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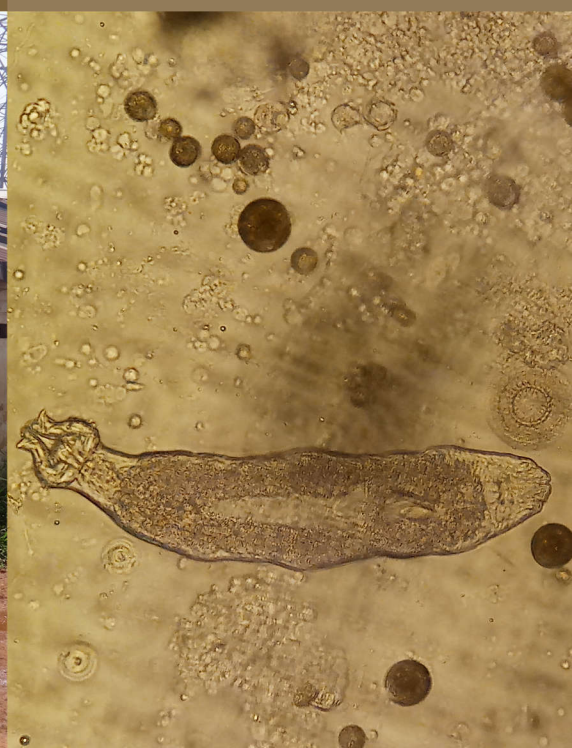
AQUACULTURE ASIA

Carp spawn production & transportation

Ornamental Aquaculture Field School

Mixed infections

Seahorse aquaculture



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

Shooting the messenger: Expensive, counter-productive and futile

Recently Srisala *et al*. were kind enough to provide some guidance on diagnosis and molecular detection methods for a shrimp virus, published on the NACA website. The last section of the advisory contains some commentary on the general state of reporting of animal pathogens by research scientists. It raises a number of concerns regarding the confidentiality of diagnostic findings with commercial clients, their legal obligations to report disease outbreaks to competent authorities, and, sadly, punishments that may be meted out to research scientists for reporting disease or even for conducting disease surveillance and testing.

In some countries, scientists face legal sanction and possible imprisonment for reporting the occurrence of aquatic animal disease. If you think this is counter-productive, you are not alone. Here are some facts:

- Disease outbreaks are the number one threat to aquaculture production. They regularly cause multi-billion dollar losses and severely damage national output, with dire consequences for farmers, region-wide or even globally.

- We know from long experience that the cost of trying to contain and eradicate a pathogen increases rapidly with time: A quick response is far, far cheaper to implement than a late one, and it is also far, far, more likely to succeed.

- Nobody can hide the presence of a pathogen from their trading partners. It is **impossible**, given the advent of modern molecular diagnostic tools. Failing to be open simply erodes trust and confidence in a government's competent authorities and health certification.This is turn can affect market access.

The costs of suppressing disease testing and reporting are huge, yet there are no apparent benefits in doing so. So why is this happening? It is because the system punishes those that report problems for short-term political expediency. We are shooting the messengers, and this needs to stop.

There are some parallels to this situation in the information technology industry: People who report security flaws in software have historically often received criminal charges as a 'reward' for informing companies that did not wish to invest resources in fixing them, or that feared their reputation would be tarnished.

This has widely been considered a grave mistake, and now many companies have 'responsible disclosure' policies, that undertake to protect researchers that provide a notice period to fix security problems before a public announcement is made. Governments also, are beginning to enact legislation to protect researchers that report vulnerabilities. Some companies, including giants like Google, Apple and Microsoft, even offer paid 'bug bounty' programmes, with financial incentives.

Governments need to provide such a 'responsible disclosure' mechanism for scientists, veterinarians, farmers and others to report aquatic animal disease. The mechanism needs to protect those that make good faith reports against legal and political reprisals. The mechanism needs to be fast, to allow an effective investigation and response to be mounted, and it needs to be transparent, ensuring that bona fide reports see the light of day, and allow unhindered scientific publications.

As noted by Srisala *et al*., for the time being, the safest course of action for many researchers is to remain silent about their findings. Is that really what we want?

Simon Wilkinson

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Ornamental Aquaculture Field School: A new extension approach

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The first ever Ornamental Fish Farmer Field School was inaugurated on 7 February 2021 at the fish farm of Shri Bhagirathi Roy of Prabhupara Village, Sadar block, Jalpaiguri, West Bengal

Aquaculture Extension – the vital link between research and farmer

Aquaculture extension services worldwide have laid emphasis on transfer of technologies, imparting training and promoting good practices in technical areas e.g., site selection, breeding and seed production, feeding and fish health (FAO, 2017). Effective extension services have had a role in increasing aquaculture production and may result in improved economic development of rural fish farmers (Tu and Giang, 2002).

