ISSN 0859-600X

Volume 27 No. 4 October-December 2023

AQUACULTURE ASIA

Shrimp welfare assessments

Tilapia parvovirus disease

Thai Fish Project

Naihati Fish Seed Market

Aquaculture Asia

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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

Aquaculture transformation

The transformation of aquaculture is a pivotal aspect in the global pursuit of sustainable intensification of food production. As we face the challenges of a growing population and environmental constraints, the role of aquaculture is becoming increasingly significant in meeting the escalating demand for protein-rich food while minimising its ecological footprint.

Aquaculture has often faced criticism for its environmental impacts, including habitat destruction, water pollution, and the use of wild fish for feed. However, a paradigm shift is underway towards more sustainable practices that prioritise environmental stewardship without compromising productivity. This transformation involves technological innovations, improved management techniques, and a shift towards more sustainable feed sources.

One of the key drivers of this transformation is the adoption of advanced technologies. Innovations in aquaculture, such as recirculating aquaculture systems (RAS), enable the efficient use of water and mitigate pollution by continuously filtering and recycling water within closed systems. RAS not only reduce the environmental impact but also allow for controlled and optimised conditions, leading to higher productivity and healthier fish.

Furthermore, the industry is exploring alternative feed sources to reduce reliance on wild-caught fish for feed. Sustainable feeds made from plant-based proteins, algae, insects, and even single-cell organisms are being developed. These alternatives may not only alleviate pressure on wild fish stocks but also contribute to a more circular and sustainable food system.

Improved management practices also play a crucial role in the sustainable intensification of aquaculture. Implementing better monitoring systems, including IOT-based solutions, for water quality, disease management, and waste disposal has the potential minimise negative impacts on surrounding ecosystems. Additionally, the use of polyculture and integrated multitrophic aquaculture, where species at different trophic levels are cultured together to utilise resources more efficiently, showcases the potential for sustainable production models.

Government policies and international collaborations are fundamental in driving this transformation. Regulations that promote sustainable practices, provide incentives for innovation, and support research and development are essential for the widespread adoption of sustainable aquaculture methods. Collaborations between governments, NGOs, academia, and industry stakeholders facilitate knowledge exchange and the development of best practices.

The transformation of aquaculture towards sustainability is not without its challenges. Investments in research and technology, changes in consumer behavior, and the need for capacity building in the industry require concerted efforts and resources. However, the long-term benefits are immense – a more resilient food system, reduced pressure on natural resources, and conservation of biodiversity.

Embracing technological advancements, innovative practices, and collaborative approaches will pave the way for a more sustainable and responsible aquaculture industry that can meet the nutritional needs of a growing population without compromising the health of our planet.

Simon Wilkinson

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How welfare assessments of farmed white leg shrimp (*Penaeus vannamei*) can benefit the whole industry

FAI Farms

https://www.faifarms.com/

The welfare of decapod crustaceans, the largest group of farmed animals worldwide, is gaining prominence in the aquaculture industry. Taking better care of the billions of shrimp farmed annually not only responds to certification standards and consumer demand, it is the right thing to do.

The shrimp industry is rapidly evolving due to emerging diseases, rising production costs, and unpredictable market dynamics. These changes have led to higher intensification, alterations in feeding and nutrition, and genetic improvements tailored to specific farming conditions. While shrimp producers strive to build successful businesses, one often overlooked aspect is animal welfare. Embracing a welfare approach has the potential to address current challenges in shrimp farming by providing insights into farming conditions and animal health, ultimately boosting production performance. Recording welfare data enhances transparency along the supply chain, ensuring that every actor, from hatcheries to shrimp buyers, understands the quality of the breeder, post larvae, or shrimp they purchase.

Scientific studies assessing the sentience (the ability to feel or perceive sensations) of decapod crustaceans are relatively recent but have led to regulatory changes in several countries and altered the perception of many retailers. We stand at a turning point. Shrimp farmers have an opportunity to gain a competitive edge by prioritising welfare.

Welfare assessment of white shrimp

In the recently published article by Pedrazzani et al. (2023), welfare indicators have been established for the different stages of production process: reproduction, larval rearing, transport, and grow-out. The indicators are categorised into four out of the five domains of animal welfare: environmental, sanitary, nutritional, and behavioural (Table 1). The indicators associated with psychological freedom were not treated as a distinct category since the other proposed indicators indirectly evaluated this aspect.

Drawing from the review of scientific publications, each of the welfare indicator is assigned a score from 1 to 3. Score 1 signifies adherence to the optimal range of variation for the target species. Score 2 encompasses variations within the acceptable limits typically tolerated by animals. Score 3 designates reference levels that exert an intolerable impact on the physiological, health, and behavioral well-being of animals, jeopardising their welfare and survival.

All indicators and scores are available on the publication “Non-invasive methods for assessing the welfare of farmed white-leg shrimp (*Penaeus vannamei*)” by A. S. Pedrazzani, N. Cozer & M. H. Quintiliano.

Scoring welfare helps farm technicians and managers to identify issues that would cause stress to the farmed animals. It helps them adjust farming practices and respond quickly to rising challenges during the production cycle.

Bringing knowledge on welfare to the industry

FAI Farms is working with industrial partners in Thailand and Vietnam to encourage shrimp farmers to perform welfare assessment. They are providing on-site and online workshop to educate farmers to have a different approach to farming and leverage farm data to document shrimp production to market.

For this purpose, FAI Farms has created a free online training course on shrimp welfare and invites all industry participants to obtain their "Shrimp Welfare Indicator" certificate:

- Enrol in the course: Shrimp welfare indicators: https://bit.ly/3uy5s4Z
- Just want a peak? A teaser of the course is available at: https://bit.ly/3SREDmI
- More information on the course content: https://fai.academy/aquaculture/shrimp-welfare-online-courses/

Additionally, FAI Farms is developing a mobile application designed for conducting welfare assessments on shrimp farms. This application will serve as both a tool for gaining deeper insights into farming conditions and addressing farm-related challenges. Simultaneously, it serves as a record that can validate a farm's adherence to good farming practices.

If you wish to learn more about the project and help shrimp farmers to have a different approach to farming, please visit **https://myshrimp.farm**. You can contact FAI Farms through this website.

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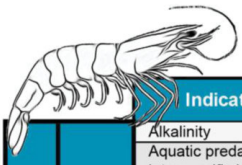
Table 1. Domains and welfare indicators during the production process of white-leg shrimp, *Penaeus vannamei* (Pedrazzani et al. 2023).



DOMAIN		Indicators	PHASE: Reproduction	Larval rearing	Transport	Grow-out
	Environmental	Alkalinity	●	●		●
		Aquatic predators and interspecific inhabitants	●			●
		Stocking density	●	●	●	●
		Dissolved oxygen	●	●	●	●
		NH_3-Ammonia	●	●	●	●
		Nitrite	●	●		●
		pH	●	●	●	●
		Photoperiod	●	●		
		Salinity	●	●	●	●
		Temperature	●	●	●	●
		Terrestrial predators	●			●
		Transparency				●
	Health	Antennae	●			●
		Epibionts		●		
		Exoskeleton (cuticle)	●	●	●	●
		Eyes	●			●
		Gastrointestinal tract	●			
		Genetic Selection	●			
		Gills	●			●
		Health certificate		●		
		Hepatopancreas	●	●		●
		Invasive procedures	●			
		Luminescence	●	●		
		Malformations		●	●	
		Mortalities rates	●	●	●	●
		Motor appendages	●			●
		Musculature	●	●	●	●
		Rostrum	●			●
		Sexual maturation	●			
		Uniformity of stages		●		
	Nutritional	Amount of food	●			●
		Analysis of gastrointestinal tract	●	●		●
		Composition/type of diet	●	●	●	●
		Distribution of feed				●
		Feed conversion rate				●
		Feed crude protein	●	●		●
		Frequency of feeding	●	●	●	●
		Size of food		●		●
	Behavioural	Anaesthesia	●			
		Escape behaviour				●
		Phototaxis		●		
		Reaction to offered food	●			
		Stunning reflexes at slaughter				●
		Swimming behaviour	●	●	●	●

Thai Fish Project: A path towards a sustainable aquaculture

Pakpitchaya Borvonsin[1], Izumi Tsurita[2], Jiraporn Charoenvattanaporn[3], Pitchaya Chainark[4], Suttinee Limthammahisorn[5], Ikuo Hirono[6]

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Thailand has always been among the top producing and exporting countries of fishery commodities. In terms of exports, it has served as the world's third largest exporter of fishery products, making up a considerable portion of the total global export value for many consecutive years (Jaya et al., 2019). A closer look reveals that a significant percentage of those fishery commodities are aquaculture products. In 2019, Thailand was ranked 10th in the world, in terms of aquaculture production (SEAFDEC, 2022). Aquaculture has been a sector of great importance to Thailand's socio-economic development. The fisheries GDP of Thailand was up to US$2.947 billion in 2015–with coastal and freshwater aquaculture together accounting for 56 percent of total fisheries production value (Yenpoeng, 2017). The sector is currently providing employment for over 650,000 people in the country (Yenpoeng, 2017). Despite such success, Thai aquaculture is not without challenges in sustaining its contribution to the economy nor its ability to satisfy increasing national and global demand for aquatic protein. This is especially the case when environmental sustainability is a major determinant for the sector's success because on multiple occasions in the past, the aquaculture industry has had negative impacts on the environment.

Generation one banana shrimp Penaeus merguiensis bred at the Trang Coastal Aquaculture Research and Development Center.

Asian seabass Lates calcarifer cultured in the Phuket Coastal Aquaculture Research and Development Regional Center.

One negative impact is the introduction of exotic species. Several major aquatic species cultured in Thailand are exotic, with some being considered invasive (Sampantamit, et al., 2020). This has the potential to disrupt local food webs and ecosystems, which can result in the decline and extinction of native species. To illustrate, the South-American whiteleg shrimp (*Penaeus vannamei*), which was introduced in Thailand in the 90s and subsequently became the country's main cultured species, has been reported to be found in Thai natural waters, including the mouth of the Bangpakong River, and in several coastal and offshore areas along Thailand's east coast (Partnerships in Environmental Management for the Seas of East Asia & Department of Marine and Coastal Resources, 2019). Some accompanying negative effects are the spread of an exotic pathogen, namely taura syndrome virus (TSV) and competition with local shrimp species.

The whiteleg shrimp is reported to have faster feeding rates than many Thai native shrimp species (PEMSEA & DMCR, 2019).

A disease outbreak also raises environmental concerns. It is suggested that the emergence and spread of diseases in fish and shrimp farms can pose a threat to wild populations and biodiversity by triggering among others, changes in predator and prey populations, changes in host abundance, and reduction in intra-specific genetic variation (Arthur & Subasinghe as cited in Walker & Mohan, 2009). Although it is also noted that environmental impacts of the disease outbreak in aquaculture farms are generally hard to assess and relatively under-researched, it certainly is a serious hindrance to the performance of aquaculture production. Thailand knows this well. From 2012 to 2013, disease outbreaks of early mortality syndrome/acute hepatopancreatic necrosis disease (EMS/AHPND) led to a substantial decline in the country's farmed shrimp production from 600,000 tons to 325,000 tons (Sampantamit et al., 2020).

Another environmental impact is water pollution. The discharge of nutrient-rich effluent from fish and shrimp farms into the environment, such as natural water bodies, can trigger eutrophication that will lead to poor water quality and consequently severe ecological damage. One study suggests the blue-green algae blooms in the Gulf of Thailand are caused by the release of nutrients (Sampantamit et al., 2020).

