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AQUACULTURE ASIA

Pathway to aquaculture biosecurity

Transition from fisheries to aquaculture

Empowering women

Transgenic tetras

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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AQUACULTURE ASIA

Genetic sequence data: A powerful tool, but not a genetic resource

The Convention on Biological Diversity (CBD) plays a crucial role in safeguarding the planet's biological resources. However, classifying genetic sequence data as a "genetic resource" equivalent to DNA or biological samples and so on under the CBD will hinder scientific progress and impede the sharing of vital information.

Open and accessible data sharing is the cornerstone of scientific advancement. Genetic sequence data is generated through collaborative efforts by scientists across the globe. It is a fundamental tool in modern biological research, enabling scientists to better understand genetic diversity, track disease outbreaks, and develop innovative solutions for the common good. Consider the role that sharing of sequence information played in the global effort to develop COVID-19 vaccines.

By considering sequence data as a genetic resource under the CBD and related instruments, we risk stifling scientific progress. The classification raises the prospect of states asserting ownership of sequence data, and will likely subject it to restrictive regulations, hampering data sharing among researchers and limiting cross-disciplinary collaborations that are vital for breakthroughs in areas such as conservation, medicine, and agriculture.

Recognising genetic sequence data as a genetic resource may lead to complex disputes over intellectual property rights. Currently, the scientific community relies on open-access databases that allow researchers to freely search for, access and analyse genetic information. If the information is subjected to regulatory controls, these databases might be subject to licensing agreements and proprietary claims, creating unnecessary barriers and inhibiting scientific innovation. Such barriers disproportionately impact developing countries, that lack the means to pay.

The primary objective of the CBD is to conserve biological diversity. However, genetic sequence data, by its nature, facilitates research and enhances conservation efforts by providing valuable insights into genetic variation, aiding in the identification and preservation of endangered species, and guiding habitat restoration initiatives. How then, will restricting access to it advance these goals?

Viewing genetic sequence data as an entity separate from genetic resources would better align with the objectives of the CBD. Genetic sequences are more properly considered 'metadata', ie. data describing some other resource. Metadata facilitates the characterisation, search, and discovery of resources.

By recognising genetic sequence data as a shared global asset rather than a genetic resource to be owned, we encourage international cooperation in research and development. Collaborative efforts to address pressing global challenges, such as emerging diseases or climate change, require unfettered access to genetic sequence data. This unrestricted flow of information would lead to accelerated progress in understanding the intricacies of life and developing innovative solutions for the benefit of all nations.

It is essential to acknowledge the unique nature of genetic sequence data and treat it as a powerful tool that promotes scientific advancement, conservation efforts, and international cooperation. By maintaining an open and unrestricted approach to sharing this data, we can collectively harness the potential of genetic sequence data to tackle the complex challenges facing humanity in the 21st century.

Simon Wilkinson

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Pathway to aquaculture biosecurity: Mitigating risks, managing progressively and engaging the value chain

PMP/AB Technical Working Group

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Management of aquatic organism health by national, regional, international and multistakeholder cooperation is necessary to sustain the growth that has been achieved" – a resolute appeal for global action made at the turn of the Third Millennium, barely 25 years since aquaculture was recognised as an industry sector. To ensure they were not ignored, "Management of Aquatic Animal Health" was enshrined in the Strategy for Aquaculture Development beyond 2000 adopted by the Conference on Aquaculture in the Third Millennium in 2000 (FAO, NACA, 2000) and reinforced in the two global aquaculture conferences that followed (Phuket 2010 and Shanghai 2020) (FAO/NACA, 2012; FAO, NACA, 2021).

As health management gained relevance and urgency, two essential pillars were introduced by FAO, WOAH, NACA, and industry and academic partners: risk management and aquatic biosecurity. These and the other components of aquatic organism health strategy have now converged into the novel initiative "Progressive Management Pathway for Aquaculture Biosecurity" (PMP/AB).

Rising output and the rise and spread of disease

World aquaculture output, from the first estimate of six million tonnes a year in 1975, had reached 126 million tonnes (worth USD 296.5 billion) by 2021 (FAO, 2023). By the 1990s, however, the emergence and spread of new and other persistent diseases began to cause concern to farmers, traders, governments, scientists, international technical organisations, and assistance agencies that these diseases were slowing the growth of the sector. Concerns focused on three issues:

1. *Increasing numbers, frequency, spread, severity and persistence of diseases.* Important cultured and wild aquatic species are affected.

2. *Increasing costs to the industry.* As damage became widespread from production loss, vanished value addition, lost employment opportunities, and the cost of disease control, measures soared. By the second decade of the millennium, it was reported that industry- wide losses caused by diseases of aquatic organisms exceeded USD six billion a year.

3. *Time lag from detection of an outbreak to development and deployment of control measures.* The damage to the industry accrues and the costs pile up during this time. Three or more years can pass between the disease being detected and the placement of control measures. For example, Acute hepatopancreatic necrosis disease inflicted a loss in shrimp production of USD 12 billion from outbreak to implementation of a control (Shinn et al., 2018).

Good husbandry and biosecurity practices can produce healthy and resilient farmed aquatic species. Photo credits (clockwise): David Huchzermeyer, Melba Reantaso, Shuaib T Muhammad , Melba Reantaso.

Magnifying these concerns is the overriding need to sustain the livelihoods of millions working along the aquaculture value chain and to ensure the food security and nutrition of over eight billion people.

Disease emergence drivers, factors and pathways

The fundamental strategy of the PMP/AB is prevention, enabled by risk management. This makes it imperative to understand the drivers, factors and pathways to aquatic disease emergence.

The following is an overview of the analysis of three important factors made by experts prior to the development of the PMP/AB.

Aquaculture biosecurity

The analysis reflects the barriers and complex challenges to carrying out the mandate from the Millennial conferences. Surmounting them depends on the sector arming itself with one basic capacity: aquaculture biosecurity. In the context of the PMP/AB, aquaculture biosecurity is the cost-effective management of risks posed by infectious agents to aquaculture through a strategic approach at enterprise, national and international levels with shared public-private responsibilities. Its key elements are risk management, a multi-level geographical coverage and value chain approach, and multi-stakeholder collaboration and collective responsibility.

Drivers, factors and pathways that contribute to aquatic disease emergence
Aquatic health management and disease control: multiple institutions involved; inadequate or poorly implemented biosecurity measures and low capacity for emergencies; perceived low incentive to report on known and emergent diseases; weak regulatory framework and lack of an effective public-private sector partnership (PPP).
Trade of aquatic organisms: highly traded commodity (70% exposed to international trade); live animals (larvae, fry, adults) and their products (live, fresh, frozen) globally traded; invasive animals are traded and pathogens carried by the primary host.
Knowledge of pathogens and their hosts: unique aquatic medium; for unknown and even known diseases, there remained significant knowledge gaps regarding transmission, immunity and genetics; diagnostics focused on known/listed diseases; breeding strategies not in place for many species; not easy for farmers to obtain efficacious and affordable vaccines.
Ecosystem change: physico-chemical conditions in aquaculture are often sub-optimal for host; aquatic hosts are cold-blooded, thus highly vulnerable to stressors; the aquatic medium is pathogen-rich, diversity changes with environment conditions; pathogens evolve and spill-over and spill-back relative to wild populations.

The special challenge

Compounding the institutional shortcomings in aquaculture biosecurity is the difficult technical/environmental challenge posed by the culture medium. Monitoring growth and keeping optimal water parameters are difficult enough. Preventing the introduction and monitoring the presence of pathogens in the surrounding and culture waters, avoiding water contamination, and reducing susceptibility to infection by mitigating stress-related impacts on the culture environment make aquaculture biosecurity much more complicated.

PMP/AB: a new way to handle the challenges

The PMP/AB aims to enhance aquaculture biosecurity capacity at the regional, national, local sector and enterprise levels. To do so, it builds on:

- Existing institutional and legal frameworks, capacity and appropriate tools, using risk-based approaches and PPP.
- Resilience to the biosecurity vulnerabilities.

Developed in two multi-stakeholder consultations and several Technical Working Group meetings (FAO, 2020), and endorsed by FAO's Committee on Fisheries Sub- Committee on Aquaculture (Tenth, Eleventh and Twelfth sessions), the PMP/AB is expected to sustain:

Diversity of aquaculture systems and environment produce diverse aquatic protein foods. Photo credits (counter-clockwise): Melba Reantaso, Paulo Padre, Dukhyun Yoon, Yngve Torgensen, Melba Reantaso.

- A reduction in disease burden.
- An improvement of health at farm and national levels.
- A minimisation of global spread of diseases.
- An optimisation of the socio-economic benefits from aquaculture.
- An attraction of investment opportunities into aquaculture.
- An achievement of the One Health goals – health of the ecosystem, people, and cultured organisms.

The PMP/AB will, therefore, contribute to SDG2, “Zero Hunger”; SDG 3, “Good health and well-being”; SDG 6, “Clean water and sanitation”; and SDG 14, “Life below water”.

How to join, practice and progress along the Pathway

A comprehensive guide to entry and execution is provided by the Progressive Management Pathway for Aquaculture Biosecurity (PMP/AB): guidelines for application (guidelines) (FAO, forthcoming). The guidelines illustrate (see figures below) and explain the pathway’s four stages:

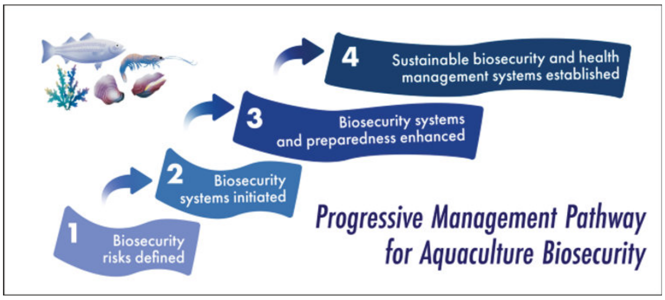
1. Biosecurity risks defined.
2. Biosecurity systems initiated.
3. Biosecurity systems and preparedness enhanced.
4. Sustainable biosecurity and heath management systems established.

Three principles guide every stage:

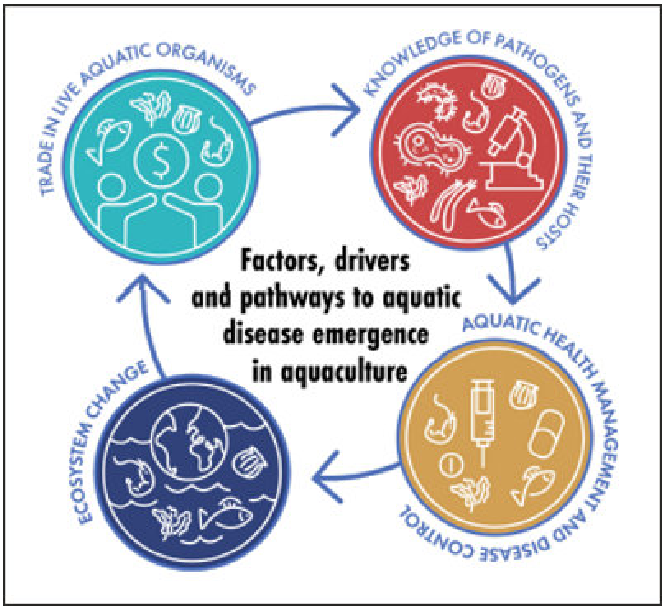
1. Risk-based.
2. Collaborative.
3. Progressive, with a good understanding of the epidemiological triad.

The triad portrays the relationship between a pathogen and susceptible aquatic population in a suitable environment that allows transmission of the pathogen and development of disease in the population. Understanding the relationship between host, pathogen and environment affected by human actions is key to the implementation of the PMP/AB.

