to fish markets at Patipukur, Howrah, Chinsurah, Srirampur (in Hooghly) and other places. Auction and wholesale fish markets grew up steadily at Moyna owing to the increase in farmed carp production; fish merchants are involved in trade from 4.00 pm to 4.00 am. There are 18 fish auction shops in Annapurna market, 70-75 in Moyna Block including Balaipanda fish market and 8 in Moyna market[4]. About 20,000 people are directly or indirectly involved with carp farming activities in gherys in Moyna Block.

Moyna Ramkrishnayan Association - helping Moyna pisciculture to prosper.

Epilogue

The individual area of quite a few gherys at Moyna exceed 81 ha or more. With a production target of 12,000kg/ha/year, the Government of West Bengal in the end of 2017 decided to provide input and technological support to fish farmer beneficiaries in different districts excluding Purba Medinipur where the Moyna model of carp farming be replicated. Scientific organic-input oriented fish farming has begun at Moyna and is flourishing (Courtesy: Official of Moyna Fishery Association). Rajendrapur wholesale market at Naihati, North 24 Parganas (one of the biggest in India for many kinds of fish seeds), Ramsagar in Bankura (widely known for carp hatcheries and quality spawn supply) and now Moyna - as if Vedic 'Matsya Yagya/Yajna' is performed with popularity in these places, which occupied a distinct place on the fisheries map of West Bengal.

With trust, fish auctioneers at Moyna lent lump sum amounts of money to fish farmers as a source of funds, on condition that after 4-5 months, these farmers have to bring the entire harvest to the disposal of the auctioneer, and must supply at a low rate. In order to get lease of a field-turned-waterbody, the farmer as renter takes out a loan from the local fish wholesaler/auctioneer to cover the cost of lease and required inputs. The author observed gherys 0.9-1.2 m deep, newly constructed within 30-45 days on the side of railway tracks between Mecheda and Panskura stations in Purba Medinipur. Another 4,500 ha of large water bodies in addition to 7000 ha have been encompassed in 'big' carp production systems in neighbouring blocks namely Sabang, Panskura, Pingla, Tamluk, Bhagabanpur and Nandakumar in Purba Medinipur and Paschim Medinipur districts, each being 3.2-8.1 ha. The new term 'jheel byabsa' (commercial carp culture in big water bodies) has emerged. In addition to carps, *Penaeus monodon* and *Litopenaeus vannamei* farming is practiced in villages south of Moyna. About 1,000 fish farmers at Moyna, mostly women, have formed a farmer-producer company. Women started *A. testudineus* and *Heteropneustes fossilis* farming in shallow earthen or concrete wells and backyard ponds; culture of *Pangasianodon hypophthalmus* is done in semi-derelict ponds (Courtesy: Sri Sasanka Maity, Secretary, Moyna Ramkrishnayan Association).

Thirty-three fish farmers at Moyna have organized themselves into the Moyna Vivekananda Fishermen Co-operative Society Ltd at Janakichak village; active since its registration in September 2003 (Courtesy: Dr Swapan Kr. Barman, Asst. Professor, P. K. College, PM). It took a lease of the 33.1 ha ghery in Janakichak for fish culture4. Indian major carps of 1,500-2,000 g can be produced in six months if *C. catla* (250 g), *L. rohita* (150-200 g) and *C. mrigala* (100-150 g) are stocked at 150-200 : 400 : 200 in every 0.13 ha water body (Courtesy: Janab C. Muzammal Hoque, ADF, South 24 Pgs). After overcoming the COVID-19 pandemic induced lockdown and crisis period since 3rd week of March 2020 in West Bengal, transportation of fresh table size major carps (90-100 fish-loaded trucks/day or 60-70 tonnes fish/day) has resumed from the end of July from Moyna, Mahishadal, Sutahata, Haldia Blocks of Purba Medinipur to Howrah, Asansol, Siliguri and other markets in West Bengal and in Bihar, Odisha, Jharkhand. Before lockdown, about 300 tonnes of freshwater fish on average were transported daily from Purba Medinipur to different places within and outside West Bengal. With restoration of expected income to normalcy, fish farmers in Purba Medinipur are able to buy fish feed in bulk and repay bank loan. In West Bengal, since the very recent past, table sized carps produced in West Bengal itself have been considered superior by consumers over imported ice-laden fish. Andhra-produced *L. rohita* and *C. catla*, 1-3 kg, are now sold in West Bengal @ 120-130 INR and 140-180 INR / kg respectively but fresh ones produced in West Bengal are sold @ Rs 150-180 INR and 200-220 INR / kg (C. catla 2-4 kg) respectively.