Thailand, sustainability, and aquaculture

Thailand places great importance on sustainable development. The country has been demonstrating its commitment to the concept through several policy initiatives. Sustainable Development Goals (SDGs) were integrated in the development agenda, including the 20-Year National Strategy Framework (2017-2036) and the 12th National Economic and Social Development Plan (2017-2021). This means that every government agency is required to align its policies and budget planning with the SDGs (PEMSEA & DMCR, 2019).

The Department of Fisheries is the principal government agency in charge of aquaculture development planning and implementation in Thailand. Its main regulatory framework is the Fisheries Act 2015, which was established to support sustainable fisheries and aquaculture. Chapter 7 of the Act specifically highlights aquaculture promotion to achieve long-term economic, social, and environmental sustainability and ecosystem balance; DOF is responsible for promoting, developing, and providing guidance with respect to aquaculture to achieve such goals "without compromising the state of the ecological environment" (Royal Ordinance on Fisheries, 2015). In short, at the heart of the Department of Fisheries' direction for aquaculture development is environmental sustainability. Other equally important considerations include food security, food safety, economic growth, and adherence to international agreement.

Thai Fish Project

The continuously growing demand for fishery products and the ongoing concerns with respect to the culture of aquatic animals highlight an urgent need for the promotion of research and development in aquaculture, which has recently become the main source of global supply for aquatic protein. In the Department of Fisheries' 5-Year Strategic Plan 2017-2021, a reference is made to several national planning frameworks and strategies, which the Department has to conform with in terms of its developmental direction. And in many of these strategies, a heavy emphasis is placed on promoting research as the way to facilitate knowledge and capacity development in order for Thailand to maintain sustainable aquaculture, effectively respond to domestic demand for fishery commodities, and improve competitiveness in the global market (Department of Fisheries, 2017).

As a result, Thai Fish Project started in 2019. Thai Fish Project is the simple name for the project more formally titled Utilization of Thailand Local Genetic Resources to Develop Novel Farmed Fish for Global Market. It is led by the Tokyo University of Marine Science and Technology (TUMSAT) and the Department of Fisheries, Ministry of Agriculture and

The 4th Joint Coordinating Committee (JCC) meeting of Thai Fish Project in 2022 - the JCC is where the research progress will be updated and monitored to make sure the project meets its goal.

Juvenile Asian seabass in the Songkhla Coastal Aquaculture Technology and Innovation Research and Development Center.

Cooperatives, Thailand, with other notable research institutes in both Japan and Thailand, involving around 200 research members.

This joint research project is funded by Japan International Cooperation Agency (JICA) and Japan Science and Technology Agency (JST). The project was initially expected to last 5 years from 2019-2024 but due to COVID-19 that had created a big disruption for project activities, the end year was extended to 2025.

Thai Fish Project aims to promote domestication and wise use of two Thai native aquatic species, namely the Asian sea bass (*Lates calcarifer*) and banana shrimp (*Fenneropenaeus merguiensis*) through increasing productivity, reducing the impact of infectious diseases, and preserving genetic resources. Considering the issues related to the sustainability of aquaculture practices, including the introduction of exotic species, disease outbreaks and water pollution, the Thai Fish Project selected Asian sea bass and banana shrimp, which are both native to Thai natural waters. The project also encompasses several specific research topics to ensure that it comprehensively addresses the concerns on safeguarding the food security and enhancing the environmental sustainability as much as possible.

In total, there are nine research sub-groups, which can be classified into four main research outputs, as follows:

1. Create through molecular breeding

The project is making use of molecular breeding technology to identify at least one useful molecular marker(s) that correlate with economically important traits of the target species. The molecular maker(s) identified will be a precise and useful piece of information, which will enhance the effectiveness of the breeding and the efficiency of the aquaculture. To begin this study, we have evaluated the genetic diversity of the target species. We are also now working to identify at least one family of each target species that possesses economically important traits. Finally, the project expects to establish a breeding program for resilient and fast-growing families.

2. Control by developing disease prevention method

The project is developing prevention methods against infectious diseases common among Asian sea bass (e.g. scale drop disease virus (SDDV), viral nervous necrosis (VNN), and infectious spleen and kidney necrosis virus (ISKNV)) and banana shrimps (e.g. WSSV, *Enterocytozoon hepatopenaei* (EHP), *Vibrio parahaemolyticus* (VpAHPND), yellow head virus (YHV) and hepatopancreatic parvovirus (HPV)). Under this output, we conduct disease surveillance of common diseases among the two target species. We aim to develop at least one on-site disease detection method and protective vaccine for Asian sea bass. Likewise, the project expects to develop a prevention method for banana shrimps against common diseases by using probiotics, taking into consideration the nature of the aquaculture environment including the season, temperature, water quality, and microbial flora.

3. Add value and wise use

The project is attempting to develop new culture technologies to produce high value-added fish and shrimp. One group of researchers is developing a nutrient-enriched diet that will enhance maturation and fertility for the target species. For

Aquaculture cage donated by JICA to the Phuket Coastal Aquaculture Research and Development Regional Center.

Asian sea bass, we aim to increase eicosapentaenoic acid (EPA) and docosahaxaenoic acid (DHA) by 20 percent. We are developing a non-fish meal and non-fish oil diet (e.g. soybean, palm oil, marine by products), and the results so far show that fish meal and fish oil replacement does not have a negative impact on the species' growth. Plus, a certain percentage of dried *Schizochytrium* sp. supplementation can lead to better growth, higher DHA, and better sensory properties of the Asian sea bass.

Another group focuses primarily on the development of a sex reversal method to enable all-female production of shrimp. Our expected outputs are that at least one sex-specific DNA marker of banana shrimp is identified to enable the sex reversal manipulation, and that novel maturation induction for the female shrimp is developed.

One other group is working on developing a feasible and effective culture method for banana shrimp, such as recirculating aquaculture system (RAS) and biofloc system. In fact, biofloc technology has been becoming more popular as an efficient alternative water management system, which effectively gets rid of excessive nutrients in the water by turning them into microbial biomass that can later become a feed supplement for the cultured species (Sampantamit et al., 2020). This can minimise the chance of water pollution caused by aquaculture operations. The result from our research so far is also pointing towards biofloc as a better system for the banana shrimp delivering improved average daily growth (ADG), feed conversion ratio (FCR), survival rate and weight gain.

4. Preserve genetic diversity through gene bank

Without attention, aquaculture practices can lead to a decline in genetic diversity, as a result of founder effects, inbreeding, and genetic drift. This can later affect disease resistance and adaptability to changes in the environment of the cultured species.

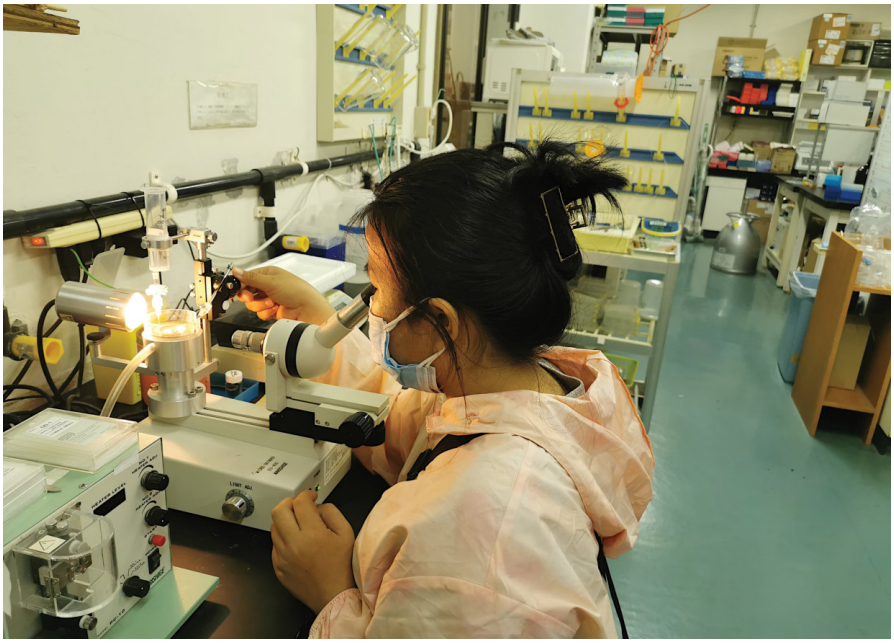
The Thai Fish Project wants to ensure that genetic diversity of native species is preserved to avoid aforementioned concerns. Under this expected output, two groups of researchers are working on the development of germ cell preservation methods—one for Asian sea bass, and the other one for banana shrimp. Our expected output is that at least one germ cell transplantation method and germ cell preservation method for Thai native aquatic animals is developed.

Future expectations

"The benefit from the Project is that our staff and students have been trained by the expertise (Group 4-2 Leader, Dr Monwadee WONGLAPSUWAN, Prince of Songkla University)".

With an emphasis on building the capacity of young researchers, Thai Fish Project aims to develop innovative aquaculture technologies that will allow for effective disease control, nutrition administration, and management of genetic diversity. Through that, we expect the establishment of a comprehensive package for Asian sea bass and banana shrimp aquaculture systems that are ready to be implemented by interested farmers and companies.

Ideally, we hope that farmers and companies that adopt our package will have a linkage to be acknowledged as a case of good practice by a globally or regionally well-known aquaculture



A researcher from Suranaree University of Technology (SUT), Thailand joining a training on germ cell transplantation in TUMSAT, Japan.

A researcher from TUMSAT demonstrating the germ cell transplantation and cryopreservation techniques to the researchers of DOF and SUT.

certification system. This is because it will play a great role in enhancing the package's credibility and notability, which can in turn, lead to the wider implementation of such a sustainable aquaculture system by other ASEAN countries.

All in all, we believe that the project strengthens Thailand's commitment to sustainability. The Project's expected outputs can allow Thailand to further express its adherence as well as simultaneously contribute to global SDGs, particularly, SDG 2 Zero Hunger, SDG 9 Industry, Innovation and Infrastructure, and SDG 14 Life Below Water. We expect this to greatly add to Thailand's effort to become an environmentally friendly and sustainable "Kitchen of the World".

If you want to know more about our project, please check out our Facebook page.

https://www.facebook.com/thaifishproject

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Nationally-recognised ornamental fish breeder Kripan Sarkar - a man to remember

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Commercial-scale ornamental fish production and its marketing have already gained popularity and wider attention in India. A good population of freshwater ornamental fish varieties inhabit the wild freshwater resources in the northern part of West Bengal and north-eastern states. Many of us know that at an interval of every fifteen years, white durable bathtubs in passenger cruise ships, made out of fibreglass reinforced plastic are removed and renewed. Knowing that these old ones are no more used and meant for sale, a person involved in ornamental fish business made up his mind to buy such bathtubs in good condition from Visakhapatnam Port, India. He brought those to his home in north Bengal, realising that these can be fruitfully used in the long run for rearing guppies and other small-sized ornamental fishes. Indeed, he was correct.

This person was Kripan Sarkar, who is with us no more. An enterprising ornamental fish breeder-cum-farmer par excellence, exporter and supplier of the same from northern part of West Bengal, passed away on 2 August, 2023 at his home near Jalpaiguri town, West Bengal after a brief illness. He was 58 years of age. As proprietor of Rainbow Ornamental Fish Farm, at Bakshipara Village in Jalpaiguri District, Sri Sarkar was an expert and authority in scientific breeding, larval rearing, propagation, research and experimentation on economically important freshwater ornamental fishes, both exotic and indigenous, familiar and less-familiar. There was a time when Sri Sarkar was the only commercial ornamental fish breeder in north Bengal. His ornamental fish farm, set up in 1998, is located about 2.5 km from Raninagar-Jalpaiguri Junction Railway Station, which is about 28 km from Siliguri town towards Jalpaiguri.