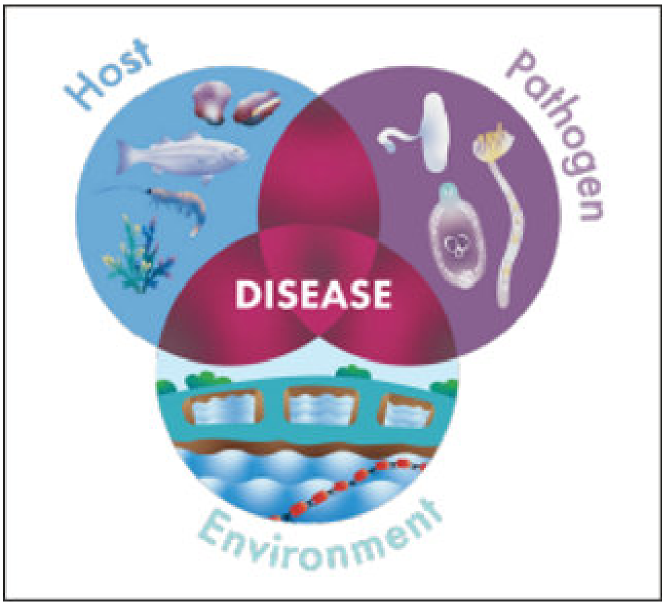
Risk assessment and emergency preparedness are carried out in every stage. Each stage has key indicators and activities. The five objectives of each stage are attained through five outcomes, whose satisfactory achievement allows the country to progress to the next stage. The four stages including the overall objectives and key outcomes to complete each stage; the details of each outcome; the recommended activities to produce each outcome; and a flowchart of the process and activities to complete Stages 1, 2 and 3 are described in the guidelines.



Four stages of the PMP/AB. Figure credits: Paulo Padre.



Factors, drivers and pathways to aquatic disease emergence in aquaculture.



Snieszko circle showing the relationship between host, pathogen and environment in disease development.

Practical guidance can also be drawn from three ongoing applications in three sectors: Seaweed, which covers all cultured seaweed species (Cottier-Cook, et al., 2022); Shrimp, which can be applied by the country, sector or an enterprise (Bondad-Reantaso, et al., 2022); and Tilapia, which adopts a value chain approach (MacKinnon et al., 2023). More guides and tools to get started and progress through the pathway are cited in the guidelines.

Benefits

The mutually reinforcing benefits accrue to a country, the industry, the farms and the enterprises along the PMP/AB. Briefly these are:

- **Better governance:** It offers countries the opportunity to harness aquaculture production that is responsive to environmental and human-induced challenges and requires enabling policies.
- **Partnership, shared ownership and responsibilities:** It provides a solid platform for public-private partnerships, through the formulation of strategic and implementation plans that are jointly developed by industry stakeholders, governance authorities and academe. This ensures buy-in and best-fit for each country.
- **Tangible benefits to stakeholders at every stage:** This encourages long-term commitment. Co-management principles ensure that problems are well defined and management solutions are identified.
- **Commitment to risk management:** It establishes risk ownership and promotes active engagement and long-term commitment to risk management.
- **Sustainability:** All the above, which can be boiled down to collaboration among the major stakeholders marked by coordinated efforts of various institutions and experts; pooling resources, sharing knowledge, expertise and experiences; cooperation and goodwill; and the sustainability of the biosecurity component of aquaculture management and the global aquaculture industry.

Way forward

The PMP/AB, which now includes aquatic plants, hence the use of the term aquatic organisms covering both plants and animals, is a paradigm shift in the way disease challenges are handled. It is infused with the principle embodied in the timeless adage – "An ounce of prevention is worth a pound of cure." Proactive and preventive biosecurity measures are less expensive than solution- based, reactive responses to outbreaks. Reducing the time taken to respond to an outbreak is crucial.

The desired outcome is healthy and safe aquatic foods, with reduced disease burden and the achievement of One Health goals, to enhance the food and nutrition security of a growing world population. The broader outcomes are increased investment in the sector; sustained economic benefits for primary stakeholders; and social, economic and environmental benefits for everyone else. To bring these about, aquaculture stakeholders need and are encouraged to take an active role in the PMP/AB, exploring the opportunities for cooperation, partnership and co-ownership – reaping the co-benefits that it offers.

One of the clearest signs of a maturing industry is when the focus is on disease prevention supported by effective governance and innovation.

Countries and aquaculture value chain stakeholders are, therefore, encouraged to embrace PMP/AB and establish biosecurity in parallel with any aquaculture development.

These specific benefits include: better risk management, cost-effective mobilisation and application of scientific, technical and physical resources, and public confidence on the safety of the products and goodwill engendered by social and environmental responsibility.

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Important considerations for feed and feeding management during Indian catfish culture

S.K. Sahoo, S. Ferosekhan, S.N. Sahoo, P.K. Tiwari, B. Mishra and S.S. Giri

Different feed ingredients used for catfish feed preparation.

Natural feeds present in ponds contribute to some extent to the nutrition of fish cultured therein. But these natural food stocks become insufficient as production intensity rises. In semi-intensive and intensive systems, nutritional inputs must be partly or wholly supplemented using external feeds to support higher growth and productivity.

Feed cost is always more than half of the production cost in catfish pond culture systems. Good quality feed is essential to achieve higher production. Poor quality feeds not only result in poor growth, but also cause deterioration of water quality due to rejection and poor biological utilisation. The selection of proper feedstuff and good formulation to meet the requirements of the cultured species will enhance acceptance and utilisation. Care should be taken to meet the nutritional needs of fish during both rearing and grow-out phases. Proper feed management is essential to reduce the production cost and achieve optimum growth for successful catfish culture.

Feed ingredients

Catfish feed is prepared by mixing feed ingredients of animal and plant origin. Different ingredients are used in variable proportions to provide the desired nutrients for the fish at stages. Ingredients of animal origin are an important source of essential amino acids, required for muscle growth and different physiological purposes. Animal-origin ingredients used for catfish feed preparation include fish meal, blood meal, fish and chicken offal, meat, and bone meal. Well-accepted plant ingredients used in catfish feeds include groundnut oil cake, mustard oil cake, soybean meal, maize, and rice bran. As the ingredients of both origins are required, the proportions should be in such a way that the prepared feed should have a good and balanced nutritional value, be well accepted by fish, easily digestible and cost-effective. Oils and vitamin minerals are also important ingredients in catfish feeds.

Nutrient requirements

Proteins in the feed play a major role in the growth of muscle tissue. The protein from the ingested feed is hydrolysed into amino acids, that are used for the synthesis of muscle tissue and the excess is stored as energy. The dietary requirement of protein for catfishes varies from 25-45%, depending on fish size, sex, water temperature, species, and rearing practices. Carbohydrates are an energy source, and excess carbohydrate will result in energy storage through fat deposition. Starch is the most important carbohydrate source in catfish feeds. Starch is digestible up to 50-80% but cellulose components are largely indigestible. Fish growth is not directly affected by dietary carbohydrate levels, which are preferred as a low-cost energy source and binder for other feed ingredients. Catfish feeds usually contain up to 40% carbohydrates and 2-10% fibre. Grain by-products are the main ingredients used in catfish feeds as carbohydrate sources. However, mono and di-saccharides are not well utilised by fish limiting the inclusion of carbohydrate in feed.

Lipid is the most important source of energy in the catfish diet. Normally 3-4% supplemental lipid in the form of oil is added to the feed. The use of excess lipids in feeds should be discouraged to avoid a decrease in weight gain. Increased fattiness is also a problem if fed high lipid diets. A suitable proportion of lipids in the catfish diet will increase the flavour of the muscle. Vitamins and minerals are added to improve the nutritional quality of feeds. These are required for good growth, skin colour, and good health of fish. Generally, 2-3% of vitamin and mineral mixture is used in catfish feeds.

Feed types used in catfish culture

Water stable feed is usually preferred by farmers. Floating, sinking, and slow-sinking feeds are mostly used for catfishes during their rearing. The size of pellets usually varies as per the age of the fish. Usually dust feed, small crumbles and pellets of 1-2 mm size are fed to catfish larvae, fry, and larger fish respectively. Floating feed as well as sinking feed is used in southeast Asian countries for *Pangasius* and *Clarias*

Sun drying pellet feed prepared by farmers during their training at pond site.

during their rearing. It is always better to provide sinking feed for *Clarias* as it is a bottom feeder. Dust feed made into small compact dough form is fed to *Pangasius pangasius*, *Clarias batrachus* and bagrid catfishes such as *Rita chrysea*, *Horabagrus brachysoma*, and *Mystus cavasius* larvae during their indoor rearing. Uniform spreading of dust feed in the nursery ponds is sometimes conducted during larval rearing of *P. sutchi*.

Feed selection

Farmers usually select feed based on cost and quality. The cost of catfish feed is higher compared to carp feed as it contains more animal protein. Apart from this, the type of feed to be used during rearing should be selected as per the feeding behaviour of the species. Improper feed selection such as a floating feed for a bottom-feeding species like *C. batrachus* larvae may hinder rearing success of this catfish. Similarly, pangas catfish accepts floating feed during fry stage and thereafter.

Ration size

The ration size during catfish culture is given usually based on their body weight. Small fish eat more compared to their body size and need to feed more frequently. More feed must be provided in ponds to ensure access by larvae and fry. Ration size should be strictly followed during fingerling production until market size. The ration changes as the fish grows. But it is not easy to monitor on daily basis. So monthly sampling is the usual practice followed to estimate growth and adjust the ration size during catfish culture. Provision of feed @2-3% of body weight is sufficient for growth of larger fish and is the typical ration for Asian and African catfish culture. However, there is a deviation in the case of highly predatory fish like Wallogo attu. The ration size in catfishes is also influenced by water temperature and they accept feed less efficiently during winter days. We have observed that the *M. cavasius* fry and fingerlings consume 10 and 7% of their body weight, respectively during the water temperature ranging 27-29°C, which is reduced to 3-4% during winter months (17-20°C). Hence the usual ration size should be judiciously monitored depending on the situation to curtail feed cost. A decrease in feed ration should also be observed in the event of stress, adverse weather condition, management practice and so on.

Feeding rate

The appetite of catfish is not constant during the rearing period. It depends on size, season, environment, and acceptability of feed. Even the feeding rate of one meal may vary between the proceeding or succeeding meal. So, the fish

Feed in dough form fed to H. brachysoma larvae during indoor rearing.

manager will decide when to give more feed from the total ration required for the fish. It will not only reduce the wastage of feed but also the fish will utilise the feed as per their need. The feeding rate in catfish is usually observed during late hours of the day compared to early morning hours.

Feed distribution and frequency of feeding

Feeding to catfish is undertaken by providing feed in few places of the tanks or distributing the feed on the water surface. Fish take a few hours to consume the ration. Some catfishes such as *H. brachysoma*, *P. pangasius*, and *P. hypothalmus* accept feed quickly. The wastage of feed during basket feeding is due to currents created by quick rushing of fish for feeding. Larger and more competitive individuals suppress the feeding of smaller and less competitive individuals, resulting in size hierarchies, which is frequently observed in *C. batrachus*, *C. magur* or *Heteropneustes fossilis* during their rearing. So, farmers must take care to provide uniform access to feed by all the fishes stocked. Correct feed distribution enables farmers to reduce size differences among harvested catfish and reduces the wastage. Sometimes the total ration is divided into a few instalments to reduce competition. The frequency of feeding is important during seed rearing in early stages of catfishes and also in highly cannibalistic catfish such as *W. attu*.