Extension systems have undergone sea changes over time with an increasing scope in terms of both contents and recipients (FAO, 2017). While agricultural (including aquaculture) extension is often narrowly defined as “technology transfer”, it should be broadened to encompass human resource development that focuses on learning and building farmers’

The field school was virtually inaugurated by Sri Sagar Mehera, Joint Secretary, Ministry of Fisheries, Government of India.

Innovations in extension and advisory services have been the focus of discussion in regional as well as global fora. Horizontal, inclusive, farmer led, and participatory extension is felt as need of the hour. A field school approach aims to increase the capacity of groups of farmers to test new technologies in their own fields and to assess the relevance of results to their particular circumstances (Braun et al. 2000). It is required to integrate the curriculum of scientific method of aquaculture like where to rear, how to rear, how to market the fish etc. These field schools cover a wide area where the progressive farmers are there and through them the technologies of fish farming viz., seed production of carp, catfish, and air breathing fish, ornamental fish etc. are disseminated.

The second Ornamental Aquaculture Field School was established by ICAR-CIFA, Bhubaneswar, on the farm of Sri Rajesh Ranjan Mohapatra on 4th Sep 2021.

ICAR-CIFA promotes farmer to farmer learning

The Farmer Field School (FFS) approach was promoted by FAO as an alternative technology dissemination mechanism to the top-down extension methods in south-east Asian countries. In order to utilise the potential of the FFS approach for aquaculture, ICAR-CIFA has piloted the Aquaculture Field Schools (AFS). AFS is a school without walls for improving the decision-making capacity of the farmers and facilitate cross learning opportunities. It is a participatory extension approach whereby fish farmers are allowed to choose the methods of aquaculture production through discovery-based approach. AFS is composed of a group of like-minded farmers who regularly meet and discuss the technical aspects of fish farming. Ideally, 20-25 farmers make an AFS.

Aquaculture Field Schools promote farmer to farmer extension. It eases the pressure on an already overstressed public sector aquaculture service delivery system. It is a participatory extension approach where one fish farmer learns from the other. The vision inherent in aquaculture field schools is that the trainers work alongside farmers as advisors and facilitators, encouraging independence, analysis and organisation. This method promotes exploration, discovery, and adaptation under local conditions. The researchers and

workers are looking to help them where they are unable to solve a specific problem amongst themselves.

Aquaculture Field School piloted

The ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar has established seventeen aquaculture field schools - eight in Odisha, six in West Bengal, one in Arunachal Pradesh, one in Assam and one in the state of Chhattisgarh, to promote farmer to farmer extension. The AFS piloted by ICAR-CIFA is the first of its kind in the field of aquaculture. Several field days and workshops on community-based aquaculture have been organised at the AFS which were attended by farmers from neighbouring villages. Post-graduate students in the fishery are also regular visitors to these field schools for gaining practical exposures. Several other researchers have documented the positive impact of field schools.

AFSs have proved to be the ground for new, meaningful, and participatory learning about scientific practices in aquaculture. Farmers' practical problems are regularly being analysed, their capacity enhanced and quality decision making ability strengthened through these field schools. The AFS approach relied heavily on non-monetary inputs with technical advice and interaction as the primary intervention. This approach of 'farmer to farmer' extension with no physical input would certainly be sustainable in the long run (De et al. 2016). The AFS initiative was started as an institute funded project during 2008-09.

Ornamental Fish Farmer Field School

The first ever Ornamental Fish Farmer Field School was inaugurated on 7 February 2021 at the fish farm of Shri Bhagirathi Roy of Prabhupara Village, Sadar block, Jalpaiguri, West Bengal. It is a unique Farmer Field School that had been established by CIFA for the farmer to farmer learning and dissemination of ornamental fish culture techniques for the first time in the country. The field school was virtually inaugurated by Sri Sagar Mehera, Joint Secretary, Ministry of Fisheries, Government of India. He appreciated the efforts made by ICAR-CIFA in helping the farmers of remote North Bengal for adopting scientific aqua farming systems. Dr Saroj Kumar Swain, Director of ICAR-CIFA, was present along with a team of scientists. Farmers and their households will be enabled to take up ornamental fish farming with technical support from the institute. The school envisages empowering over 500 ornamental fish farmers in 20 nearby villages of North Bengal, contributing greatly to the extension and advisory services delivery.

This is a major intervention by ICAR-CIFA to popularise ornamental fish breeding and developing entrepreneurship in North Bengal districts. Under the flagship Prime Minister Matsya Sampada Yojana scheme (PMMSY) this sector is being given lot of emphasis. With active involvement of farmers, farm women and related stakeholders the sector will witness growth given the congenial agro-climatic condition prevailing in this part of the country.