Near to Teesta irrigation canal, Sri Sarkar's farm occupies 1.2 ha with twelve zooplankton-rich earthen ornamental fish culture ponds, in addition to several well-maintained rectangular cement cisterns and large-sized glass aquaria in tiers, for rearing. Four permanent labourers take care of the farm. He had supplied different kinds of ornamental fishes in oxygen-packed condition to many places in the eastern and north-eastern states of India; and exported the same to USA, parts of Europe, Bangladesh, Nepal, and parts of south-east Asia. His fishes include goldfish, black molly, ornamental carps, tiger barb, rainbow shark, angelfish, guppies, many species of tetra, platy, koi carp, sucker mouth, gourami, red tail and others. Sri Kripan Sarkar was also widely known as an advisor, consultant, eloquent speaker and trainer to ornamental fish farmers and beneficiaries. This dynamic person deserves special importance, as he was the force behind improved management practices, technologies and entrepreneurship development for both men and women in connection with farming of different ornamental fishes of commercial importance.

Sri Kripan Sarkar wil remain in hearts of ornamental fish growers.

Glass aquaria for ornamental fishes at Rainbow Ornamentals.

Koi carp at Sri Sarkar's fish farm.

Jaldhaka River in Jalpaiguri District, north Bengal.

The beginning

In 1988, at 23 years of age, Sri Sarkar brought his first aquarium while teaching at a school in Nepal and became fascinated with ornamental fishes. As the only person producing ornamentals in the entire north Bengal and Nepal, he began by breeding exotic fishes such as molly, guppy, tiger barb, and finally angelfish in 1992, attaining success in breeding under the climatic conditions of north Bengal. After returning to India in 1993, he obtained financial support from the West Bengal Fisheries Department under the 'Pradhan Mantri Rozgar Yojana' scheme from the then Assistant Director of Fisheries, Jalpaiguri in 1995. This support enabled him to start a small aquarium fish breeding unit in Jalpaiguri District. He mastered the art and gained success in breeding all of the available ornamental fish varieties found in the local market at that time. He continued with breeding several varieties of ornamental fishes following 'home protocols.' Besides this, he used to buy local fishes such as mahseer, zebra danio and others from fishermen (who caught from local rivers) and sold those again to dealers in Kolkata, Kalimpong, Darjeeling, and Siliguri within West Bengal, as well as to international dealers. He frequently visited riverbanks and sought for correct identification and names of these riverine cold-water fishes caught in nets.

Slowly and steadily, he learnt the breeding behaviour and captive breeding technique of indigenous ornamental fishes and food fishes including mahseer and medium carps of the Teesta River. Koi carp of different colours and a hybrid variety were produced in the hatchery unit of Rainbow Ornamental Fish Farm by crossing Kohaku and Showa, two exotic ornamental koi carp types of high demand. In the initial years, Sri Sarkar used to sell thousands of angelfish per month to an exporter from China, who used to on sell them to Israel. He was successful in artificial seed production of some important exotic ornamental fish species in glass tanks before 2005 and continued with it on a large scale. In 2004, he obtained a subsidy from MPEDA after completion of construction of his angelfish breeding and farming unit.

His thoughts based on experience

In his speeches more than once, Sri Sarkar had expressed about his inability to produce and supply enough ornamental fishes, indicating that he was unable to fulfil the demand (orders) he received. He expressed the need for an adequate transport system for ornamental fishes from farm site to markets so that producers get a good price and good amount of profit, that fish farmers should get access to government subsidies, and expressed concern over a percentage of fishes that die during long-distance transportation on buses and four-wheelers. He was interested in cluster develop-

ment, eager to form a co-operative society in north Bengal comprising about a hundred ornamental fish farmers. To become progressive enough and prosper in this business, Sri Sarkar expressed the need of proper training for ornamental fish farmers, catfish, and major carp cultivators, and for modern methods of disease prevention, cure, bagging and transportation, and other aspects.

Sri Sarkar emphasised that the practice of the Green Certification Board is a must and can provide a new dimension to ornamental fish business, and that Government including NFDB may financially support some newcomers and established ornamental fish breeders and farmers in West Bengal to develop infrastructure facilities with more space and brood banks for ornamental fishes. He opined that it would be good if ornamental fish cultivators in this state were able to get loans from the West Bengal State Co-operative Bank in a smooth manner. He desired to introduce some small to medium-sized indigenous fish species in good numbers into the Karala River in Jalpaiguri District of north Bengal to restore natural balance of the river and have its water inhabited by fishes. He strongly wished for empowerment and employment of rural women self-help groups in ornamental fish farming utilising their backyard ponds and small homestead land, imparting need-based training to them.

As an invitee

In a training programme for ornamental fish farmers in north Bengal organised under the initiative of NABARD and West Bengal Fisheries Department on 7 October 2002, Sri Sarkar mentioned that farmers and entrepreneurs would be able to rear ornamental cichlids, all species of tetra, catfish and angelfish easily with a little know-how. At the invitation of West Bengal Fisheries Department and BENFISH, he lectured in over seven training programmes until 2011 on topics such as ornamental fish feed preparation, identification of brooders, larval rearing, and live food production. In 'Indaquaria 2010', organised by MPEDA at Chennai during 8-10 January 2010, he spoke elaborately on advances in ornamental fish farm management. Sri Sarkar was invited as resource person in the training programme on 'Ornamental fish breeding and culture for fish farmers', organised at Zoology Department of Gauhati University, Assam on 14 February 2010. He participated as a resource person in the NFDB Workshop on 'Integrated development of ornamental fish production and marketing' in October 2011 at Hyderabad.

MPEDA, Government of India had organised an 'Advanced training programme on ornamental fish farm management' on 21-22 September 2012 at the MPEDA Ornamental Fish Training Centre at Integrated Rural Technology Centre,

Rectangular cement cisterns under good quality tin shed.

Palakkad, Kerala. In this programme, Sri Sarkar took classes as an experienced ornamental fish breeder from West Bengal. In 'Aqua Aquaria India 2015', an aquaculture - aquariculture show organised by MPEDA during 20-22 February 2015 at Vijayawada, Sri Sarkar made a presentation on live food culture with videos and photographs in the session 'Technological advances in ornamental fish sector'. He lectured and demonstrated on breeding and culture of some commercially important exotic and native ornamental fishes as well as live food culture in front of prospective fish farmers and researchers in the 'Training programme on ornamental fish breeding and culture', organised at Gauhati University during 11-12 February 2017. In the Training programme on 'Ornamental fish farming' at the Department of Life Sciences, Dibrugarh University on 16-17 March, 2017, Sri Sarkar shared his experiences with farmers on live food culture and on-farm production of freshwater aquarium fishes.

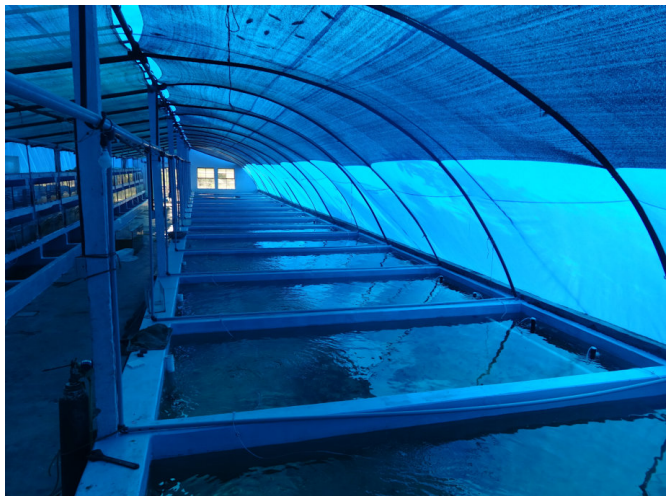
He was invited to the 'Workshop on ornamental fisheries entrepreneurship development', organised by National Co-operative Development Corporation, NFDB and Government of West Bengal on 25 January 2020. Sri Sarkar was invited as a panellist in the National Fish Farmers' Day programme, organised by ICAR-CIFA, Bhubaneswar on 10 July 2020. He was invited in the National Stakeholder Consultation on 'Indian Ornamental Fisheries 2.0 - The way forward', organised by NFDB, Hyderabad; ICAR-CIFA, Bhubaneswar and Department of Fisheries, Animal Husbandry and Dairying, Govt of India during 22-24 April 2021. Here he spoke in the Technical Session on 'Enhancing ornamental fish production and addressing the constraints in marketing'. Recently he was invited as an expert in the stakeholder consultation-cum-mass awareness and ornamental fish farming live demonstration programme, organised by ICAR-CIFRI, Barrackpore at Sukhia Block, Mirik Sub-division and Sittong-Khasmahal in Kurseong Sub-division in Darjeeling district during 5-6 February 2023.

Sri Sarkar's publications

Sri Kripan Sarkar's collaborative research paper on growth of the ornamental carp, *Cyprinus carpio* var. *koi* in concrete tanks using different dosages of organic manures was published in the Turkish Journal of Fisheries and Aquatic Sciences in 2004 as second author; it was inferred that an application rate of 0.26kg/m³, every 10 days, is most suitable for koi carp tanks manured with both cow dung and poultry excreta[1]. Another paper (as co-author) on fish biodiversity studies of seven rivers in the Jalpaiguri, Coochbehar and Alipurduar districts of the eastern Himalayas for conservation strategies (in search of new indigenous riverine fish having ornamental importance) was published in the International Journal of Applied Research in 2015. Along with the eminent Indian fishery scientists Late Dr E. G. Silas, Dr A. Gopalakrishnan, Dr Alappat Ramachandran, Dr T. V. Anna Mercy, Dr K. R. Pushpangadan, Dr P. Anil Kumar, Dr M.K. Ram Mohan and K. K. Anikuttan, Sri Kripan Sarkar contributed as co-author in the compendium 'Guidelines for green certification of freshwater ornamental fishes', published by MPEDA, Government of India, Kochi in 2011.

Scientists-cum-authors from UK, Sweden and Germany acknowledged Sri Sarkar for help with field work in their research paper on colour processing ability of zebrafish, published in Current Biology (Cell Press) in 2018. In the paper on observation of wild zebrafish in India, published

Cruise ship bath tubs recycled for rearing ornamental fishes.



Series of cement cisterns for aquarium fishes under greenhouse net shed.

Male fighter feather fish at Sri Sarkar's farm.

in the journal Zebrafish in 2019, Sri Sarkar was included as one of six co-authors, which included four foreign scientists-authors. In another paper published in Conservation Physiology (Oxford University Press) on testing of thermal tolerance in wild and laboratory zebrafish populations, Sri Sarkar was in the team of seven authors, which included five Norwegian scientists-authors. In such research studies, Sri Sarkar led in the collection of zebrafish from twelve sites in the foothills of the Himalayas, close to India-Bhutan border. Ph.D. researchers in Zoology (specialisation in fisheries/ aquaculture/fish biology) of North Bengal University and Gauhati University did a part of their research studies and field experiments at Sri Sarkar's ornamental fish farm - Sri Sarkar gave them advice and technical expertise.