Feeding schedule

It is a usual practice to feed once or twice in traditional or extensive culture systems. We have also seen that some farmers practice a feeding holiday during the week to reduce the nutrient load on the environment. Feeding schedules change with water temperature. Catfish farmers feed a minimum twice a day when water temperature is above 25°C to ensure access of less competitive individuals to feed during the second instalment. The fry and fingerlings of *M. cavasius* eat less (30-50%) when temperature is low compared to optimum conditions. So, it is always beneficial to account for such factors by adjusting the feeding schedule to reduce feed wastage while maintaining good growth of catfish during their rearing.

Daily feed allowances

The daily feed offered in catfish ponds varies during the culture period. The day-to-day variation in feed consumption is due to water temperature, size of fish, culture condition, water quality and so on. So the usual feed allowance of 2-3% of body weight may be adjusted as per the response of fish to the feed. Successful catfish growers always monitor feed consumption patterns before manipulating the feed allowances.

Feeding time

All fishes show a rhythmic pattern of feeding and may be categorised as nocturnal, diurnal and crepuscular feeders. A suitable time for feeding catfish depends on the nature of a particular species and can have great effect on feed utilisation and growth. A positive effect on growth due to feeding during night hours has been reported in Indian catfish such as *H. fossilis*. We have also observed that access to feed of *C. batrachus / C. magur*, *M. cavasius*, *H. brachysoma*, *Ompok pabda / O. bimaculatus* is reduced during the morning in winter months. Hence it is advisable to feed during mid-noon to fishes irrespective of period during the year. Hence the optimal time for feeding is an important management consideration to improve feed efficiency during catfish culture as feed intake matters for the somatic growth.

Effect of season on feeding

The suitable temperature required for optimum growth of catfish is approximately 30°C. A decrease in water temperature as well as high temperature reduces the feed consumption. The usual feed consumption in catfish is hampered when the water temperature falls below 20°C in tropical waters. So the normal feeding schedule during this regime may lead to wastage and an accumulation of uneaten feed on the pond bottom. This will create water quality problems due to oxidation of unconsumed feed in the pond. Feeding during these periods should be reduced. The usual feeding ration of 2-3% of body weight in general should be reduced on winter days. Sometimes catfish farmers stop giving feed to fish, which leads to weight loss. It is always beneficial for judicious feeding during these days to keep the fishes healthy. Alternative day feeding or at two-day gap may be followed. But a non-response to feed is not noticed on summer days. However, there may be a problem on the acceptance of floating feed during mid-day in summer due to the high temperature of the surface water. Hence the use of slow sinking feed to catfishes is preferred during these days. But it is not problematic to feed bottom dwelling catfishes during these days.

Feeding technique

Several feeding techniques such as hand feeding, baskets and automatic feeders are used in catfish farming. The feeding technique always depends on the level of production and the type of catfish in the culture ponds. Hand feeding is a simple practice in a small farm. It helps to know when the fish reach satiation so further wastage of feed may be reduced. Catfishes like *P. pangasius*, *P. hypothalmus*, *H. brachysoma*, *M. cavasius*, *M. vittatus* etc are the most suitable to be fed by

Feed baskets in pond during catfish rearing.

A row of gunny feeding bags during grow out culture.

hand with floating feed. Basket or tray feeding is also another device for catfish feeding. It has similar advantages to hand feeding. The farmers can lift the basket to observe the state of feed acceptance. If feed remains continuously in the basket, it may indicate disease, a poor environment, stress on fish or over supply of feed. So it is easier for the farmers to monitor the situation to protect the fish stock. This basket or tray feeding is commonly used while culturing bottom dwelling catfishes, which are more difficult to observe. Many bagrid and pangasid catfishes are also fed through basket method during their culture. Automatic feeders are most advanced feeding device used during intensive aquaculture. But they are expensive and small farmers can't afford them. It may be suitable for surface and column feeding catfishes but may not be suitable for bottom dwelling catfishes. In many instances, feed is provided in gunny bags with small hole at the bottom hung in series through a rope for feeding of carp and catfishes, which may function as an indigenous automatic feeder.

Conclusion

Although natural foods provide some nutrition to pond cultured catfish, the supply of prepared feed is required as culture intensity increases beyond levels that natural productivity can support. High quality, and an optimum quantity of cost-effective feed is always desirable for good growth and high production. Catfish farmers should select an appropriate feed format for the species under culture to ensure efficient growth for successful catfish culture.

A transitional journey from fisheries to aquaculture in Moyna

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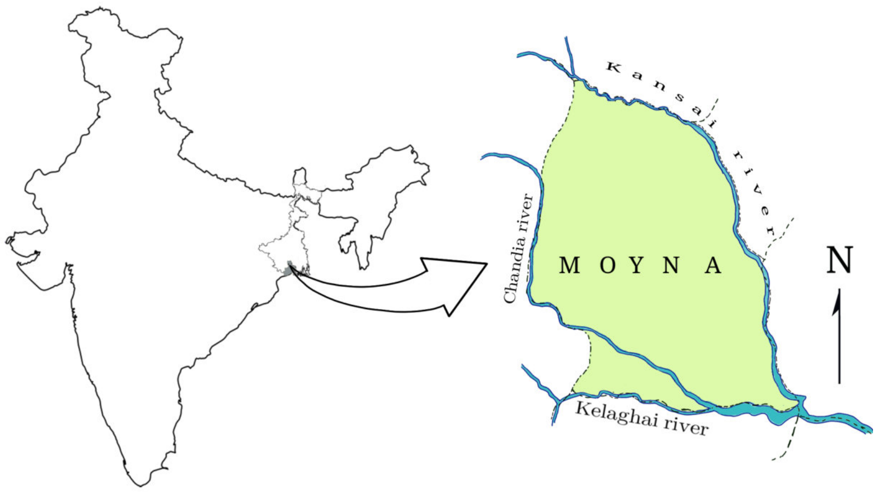
A scenario of traditional capture fishery in Moyna with the eye of an artist.

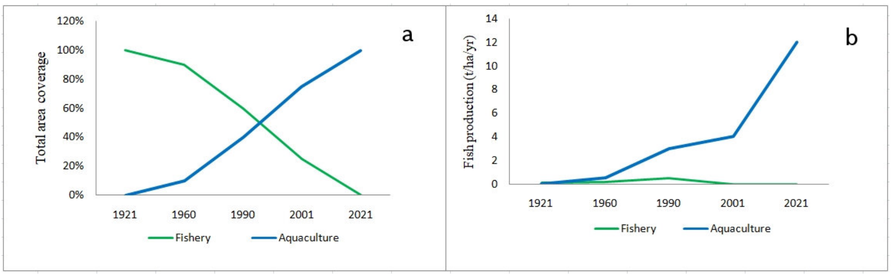
Genesis

This story looks back a century from 1922 until 2022 over the fisheries scenario in Moyna, a community development block of East Midnapore District, West Bengal, India. Moyna is itself news in the context of aquaculture development. The Government of West Bengal proclaimed Moyna as an 'aquaculture hub', giving it a prominent place on the aquaculture map. The tremendous success of aquaculture practice in Moyna has strongly influenced farmers of surrounding districts to convert agricultural lands to aquaculture. Traditionally, capture fisheries in Moyna have had a rich heritage that strides across the twentieth century to meet the twenty-first with a steady progress. The long journey that began with traditional 'deep-water paddy cum capture fishery' to 'paddy cum fish farming' to aquaculture. Fish production in Moyna has reached a significant average yield of 12.5 tonnes/ha/year. This achievement has encouraged other aquaculture practicing areas to adopt similar practices.

The area under discussion is a basin covering around 147 km^2 that is susceptible to heavy rain and flooding. The entire area is situated slightly below mean sea level and is surrounded by three rivers namely the Kansai, Chandia and Keleghai. The Kansai River flows from north to south, covering the east side; the Chandia originates from Kansai at the north flowing west to meet the Keleghai, which in turn flows from west to east on the southern side to make confluence with Kansai in the south-east corner. All of these rivers are under tidal influence during high tidal spring surges. The rivers are mainly freshwater except for the south-east periphery area, which has brackish water with salinity ranging up to 5 ppt.



An outline of Moyna Block.



A transitional shift from fisheries to aquaculture over the decades: a. area coverage, and b. fish production.

Traditional deep-water paddy cum capture fisheries

Early scenario

Before the shadow of climate change was felt there was a uniform trend of rainfall under southwest monsoon that would arrive early June every year in the eastern region of the Indian sub-continent, including West Bengal. There was a continuous moderate rainfall from early June to late September, with intermittent heavy showers. The cultivable lands were flooded with rainwater to as much as 30 cm depth, while lowlands had prolonged submergence with water depth ranging between 0.5-1.0 m, even 1.5 m in some areas. Traditional paddy cultivars with a plant height of around 1.40 m were grown in waterlogged areas in a practice known as deep-water paddy farming, which usually had poor productivity. The ecological conditions in deep-water paddy fields seemed unfavourable due to sudden fluctuation of water depth, and variable duration of submergence, depending on rainfall.

Ecological factors to support growth and development of fisheries

Given a vast area flooded during the monsoon, the natural fisheries resources became nature's gift to the common people of Moyna. The prevailing environmental conditions favoured paddy fields as a suitable habitat for fish growth and development. As soon as the rains started, fish migration from perennial water bodies to the newly submerged paddy fields was stimulated. Most paddy fields were connected by water bodies of diverse forms including ponds, canals, beels, jheels, and karanjali. Fish would migrate into paddy fields and spend a major part of their life cycle there. Parameters that supported fishery development included rainfall of around 175 cm annually with 113 days of rain per year; water temperature 27-31°C; pH, 6-8; and dissolved oxygen 8-11 ppm. Under the regime of such a freshwater environment, there were large numbers of diverse wild fish species, including large quantities of minnows.

Plankton populations are an important food source for fishes and other aquatic biota, and phytoplankton also maintain dissolved oxygen levels in the water through photosynthesis. Periphyton - microalgae and other small organisms growing around paddy tillers - act as an ideal food for browsing fish species and benthic organisms. Although paddy production had a low yield, this was compensated by the production of a substantial number of wild fish. Thus, the deep-water paddy cum fishery was an ecosystem that provided both paddy and fish at the same time. It continued until more advanced fish farming techniques replaced the traditional system.

Deep-water paddy cum fishery: A nutritional support to poor people

Deep-water paddy varieties which were sown during April-May every year could grow into tall seedlings by July-August. The season is known as Kharif, which coincides with the breeding period of several indigenous freshwater fishes. People preferred these fish species for their unique taste as well as nutritional value. In addition to protein, these varieties of fish were valuable sources of minerals to combat hidden hunger and benefit poor people and assist in maintaining their health. People of all ages and economic status traditionally collected fish with indigenously made fish traps such as ghuni, mugri, and janta, which were made in such a way that fish can enter but not exit. Catching fish was a community event that would turn to a festive mood. The production of those traditionally grown fish might range up to 100 kg/ha/season, corresponding to 500 kg/ha/year. Surplus fish above immediate needs were preserved by drying with turmeric powder and salt. The poor used to consume these dry fishes during the lean period when the natural fish population declined, and the demand for fresh fish became high, which they could not afford.

A haul of harvested Indian major carp.