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13th Technical Advisory Committee

The 13th meeting of the Technical Advisory Committee (TAC) was held via video conference from 26-28 August 2020. Participants were welcomed by Dr Huang Jie, Director General of NACA. The meeting was Chaired by Dr Yuko Hood, from the Department of Agriculture, Water and the Environment (Australia).

Participants included experts from 13 member states, the Regional Lead Centres for India, Thailand and the Philippines, inter-governmental agencies including INFOFISH, WorldFish and the Food and Agriculture Organization of the United Nations, plus Shanghai Ocean University and the Yellow Seas Fisheries Research Institute, China.

The purpose of the meeting was to review the previous five-year plan and propose revisions to aid formulation of a draft Five-Year Strategic Plan (2020-2024), to be tabled for consideration at the next Governing Council Meeting. Participants were invited to speak on their views as to priority and emerging aquaculture development issues in the region. Issues that are of common interest to several governments form the basis for development of collaborative activities. Several of the key issues are highlighted below.

Unsurprisingly, COVID-19 dominated proceedings, due to the profound impact the pandemic has had on the market and logistical chains, and consumers at every level. To date, discussion of the impact has tended to focus on somewhat superficial analysis of trade and sales data, while many of the impacts may be the knock-on effects of bottlenecks in logistics and transport networks and storage. Of particular concern, analysis of the socio-economic impacts on small-scale farmers and poor rural communities is lacking, although clearly the impact has been very heavy, with declining production, falling farm gate prices and many reports of forced harvests. The Secretariat proposed to convene an online consultation for members to share experience on relief measures that have been implemented for small-scale farmers and their relative effectiveness, to assist in supporting the sector and building resilience going forward.

TAC 13 marked the first time that the ageing farmer population has been raised across a wide range of member states, including both developed and developing economies. There is a common region-wide trend of young people leaving agricultural communities to seek alternative employment elsewhere. Many members states have implemented training and education programmes and demonstration farms to try and encourage young people to take up farming, but the sector is often seen as a high-risk and low-income by young people. Governments need to find ways to increase the attractiveness of the sector to new entrants.

Climate change is now a regular feature of all NACA consultations, including the TAC. The growing urgency to address this issue, while ensuring food security is leading some states to investigate the use of more intensive, controlled environment production systems such as recirculating systems, in-pond raceways and use of “smart farm” technologies that offer the potential to improve production efficiency, in terms of resource consumption per unit production. It was noted the culture-based fisheries also offer a largely untapped opportunity to improve local food security in a low emissions manner, harnessing the natural productivity of water bodies (ie. without feeding).

Aquatic animal health remains a high-profile issue, and several member countries are now actively working to bolster local seed production to reduce dependence on imports and reduce the risk of transboundary disease transfer, especially with regards to crustaceans.

Presentation of the State of World Aquaculture and Regional Aquaculture Reviews 2020

In preparation for next year’s Global Conference on Aquaculture (22-27 September 2021, Shanghai), a series of webinars will be held on topics relevant to the sustainable development of aquaculture. The first of these will be a presentation of advanced (pre-final) versions of *The State of World Aquaculture 2020* and six regional review papers, which will be held during the week of 26–29 October 2020.

These reviews provide up-to-date information on the status and trends of the sector, at regional and global levels, developed from national, regional and global datasets, supplemented with expert opinion and literature reviews. The reviews can be of pertinent interest and use to national governments, regional organisations, policymakers, aquaculture farmers and other aquaculture value chain actors, investors, civil society organisations, research and training institutions as well as the general public.

These webinars will be convened by FAO, in partnership with NACA and the World Fisheries Trust. For each review, a presentation of key messages will be followed by a panel discussion. Question and answer sessions provide opportunity for interested parties to comment on the reviews, ahead of their final publication.

The webinars will be held via Zoom (you must install the free Zoom software client) and registration is required to participate. The schedule and registration links are available at:

https://aquaculture2020.org/reviews/

Online Training Course on Mariculture Technologies for the Asia-Pacific Region

The Yellow Sea Fisheries Research Institute, Chinese Academy of Fisheries Sciences and NACA organised an online training course on mariculture technologies from 21-25 September 2020. Over 150 people attended from diverse countries and backgrounds, including government officials, researchers, enterprise managers and technicians.

The course was opened with welcome remarks by Dr Jin Xianshi, Director of the Yellow Sea Fisheries Research Institute, Mr Simon Wilkinson (on behalf of DG NACA), and Dr Liu Yingjie, Vice President of CAFS.