About his accomplishments and contributions

Speaking about Sri Sarkar, the Late Dr P. Jha, Former Principal of Raiganj Surendranath Mahavidyalaya, Uttar Dinajpur District had mentioned in 2006 that Kripan Sarkar was a scientist without degrees. Dr Jha had educative discussions on some aspects of his research with Sri Sarkar. Even not having any formal higher education, Sri Sarkar had a command of any aspect related to live food culture and proper water quality management for ornamental fish farming. With around three decades of experience in ornamental fish culture and trade, coupled with his extensive reading habit and frank way of speaking, Sri Sarkar was an exemplary teacher and an extraordinarily affectionate friend. In the words of teachers of the Eastern Institute for Integrated Learning in Management - Jalpaiguri Campus (students had an excursion to Sri Sarkar's Rainbow Ornamental Fish Farm), Sri Sarkar was a man of immense power, energy, enthusiasm to create and motivate all – and had remarkable entrepreneurial skills.

In 2012, Dr S. Barat, Retd. Professor of Zoology, North Bengal University had mentioned: 'Kripan Sarkar has developed an expertise in captive breeding, and he has widely researched fish species. He is an amateur expert, has been working for the past three decades and for the last eight years, or so, he has been working as a guide for our researchers'. Sri Sarkar was Research Advisory Committee member of ICAR-CIFA, Bhubaneswar as a progressive fish farmer. Considered as an eminent entrepreneur of West Bengal and intellectually sound person, Sri Sarkar had obtained success in captive breeding and rearing programmes of some indigenous riverine ornamental fishes of north Bengal, viz., *Puntius jelius* and other species, *Colisa* sp., *Chela* sp., *Botia dario* ('rani machh'), *Badis assamensis*, *Mastacembelus* sp., two species of boroli *Barilius* sp. - the prized small indigenous fish of north Bengal, and a species similar to *Heteropneustes fossilis*, i.e., 'gangsinghi'. He was successful in acclimatising the cyprinid *Neolissochilus hexagonolepis* at his farm from sub-adult to brooder stage, did its breeding and seed rearing, and thereafter supplied seed to interested fish farmers in hilly areas.

Sri Sarkar was associated with the ornamental fish business for many years, served as motivator and role model for young entrepreneurs, helped others to grow. He disseminated the technology of ornamental fish breeding and rearing among local fishermen in different districts of north Bengal, and spread the concept of ornamental fish industry. He rightly understood that the vocation of breeding and propagation of different kinds of ornamental fishes and both domestic and international trade of the same could become a profitable and sustainable source of income and entrepreneurship opportunity for unemployed youths in suburban areas and villages in West Bengal, and other eastern and north-eastern states in India. He set up a training centre on ornamental fish breeding and rearing for unemployed youths and a farm in the Babubasa area near Champasari in Darjeeling district. Four women's self-help groups with ten members each working in the ornamental fishery sector were formed in Raiganj Block of Uttar Dinajpur District under his initiative, the same also in Gazoldoba Village in Jalpaiguri District.

Boroli fish Barilius barila 7.5cm.

Sri Sarkar gave importance to simple and easily adoptable indigenous technologies, or home protocols. He himself used to prepare the right kind of formulated feed for the larvae of his ornamental fishes and gave special attention to culture of live fish food organisms. For instance, he believed that culture of mosquito larvae can be done in ornamental fish breeding-cum-farming units to feed growing ornamental fishes.

The organisms may be sieved from culture medium using fine-mesh silk/cotton cloth, kept in normal water and added to brooder fish tanks (concrete or large glass tanks) later on. Sri Sarkar cultured *Brachionus* sp., *Moina* sp. and *Daphnia* sp. in small segregated earthen chambers, also *Paramecium* sp. using boiled hay and *Artemia salina*, which were meant to be fed both to larvae of *Clarias magur* and ornamental fishes. He demonstrated that mixing and applying poultry manure, mustard oil cake and crumbs from a nearby cake factory into ornamental fishponds could encourage zooplankton *Daphnia* sp. growth in water.

Sri Sarkar even trained some farmers hands-on in north Bengal and Assam on induced breeding and seed production of air-breathing catfish *Clarias magur* and on novel recirculatory aquaculture system project. In a self-taken video, he captured and studied remarkable moments during the spawning process of *C. magur* in captivity and behaviour of the male brooder. He had an innovative mindset, came up with new ideas, and was ahead of others during his time. He could prepare glass aquarium tanks of different sizes, repair filters, blowers, and other associated machineries on his own when required. In his visit to Shanghai, China in 2019 and Bangkok, he selected and bought aerators, pumps, and other accessories for his fishes in glass tanks and rectangular concrete cisterns. In 2021, he was eager to establish an ornamental fish farm at Darrang District, Assam. He supplied fishes here and to Arunachal Pradesh regularly from his farm at Jalpaiguri on the roadway, and fishes that will be produced and transported from this new farm will help to minimise the distance and time required during transportation. It may lead to increased survivability of fishes, he believed.

In addition to captive breeding, Sri Sarkar collected early stages and sub-adults of indigenous (wild) ornamental fishes from hilly rivers of north Bengal, Assam, and Meghalaya, nurtured and domesticated those in simulated natural environment in his farm up to marketable size. Fishes retained their normal and appealing wild body colour in confinement. In an Ornamental Fish Exhibition organised at Eco Park at Papum Pare, Arunachal Pradesh under the initiative of ICAR-CIFA, Sri Sarkar spoke about breeding technologies and the ornamental potential of some small-sized indigenous fish species found in hill streams of Arunachal Pradesh. Ornamental murrels *Channa stewartii*, *C. aurantimaculata*, *C. orientalis*, loach *B. dario*, *Mystus bleekeri*, *Macrognathus aculeatus*, etc are found in border areas of Assam and Arunachal Pradesh. Sri Sarkar attempted to breed *Botia rostrata* - the rare endemic fish of Arunachal Pradesh. The early stages of golden mahaseer *Tor putitora* was reared at his farm to adult stage in 2003 on the initiative of the West Bengal Fisheries Department. He helped in fabricating the large aquarium house at the Integrated Ornamental Fish Farming Unit within the Gauhati University premises, supplied exotic and indigenous ornamental fishes to this place.

End note

In India, some eminent fishery entrepreneurs have shown their reflection in the society, like the Late Nilu Ghosh near Kolkata, Ashis Sarkar, Dipak Roy and Kripan Sarkar of north Bengal[2]. For the first time, I saw the photograph of Sri Sarkar and his farm in a Bengali publication of West Bengal Fisheries Department, published in October 2005, and made a visit there on 9 April 2017 for the first time. Sri Sarkar was a consultant to progressive ornamental fish farmers in Meghalaya, Arunachal Pradesh, Assam, Mizoram; used to visit these places quite often enthusiastically, shared his technologies with ornamental fish farmers in these states with great efforts and had so much involvement. He was known to many scientists working in fishery and aquaculture institutes under ICAR in different parts of India, had considerable depth of knowledge.

About ornamental fish broodstock maintenance and other aspects, Sri Sarkar did not hesitate to extend and share his expertise and technical knowledge to farmers and entrepreneurs who came forward, in his best possible capacity. With problem-solving abilities, he kept on conducting research on anything new, which helped in developing his skills. We have lost a pioneer in ornamental fishery sector in eastern and north-eastern India, namely Kripan Sarkar, who used to remain mentally and physically engrossed in breeding and rearing ornamental fishes. The ideas and legacy, which he left behind, will remain immortal.

Acknowledgement

Author gratefully acknowledges the help received from Sri R. Foning Lepcha, Retd. Additional Director of Fisheries, West Bengal; Dr S. Barat, Retd. Professor of Zoology, North Bengal University; Dr D. N. Das, Professor of Zoology, Rajiv Gandhi University, Arunachal Pradesh; Smt. M. Sarkar Kamti and Sri B. K. Kamti, daughter and son-in-law respectively of Late Kripan Sarkar while preparing this write-up.

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Tilapia parvovirus disease: An emerging threat for the tilapia aquaculture industry

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Tilapia is a warm-water fish species extensively cultured in over 100 countries, with a global annual production of more than 6.5 million tonnes[1]. Tilapia farming is practiced in various states across India, including Andhra Pradesh, Tamil Nadu, Maharashtra, Kerala, Karnataka and West Bengal. The southern states, particularly Andhra Pradesh, are among the leading producers of tilapia. The intensification of tilapia aquaculture and prevailing climate change have created a stress situation in the culture environment which leads to an increasing number of emerging infectious disease occurrences[2,3,4,5]. In the dynamic world of aquaculture, where innovation and challenges often swim hand in hand, some new viruses have emerged on the scene, casting their shadow on the vibrant tilapia farming industry. In the last few years, outbreaks caused by two viruses i.e. tilapia lake virus (TiLV) and infectious spleen and kidney necrosis virus (ISKNV) have caused havoc in tilapia aquaculture industry[5,6]. Recently, a novel tilapia parvovirus (TiPV) infection was reported in red tilapia farming in Thailand for the first time[7]. Moreover, the synergistic effect of its co-infection along with TiLV has been reported subsequently causing severe mass mortality in tilapia. These unprecedented threats of TiPV have necessitated continuous screening and research investigation to study TiPV disease characteristics, pathophysiological changes, disease spread, diagnosis and management strategies. This article intends to reach out to the readers to be aware of TiPV infections and its epidemiology.

Disease incidence in the Indian subcontinent

As the culture of tilapia is gearing up in India, several emerging diseases have been reported from the culture environment causing mortality including diseases like TiLV and TiPV. During September 2022, a huge mortality of tilapia was observed in Balasore District, Odisha India. A co-infection of TiLV and TiPV was found to be the cause of this mortality[8]. Further, during the summer of 2023, mass mortalities of tilapia were also reported from several tilapia farms located at different distant locations of Odisha. TiPV was found to be the only pathogenic organism present in those infected fishes causing large-scale mortality in the pond aquaculture. The virus has already been identified as posing a threat to tilapia aquaculture in several countries and in India also it may be a great threat in the coming days.

Clinical signs observed in infected fishes are lethargy, scale loss, redness on body with haemorrhages on the operculum, base of fins and ventral part, opaqueness of eyes, swimming near the pond edge and loss of appetite before death.

Tilapia parvovirus disease characteristics

Initially, the virus was thought to be non-infectious as it was identified from the intestinal sample of healthy tilapia and faecal samples from tilapia-fed crocodiles. But subsequently, it was observed that the virus can be lethal to the tilapia and cause mortalities up to 90%. Infection can lead to a range

Typical clinical signs of tilapia infected with TiPV.

of symptoms in tilapia including lethargy, reduced feeding, discolouration, cutaneous haemorrhages, exophthalmia and severe ocular lesions and mortality on rare occasions. Infected fish also exhibit abnormal behaviours such as staying near the water surface or abnormal swimming patterns. TiPV has been reported to be the cause of mass mortality episodes in tilapia farming in association with TiLV and other bacterial pathogens. In China, an outbreak of TiPV resulted in the mortality of tilapia of 60-70% in natural conditions. In Thailand, the mortality percentage was recorded as 50–75% in all age groups of tilapia. The viral signature of TiPV was detected in various organs of tilapia including eyes, gills, heart, brain, anterior kidney, liver, intestine, spleen, dorsal muscle, and mucus with the highest load of TiPV being observed in the anterior kidney and spleen[9].