Deep-water paddy cum fish farming: A step towards aquaculture

An early system adopted as a trial

People of Moyna went ahead of its time because of their education. Moyna Pedi School which was established during British period illuminated knowledge among ordinary people who became advanced in all the fields including agriculture as well as fishery. With the long experience of 'deep-water paddy cum capture fishery', farmers of Moyna were able to think differently as deviating from the traditional practice of capture fisher to adopt fish farming in a few plots as a trial. With a favourable climate, they developed the suitable design of fish farming within capture fishery by implementing techniques such as fish stocking, manipulating stocking size, selection of species with preferred ratio, and cultivation time befitting with paddy saplings growth and development. During flooding, the field water contains more anions, such as carbonate, chloride, sulphate, phosphate and nitrate; metallic cations of calcium, sodium, potassium, magnesium and iron; and organic compounds of phosphorus and nitrogen, with increasing levels of organic carbon. The cumulative effect of rich inorganic and organic elements favours the growth of a diverse group of biotic communities such as phytoplankton, periphyton, benthos, zooplankton and other microorganisms which seemed to make a complete food web among different trophic levels of deep-water paddy cum fishery ecosystems. Such an ideal ecology promoted fish growth to a great extent as reflected in a good yield that farmers harvested and felt satisfied. The trial was successful.

In the course of time, 'deep-water paddy cum fish farming', established on a pilot scale, gained momentum because of two-threefold more yields of both paddy and fish crops as compared to earlier production. The success encouraged

A haul of harvested exotic fish.

Farmers use organic ingredients as fertilisers for apply in water bodies.

other farmers to bring more agricultural fields under such culture practice with sound technologies of scientific approach. As more high fish yields were harvested, more farmers stepped forward adopting deep-water paddy cum fish farming as a reliable cultivation practice. Needless to say, fish has always been a high demand commodity in Bengal. With time, fish became not only a primary crop but a major earner for the livelihoods of people of Moyna, while paddy seemed a secondary crop.

Construction of sink/basin/sump in paddy fields for paddy cum fish farming

Gradually, paddy farming got reorientation in its way. The high yielding varieties of paddy were introduced to Moyna during the 1980s. They made changes in the paddy fields by constructing a central basin/sump/sink with a few peripheral trenches along the dykes. As per individual needs, the excavation followed variable designs: 10m×10m×1m depth basin or 5m×5m×1m depth, covering 10-15% area of single paddy field. There were 2-4 sinks constructed in each paddy field and 40-50m×5m×1m peripheral trench. During flooding, fish use the sinks as passages to move around the paddy fields. In other seasons, the sinks provide a permanent refuge for fish when the water recedes from the paddy fields, and they provide a shelter to avoid high temperatures. The basins also act as water storage to irrigate paddy fields when there is an acute water shortage. In such a case, farmers used to harvest fish from sinks phase-wise. The advantage of such sinks was that a variety of wild fish species and cultivable ones congregate within them. Such a practice maintains the wild fish gene pool along with cultivable ones that could serve common people in providing much needed protein, vitamins, and minerals. However, change is the law of nature. Profitable paddy cum fish farming attracted farmers into stepping up to earn more income, which has in turn brought a paradigm shift in cultivation practices in Moyna. The entire cultivable land of Moyna that was paddy cum fish farming has been converted to aquaculture – a transformation that represents a sea-change in fish production.

Aquaculture practice: The only way of livelihood for people of Moyna

Fish production

The beginning of the 21st century witnessed the shifting of livelihoods from one practice to another. The entire agricultural land was converted to water bodies to dawn a large-scale aquaculture practice. A total water area of 7,550 ha including 7,000 ha freshwater and 550 ha brackish water areas comprises 4,465 freshwater and 929 brackish water coverage, with the size of individual water area in the range of 5-10 ha. The total production amounts to 84,000 tonnes of fish and 3,850 tonnes of prawn, averaging 10 tonnes/ha/crop (6-8 months). There is also a practice of farming a few exotic species introduced in the recent past. Given that aquaculture has a unique support system for only way of livelihood in Moyna, many academic institutes have shown their interest to know how farmers achieve such a tremendous yield. In this context, the Regional Research Center, ICAR-CIFA, Kolkata assesses the aquaculture activities of Moyna with a

Raking pond bottom after application of fertiliser.

Mechanised aerators to help maintain dissolved oxygen levels over a large water area.

specific motif as to make culture practice sustainable, keeping the ecological health of water bodies fresh and vibrant. We view the entire culture practice into specific segments: Fish farming, feeding operations, environmental health, disease prevalence, and fish trading. Dr Tarun Bera, Research scholar and academic who used to deal with different aspects of aquaculture also shared his experience with us.

Multiple stocking and partial harvest

Moyna farmers usually adopted two types of culture practices:

- The ‘multiple stocking and multiple harvesting’ method of culture practice: The initial size of the fishes in a single stocking range between 75 – 250 g, and the harvested size of the fishes was 500 g to 1 kg over multiple harvestings (4-5 times) and 10 months of total culture. Mainly, three carp species such as catla (*Labeo catla*), rohu (*Labeo rohita*), and mrigal (*Cirrhinus mrigala*), are stocked in the ratio 30:40:30 as a polyculture practice to utilise natural foods in different layers of a water body.

- Raising fingerlings: A few farmers procured carp spawn and raise them up to fingerlings. They stock Indian major carp with 700 kg fry (average weight 6.6 g i.e. 150 pieces/kg) in a 0.4 ha pond with 1.8 m water depth.

However, the second practice does not seem to continue because of variability of market demand based on consumer preference. When farmers do not get an economic benefit, they immediately change their culture practice and switch over to either monoculture of single carp such as rohu, which is easy to transport long distances to market, or choose an exotic carp.

Saleable live fish kept within net enclosure with aeration facility.

Live fish lifted and weighed before loading into mini-truck.

Ingredients used as fertilisers

Farmers commonly use the following ingredients as fertilisers: black molasses (5 kg), yeast (2 kg), ground nut oil cake (43 kg) and mustard oil cake (50 kg) in a 0.4 ha pond at six-day intervals up to 75 days i.e. 12 times. After six days of stocking, fry are fed with a mixture of rice bran (100kg), ground nut oil cake (25 kg) and soybean dust (25 kg) in a slurry form every day up to one month. After 30 days, that feed was applied at 15-day intervals up to 75 days (i.e. 3 times), followed by pond raking.

Feeding operation

Common feed ingredients used are ground nut oil cake, maize, soyabean meal, micronutrient, probiotics, and mineral mixture in different proportions. The feed companies play a pivotal role in Moyna aquaculture. The farmers get branded commercial feed on credit and add some portion in their own prepared feed. They used different oil cakes and rice/wheat bran in the form of juice. The juice was used either weekly or bi-weekly for plankton production. The types of feed applied included pelleted feed, de-oiled rice bran, ground nut oil cake, and mustard oil cake. The amount of these feeds used in the different ponds was more than required quantities.

Environmental health – responsible management for sustenance

The pH of the water typically remains slightly acidic around 6.0 and dissolved oxygen (DO) is maintained around 6.0 ppm. The ponds have low salinity feature ranging from 0.03 ppt to 1.2 ppt. The electrical conductance varies from 0.8 to 2.33 milliohms/cm. The total dissolved solids were recorded in from 400 to 1,250 ppm, while the hardness was between 120 to 160 mg $CaCO_3$/l. Three types of conditions prevailed in culture ponds:

Loading live fish.

A series of mini-trucks each with 5 HP pump set on its overhead ready for transporting live fish to distant markets.

1. Pre-stocking ponds which are ready for stocking have the highest plankton population (average phytoplankton and zooplankton population respectively as 11×104 individuals/l and 5×104 individuals/l) with gross primary productivity and net primary productivity of 625 mg carbon/ m^3/hour and 250 mg carbon/m^3/hour.

2. Stocking ponds: Exhibited less plankton population (average phytoplankton and zooplankton population respectively as 6×104 individuals/l and 4.5×104 individuals/l) with gross primary productivity and net primary productivity of 50 mg carbon/m^3/hour and 25 mg carbon/m^3/hour.

3. Harvesting ponds have a higher plankton population (average phytoplankton and zooplankton population respectively 9×104 individuals/l and 5×104 individuals/l) than that in the stocking pond with gross primary productivity and net primary productivity as 175 mg carbon/m^3/ hour and 50 mg carbon/m^3/hour.

Disease prevalence

Disease problems mainly occur during June – September and cause economic loss every year. Bacterial haemorrhagic septicaemia, lernaesis, argulosis, dactylogyrosis, epizootic ulcerative syndrome, dropsy, ulcer and lymphocystis are significant problems. Parasitic diseases represented about 53.85% of problems, with 42.30 % being argulosis; bacterial diseases were around 30.77% of problems with red spots/red scales the most common issue at 15.38%; fungal diseases are about 11.54% of problems with dropsy at 11.54%, and other diseases around 3.85%. Farmers do not have a good understanding of how to treat different conditions and may use sanitisers, disinfectants, antibiotics, anti-parasitic medicines and probiotics to try and control disease outbreaks and also as prophylaxis measures.

Assessing pond condition through carbon footprint

Pond aquaculture has three levels of feed loading: Low (11 to 13 tonnes/year), moderate (16 to 18 tonnes/year) and high (30 to 32 tonnes/year). The ponds with high feed loading had the highest mean sediment accumulation rate (11.0 ± 3.0 cm/year), higher than the moderate (9.0 ± 2.5 cm/year) and lowest (7.0 ± 2.0 cm/year) groups. The group with high feed loading also has the highest mean carbon storage (704 ± 30 g carbon/m²/year), significantly higher ($p < 0.05$) than the groups with moderate (506 ± 24 g carbon/ m²/year) and low feed loading (343 ± 17 g carbon/m²/year). The highest fish production is related to the minimum CO_2 emission that manifests to minimum inputs requirement. The principle of environmental management is to apply minimum inputs and maximum output in return as assessed accurately through carbon footprint study.

Fish trading: A livelihood option for self-employment

After harvest, live fish are kept within high net enclosures with aeration facilities. Every day live catla, rohu and mrigal of an average 1 kg weight are transported from Moyna via 250-400 mini trucks to different parts of Bengal from 100-300 km distant. In each mini truck, a large container wrapped with thick polythene is carried, with a typical capacity of 4,500 litres. One five-horsepower diesel pump is placed overhead on the mini truck for oxygenation through re-circulation. During transportation Glucon-D @ 1g/l is mixed for energy supply and Oxymore or Activate tablets are also used to

List of indigenous freshwater fish species recorded in deep-water paddy cum capture fishery:

Amblypharyngodon mola, *Anabas testudineus*, *Chanda nama*, *Channa marulius*, *C. orientalis*, *C. punctatus*, *C. striatus*, *Clarias batrachus*, *Colisa fasciatus*, *C. lalia* , *Esomus danricus*, *Glossogobius giuris*, *Gudusia chapra*, *Heteropneustes fossilis*, *Lepidocephalus guntea*, *Macrognathus aral*, *M. pancalus*, *Mastacembelus armetus*, *Monopterus cuchia*, *Mystus bleekeri*, *M. tengara*, *M. vittatus*, *Nandus nandus*, *Notopterus notopterus*, *Pseudambassis baculis*, *P. lala*, *P. ranga*, *Puntius chola*, *P. sarana*, *P. sophore*, *P. ticto*, *Ompok pabda*, *Osteobrama cotio*, *Salmostoma bacaila*, *S. phulo*, *and Xementodon cancela*.

improve oxygen supply to the fish. This is an indigenously developed technique that is capable of maintaining a substantial number of live fish during transport.

Conclusion

The ICAR-CIFA Regional Research Centre, Rahara, has studied aquaculture practices that farmers adopted on a large scale in Moyna. The centre has observed a gloomy picture with regards to the sustainability of future aquaculture practice, with the following issues requiring address:

- Excessive use of feed needs to be checked, with feed consumption monitored and rations adjusted based on need, to avoid excessive algal blooms and deterioration of water quality.
- When fish movement is unusual and they come to the surface to gasp, external water supply through fountains needs to be started using a pump. The density of plankton population is to be maintained proportionately, otherwise oxygen depletion may occur.
- Indiscriminate use of pesticides for prophylactic measures and disease control should be stopped, and controls on the legitimate use of antibiotics and chemicals for treatment of legitimate disease issues introduced.