The programme covered breeding, disease control and prevention, nutrition and feed research, breeding model construction, farm technology development, engineering, quality, safety and inspection technology for aquatic products. Specific topics covered included:

- Aquaculture in China (Dr Wang Qingyin).
- Surveillance plan and biosecurity system for shrimp farming (Dr Huang Jie).
- Introduction to the Yellow Sea Fisheries Research Institute (Dr Xu Jiakun).
- Global aquaculture development status and technology innovation (Dr Yuan Xinhua).
- Aquaculture of Sea breams (Dr Liu Xinfu).
- Theory and technology of *Porphyra* culture (Dr Wang Wenjun).
- Cage mariculture in China (Dr Cui Yong).
- Breeding and culture techniques of *Apostichopus japonicus* in China (Dr Liao Meijie).
- Viral nervous necrosis of teleost fish (Dr Shi Chengyin).
- History, current status and prospect of shrimp culture in China (Dr Wang Xiuhua).
- R&D and application of rapid detection kits for aquatic pathogens (Dr Zhang Qingli).
- Progeny production and culture technology of marine fish (Dr Xu Yongjiang).
- Seafood products processing (Dr Cao Rong).
- Clinical treatment technique and its application on major shrimp diseases (Dr Wang Yingeng).
- Theory and technology of *Saccharina* culture (Dr Liu Fuli).
- Treatment of aquaculture wastewater with constructed wetlands (Dr Cui Zhengguo).
- Development of coastal integrated multi-trophic aquaculture in China (Dr Zhang Jihong).
- Best management practices for feeds and feeding / lipid nutrition for fish aquaculture (Dr Xu Houguo).
- Health management in grouper aquaculture (Dr Eduardo Leano).

The course was taught in English, with question and answer sessions after every session and a group discussion and presentations by participants on the final day. Participants that completed the five days will be awarded a certificate (in process). Audio and video recordings of the lectures will be published on the NACA website in due course. Links will be announced in the next newsletter.

The NACA Secretariat would like to express our sincere thanks to the Yellow Sea Fisheries Research Institute and Chinese Academy of Fisheries Sciences for developing the programme and sharing their expertise, they clearly put a great deal of effort into the course, and we appreciate it.

This course was in fact NACA's first step into online training, and we were very pleased with the level of interest and the enthusiasm of the trainees. Over the coming months, NACA will offer further webinars, training and discussion opportunities on a range of subjects, which will be largely technical in nature. The details will be published on the NACA website and the newsletter in due course.

Quarterly Aquatic Animal Disease Report, January-March 2020

The 85th edition of the Quarterly Aquatic Animal Disease Report contains information from nine governments. The foreword provides a disease advisory concerning decapod iridescent virus 1 (DIV1), an emerging threat to the shrimp industry.

Free download from: https://enaca.org/?id=1116

Regional Webinar on Infection with Decapod Iridescent Virus 1 (DIV1) and Preparedness for Emerging Shrimp Diseases

The shrimp industry has been beset by many devastating diseases in the last three decades, which have caused severe production and economic losses and even caused the collapse of the industry in some countries. Recently, emerging shrimp viral diseases have threatened the shrimp industry. For example, the virus, formally named decapod iridescent virus 1 (DIV1) by ICTV, has caused mortality in farmed Pacific white shrimp (*Penaeus vannamei*) and giant freshwater prawn (*Macrobrachium rosenbergii*). The virus infects all stages of shrimps and has also been observed to infect crayfish (*Cherax quadricarinatus*).

China extended its National Targeted Surveillance Program to cover DIV1 since 2017 and revealed that DIV1 had been detected in 9 out of 15 provincial administrative regions. Positive cases have been reported in the wild populations of *P. monodon* caught in the Indian Ocean. In June 2020, Taiwan, Province of China reported the disease in crayfish and shrimp farms. The geographic distribution of DIV1 may be wider than currently known, since mortality may not have been investigated in other countries or regions.

In order to provide updated knowledge, recommendations, and emergency preparedness for DIV1 and other emerging shrimp diseases, NACA organised a public consultation, the Regional Webinar on Infection with Decapod Iridescent Virus 1 (DIV1) and Preparedness for Emerging Shrimp Diseases, which was held online from 10-11 September 2020. The webinar was attended by 403 people from around the world.

The regional consultation was undertaken with the primary objectives of discussing and planning actions for the prevention and management of the disease. Specific objectives were to:

- Provide updated technological information on DIV1.
- Advocate the strengthening of diagnostic capacities as well as active surveillance of DIV1 (to detect presence or absence of the virus).
- Formulate recommendations on sanitary measures (including biosecurity) for disease prevention.
- Promote emergency preparedness for emerging diseases.

Audio and video recordings of selected presentations will be made available on the NACA website in due course. Links will be announced in the next newsletter.