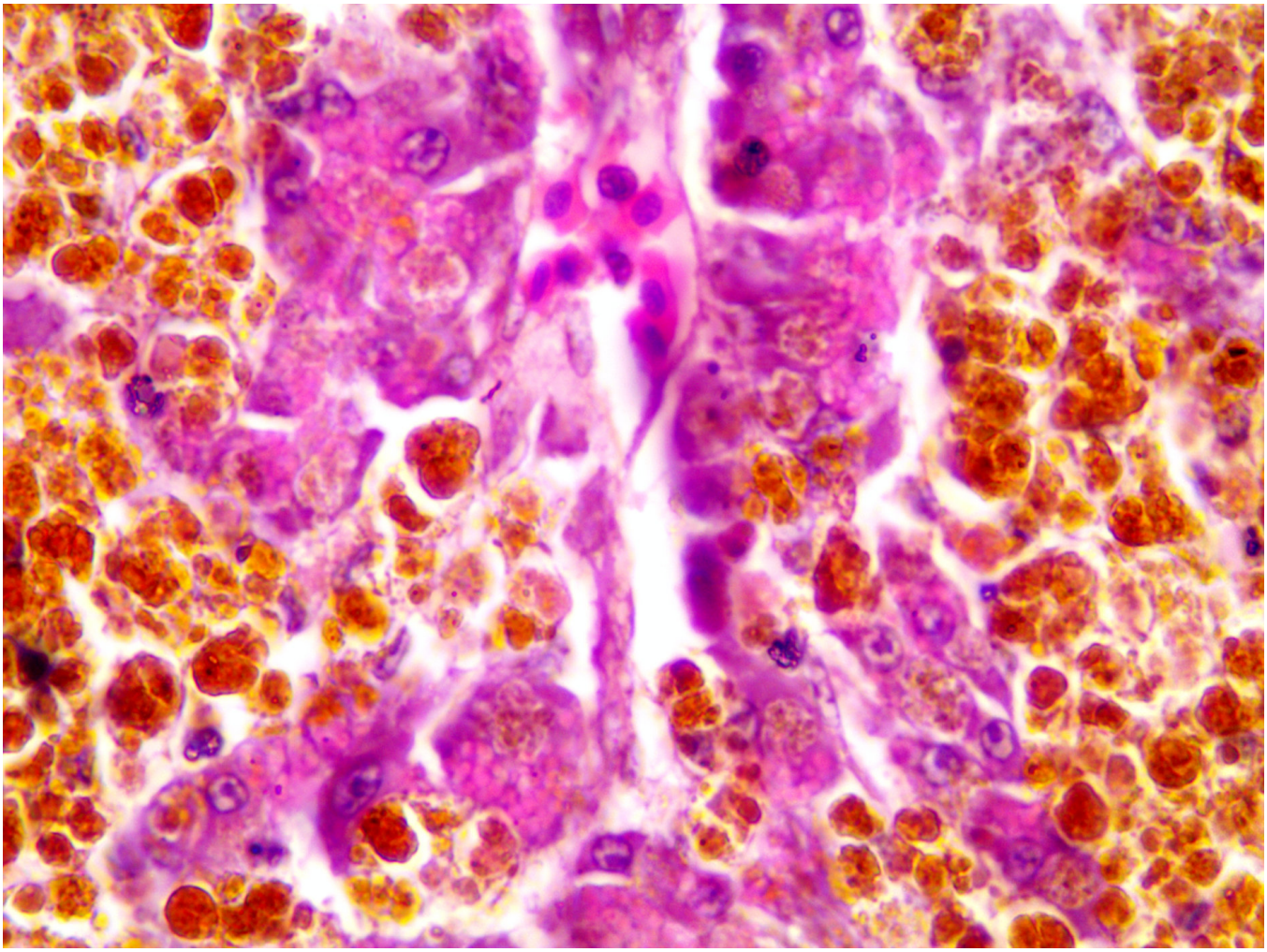
About TiPV

Tilapia parvovirus is a single-stranded DNA, spherical, non-enveloped virus with a diameter of 30 nm belonging to the genus Chapparvovirus, family Parvoviridae. The genome size of TiPV is 4269 bp which includes 208 bp 5' UTR, 396 bp ORF1 and 1875 bp non-structural protein 1 (NS1), 504 bp NS2, 216 bp ORF2 and 1665 bp capsid protein 1 (VP1), and 46 bp 3' UTR9.

Mass mortality in a tilapia farm with TiPV infection.

Transmission

The virus can spread among tilapia populations through various means, including contaminated water, infected fish, and contaminated equipment. There is a concern about the virus spreading between different fish farms and even across borders.



Augmented melanomacrophage centres in the spleen of TiPV infected tilapia (H & E x 100).

Impact

Tilapia parvovirus infection can have significant economic consequences associated with high morbidity and mortality in the aquaculture industry. Not only monetary loss, dramatically slower growth and reduced fish production are evident in a few reports. It can be devastating to tilapia farms. The disease has the potential to lead to disruptions in local and international trade of tilapia products. In Thailand and China, the disease was found to cause mass mortalities. The major drawback allied with TiPV is its association with other devastating pathogens which make it more deadly. Also, improper disposal practices could lead to the spread of the virus to wild fish populations, potentially impacting aquatic ecosystems. Hence, proper biosecurity is a must to prevent disease outbreaks. As the virus persists for a long time in the survivors and in the environment, it is essential to reduce stress factors in the culture system for its emergence leading to mass mortality.

Diagnosis

Diagnosis of TiPV involves a combination of clinical signs, histopathological examination and molecular techniques such as polymerase chain reaction (PCR) and real-time PCR-based detection to detect the presence of viral genetic material in fish tissues. Histological findings in relation to TiPV are extensive infiltration of lymphocytes, augmented melanomacrophage centres in the spleen and anterior kidney, and erythrocyte depletion in the spleen and hepatic syncytial cells. Recently, Dong et al.[10] demonstrated that the pancreas as a prime target of TiPV infection for histopathological diagnosis in Nile tilapia. In the pancreas, Cowdry type A inclusion bodies were identified as a histopathological diagnostic feature in adult Nile tilapia naturally infected with TiPV. Moreover, TiPV-diseased fishes were found to be co-infected with secondary pathogen *Streptococcus agalactiae* and exhibited multifocal granulomas in tissues.

Prevention and control

Preventing the spread of TiPV involves a combination of biosecurity measures, such as proper disinfection of equipment and facilities, controlling the movement of fish, reducing stress factors in the culture environment and avoiding the introduction of infected fish into new areas. The upkeep of optimum water quality parameters is also key for the management of TiPV outbreaks. In the case of fish mortality, the farmers are also advised not to throw fish in an open area as birds may act as vectors for the transmission of the disease. Stringent quarantine protocols, continuous screening and reporting should be activated to minimise incidences in the aquaculture system. Fish with symptoms should not be left unattended in pond water which to help to break the synergism between viral pathogens and subsequent bacterial infections. If a potential outbreak of tilapia parvovirus infection is suspected, farmers are recommended to consult with fish health experts, aquatic veterinarians, or local fisheries authorities for the most up-to-date and relevant information on diagnosis, prevention, and control strategies.

Acknowledgements

The authors wish to thank the Director, ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, India for providing the necessary facilities during this study.

Funding support by the Department of Fisheries, Ministry of Fisheries, Animal Husbandry and Dairying, Govt. of India under the National Surveillance Programme for Aquatic Animal Diseases is duly acknowledged.

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Naihati fish seed market as state-of-the-art for sustainable support services to fish growers, buyers and traders

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Naihati fish seed market of West Bengal was established in 1976 and is the largest seed market (and probably the only established and organised fish seed market) in India. With the advent of induced breeding technology and hatcheries, fish seed is now available almost year-round, catering to the need of Indian farmers. Known as a leading fish seed growing state, West Bengal produces seed through a network of established hatcheries and other small producers. Fish seed production starts in early March and continues through to early October every year. Although fish seed are produced in different parts of south Bengal, Naihati is their destination for sale. Situated in North 24 Parganas, Naihati wholesale fish seed market is a well-known establishment that provides multifaceted services to stakeholders including fish seed growers, retailers, sellers, and mediators. Over the course of its journey, the market has prioritised customer satisfaction by means of prompt sale-service, availability of a wide variety of fish seed in large quantity, quality products and reliability pertaining to customers' feedback. Established with a strong foothold as a 'fish seed market' to attract both buyers and sellers, it has prospered.

Naihati fish seed market is open from midnight until 6am, with fresh stock arriving from suppliers around open and being transported out towards close as buyers leave with their orders.

Status of fish seed sales

Fish species and size of graded seed

Fish seed available in the market are referred to mainly based on size (Jhingran 1986) such as spawn (up to 8mm), fry (Early fry >8-25mm; Fry >25-40mm) and fingerlings (fingerlings >40 -100mm; advanced fingerlings >100-150mm). A total of 27 fish species (Table 1) are sold in the market (Fig. 2). Of these, the Indian major carp (rohu, catla and mrigal) seeds fetch the highest price, with rohu seeds having the greatest demand and mrigal seeds somewhat less so. Across all species, around 80% of seed are spawn size, while the other 20% are fry and fingerlings. Fry is the most highly sought after size by customers, but its availability is lower compared to spawn because an additional 15-20 days of rearing time is required to produce it. Rearing of fry from spawn is a laborious task that requires careful management and poses an additional risk, as only 30-40% of spawn survive to be fry. The size and quantity of seed varies according to the time of year in which they are harvested, seasonal factors, the physical nature and scale of growing in the rearing areas such as pond food resources, water availability and soil type.

Figure 1: Midnight view of Naihati fish seed market.

Demand for fish seed in different states of India: A glimpse

Fish seed is supplied to different states of India (Fig. 3). The major receiving states include Andhra Pradesh, Uttar Pradesh, Bihar, and Assam; the medium receiving states are Punjab, Rajasthan, Haryana, Chhattisgarh, Maharashtra, Odisha, Madhya Pradesh and Telangana, and smaller receiving states are Karnataka, Himachal Pradesh and Uttrakhand apart from the North-eastern States of India such as Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh and Mizoram, which also receive a fair amount of seed. Fish seed is also transported to the Andaman and Nicobar Islands, and exported to Nepal and Bhutan.

Indian major carp seed have the highest demand. These species have the advantage that they can be reared in a closed enclosure like a cage placed into larger water bodies such as lakes, reservoirs, dams and rivers. With their suitability for cage culture, there is a huge scope to manage Indian major carp seed with different culture practices and to harvest them as and when required. Pangas (*Pangasianodon hypophthalmus*) is the second most sought after species and is mainly supplied to Andhra Pradesh, which is the main Indian state for pangas grow-out culture.

Estimate of fish seed sales – an important trading scenario

A total of around 1.0-1.2 million seed (700-800 kg) is sold daily during the peak season from May to September, and 0.3-0.5 million seed (200-300 kg) are sold per day in the rest of the year. An average of 400 licensed members sell seed daily; each is allowed to sell four hundi (a container made of

Figure 2: Fish seed of different sizes and species

Labeo catla.

Heteropneustes fossilis.

Chitala chitala.

Labeo rohita.

Heteropneustes fossilis (advanced fry).

Piaractus brachypomus.

Labeo calbasu.

Mystus gulio.

Mylopharyngodon piceus.

Ompok bimaculatus (advanced fry).

Anabas testudineus.

Pangasianodon hypophthalmus.

Lates calcarifer.

Clarias magur.

aluminum) of seed at a time, and after selling this allowed to refill the hundis again. Two types of hundis containing seeds are found in the market, a 60 cm hundi with a capacity of 10-15 kg carp seed, and 65 cm hundi with capacity of 20-25 kg of pangas or pacu (*Piaractus brachypomus*) seed. The number of fish sellers increases from April onward. Of the total seeds sold, 50% are Indian major carps, 25% are pungas or pacu, and the remaining 25 % includes all other fish species in totality.

The market is also an important source of other seed including monosex tilapia (*Oreochromis niloticus*), chitala (*Chitala chitala*), climbing perch (*Anabus testudineus*), singhi (*Heteropneustes fossilis*), desi magur (*Clarias magur*), amur carp (*Cyprinus carpio haematopterus*), black carp (*Mylopharyngodon piceus*), bighead carp (*Hypophthalmichthys nobilis*) and grass carp (*Ctenopharyngodon idella*). Seed of these species, which are sometimes difficult to obtain elsewhere, are assured to be available in Naihati market, which is one factor in the market's popularity (Fig. 4).