Moyna started its journey on fish production long before aquaculture was widely practiced. Moyna has a rapidly growing aquaculture industry that employs a diversity of production systems and unique indigenous transport techniques. Given the widespread transition of farming land towards aquaculture it is vital that good husbandry is practiced to maintain the sustainability of the system and supporting environment.

Acknowledgement

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Colour widow tetra: A new and highly preferred aquarium fish in West Bengal

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Different varieties of colour widow tetra.

Known as ‘glow widow tetra’, ‘glow skirt tetra’, ‘colour widow tetra’ in the ornamental fish industry, a genetically modified variety of the black widow tetra *Gymnocorymbus ternetzi* is the most favoured by aquarium fish hobbyists in West Bengal. Stunning and sparkling red, blue, yellow, green, pink, orange, and purple bodied colour variations of this tetra have been developed through gene transfer or transgenic technology. The fish glow when kept under blue LED lights, hence the name ‘glowfish’.

Maintenance of these brightly coloured and reasonably priced fish in small and medium-sized aquariums at home, the office, hotels, and other settings has become popular. A peaceful, schooling fish, the glow widow tetra is attractive and adds colour to the aquarium. Many hobbyists keep at least four different colour varieties together. From around 15 mm in length, colour widow tetra takes 30-45 days to reach 50-60 mm. In a large-sized aquarium, it can be kept with other small community-friendly fishes such as zebrafish and barbs but is not compatible with larger cichlids or figher fish. Other tetras such as neons and emperors, and dwarf gourami are suitable tank mates.

Colour widow tetra are essentially the same as the unmodified black widow in terms of behaviour, feeding habit, body shape, and size; the only difference is the colour, the natural type being dark bodied with black stripes. Black widow tetras are native to the rivers of Brazil, Bolivia and Paraguay in South America.

The science behind production of transgenic colour widow tetra

Aquaculture biotechnologists have created transgenic tetras of different colours by inserting genes that code for fluorescent proteins into normal black widow tetras. The genes were sourced from a variety of marine invertebrates:

- In February 2012, Yorktown Technologies based at Texas, USA brought a green coloured black widow tetra to market for the first time incorporating a fluorescent green protein gene from the jellyfish *Aequorea victoria* found off the west coast of North America. To produce this transgenic and stable green fish, jellyfish green fluorescent protein gene was ligated to two promoter sequences used, namely krt8 and mylz2.

- Yellow, pink, blue and purple widow tetras contain fluorescent protein genes isolated from corals. Additional red and green fluorescent protein genes have also been isolated from corals.

- The red widow tetra contains a fluorescent protein encoding gene isolated from an Indo-Pacific sea anemone *Discosoma* sp.[2]

- Orange and yellow-orange widow tetra contain a modified jellyfish fluorescent protein gene, i.e., a variant of jellyfish gene giving rise to a different colour.

- In 2020 Yorktown Technologies made fluorescent widow tetras available in six colour varieties. The colours stay with fish all throughout their life, they are born with it and the genes are passed onto next generation.

In gene transfer research conducted with black *G. ternetzi*, foreign genes of economic importance were introduced at early stages of embryonic development, integrating them into the genome. Subsequently, expression of the target genes occurred (facilitated by appropriate promoter/regulatory gene sequences made to combine with coding/structural gene of choice, i.e., fluorescent colour-encoding genes), which are passed on to offspring as a hereditary trait.

In a study at the National University of Singapore during 2007-2008, a muscle-specific promoter sequence of zebrafish mylz2 was used to create red widow tetra. The gene construct rfp (red fluorescent protein gene, a reporter gene) - mylz2 was prepared, and DNA solution microinjected into the eggs of black *G. ternetzi* within 50 minutes of fertilisation at the 1-8 cell stage. Finally, the expression of red fluorescent protein gene occurred, bright red colour was prominently observed in adult fish[1].

Hapa nets containing different aquarium fishes including colour widow tetra.

Different body colours of colour widow tetra in a farm.

Breeding and seed production process

Around twelve private aquarium fish breeders-cum-farmers in Howrah District are doing controlled breeding, seed production and farming of coloured widow tetras. Water sources used include rainwater, filtered tap water, or deep tube wells. Fish are bred in small, rectangular cemented tanks with a 15 cm depth. Large green nylon spawning mops are placed on the tank bottom at one corner to imitate small aquatic plants occurring in nature, which assists in inducing spawning in confinement. The fertilised eggs are demersal and non-sticky.

Males and females are kept separately for ten days or more prior to scheduled date of breeding and their release into breeding tank causes a quick release of eggs. In a farm, females of any 3-4 colours out of all are often gravid and ready to spawn. Tank water temperature must be adjusted. Females are released first into the spawning tank and allowed to acclimatise to the new environment. Around 30 minutes later males are released into the tank, maintaining a 1:2 ratio of females to males.

Females lay eggs in the early morning onwards of the next day. The spawning process continues for 4-5 hours. All the females lay eggs at once, producing good numbers of fertilised eggs with a high fertilisation rate. Females lay eggs only in presence of males. Brood fish are carefully removed, and aeration maintained. The fertilised eggs, around poppy seed in size, lie underneath the mop on the tank floor. Fertilised eggs have a faint golden colour and are transparent. A few

Male brooders of red widow tetra in large glass tank.

Five body colours of adult colour widow tetra.

drops of anti-fungal medicine are added to keep eggs safe and free from fungal contamination. The upper portion of tank is covered with a nylon mosquito net to prevent entry of mosquitoes. If the tank is kept outdoors, it must be protected from rainwater.

Coloured widow tetra larvae hatch within 48-72 hours. Proper-sized brooders must be at least seven months in age and can be bought from breeders in West Bengal at INR 45/ piece. Adult/marketable sized fish are one and a half to two months in age, and highly preferred by aquarium fish keepers and hobbyists. In concrete rearing tanks, an aquarium fish farmer-cum-breeder may have 450-500 pieces in stock, which are 25-26 days old. During breeding, 3-4 gravid females may be paired with 7-8 males in medium-sized 20-25 cm diameter plastic circular trays. Females are fat with a rounded body, greater in size than males, with round anal fins and a prominent notch in the shoulder region. Males are shorter, having a lengthier slim body and a pointed anal fin, and shoulder notch isn't distinguishable. The body colours of females fade slightly as they attain gravid condition, while the colours of brooder males remain bright. Both are 36 mm and above in length at 5-6 months and above in age.

It is better to keep males and females segregated for about a month before arranging breeding. Live tubifex worms are fed for 2-3 days in a week, and dry pelleted feed every morning. Mosquito larvae or pupae are fed for another 2-3 days in week; bloodworms may also be used alternatively. Zooplankton *Daphnia* sp. is fed to brooders one the remaining 2 days. All live food is provided during evening hours. This schedule continues for 30 days. Farmers-cum-breeders have around 70% hatching success, out of which, 50-55% larvae survive and reach adult stage.

Breeding tank water should be iron- and chlorine-free. Rock salt is added @ 5 g/25 litres water and allowed to settle, with the upper portion of water used for breeding after decanting it. Water is left in the breeding tank undisturbed for three days with the addition of a commercially available anti-chlorine treatment. Thereafter methylene blue may be

Green widow tetra broodstock.

added. Submerged weed *Hydrilla* sp. can be kept in the tank. Coloured widow tetra is bred alternatively in 18-20 litre plastic buckets. A heater used in these tanks during winter months and dosage of methylene blue increased. Each female lays 200-250 eggs in a single spawning. Any colour combination of male and female fishes (in appropriate breeding condition) may be selected and used. From the seventh day onwards, hatchlings are fed boiled egg yolk suspension as a dense liquid in very small droppings, using a 50 ml syringe. There is no need to feed in the first 2-3 days after birth.

In South 24 Parganas, two or three farmers are breeding coloured widow tetras. Grown adults are sold to owners of aquarium shops @ INR 20-22/piece. Blue fish are the most preferred colour variety, sold to shop owners @ INR 25/piece, and retailed at @ INR 30/piece. In large aquarium tanks of 120-180 cm in length the fish grow to 48-60 mm but do not grow conspicuously in smaller aquariums of 60 cm. In mid-2020, for the first time, coloured widow tetra were imported to Kolkata city from Thailand and Singapore in oxygen-packed condition. These fish were sold @ INR 150-200/piece in the beginning. Later, the wholesale price fell to INR 80-82/piece and with retail to hobbyists @ INR 90-100/piece. From March-April 2021 onwards, seed production and farming have been conducted locally in Howrah and South 24 Parganas districts in private ornamental fish farms.

A farmer in South 24 Parganas District explained that this fish can be bred three times during April (onset of summer) to September every year. A total of 50 males and females were introduced into a glass tank of 1.8 m x 0.9 m, whereas 15 of each sex were placed in multiple 1.2 m x 0.45 m breeding tanks. He observed fertilised eggs within 18-24 hours of release of brooders. Once fertilised eggs are produced the speed of two diffuser aerators is reduced. Whether in large

Square cement tanks for colour widow tetra and other aquarium fishes.

glass tanks or rectangular cement cisterns, male and female broodstock or near-brooder stage are not kept in same place to avoid unwanted and untimely spawning. Presently some aquarium fish shop owners in Kolkata buy colour widow tetra @ INR 15-16/piece (24-36 mm), maintain them for a brief period with proper water quality and feeding management and sell onwards @ INR 25/piece. Sometimes shopkeepers in Kolkata buy fishes of 12-15 mm in length from Eastern India's renowned Galiff Street aquarium fish wholesale market @ INR 4-6/piece, maintain in their set-up and sell grown-up fishes @ INR 30/piece.

Rate of sale of colour widow tetra

In some well-established ornamental fish farms located in Howrah Sadar Sub-Division and some under Howrah Municipal Corporation of Howrah District near to Kolkata, colour widow tetra is now bred. Seed is produced on a medium- to large scale, with good quality and shining colours, and sold to buyers in and outside West Bengal, mostly aquarium shop owners. Breeding and seed production continues from March till early-November every year. From a farm, 15–18-day-old seeds are sold at varying prices depending on the colour:

- Purple: INR 3/piece
- Yellow: INR 1.50-2.00/piece
- Red: INR 3.00-3.50.

There is demand for younger 10-day-old seeds also, with price lessened by INR 0.50-0.75/piece. The 15-18 days-old seed have to be fed *Daphnia* for the next 25-30 days. On the 45th day, aquarium shop owners can sell fishes to hobbyists. In aquarium conditions fishes which are 20-24 mm in size may be fed *Daphnia* for the first month; thereafter small amounts of tubifex worms and a little *Daphnia*. Subsequently, dry fine pelleted feed or flake feed should be used for the fishes. Red widow tetra, 24-25 mm in length and 35-40 days old, are sold @ INR 7/piece. Three-week-old small-sized seed of the same fish are sold @ INR 5/piece.

At another farm, the owner maintains semi-adult fishes in small ponds (160-200 m^2) with concrete sides and bottom. After harvesting, those kept in rectangular cement tanks for another ten days are sold to general customers (after 'setting' and 'seasoning', in words of farm owner). Fishes harvested from such larger open areas are not directly packed and transported, otherwise it will cause mortality. Here, the retail price of red widow medium size is INR 15/price. Four month old red widow broodstock are also maintained. Medium to large colour widow of 28-30 days old are sold @ INR 15-16/piece in winter months and INR 8-9/piece in summer. Normal black widow tetra sold @ INR 4/piece.