China announces import measures to respond to nucleic acid positives of COVID-19 detected from the outer packaging of frozen white leg shrimp from Ecuador

According to CCTV news, the Joint Prevention and Control Mechanism of the State Council of China held a press conference on the afternoon of 10 July. At the meeting, Mr Ke-Xin Bi, Director of the Import and Export Food Safety Bureau of the General Administration of Customs, informed that in order to prevent the risk of introducing COVID-19 through imported cold chain foods into the country, Customs had launched inspections for novel coronavirus in imported foods.

As of midnight on July 9, China's Customs had inspected 227,934 samples, including 43,964 product samples, 147,568 inner and outer packaging samples, and 36,402 environmental samples.

On 3 July, Customs in Dalian detected nucleic acid positives of COVID-19 in one of the samples collected from the inner wall of containers of the frozen white leg shrimp produced with Ecuadorian registration No. 24887 and three outer packaging samples of the frozen white leg shrimp produced with Ecuadorian registration No. 681.

On the same day, the Customs in Xiamen detected nucleic acid positives of the novel coronavirus in two samples of frozen white leg shrimp produced with the Ecuadorian registration number 654. Nucleic acid tests of the shrimp body and the internal packaging were both negative, and all the other 227,928 samples tested negative.

Experts believe that the positive results did not represent infectious virus, but reflected that food safety management systems in the relevant enterprises were not in order. In order to protect the health of consumers, the General Administration of Customs decided to suspend the registration of the relevant Ecuadorian enterprises, suspend the import and export of the products of the relevant enterprises, and take measures such as the return of goods and destruction of goods temporarily detained.

According to the current knowledge, 2019-nCoV cannot infect aquatic animals, but the virus or its nucleic acid may contaminate products during farming, harvesting, processing, packaging, and shipment. The announcement of China's Customs clearly indicated the positives were only detected on the inner walls of a container and the outer packaging materials with a positive rate of 0.0027% over 147,568 packaging samples. No positive was detected in the over 43,964 product samples themselves and the 36,402 environmental samples. It is speculated that the positives were contaminated by infected packers for outer packaging or porters, but not from the aquatic animals or the processing chain. As cold chains will protect the inactivation of virus or the degeneration of the nucleic acid, cold chain products will have a higher possibility of being detected after contamination with the virus. Basic biosecurity and food safety measures should be strengthened in handling and processing during the pandemic. Workers infected with 2019-nCoV should not be involved in the production chain of aquatic products until recovery. Any susceptible animals, such as bats, cats, minks, civet, etc., should be kept away from cold chains and products. Necessary disinfection measures should be strictly implemented.

NACA would like to remind our members to strengthen safety management systems in the manufacture of aquatic products during the COVID-19 pandemic. It is reasonable to quarantine products from regions with an outbreak of COVID-19, but the public does not need to fear or be cynical about aquatic products. In contrast, with high contents of quality protein, high unsaturated fatty acids, and micronutrients, eating more aquatic products will better improve human immunity to prevent the disease.

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Translation of the Notice No. 81 of 2020 by the General Administration of Customs, the People's Republic of China: Notice on suspending the registration of three Ecuadorian manufacturing enterprises in China

From http://www.customs.gov.cn/customs/302249/2480148/3185285/index.html

Customs recently detected six nucleic acid positives of the novel coronavirus from the samples collected on the inner walls of containers and the outer packaging of frozen shrimp imported from three Ecuadorian enterprises, including Industrial Pesquera Santa Priscila S.A. (registration No. 24887), Empacreci S.A. (Registration No. 681), and Empacadora Del Pacifico Sociedad Anonima Edpacif S.A. (Registration No. 654). The test results of both the shrimp body and inner packaging samples were negative. Through nucleic acid sequence analysis and expert judgment, the test results indicated that the container environment and packaging of the products of the three enterprises were at risk of being contaminated by the novel coronavirus, and that the food safety management system of the enterprises was not fully implemented. In order to eliminate risks of the hidden dangers and protect the health of the people, in accordance with the provisions of the Food Safety Law of the People's Republic of China and its Implementing Regulations, as well as relevant customs regulations, the following announcement is made:

1. The above three enterprises shall be suspended from registration in China.

2. The import of the products of the three enterprises mentioned above shall be suspended, and the import declaration of the products of the three enterprises shall be suspended.

3. The importer shall immediately recall the frozen shrimps produced by the above three enterprises after March 12, return the frozen shrimps temporarily detained by the customs after March 12 and destroy them, and provide the import and sales records of the goods to customs at the place of import. In case of refusal to implement the provisions, Customs shall deal with them in accordance with the Food Safety Law of the People's Republic of China and its implementing regulations, as well as relevant customs rules.

This announcement shall come into effect as of the date of promulgation.

This is to announce.

The General Administration of Customs, People's Republic of China

On July 10, 2020

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NACA is a network composed of 19 member governments in the Asia-Pacific Region.