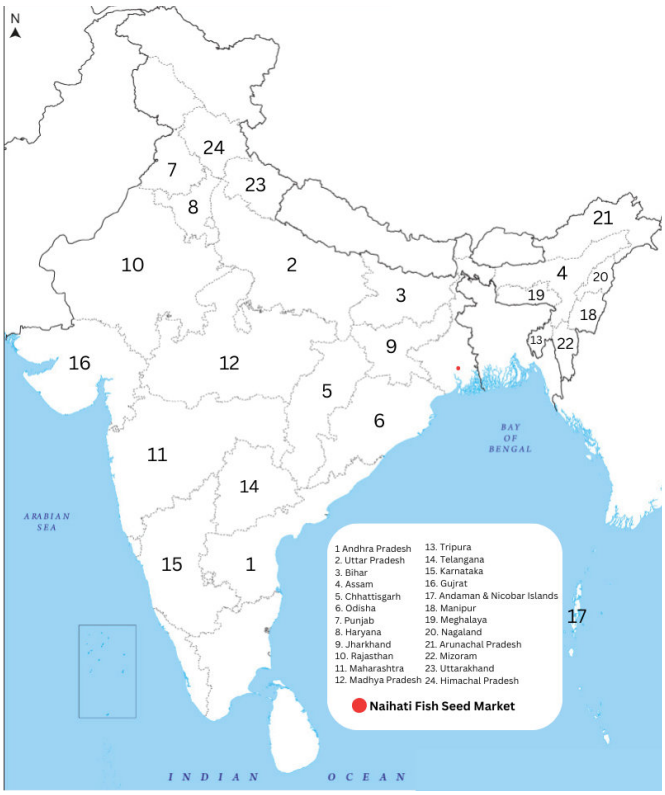
Procedure of fish seed sale

Only licensed members can sell seed in the market. Presently the market has 669 licensed members, but an average of 400 members are selling fish daily in the peak season. The market receives seed from around 1,000 producers from different areas within West Bengal. Usually, the business of the market comprises three groups: (i) wholesale fish producers known as golder, (ii) licensed members known as patil wallah, and (iii) middlemen/mediator known as dalal.

Wholesale fish seed producers with a hatchery set up produce a huge amount of spawn, often 1.0-1.5 million at a time, and sell to licensed members. There are number of seed producers, which may be large or small. All maintain a cordial relationship among themselves in the interest of business. When there is a shortage of available seed the required amount is collected from another producer. A good communication exists between seed producers and licensed members by middlemen who inform licensed members about which producers has how many available seeds and of what species. This allows buyers to get updated information. This procedure of selling seed involving producers, licensed members, middlemen and customers seems complex but makes it easy for all players to obtain the necessary information.

Middlemen who are involved in communication and connecting seed producers with licensed members/customers are paid commission in return for their efforts. The monetary benefit is not fixed and varies among individuals. Sometimes, the middleman earns a higher amount if the seed price increases. They used to collate information regarding the availability of different size grades of seed from different producers and the price of each grade. They also informed customers about which producer maintained the quality of seed in terms of the genetic purity and health. They try to convince licensed members/customers regarding the quality of products. The middlemen who negotiate the sale of fish seed to licensed members/buyers typically get one-third of the total price after seeds being sold. For instance, if seed is sold @ Rs.150/kg (1US$ = Rs. 82.00), the owner will get Rs. 100 while a middleman gets Rs. 50, who is responsible for paying for transportation, water, and bears the loss of seed during transport.

Figure 3: Fish distributed to different states of India



Licensed members who are eligible to sell fish seeds in the market bring them in aluminum hundi. Customers who require a small amount can purchase the whole/part of the amount in the hundi, while those who require a large amount of seed may use it as a sample before purchase. When buyers are satisfied, they order the required quantity from the licensed members. In such cases, licensed members purchase the required quantity from a producer prior and hold them in hapa (nylon nets) fixed and set in small ponds nearby. The hapa in which seeds are held temporarily cost Rs. 500 per hapa/day. The longer the seed are held into hapa, the lesser is shelf life of the seed. Seed that have been kept in hapa longer are usually sold at a lower price than fresh ones. Licensed members maintain a distinct identity in selling fish seed: A persons who sell carp seed will not switch into selling other species; likewise sellers of catfish or exotic seed sellers and others bear their distinct identity.

Supply and trade of fish seed

A bidirectional trade

Two distinct directions of business exist. The market acts as a hub that attracts seed producers for sale of produce. The market also attracts buyers and traders that carry seed to the field or to other parts of India.

In the first case, around 60% of fish seed in the market are estimated to originate from Bardwan, Hooghly, Nadia and North 24-Parganas districts, 35% from other districts altogether, and the rest 3-5% seeds from Ramsagar, Bankura District. Fish seed from Ramsagar are sold outside Naihati market and transported to outside West Bengal via Naihati traders. Seed producers to not usually come to the market for

Table 1: Number of fish seed sold in Naihati market.

Scientific name	Local name	Status of seeds sale			Status
		Spawn	Fry	Fingerling	
*Anabas testudineus**	Koi	-	+ +	++	Indigenous / exotic
Barbonymus gonionotus	Japani punti	+	+	+	Exotic
Chitala chitala	Chital	-	+++	++	Indigenous
Cirrhinus mrigala	Mrigal	+	+++	+	Indigenous
Clarias magur	Magur	+	++	++	Indigenous
*Clarias gariepinus***	African magur	-	-	+	Exotic
Ctenopharyngodon idella	Grass carp	-	+	+++	Exotic
Cyprinus carpio	Common carp	-	+++	++	Exotic
Cyprinus carpio haematopterus	Amur carp	-	+++	++	Exotic
Heteropneustes fossilis	Singi	+	++	-	Indigenous
Hypophthalmichthys molitrix	Silver carp	+	++	-	Exotic
Hypophthalmichthys nobilis	Bighead carp	+	++	-	Exotic
Labeo calbasu	Kalbose	+	++	++	Indigenous
Labeo catla	Catla	+++	+++	++	Indigenous
Labeo rohita	Rohu	+++	+++	++	Indigenous
Labo bata	Bata	+++	+++	++	Indigenous
Lates calcarifer	Bhetki	-	++	+++	Indigenous
Macrobrachium rosenbergii	Golda chingri	+	+	+	Indigenous
Mylopharyngodon piceus	Black carp	-	+	+	Exotic
Mystus cavasius	Gulsa tangra	+	++	+	Indigenous
Mystus gulio	Nona tengra	+++	++	+	Indigenous
Ompok bimaculatus	Pabda	+++	++	+++	Indigenous
Oreochromis niloticus	Monosex tilapia	+++	++	+++	Exotic
Osteobrama belangeri	Pangba	-	+	+	Indigenous
Pangasianodon hypophthalmus	Pangus	+++	++	+++	Indigenous
Piaractus brachypomus	Pacu	+++	++	+++	Exotic
Systomus sarana	Sar punti	+	+	+	Indigenous

Legend

- Seed unavailable.
+ Indicates relative availability of seeds.
* Both Indian & Vietnamese (more common) strains available.
** indicates banned fish in India.

selling seed, while licensed members who transport and sell seed reach the market carrying hundi by foot or by a variety of conveyances such as train, bus, bicycle, rickshaw van, and paddle van as per individual circumstances and convenience. In the second case, Midnapore (both east and west) District receives 50% of the locally distributed seed supply, which is approximately 2.0 million seed/ seed/day. Of the rest, 15% reaches Murshidabad, 10% to North-24-Paraganas, 5% each goes to Maldah, Bardwan and Howrah, and 10% is distributed to northern parts of West Bengal comprising North and South Dinajpur, Jalpaiguri, Siliguri (sub-division of Darjeeling District), Cooch Bihar and Alipurduar districts.

Transport – an essential support system

Spawn and fry are convenient commodities for packaging and distant transport because they can maintain a good condition after 1-2 days of transport. Usually, each producer transports 500,000 (100 kg) of fry per 1,460 litre tank (2-4 tanks per truck). Some producers used to transport hundies (50-60 per truck) for spawn and 30 transports are used a day each of which carries between 20,000 and 50,000 spawn. Each licensed member (patil wallah) usually stocks an average of 12 kg of 0.2g fry per hundi for local transport. For short distances (4-6 hours journey) (Fig. 5), spawn are transported on demand to those who rear seed in nursery ponds. Close districts such as Hoogly, Bardhaman, Howrah, North 24 Parganas, South 24 Parganas, Nadia, East Midnapore, West Midnapore and Bankura receive fry and fingerlings because transportation time is less than eight hours. Birbhum and Purulia districts (poor culture practices) usually get seed from Bardhaman and Bankura districts respectively. Fish seed that are are contained in tanks are transported by truck for up to 1-2 days to north Bengal districts as the longest journeys within West Bengal. Fish seed stocked in containers for long range transport may be stocked at a lower density than the relatively high numbers stocked for short distances. About 40 ml of spawn are stocked for journeys lasting up to 24 hours, 30 ml for journeys up to 48 hours and 20 ml for journeys up to 60 hours to improve survival.

Distant transport - a journey outside West Bengal

Distant distribution refers to the transportation of fish seed to other states of India. The size of fish seeds transported is generally smaller, being spawn and fry ranging from 0.02g to 0.5g. Assam, a north-eastern state of India, receives seed early due to its earlier rainy season in comparison with other regions of India. Some 50-62 million fry kept in the tank are taken by truck every day (45 trucks/day) from mid-March

Figure 4: Market activities.

Sellers counting fish seed before sale.

Sample fish seed put into a dish to display for customer.

Customer observing condition of fish seed before sale.

Interaction between a seller and a buyer.

Sample fish seed put into a net to show customer.

Sorting of fish seed before sale.

Figure 5: Transport.

A motor van ready to transport fish seeds for customers.

A tempo car to transport fish seeds to customers' areas.

to mid-May, which accounts for approximately 37% of the distant distributed stock. By contrast, seed transported to Andhra Pradesh may involve six-wheeler trucks, which carry 580 kg seeds with 1,800 pieces/kg, and four-wheeler Bolero which carry 280 kg seeds with 2,500-3,000 piece/kg. Uttar Pradesh and Bihar receive the second largest quantities of stock (14% each). The other states receive less than 10% of the distributed stock and Rajasthan and Punjab being the lowest receiver. Punjab, Rajasthan and Haryana receive smaller average size of spawn than the spawn received by other States. For high altitude states as Himachal Pradesh and Uttrakhand, one six- wheeler truck carries 1,500 kg and 1,200 kg seed for 2 and 4 days transport respectively. They exchange water at 4 hour intervals. The seeds of catla (*Labeo catla*) and rohu (*Labeo rohita*), silver carp (*Hypophthalmichtys molitrix*), grass carp and bighead carp are transported either by air or by truck. The two catfish species such as pangas and magur were only species sent to Andhra Pradesh and only the latter one to Punjab and Haryana. Karnataka receives grass carp and common carp, whereas Uttar Pradesh and Bihar receive only the latter species.

When the seasonal demand for fish seed from Assam decreases, demand from other states of the west, north and south parts of India increases and is maintained until early October. The nearer states such as Odisha, Bihar, Jharkhand, and Chhattisgarh get seeds through transport by truck or by hundi on train, whereas distant states such as Punjab, Haryana, Maharashtra, Karnataka, Andhra Pradesh, Telangana, Madhya Pradesh, Uttar Pradesh, Rajasthan, Gujarat, Uttarakhand, and Himachal Pradesh usually receive seed by air. The north-eastern states of India such as Manipur, Meghalaya, Nagaland, Tripura, Arunachal Pradesh and Mizoram have started receiving amur carp seed recently, as it grows and survives well. The only island state receiving major carp seeds is the Andaman and Nicobar Islands.