From a third farm, small-sized red widow (15-20 mm) are sold at a wholesale rate of INR 6-7/piece. From fourth farm, breeder-size (maximum size) red widow tetra sold @ INR 100/piece, purple widow INR 60/piece, yellow @ INR 50, green @ INR 60-80. Smaller-sized green widow sold @ INR 8/piece (two colours of green available, rare green and common green); smaller-sized yellow @ INR 10 and purple @ INR 15/piece, red @ INR 28/piece.

Some red widow tetra maintained in cement tank.

From a fifth farm, five colours available for brooder size widow tetra, blue is rare. Fry are available for sale @ INR 2/piece for green, INR 2.50 for yellow. Fry of other colour fishes all have separate rates. Here, medium-sized colour widow tetra are made available for sale in October and thereafter. This farm owner does not breed colour widow tetra any more as great numbers of sub-adult fishes are now available in market. He sells brooder size fish @ INR 25-30/piece (48-60 mm; red, green, yellow, purple, blue) and smaller ones (24 mm) for INR 7-10/piece.

Brooder widow maintained in a sixth farm are not sold; the smallest sized sellable fry sold @ INR 1.00-1.50/piece (depending on size). In a seventh farm, light green/yellowish green widow sold @ INR 10-12/piece (wholesale rate), standard size. At an eighth farm, 24 mm-sized colour widow tetra sold @ retail price INR 5.50/piece (purple, green, yellow, red). At a ninth farm, brooders are maintained belonging to same four colours; 25-day-old fry sold @ INR 1/piece. At a tenth farm, 10-12 mm-sized seeds sold @ INR 1/piece; INR 10/piece is wholesale price for 'medium-large' size (36-48 mm) fishes. From a wholesaler and exporter shop at CTI (Central Training Institute), Dasnagar in the same district, fishes sold at wholesale rate; standard size @ INR 6.50/piece and large/breeding size @ INR 25-30/piece. Mainly, five colours are available in stock, namely red, yellow, purple, green, and blue. Blue is only seldom available, INR 15/piece at standard size, with the same sized purple widow reaching INR 12/piece.

Live food culture for colour widow tetra

Tubifex worms

In nature, tubifex occurs in places with heavy organic content. Aquarium fish breeders-cum-growers can culture tubifex, which involves the following steps: Spread mud enriched with sand (50%), silt, clay and organic manure spread over the floor of a small rectangular concrete tank; this is base media. Maintain a low water level in the tank and inoculate with tubifex @ 50 g/m^2. After 2 hours, feeds such as dairy sludge, rice mill sludge, or manure can be given @ 40 g for every 10 g of tubifex inoculated on a daily basis. Maintain a continuous water flow @ 1.2l/minute over culture media. After

Colour widow tetra in a large hand net on farm.

10-14 days, tubifex can be harvested by draining. Part by part, the entire content of base media can be screened over a fine-meshed nylon net or white cloth and washed with water. The tubifex biomass remains within the net/cloth and can be collected and put into freshwater (Courtesy: Kalyani Regional Centre of ICAR-CIFA, West Bengal).

Daphnia

Culture of the zooplankton *Daphnia* sp. can be done as follows: In small rectangular or circular cement tank, 15 g cow dung, 10 g mustard oil cake and 1 g bakers yeast are added to every 50 litres of water and exposed to sunlight. After a period the water will turn green as a phytoplankton bloom develops, which is food for *Daphnia*. Add a small number (25-80) *Daphnia* for every litre of water, and add the mixture to a tank at intervals of around a week. After three weeks a good population of *Daphnia* will grow, which can be harvested with a fine mesh net and fed to fish in the rearing tanks. Baby *Daphnia* can grow to maturity and breed in around eight days.

End note

In comparison to 2021, hobbyists in West Bengal have had to pay a lower price to buy this GMO fish in 2022 because of high availability in the market. The sale price of adult colour widow tetra at some wholesale shops in Kolkata is now INR 4.50-5.00/piece. Coloured widow tetras are now a preferred variety with higher popularity than traditional molly, goldfish, platy, guppy, and swordtail. Aquarium fish growers opined that it has led the market down for other familiar exotic aquarium fishes. If a hobbyist wishes to buy one or two dozen colour widow tetra from a large aquarium shop, he will get it at retail price. But if bought in quantity of 50 or more, the customer will get it at a reduced wholesale rate. One can get the fish at a wholesale rate if placing an order for 500-2,000 of the same from fish farms-cum-breeding units and in quantity of 2,000 or more from aquarium fish businesses at wholesale delivery shops at CTI Dasnagar. Many self-employed youths and elderly persons in the Howrah Sadar Sub-Division and Howrah Municipal Corporation areas do breeding, seed production and propagation of different exotic freshwater aquarium fishes on 80-320 m^2 of land at home as a profession on a commercial scale.

One of the reasons for genetic manipulation of species used in aquaculture is to produce new expensive variants of ornamental species with novel shapes and/or colours[2]. It must be remembered that since multi-coloured widow tetra and fluorescent 'glofish' zebrafish are genetically modified, like other exotic species, they must never be released by hobbyists into ponds or natural water bodies.

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Expanding the horizon of aquaculture through women's empowerment

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Recently the fifth National Family and Health Survey (NFHS) carried out by the Government of India between 2019 to 2021 has found that India has 1,020 women for every 1,000 men. That means for the first time, India has more women than men and is no longer experiencing a population boom, indicating a significant societal shift in the country (NFHS-5, 2021). As the population of women has increased, their working areas have also been diversified. A World Bank report (1986) also states that, “Women are central to the success of poverty alleviation efforts in the short, medium and in the long run”. Women in the fisheries sector participate extensively and actively in all phases of work performed on fish farms. They are involved in small-scale production, post-harvest industrial and artisanal processing, value addition, marketing and sales. In aquaculture, women participate in construction of ponds, feeding, cleaning the pond environment, sorting of fingerlings and harvesting. Despite having other family chores, women in these groups together with male counterparts work for an average of 18 hours a week. However, such a contribution is not reflected in available documents as there are few sex-disaggregated statistics that track women in aquaculture that make women’s presence and interest visible.

The concept of “empowerment” was introduced at the International Women’s conference in 1985 at Nairobi, which defined empowerment as a “redistribution of social power and control of resources in favour of women”. In recent years the development of women has emphasised providing equal opportunities to women by removing gender bias, empowering women and creating self-reliance among them. Empowerment of women and gender equality is recognised globally as a key element to achieve progress in all areas. Globally, the role of women and the need to consider gender issues in aquaculture development was first recognised by the FAO-NORAD sponsored workshop on “Women in Aquaculture” in 1987 (Nash et al., 1987).

Training programme on culture of Indian major carp.

Packing of fingerlings.

All aquaculture labour practices should embrace the targets of Sustainable Development Goals (SDG) no. 5 (gender equality and empowerment of all women and girls), and no. 8 (decent work and economic growth). To reach the SDG targets, all aquaculture participants have responsibilities. Hence, gender equality must be mainstreamed into aquaculture planning, development, monitoring and evaluation, requiring political action by sector leaders, advocates and gender champions, supported by new technical instruments for implementation.

Women in aquaculture

Over the last four decades more women have graduated in aquaculture from higher educational institutes than men. The national Government is promoting many campaigns on girl’s education, their changing perception about professional career prospects, accessing resources directly and indirectly related to aquaculture in order to achive gender equality in the aquaculture sector. However, in most societies educated girls rarely choose aquaculture as potential career option.

Sex-disagrregated figures are available in some institutes, such as the number of women in highly skilled employment e.g., research postions and lab technicians, in supporting services e.g., accounting. It is seen that education can give women access to a greater range aquaculture activities. However, women are hired and promoted in far lower numbers than advanced degree completion rates in fisheries

Collection of marine fish at landing centre.

and aquaculture indicate. The participation of women in fisheries in aquaculture has been increasing but they are far from equal in pay, status and career progress.

Integration of women into conservation will better address the gender issues in fisheries which can provide improved ecological results. When the roles of women are understood then the effectiveness of the programmatic approach will improve. For example, implementation and enforcement of regulations in the coastal area especially nearshore ecosystems will improve by engaging women as stewards. Additionally, women in fish processing industries reduce product loss or by-product and also increase product value. Despite having a great chance of advancing gender equality, the sector still faces gender inequality challenges due to harmful social norms and structural inequality put women in a vulnerable situation and rise gender-based violence.

In this concept, several researchers have identified that there are various factors which are affecting women's empowerment. According to Johnson (2005), seven factors responsible for women empowerment are perceptions of power and competence are: Self-nurturance and resource access, interpersonal assertiveness, awareness of cultural discrimination, expression of anger and confrontation, autonomy, personal strength and social activism. Later Mahmud et al. (2012) gave some additional factors such as demographic status (age), social status (education), media exposure (TV and/or radio), economic status (household wealth) etc.

Nowadays, women are engaged in fisheries and aquaculture including fishing, gear making and so on and contribute an important part to the total revenue. Women who are engaged with fishing gear making or net making can reduce the cost of production in aquaculture. Women often participate in feeding in aquaculture and the processing of fish and shellfishes. But in technical and physical activities in fisheries and aquaculture such as fish feed preparation, pond maintenance, harvesting, etc., women tend to be less demanding human resources. Educationally, financially and mentally well-prepared women can manage all tasks in aquaculture including as record keeping and finance, decision making, social participation, laboratory work (water quality estimation, disease diagnosis, feed quality estimation, research etc.), preservation of the ecosystem, and policy making. So, there is a need to open opportunities in the aquaculture industry irrespective of gender that can improve the overall fisheries sector including enterprises and entrepreneurship.

At present, women of some states are facing different kinds of challenges to engage themselves in the aquaculture sector. To achieve the SDGs of poverty reduction and nutritional security, gender equity plays a key role in all sectors including fisheries and aquaculture. Gender equity may help to improve productivity and revenue generation as well as household income and nutritional outcomes. According to the State of Fisheries and Aquaculture published by FAO (2014), gender improvement has been noticed and more than 19% of women engaged directly in fisheries and aquaculture. In terms of numbers, women contribute 50% of the workforce when both primary and secondary fisheries sectors are combined (Jennifer, 2016).

Strategic interventions for addressing women in fisheries

Based on their interest, both men and women have an equal right to participate in the development process. Women's involvement in aquaculture greatly varies from place to place, religion, caste, family hierarchy. Several strategies can be implemented to promote women's empowerment in fisheries and address gender issues.

Combat gender blindness

The first step towards gender equality in aquaculture is overcoming gender blindness. This is everyone's responsibility, not the business of a few gender specialists. Women and men in farms, companies and institutions, regardless of their positions, have to be engaged on gender issues in a meaningful way throughout the spectrum of projects, research initiatives, education, government and donor and private interventions. To achieve this mindset change will need the work of gender champions, female and male role models and

Fisheries officer checking quality of fish.

Training programmes open new opportunities.

concrete suggestions showing how carefully targeted and sensitive actions at different levels can revolutionise women's engagement and enhance the contribution of both women and men in making the aquaculture sector more gender equal.

Supporting women's leadership and entrepreneurship

Due to the rapidly growing population in India, job opportunities have been decreasing. Entrepreneurship is the only possible way to feed ourselves besides creating ample job opportunities for livelihoods. Entrepreneurship is the propensity of the mind to take calculated risks with confidence to achieve a pre-determined business objective with correct decision-making. Women are seen to have a lower rate of entrepreneurship than men which indicates lower income returns of women from entrepreneurship. There is an abundant scope for women to improve their economic condition and contribute to the national income through entrepreneurship. Ornamental fish-based enterprise in India is generating high value and popularity in the present day. This is one of the simple and easiest ways of starting a business from backyard facilities available in the home with little investment. Here two modules are available – Firstly, aquarium construction, set up and marketing of ornamental fishes; and secondly, ornamental fish breeding and marketing. Ornamental fish breeding and culture is considered a profit-able business and has high market demand.