Priorities before transport – an essential health check-up

Distribution from the market by air takes no longer than one and a half days while truck transports take from one day to neighboring Bihar and up to 4 days for Karnataka and Maharashtra. Spawn are transported by air to other states, either directly from nursery operators or fish seed traders. Seed are put into polythene bags containing oxygen-saturated water and then each polythene bag is packaged into cardboard (Fig. 6). Prior to dispatch seed quality and fitness is assessed according to their mobility. As much as 500 million seed are distributed by air to other states within the country each year.

Administration

The market has the registered administrative office known as 'Matsya Society' controlled by a board of 51 members including one secretary, one treasurer and other general members. However, a three-member committee handles monetary transactions and is responsible for submitting the financial report to the general body meeting. The board committee comprises 51 members and is fixed and supposed not to be extended further. If any member resigns or dies, another person among licensed members will occupy the position. However, presently the general committee has 669 licensed members entitled to do business who were 300 persons from initial enrollment as licensed traders. The secretary who is selected among the registrar members performs overall management of the market, following the 'By Laws', a legal guideline to execute market administration. Each person of the society has to deposit Rs. 500 as an annual membership fee; this is used for electricity bills, cleaning market and all other essential services required for the benefit of the market. After five years, the committee is reconstituted for better performance necessary for market administration.

State-of- the-art

Naihati fish seed market has many attributes that have contributed to its success as a state-of- the-art market:

- **Aims and scope:** The market facilitates seed growers, sellers, and buyers by adjusting the price suitable for all parties thereby encouraging business development.
- **Execution:** An effective execution and co-ordination exists to facilitate exchange and allocation of fish seed and services among all market stakeholders.

Figure 6: Packing.

Packing seed for air transport.

Filling packed seed bags with oxygen.

- **Transportation:** A well connected road and rail network beside the market and nearby airport provide good options for transportation of seed to both near and distant locations.

- **Ancillary businesses:** A versatile system of marketing set up comprising small to medium businesses has been developed around this market. Shops keeping aquaculture and fishery related goods and items are available to facilitate requirements of all the parties involved in this market.

- **Service provision:** About 500,000 people are engaged in pond preparation, net preparation, hapa setting, netting, fish catching, packing, oxygen filling, packaging, labeling, carrying, loading, unloading, and transporting are earning and thus running their livelihoods based on this market. In one night, about 400 paddle vans reach the market to sell fishes, and every paddle van has an average of five people who stay at the market during business hours. A total of around 2,000 come to the market every day.

- **Quality assurance:** Fish seed are quality assured as much as possible and are well processed under the guidance of experts, with maintenance of experienced professionals, fishery experts, chemists and other employees to check quality assurance of seeds for sale and transport. That is why the market has been advanced as a reliable centre in India. The ability to efficiently meet the demands of fish farmers has helped the market in achieving an outstanding position growing day by day.

- **Relentless efforts:** This business employs individuals who are dedicated to their respective roles and put in a lot of effort to achieve the common vision and larger goals of the market for its sustenance. Importantly, this market seems to expand daily with modernity in every aspect including products and services dealing with customers' satisfaction. The market is facilitated by access to readily available transportation services, provision of food round the day, and short stay shelters, which satisfy the requirements of all stakeholders.

End note

Since its journey nearly five decades, the growth and development of Naihati market seems promising, vibrant and sustainable. The market is unique because a diverse group of professionals including fishery, management, research, academics, traders, to name a few are directly or indirectly involved vis-à-vis resources of the market are catered as potential input for their

Figure 7: Ancillary shop with relevant equipment for sale.

growth by any means. However, aquaculture, which is one of the fast growing sectors has been extended in India, for which the contribution of Naihati seed market is worth mentioning. Fish seed is an essential input for aquaculture and is available for as many as 27 fish species of culture potential. More and above, the facilities and amenities that Naihati market maintains are both attractive and customers and trader friendly.

Acknowledgment

The authors thank the people of Naihati market for sharing information and fish seed photographs.

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NACA Newsletter

Published by the Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand

ISSN 0115-8503

Volume XXXVIII, No. 4
October-December 2023

Kingdom of Saudi Arabia joins NACA

Chiang Mai, Thailand: The 32nd Governing Council today unanimously approved the Kingdom of Saudi Arabia's membership of NACA, bringing the total number of member states to 20.

Mr. Tanes Poomtong, Chair of the NACA Governing Council said, "I am delighted to welcome the Kingdom of Saudi Arabia to the NACA family."

"Our members believe that Saudi Arabia's membership will bring substantial benefits to NACA, opening new opportunities for technical exchange and sharing of experience for the mutual benefit of all."

Dr. Huang Jie, Director General of NACA said "Saudi Arabian membership will bring diversity, new ideas and thinking about how aquaculture can develop under different conditions."

"The innovative approaches to development in the Kingdom provide are instructive for the transformation of Asian aquaculture and provide a showcase of what should be possible in the region."

Accepting the letter of confirmation, Dr. Ali Mohammad Alshaikhi, CEO of the National Livestock and Fisheries Development Program, said "Although our aquaculture industry is still relatively small, the Kingdom of Saudi Arabia aspires to become a major producer and is committed to expanding production to meet its 2030 vision."

"Asia is the heart of global aquaculture production. As a member of NACA, there are many opportunities for us to learn from the other member states, and we are also excited to share our own experience."

Applications for the position of Director General, NACA

The incumbent Director General, Dr Huang Jie will be completing his term of office in April 2024. The NACA Governing Council has instructed to call for applications from suitably qualified and experienced persons from NACA member states for the position of Director General, tenable from May 2024 for a fixed period of five years. The selected candidate is expected to assume the position by 1 May 2024 after a brief handover period.

Applications will close at 5 PM (Bangkok time) on **31 January 2024**. Candidates must be less than 60 years of age on the closing date. Shortlisted candidates will be expected to attend an interview with the 33th NACA Governing Council

meeting, which is tentatively schedule for March 2024, India. Only short listed candidates will be notified of the results of application.

Responsibilities

The Director General is responsible for developing and conducting a work programme over a five year period in accordance with the mandate of NACA. The position will be based in the NACA Secretariat, Bangkok, Thailand.

The incumbent will be expected to travel extensively within and outside the region. The responsibilities of the Director General will include management of the Secretariat staff in pursuit of the goals of NACA both in terms of technical and administrative performance standards, and will be the chief financial officer.

Further supporting information can be found on the NACA website.

Qualifications

- A post-graduate degree related to aquaculture.
- A minimum of 15 years' experience in regional or international aquaculture development and research.
- An established track record of successful fund raising.
- Demonstrated expertise in project management and development.
- Previous experience in management and administration.
- Excellent inter-personal skills and experience in human resource management.
- Must be a citizen of a NACA member state.

Remuneration

The remuneration package includes health insurance, child education allowance, relocation and dependents allowances and a vehicle.

Applications

Those intending to apply for the position should submit the following via email to jie.huang@enaca.org with copies to ddgfs.icar@gov.in and info@enaca.org. Applications must include:

- Detailed curriculum vitae, including publication list and proof of age.
- A short statement why you are seeking the position of Director General (not exceeding one page).
- A short statement of your aspirations for NACA (not exceeding three pages).

The online version of this announcement / further details about the NACA organisation are available from: https://enaca.org/?id=1299.

NACA awarded the Aziz-Ul Haq Rural Development Medal

A highlight of the 32nd Governing Council Meeting in Chiang Mai was the award of the Aziz-Ul Haq Rural Development Medal to NACA by the Centre on Integrated Rural Development for Asia and the Pacific (CIRDAP).

The award was presented by Dr Cherdsak Virapat, Director General of CIRDAP on behalf of the CIRDAP Governing Council, which had determined to confer the award at a Special Session of the Executive Committee on 25 May.

The award was granted to NACA "…for its remarkable contributions to rural development through sustainable aquaculture and aquatic resource management programs, policy dialogue and regional cooperation in Asia and the Pacific region and for unwavering support to the CIRDAP mission to promote regional sustainable aquaculture development and resilience to climate challenges."

NACA's support to CIRDAP's mission has included collaborating on a joint statement on building Climate Resilience in Aquaculture and Agriculture Systems for the Shanghai Declaration Session on SDG 13 (Climate Action) at the Global Conference on Aquaculture Millennium +20, co-authoring a thematic article on Strengthening resilience of small-scale farmers and farming systems to climate change impacts through aquaculture: a regional perspective, and collaborating with CIRDAP to development of projects to address climate change action.

NACA would like to express our thanks and gratitude to CIRDAP and its staff for the enduring partnership between the two organisations.

CIRDAP DG Dr Cherdsak Virapat (right) presenting the medal to NACA DG Dr Huang Jie.

Training Course on Risk Analysis in the Aquaculture Value Chain held in Bangkok

FAO organised a Training Course on Risk Analysis in the Value Chain, under the project GCP/GLO/352/NOR from 3-5 September in Bangkok, Thailand, in collaboration with the Department of Fisheries (DoF) and the ASEAN Network of Aquatic Animal Health Centres led by the Thai DoF, and NACA and INFOFISH. The organisers wish to gratefully acknowledge the financial support provided by the Norwegian Agency for Development Cooperation (Norad) and the Thailand DoF.

The development of a national aquatic organism health strategy is a key component of safeguarding a country's aquaculture industry and biodiversity. It also plays a key role in securing international trade in aquatic products and in maintaining market access.

Risk analysis is an essential component of a national aquatic organism health strategy. Now widely applied in many fields, risk analysis provides a science-based framework for evaluating hazards, determining the likelihood and extent of potential harms, mitigating risks and guiding policy decisions.

Value chain analysis is a detailed study of the processes throughout the value chain, including production, marketing, processing, retailers, and consumers. This includes understanding aquaculture production systems and how stakeholders operate and the decisions they make.

Combining risk and value chain analysis provides a risk-based and people-centred approach to managing disease risks and planning control measures for aquaculture systems.

The course aimed to build capacity in conducting risk analysis to support the development of national aquatic organism health strategies, as a first step in the implementation of the four-stage Progressive Management Pathway for Aquaculture Biosecurity initiative of FAO.

The course included training on:

- Disease emergence in aquaculture.
- Risk-based approaches to progressive management pathways to aquaculture biosecurity.
- National aquatic organism health strategies.
- Health management and biosecurity.
- Import risk analysis.
- Value chain analysis.
- Transmission pathways.
- Biosecurity vulnerabilities, risk hotspots and risk factors.
- How to create risk pathways, assign likelihoods and use matrices.
- Movement of aquatic organisms in ASEAN.

Participants conducted a desktop value chain risk analysis exercise for selected aquatic commodities involving value chain risk analysis, hazard identification, identification of risk factors and biosecurity vulnerabilities, and a risk assessment proper. Participants also completed five elearning lessons from the FAO elearning Academy on Pathway to aquaculture biosecurity: managing risks in the value chain and received a digital badge.

The course was attended by some 70 participants from 16 countries from south and southeast Asia, Australia, China, Ethiopia and Saudi Arabia, representing government, private sector and academia. It was taught by Dr Richard Arthur (Canada), Dr Yuko Hood (Australian Department of Agriculture, Fisheries and Forestry), Dr Brett Mackinnon (City University of Hong Kong), Dr Melba Reantaso (FAO) and Dr Saraya Tavornpanich (Norwegian Veterinary Institute).

The manual for the course is available for download from the link below.

https://enaca.org/enclosure/?id=1291

Free FAO publication: Genetic management of Indian major carps

Indian major carps are cultured widely across the sub-continent with the main culture system being a multi-species polyculture in ponds, often including other carp species. The sector is supported by hatcheries producing over 50 billion seed/year.

This study analyses genetic management of Indian major carps since they were first domesticated in the 1950s. A literature review and survey of common hatchery practices identifies significant problems prevalent in the sector including loss of genetic diversity, inbreeding and uncontrolled hybrid introgression.

This case study identifies some of the root causes of poor genetic management and better practices that could bring about an improvement in hatchery management. Download this publication for free from:

https://enaca.org/enclosure/?id=1296

7th International Symposium on Cage Aquaculture in Asia (2nd announcement)

CAA7 will be held in Hainan, China, from 29 November to 2 December, with an option for online participation via Zoom for people that cannot attend in person. The symposium will be conducted in English and will feature a poster exhibition.

The theme of the symposium is "Sustainable development of cage aquaculture in Asia". Sessions will be held on:

- Production systems.
- Breeding and seed production.
- Nutrition and feed.
- Carbon sink and fouling organisms.
- Health and environmental management.
- Economics, gender, livelihood and policy.

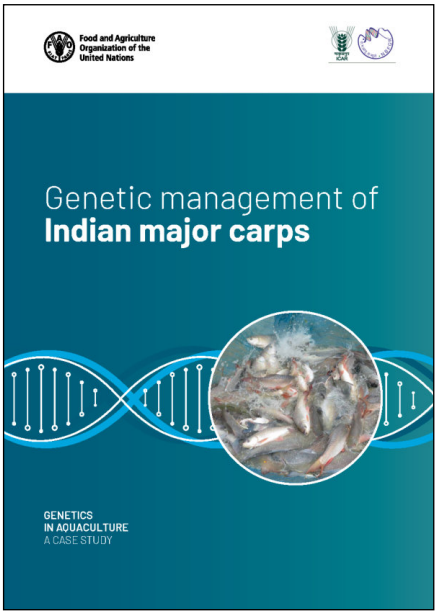
The symposium is organised by the Asian Fisheries Society, Hainan University, Shanghai Ocean University, and the China-ASEAN "Belt and Road" Joint Laboratory of Mariculture Technology, Center for Ecological Aquaculture.

For more information and registration details, please download the second announcement and prospectus below.

https://enaca.org/enclosure/?id=1294

PhD scholarships: Shanghai Ocean University PhD Programme 2024

Shanghai Ocean University (SHOU) is offering full scholarship PhD programmes in a wide range of marine sciences in 2024. Disciplines include: Aquaculture, biology, fishing science, fisheries resources, marine science, food science and engineering, fishery economics and management, marine engineering and information.



Scholarships

The scholarships are open to non-Chinese citizens under 30 years old who have a master's degree with a good academic record and outstanding research potential. The scholarships cover tuition, accommodation, medical insurance and include monthly stipend.

Applications

Applications are due 1 February 2024. For details of the programmes, eligibility criteria, required documentation and application procedures, please download the prospectus linked below.

If you have any questions, please email admissions@shou.edu.cn or add the Admissions Officer Ms. Louise as a Facebook contact or on WeChat (louise2shou).

Postgraduate opportunities

Postdoc positions are available for excellent graduates and full-time faculty positions are available for excellent international postdocs.

Download the prospectus:

https://enaca.org/enclosure/?id=1298

WAS Journal Special Issue:

Global Conference on Aquaculture Millennium +20 Thematic Reviews

Eight thematic reviews prepared as preparation for the Global Conference on Aquaculture Millennium +20 (GCA +20) have been published in a Special Issue of the Journal of the World Aquaculture Society "Aquaculture for Food and Sustainable Development". The reviews are available for download from:

https://onlinelibrary.wiley.com/toc/17497345/2023/54/2

The reviews were prepared under the guidance of the International Programme Committee, with the objective to review and update the current understanding on key issues relating to the development of sustainable aquaculture.

A group of experts prepared advanced working drafts of each thematic review and the key findings from each theme were presented and discussed by expert panels during the GCA +20. Participants were then invited to provide their feedback and perspectives on the reviews and their key messages for consideration in finalisation of the papers.

Papers available for download:

- Editorial: A decadal outlook for global aquaculture
  Graham Charles Mair, Matthias Halwart, Yuan Derun, Barry Antonio Costa-Pierce

- The contribution of aquaculture systems to global aquaculture production
  Marc Verdegem, Alejandro H. Buschmann, U. Win Latt, Anne J. T. Dalsgaard, Alessandro Lovatelli

- Sustainable management and improvement of genetic resources for aquaculture
  A. K. Sonesson, E. Hallerman, F. Humphries, A. W. S. Hilsdorf, D. Leskien, K. Rosendal, D. Bartley, X. Hu, R. Garcia Gomez, G. C. Mair

- Perspectives on aquaculture's contribution to the Sustainable Development Goals for improved human and planetary health
  Max Troell, Barry Costa-Pierce, Selina Stead, Richard S. Cottrell, Cecile Brugere, Anna K. Farmery, David C. Little, Åsa Strand, Roger Pullin, Doris Soto, Malcolm Beveridge, Khalid Salie, Jorge Dresdner, Patricia Moraes-Valenti, Julia Blanchard, Philip James, Rodrigue Yossa, Edward Allison, Christopher Devaney, Uwe Barg

- Harvesting the benefits of nutritional research to address global challenges in the 21st century
  Brett Glencross, Débora Machado Fracalossi, Katheline Hua, Marisol Izquierdo, Kangsen Mai, Margareth Øverland, David Robb, Rodrigo Roubach, Johan Schrama, Brian Small, Albert Tacon, Luisa M. P. Valente, Maria-Teresa Viana, Shouqi Xie, Amararatne Yakupityage

- Biosecurity: Reducing the burden of disease
  Rohana Subasinghe, Victoria Alday-Sanz, Melba G. Bondad-Reantaso, Huang Jie, Andrew P. Shinn, Patrick Sorgeloos

- Dynamics of aquaculture governance
  Curtis M. Jolly, Beatrice Nyandat, Zhengyong Yang, Neil Ridler, Felipe Matias, Zhiyi Zhang, Pierre Murekezi, Ana Menezes

- Humanizing aquaculture development: Putting social and human concerns at the center of future aquaculture development
  C. Brugere, T. Bansal, F. Kruijssen, M. Williams

- Value chains and market access for aquaculture products
  Lahsen Ababouch, Kim Anh Thi Nguyen, Marcio Castro de Souza, Jose Fernandez-Polanco

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Seminar on *Artemia* Research and Production: Videos

A *Seminar on Artemia Research and Production: Exploring Translational Advancements, Global Perspectives, and Shared Benefits* was held on 28 July 2023 in Putrajaya, Malaysia, in conjunction with the first meeting of the International Artemia Aquaculture Consortium Steering Committee.

Video recordings of the technical presentations are available from the International Artemia Aquaculture Consortium website at:

https://artemia.info/news/?id=74

Technical programme

- NACA's role with the International Artemia Aquaculture Consortium
  Mr Simon Wilkinson, Network of Aquaculture Centres in Asia-Pacific

- Brine shrimp *Artemia* culture and research in Malaysia
  Prof. Yeong Yik Sung, Universiti Malaysia Terengganu

- Production and use of *Artemia* in Iran
  Prof. Naser Agh, Artemia and Aquaculture Research Institute, Urmia University, Iran

- UGent Laboratory of Aquaculture and Artemia Reference Center
  Prof. Annelies Declercq, Laboratory of Aquaculture and Artemia Reference Center

- AR-ARC actions towards sustainable utilisation of Artemia resources
  Prof. Sui Liying, Asian Regional Artemia Reference Center, Tianjin University of Science and Technology, China

- *Artemia* pond production: Pros and cons
  Prof. Nguyen Van Hoa, Can Tho University, Vietnam

- Feeding 9 billion by 2050: Embracing *Artemia* in nourishing a growing world
  Parisa Norouzitallab and Kartik Baruah, Swedish University of Agricultural Sciences

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the First Quarter of 2023

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 first quarter of 2023 and the original and updated reports can be accessed at https://enaca.org/?id=8.

The following diseases were reported:

Finfish diseases

- **Infection with *Aphanomyces invadans* (EUS):** Bangladesh in catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*); and, India in tilapia (*Oreochromis* sp.), snakeheads (*Channa striata* and *Channa* sp.), rohu (*Labeo rohita*), Kuria labeo (*L. gonius*), catla (*L. catla*), *Cirrhinus mrigala*, grass carp (*Ctenopharyngodon idella*), silver carp (*Hypopthalmichthys molitrix*) and catfish (*Wallago attu*).
- **Infection with red seabream iridovirus (RSIV):** Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*); and, India in seabass (*Lates calcarifer*).
- **Carp edema virus disease (CEV):** India in Koi carps (*Cyprinus carpio*)
- **Viral encephalopathy and retinopathy (VER):** Australia in groupers (*Epinephelus lanceolatus* and *E. malabaricus*); Chinese Taipei in hybrid grouper (*Epinephelus fuscoguttatus* x *E. lanceolatus*), seabass (*L. calcarifer*) and Japanese seabass (*Lateolabrax japonicus*).
- **Infection with Tilapia lake virus (TiLV):** India in tilapia (*Oreochromis niloticus*).

Molluscan diseases

- **Infection with *Perkinsus olseni*:** India in farmed mussel (*Perna viridis*), and wild samples of charru mussel (*Mytella strigata*) and short-neck clam (*Paphia malabarica*).

Crustacean diseases

- **Infection with white spot syndrome virus (WSSV):** Australia in black tiger shrimp (*Penaeus monodon*); Bangladesh in mudcrab (*Scylla serrata*); Chinese Taipei in whiteleg shrimp (*P. vannamei*); India in *P. monodon* and *P. vannamei*; and, the Philippines in *P. vannamei* (nauplii, PL, juveniles, grow-out culture, and adult), *P. indicus* (grow-out culture), *P. monodon*, and *S. serrata* (grow-out culture).
- **Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV):** the Philippines in *P. vannamei* (grow out culture).
- **Acute hepatopancreatic necrosis disease (AHPND):** Chinese Taipei in *P. vannamei*; and, the Philippines in *P. vannamei* (PL and grow-out culture) and *P. monodon* (brood-stock).
- **Infection with Infectious myonecrosis virus (IMNV):** India in *P. vannamei*.
- **Hepatopancreatic microsporidiosis caused by Enterocytozoon hepatopenaei (EHP):** Chinese Taipei in *P. vannamei*; and, India in *P. vannamei*.

Amphibian diseases

- **Infection with *Batrachochytrium dendrobatidis*:** Australia in tusked frog (*Adelotus brevis*).

Other diseases

- Bangladesh reported **infection with *Streptococcus agalactiae*** in tilapia (*O. niloticus*), and **infection with *Aeromonas* spp**. in shing catfish (*Heteropneustes fossilis*), and pangas catfish (*Pangasianodon hypophthalmus*).

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Larvi 2024 and first International Artemia Aquaculture Consortium conference

The first conference of the International Artemia Aquaculture Consortium will be organized on September 9, 2024 in Ostend, Belgium. The 8th International Fish & Shellfish Larviculture Symposium - Larvi '24 - will be organised at the same venue in Ostend from 9-12 September 2024.

A more detailed first announcement with call for presentations will be mailed in the first week of October 2023. A preliminary website has been opened where you can register your interest to participate in this event:

https://forms.gle/rqfryjyqYGQgE63M8