There is some evidence found on women's leadership in aquaculture in Tamil Nadu. Renuka was the manager of a green crab or mud crab hatchery in Kancheepuram District. She had very strong leadership qualities and also expertise in induced maturation, larval rearing, post-larval rearing, live-feed culture, broodstock maintenance, and other related activities. Several other women of Tamil Nadu with good leadership and entrepreneurship quality in aquaculture include Mrs Annai, engaged in pond-based crab farming, Mrs Kayal, engaged in crab fattening in the cage, Mrs Akila (Nagapattinam District), engaged in shrimp farming, and Mrs Latha (Kancheepuram District, engaged in ornamental fish farming.

Strengthening women's voices

Women's organisations and NGOs have the potential to provide benefit to women in fisheries by supporting them in their work and to overcome the social and cultural barriers of the society by promoting education, finance, skills, resources, and technology. The organisations can raise their voices on behalf of the women's community with regard to gender biases and stereotypes and can help women to engage in sustainable fisheries production and management. These organisations can also support women's enterprise financially and psychologically.

Promoting the processing industry to add value to fisheries products

A group of professionally trained women can organise post-harvest processing technologies and add value to fisheries products and improve community health. The contribution of women workers in fish processing industries is very crucial. They are engaged with all kinds of activities such as sorting, weighing, peeling, washing, gutting, drying, processing, preserving, packaging, marketing, and so on. The contribution of females in the industrial sector is higher than that of male workers and the majority of the women may be from an economically weak background. Men are mainly involved in office work, supervision, as managers, and in some heavy manual work such as loading and unloading of containers.

Improving marketing and sales skills

The livelihoods of women can be improved by better marketing and trading of fisheries products. In different states of India, the role of women in marketing is also different. In

Selling dried fish.

Selling marine fish.

Gujarat, women are usually engaged in unloading the fish catch, sorting of fish species wise, and their auctioning. The boat owner used to give a monthly salary. Some women workers also borrow some amount of money in advance in the off-season for their livelihood and later the boat owner deducted the money from their salary in the fishing season. The main problem related to the hiring of women workers is that they get lower wages compared to men but the effort that they give is the same.

The market channel involves women at various levels of marketing activities such as wholesaling, retailing, collaboration with other companies (in case of fish feed), distribution, and advertising. The local fish markets of some coastal states of India such as Gujarat is completely dominated by women and the majority of them are used to engaging in wholesaling and retailing activities. To convert the fish into money, fishermen depend on women.

Gear manufacturing

Fishing gear industries are a vital components of fisheries on which the catch or the quantity of fish harvest is dependent. Net making, repairing and rope making are profitable enterprises that can be a source of employment skilful women. ICAR-CIFT and CIFNET are key institutes developing technologies for this industry and also provide training to willing people. The activities are mainly carried out in off-season which provides a supplementary income. These activities can be done in the home and by everyone irrespective of gender.

Status of women's empowerment in India and the world

Women in emerging regions have integrated into this liberalised labour market. Typically, industrial growth in the global economy is centred in special economic zones. In most cases, enterprises in these zones hire young unmarried women, and women's labour is frequently undervalued, insecure, overworked, and paid at lower rates. Large boats that fish offshore and deepsea in most locations have male crews. Women control smaller boats and canoes in coastal or inland waters - harvesting bivalves, molluscs and pearls, collecting seaweed, and setting nets or traps. Women contribute equally to that of men in nations such as South America, Sri Lanka, and West Africa. In the fishing industry, men and women work in complimentary roles. In Japan, female employees make up 13% of those engaged in fishing activities, 38.4% of land-based workers, and 64% of those working in the marine products-processing sectors. The census mentions that small-scale fishing is done primarily by men in Central America (92.5 per cent of regional activity) and the contribution of women is just 7.5 per cent.

Cambodian women have limited education and lack basic skills. They receive minimal assistance in terms of training and extension services compared to their contribution to the country's overall fish production, processing and marketing potential. Moreover, it is a well-recognised fact that information on women in fisheries in the country is limited and unreliable. In Malaysia and Indonesia, gender equality is protected by the state. In these two countries, women participate actively in many aspects of fisheries activities, especially in post-harvest and trading activities.

In India, approximately 25% of women workers are active in preharvest operations, 60% in export marketing, and 40% in internal marketing. Out of a total workforce of 1.6 million, approximately 0.5 million women work in pre and post-harvest operations in the marine fishing sector. However, their scale of operation is limited by their low investment and risk-bearing abilities because of the lack of access to resources such as institutional credit, and technological innovations like ice boxes and proper storage mechanisms. In Kerala, a high percentage of illiteracy among fish vendors and retailers indicated that being traditional fisher folk, they had limited opportunities in terms of money, facilities and family to support education. They were forced into this profession at a younger age group and continued their career even in their late sixties.

In Tamil Nadu District of Ramanathapuram, It was observed that over 5,000 women relied on the seaweed businesses for a living and that if the available resources were gathered to their full potential, it might employ another 20,000 coastal fisherfolk in the harvesting sector and an equivalent number in post-harvest activities. Fisherwomen are involved in the gathering and post-harvesting of seaweeds.

Fisherwomen on the Maharashtra coast are generally engaged in fishing, working as crew on the boats with males, and in post-harvest duties. Sorting, washing, and drying fish should be improved to reduce the amount of energy required by women to do these tasks.

Fresh fish trading and traditional fish processing are among the most chosen activities of fisherwomen in the southern maritime states of Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu for their livelihoods. Furthermore, fisherwomen are involved in fishery-related activities such as clam collection and processing in Kerala, fish processing and aquaculture in Kerala, prawn seed collection, fish and shrimp farms and hatcheries, salt loading in Andhra Pradesh, and working at landing centres, byproduct units, and surimi plants in Karnataka.

Several steps have been taken by the both governmental and nongovernmental agencies are trying to reduce poverty among coastal villages by improving livelihood activities in women's groups. This has included providing opportunities for further adult education and access to ICTs through the ICT Livelihood Project being implemented in Kenya and India, which seeks to alleviate poverty in coastal villages through an integrated approach. In Tuticorin District of the Gulf of Mannar in Southeastern India, the local fisherwomen SHGs in five coastal villages were being trained through the provision of ICTs, adult education, environmental education and alternative livelihood schemes to enhance literacy. The goal was to improve their socio-economic status, aiming to reduce pressure on marine resources and the economic vulnerability of coastal communities.

Conclusion

Fisheries play a major role in livelihoods and in the eradication of poverty and malnutrition.Women are involved in aquaculture since time immemorial. However, their contributions were not recorded. Women have the potential to engage in aquaculture enterprises such as fish hatchery and rearing, grow out culture, integrated aquaculture, sampling, record-keeping and feed making. Government should encourage women to participate in aquaculture by providing financial support to the rural population. Extension workers should demonstrate technical skills to overcome the problems faced in aquaculture. Seaweeds are upcoming high demand commodity for pharmaceuticals and food. Training in modern seaweed cultivation, transplantation, breeding and harvesting methods can improve living standards. In these aspects aquaculture will play an evolutionary role by showing promise for improving nutrition, raising household incomes and empowering women. Nutrition options include growing small nutrient rich species, growing species for home use along with other species destined for market sale, and providing nutrition information and extension on eating behavior and patterns.

Packing of fish seed with guidance from fisheries officer.

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Fertilisation of aquaculture pond.

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Artemia side event at the FAO Sub-Committee on Aquaculture, Mexico

Left to right: Dr Matthias Halwart, COFI SCA Technical Secretary (speaking), Prof. Patrick Sorgeloos, Dr Eduardo Leano, Prof. Yeong Yik Sung (IAAC Chair) and Betty Nyonje.

A side event on the *Potential of brine shrimp Artemia production for aquaculture transformation* was held on 16 May at the 12th Session of the FAO Sub-Committee on Aquaculture (COFI-SCA), Mermosillo, Mexico (16-19 May).

Artemia is a critical resource for the aquaculture industry, underpinning around 10 million tonnes of fish and crustacean end product. The event was an opportunity for the newly established International Artemia Aquaculture Consortium (IAAC) to explore issues in providing a sustainable supply of *Artemia* cysts to support hatcheries and seed to the aquaculture industry. The consortium is hosted by NACA.

The event was opened by Dr Matthias Halwart, COFI SCA Technical Secretary, who reflected on FAO's early publications and ongoing role promoting good practices in *Artemia* hatchery production, most recently through a workshop on SDG-aligned Artemia Aquaculture, held in conjunction with the Global Conference on Aquaculture Millennium +20 in Shanghai.

Prof. Patrick Sorgeloos gave a presentation on the history of *Artemia* use in aquaculture from the Kyoto conference in 1976; the establishment of the Artemia Reference Center and the International Study on *Artemia*; the boom in hatchery utilisation of *Artemia* for marine fish and shrimp; and the integration of *Artemia* production with artisanal salt farming.

Dr Betty Nyonje, Kenya Marine and Fisheries Research Institute, gave a presentation on *Artemia* production interests and activities in Africa.

Dr Eduard Leano, NACA, gave a presentation on formation of the IAAC, its recent activities including webinars on *Artemia* management in the Great Salt Lake, activities in Africa, and the status of cyst utilisation in hatcheries world-wide.

Prof. Yeong Yik Sung, Chair of the IAAC, gave a presentation on a series of ten recommendations formulated by the consortium. This was followed by a series of video interviews between consortium members and Mr Simon Wilkinson, NACA, on recent activities and developments:

- Pond production of *Artemia*
  Dr Nguyen Van Hoa, Can Tho University, Vietnam and Dr Meezanur Rahman, Artemia4Bangladesh, WorldFish

- *Artemia* resources and use in China
  Prof. Liying Sui, Director Asian Regional Artemia Reference Center

- Sustainable harvesting of inland salt lakes
  Mr Thomas Bosteels, CEO Great Salt Lake Brine Shrimp Cooperative

- Potential for improved use of *Artemia* in fish and shrimp hatcheries
  Dr Philippe Léger, former Managing Director of Inve Aquaculture (Benchmark Holdings Group) and Mr David Garriquez, Sustainable Shrimp Farming Solutions LLC

- Use of *Artemia* biomass as human food
  Dr Shahina Syeda, WorldFish

The interviews will be made available on the NACA YouTube channel shortly, under the International Artemia Aquaculture Consortium playlist:

https://www.youtube.com/@aquacultureasia/playlists

The discussions and recommendations from the event were tabled at the COFI SCA and reflected in the report, which will be released by FAO in due course.

Great Salt Lake Brine Shrimp Fishery Meets MSC's Fishery Standard

The Great Salt Lake is still the largest supplier of Artemia cysts to the global aquaculture industry.

SALT LAKE CITY, May 15, 2023 – Utah's Great Salt Lake brine shrimp fishery has officially achieved the Marine Stewardship Council's (MSC) sustainable wild fishery certification, making it the first inland fishery in the United States to earn this prestigious certification.

Brine shrimp (*Artemia franciscana*) are a small, shrimp-like crustacean that live in hypersaline lake environments and are a vital part of the lake's ecosystem, serving as a food source for numerous bird species and providing an important source of income for local fishermen.

The MSC certification process is rigorous and requires fisheries to meet strict standards for sustainable fishing practices, environmental impact, and management. The Great Salt Lake brine shrimp fishery underwent a thorough 8-month assessment by an independent, third-party certifier and was found to meet MSC's criteria for environmentally sustainability fishing practices.

"Great Salt Lake brine shrimp fishery's achievement of MSC certification is a testament to the hard work and dedication of local fishermen, who have been practicing sustainable fishing for generations," said Nicole Condon, MSC US Program Director. "By earning this certification, the fishery is demonstrating their commitment to the long-term health of the lake's ecosystem and the communities that depend on it."

Great Salt Lake is the largest saltwater lake in the Western Hemisphere and is home to one of the largest brine shrimp populations in the world. It is also the only commercial source of brine shrimp in the Western Hemisphere.

The MSC fishery certificate is held by the Great Salt Lake Brine Shrimp Cooperative. The Cooperative uses unique gear such as rakes and containment booms to harvest the cysts of brine shrimp. They also use spotter planes to identify brine shrimp cyst blooms from above. Brine shrimp cysts are stored and hatched for use as live feed, for example for prawn hatcheries, with approximately 99% of the product exported to more than 50 countries around the world.

"Sustainability defines our industry in unique ways," said Timothy Hawkes, Vice Chair and General Counsel for Great Salt Lake Brine Shrimp Cooperative. "The harvest management system in place on Great Salt Lake—developed in collaboration between industry and the State of Utah—harvests only the excess cysts in the system. That management system sets up the brine shrimp population for the best possible start the following year, which benefits not only the population itself, but the brine shrimp industry and the tens of millions of migratory birds that also rely on the resource. We are grateful to be recognised for our dedication to sustainability with the MSC certification."

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Fourth Quarter of 2022

With the implementation of the new aquatic animal disease reporting in the Asia Pacific region from January 2021, and in lieu of the published QAAD Reports (last issue published was 4th quarter of 2020), NACA is publishing reported aquatic animal diseases submitted by countries in the Asia-Pacific region. This report covers the fourth quarter of 2022 and the original and updated reports can be accessed from the QAAD page at: https://enaca.org/?id=8

The following diseases were reported:

Finfish Diseases

- **Infection with *Aphanomyces invadans* (EUS):** Bangladesh in rohu (*Labeo rohita*), catla (*Labeo catla*) and mrigal (*Cirrhinus mrigala*); and, India in *Puntius japonicus*, *C. mrigala*, snakeheads (*Channa marulius*, *C. striata*), and catla (*Labeo catla*).

- **Infection with red seabream iridovirus (RSIV):** Chinese Taipei in Asian seabass (*Lates calcarifer*), hybrid grouper (*Epinephelus fuscoguttatus* x *lanceolatus*) and goldlined seabream (*Rhabdosarbus sarga*); and, India (ISKNV) in freshwater angelfish (*Pterophyllum scalare*), Ram cichlid (*Mikrogeophagus remirezi*), Oscar (*Astronatus oscellatus*) and *L. calcarifer*.

- **Carp edema virus disease (CEV):** India in Koi carps (*Cyprinus carpio*)

- **Viral encephalopathy and retinopathy (VER):** Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *lanceolatus*).

- **Infection with Tilapia lake virus (TILV):** Chinese Taipei in tilapia (*Oreochromis niloticus*); and, the Philippines in tilapia juveniles (*Oreochromis*).

- **Enteric septicaemia of catfish:** Vietnam in pangas catfish (*Pangasius microneme* and *P. hypophthalmus*).

Molluscan Diseases

- **Infection with *Perkinsus olseni*:** India in mussel (*Perna viridis*).

Crustacean Diseases

- **Infection with white spot syndrome virus (WSSV):** Bangladesh in tiger shrimp (*Penaeus monodon*) and mud crab (*Scylla serrata*); Chinese Taipei in whiteleg shrimp (*P. vannamei*); India in *P. monodon* and *P. vannamei*; the Philippines in grow-out of *P. monodon*, *P. vannamei* and *S. serrata*; and Vietnam in *P. monodon* and *P. vannamei*.

- **Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV):** The Philippines in *P. vannamei*.

- **Acute hepatopancreatic necrosis disease (AHPND):** The Philippines in *P. vannamei* and *P. monodon*; and, Vietnam in *P. monodon* and *P. vannamei*.

- **Infection with Infectious myonecrosis virus (IMNV):** India in *P. vannamei*.

- **Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP):** India in *P. vannamei*; and, the Philippines in *P. vannamei* and *P. monodon*.

Amphibian Diseases

- Infection with *Batrachochytrium dendrobatidis*: Australia in adult tusked frog (*Adelotus brevis*) and growling grass frog (*Litoria raniformis*).

Other Diseases

Bangladesh reported Infection with *Streptococcus agalactiae* in tilapia (*O. niloticus*), and Infection with *Aeromonas* spp. in climbing perch (*Anabas testudineus*), shing catfish (*Heteropneustes fossilis*), gulsha (*Mystus cavasius*) and pabda (*Ompok pabda*).

E.M. Leaño
Senior Programme Officer
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Report of the 21st Asia Regional Advisory Group on Aquatic Animal Health

This report summaries the proceedings of the 21st meeting of the Regional Advisory Group on Aquatic Animal Health, held 17-18 November 2022. The role of the group is to review trends in disease and emerging threats in the region, identify developments in global disease issues and standards, to evaluate the Quarterly Aquatic Animal Disease Reporting Program and to provide guidance on regional strategies to improve health management. The meeting discussed:

- Progress on NACA's Asia Regional Aquatic Animal Health Program.

- Updates from the OIE Aquatic Animal Health Standards Commission.

- Aquaculture biosecurity.

- WOAH Aquatic Animal Health Strategy 2021-2025.

- Report on aquatic animal health activities of WOAH-RRAP.

- Updates on prevention and control measures on important aquatic animal diseases in China.

- Updates on regional disease reporting and disease list.

Download the report from: https://enaca.org/?id=1269

Thai Fish Project

Left to right: Dr Yuan Derun and Simon Wilkinson (NACA), Dr Ikuo Horono (TUMSAT), Dr Izumi Tsurita (Project Coordinator) and Khun Pakpitchaya Borvonsin, Project Assistant.

Dr Izumi Tsurita, Coordinator for the JICA-funded Thai Fish Project visited the NACA Secretariat on 18 May to discuss collaboration in outreach and extension of the project's conclusion. The meeting was also attended by Dr Ikuo Hirono from the Tokyo University of Marine Science and Technology (TUMSAT), and Khun Pakpitchaya Borvonsin, Project Assistant.

More formally known as the Research Project for the Utilization of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market, the project led by TUMSAT and the Thai Department of Fisheries, is engaging many research institutes in both Japan and Thailand and has involved around 200 scientists. The project commenced on 1 June 2019 and will conclude in May 2024.

The Thai Fish Project aims to promote domestication and wise use of Thai native aquatic species by increasing farm productivity, conserving genetic resources, and reducing infectious disease impact.

Thai Fish Project is engaged in a wide range of activities, principally concerning two species, the Asian seabass *Lates calcarifer*, and banana shrimp *Penaeus merguiensis*.

Key outputs of the project's research are:

- Molecular markers for selection of economically important traits.
- Identification of families from the target species with economically important traits.
- Development of vaccines against important diseases of seabass and shrimp.
- Improvement of the nutritional profile (DHA and EPA) of farmed seabass.
- Development of novel maturation induction method for female banana shrimp.
- Development of germ cell transplantation and preservation techniques.

As the project approaches its conclusion, NACA has undertaken to assist with dissemination and outreach of the conclusions and techniques that have been developed.

For more information about the Thai Fish Project, please visit:

https://www.facebook.com/thaifishproject/

NACA participates in Coordinating Working Parties on Fisheries Statistics

NACA attended an intersessional meeting of the Coordinating Working Parties (CWP) as a virtual participant in a hybrid meeting from 28-30 June 2023.

The meeting combined the 8th meeting of the Aquaculture Subject Group and 30th meeting of the Fisheries Subject Group, and was held at the North East Atlantic Fisheries Commission Headquarters in London.

With regards to aquaculture subject matter, the meeting considered progress on the CWP ad-hoc Task Group on Aquaculture, whose major activity has been the development of the aquaculture component of the CWP Handbook, with input from NACA.

Comprehensive global and regional statistics on fisheries and aquaculture require national statistical programs to be coherent and consistent, and based on a common set of statistical standards which apply internationally recognized definitions, classifications and codes. The CWP Handbook was created to serve as the basis for this integration, initially for capture fisheries but now it is being extended to aquaculture.

The Handbook covers the concepts, definitions, classifications and data exchange protocols including the codes as applied to capture fisheries statistics and aquaculture globally, with a focus on the principles applicable to regional and global organizations. While national agencies often use statistical systems which are developed for specific national purposes and thus may differ from those employed internationally, the principles described in the Handbook may also be relevant to those national systems.

The intended users of the Handbook are CWP Member agencies, national fishery and aquaculture statistics offices, national administrations and other fishery and aquaculture agencies. The Handbook is also intended to assist in the development of national standards as logical extensions of the international standards.

The scope of the Handbook is to:

- Document concepts that are relevant to fishery and aquaculture statistics.
- Define statistical standards for specialized concepts as adopted by CWP.
- Define statistical standards for concepts that have a wider scope as adopted internationally.
- Review methodological issues that are specific to fishery and aquaculture statistics.
- Define minimum requirements for data collection.
- Define desirable levels of information.

Other issues relevant to aquaculture discussed at the meeting included discussions on workflow and confidentiality requirements in the collection, handling and presentation of statistical data, a report on the Task Group on Small-Scale Fisheries, issues related to employment statistics, and amendments to the ASFIS List of Species for Fishery Statistics Purposes.

NACA signs MOU with Cagayan Valley R&D Consortium

NACA signed an MOU signed with the Cagayan Valley Agriculture, Aquatic and Natural Resources Research and Development Consortium Institutions (CVAARRD) on 1 June, during a visit by a CVAARRD delegation to the Secretariat. The MOU was signed by Dr Ricmar P. Aquino, RRDCC Chair and University President of ICU, and Dr Huang Jie, Director General of NACA in the presence of the 35-person delegation.

The CVAARRD Consortium is a non-profit organisation that was created to promote science and technology applications for agriculture, aquatic, forestry and natural resource sectors. The consortium is a venue for joint planning, monitoring, evaluation and sharing of resources through collaborative interventions mong its members through the implementation of R&D management and coordination, strategic R&D / extension, R&D results utilisation, capability building and governance, policy analysis and advocacy.

The purpose of the MOU is to facilitate collaboration between NACA and the CVAARRD Consortium in professional capacity building, joint research, training and experiential exchanges and research visits. It is anticipated that cooperation will also include training, workshops and learning programmes, sharing information and organisation of joint conferences, seminars, and events.

Shrimp Summit, 24-26 July, Ho Chi Minh City, Vietnam

The 2023 Shrimp Summit will convene the global seafood value chain to address the critical challlenges of Asia's shrimp-farming sector, from stagnant production to growers' livelihoods, with a cross-topic focus on sustainability and climate change. The Summit is presented by The Center for Responsible Seafood (TCRS) and co-hosted by the Global Seafood Alliance.

The format of the 2023 Shrimp Summit will allow the industry to develop a common understanding of issues, address key challenges through discussion and work toward consensus and actionable solutions.

This in-person and virtual event will feature discussions, relevant content and informative webinars before, during and after the event in the TCRS Online Community.

Session topics include: Global Production & Markets; Sustainable Feeds; Improver Programs; Investment; Shrimp Breeding & Diseases; Growout Intensification; Collective Marketing; and Innovations. For more information, visit:

https://responsibleseafood.org/shrimp-summit/

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