Odisha's first ornamental aquaculture field school opened

Sri Rajesh Ranjan Mohapatra (42) is a progressive ornamental fish farmer of Kochila Nuagaon Village, Dasasahi, Cuttack District. He is an adopted farmer of the ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar. He had come in contact with CIFA in 2006 and received training. By dint of his sheer efforts and hard work he has been able to establish himself as a well-known figure in the ornamental fish seed business in Cuttack and neighbouring districts. He owns a farm of 2 ha comprising 21 ponds spread over 1 ha, 78 cement tanks, and four ornamental fish breeding hatcheries.

The farmer is dealing with several exotic and high value ornamental fish. Important ones are zebra fish (yellow, red, pink); koi Carp; angel fish; cichlids (blue); sword tail (pink, red); lion head, red cap, fan tail and telescopic eye goldfish; honey gourami; kissing gourami; Amur carp; discus; fighting fish (deep red, maroon) and others. He has a clear vision – attractive colour and quality product. With the proper guidance and training by Dr Saroj K Swain, Principal Scientist of ICAR-CIFA, Sri Mohapatra can produce around 100,000 colourful fish per year. His annual turnover is around Rs 3,000,000. He makes a profit of over Rs 750,000. He is planning to bring in more varieties of ornamental fish, intensify production involving women, utilise a 'hub and spoke' business model and launch online trading. The Ornamental Aquaculture Field School was established in his farm by ICAR-CIFA, Bhubaneswar on 4th Sep 2021. This is the second such school piloted by ICAR-CIFA to facilitate horizontal spread of technology and advisory services.

State of the art of carp spawn production and transportation at Ramsagar, Bankura District, West Bengal, India

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Tricycle motor trolley carrying spent major carps to broodstock pond.

Tradition of carp seed production in West Bengal

For the last five decades or so, West Bengal has held the glory as the leading state in India for fish seed production and supply (major carp fry; 22-25 mm). It has presently 454 private and six state government carp hatcheries, respectively. Undoubtedly, the success of commercial freshwater fish culture is due to the availability of adequate quantities of healthy and pure seed, fry and advanced fry of the major carps, *Labeo bata*, pangas catfish and air-breathing catfishes. The author once again presents this information after a previous discussion[1] to uphold the lesser-known contribution of elderly and progressive fish breeders in rural West Bengal. These people have achieved excellence and are producing good quality fish seed using scientific methods, catering to the requirements and demand of fish culturists within West Bengal and other states by virtue of honesty, skill, and experience. Significantly, they are trying to keep up their vocation and this tradition during aberrant weather, cyclonic storms, COVID-19-induced nationwide lockdowns, bad road conditions linking hatcheries proper to the main highway for fish seed and broodstock transportation, and other obstacles.

Carp spawn production at Ramsagar Gram Panchayat

The 15-18 days old carp fry are produced in earthen nursery fishponds, beginning from stocked spawn, induced-bred 72-75 hours old 7-8 mm stage produced and supplied from hatcheries. From an article published twenty years back[2],

we come to know about the prominence and repute of carp spawn production in large and commercial scale achieved at three distinct towns in West Bengal, namely Ramsagar in Bankura, Naihati in North 24 Parganas and Kalna in Purba Bardhaman districts. Villages in Ramsagar contribute 65-70% of the total carp spawn produced in West Bengal every year. Most of the villages, namely Barpetya, Hetamuya, Jadabnagar, Shinghati, Teliberia, Baruipara, Mouchura, Sinpur, Surmanagar, Sinargoria, Kalyari within the jurisdiction of Ramsagar Gram Panchayat under Onda Community Development Block and Police Station in Bankura, West Bengal collectively form a cluster, i.e., an effective centre of carp spawn production activity. In each of these villages, from 3-20 of hatcheries exist.

Eminent fishery experts in West Bengal Dr Punyabrata Das and the Late Prof. Nihar Ranjan Chatterjee emphasised the use of matured brooders of proper age and size in hatcheries and the renewal of broodstock major carps of either or both sexes (or its exchange with that of another hatchery owner at a distant village) every year to prevent inbreeding and the occurrence of low-quality fish seeds. Indeed, on 7-8 May, 2022, the author learnt that such recommended practices are followed by fish breeders and hatchery owners at Barpetya and other places in Ramsagar; many of them possess a good understanding of inbreeding and its unwanted impacts. It is noteworthy that in these hatcheries, forced release of fish gametes (stripping method) is completely avoided, only fish pituitary extract is used for hormonal injection to brooder

View of 72 hours old Catla catla spawn.

carps and no cross breeding is practiced among parents of related but different carp species. Only 100% pure spawn of the economically important carps are produced here, namely *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, *Ctenopharyngodon idella*, *Hypophthalmichthys molitrix* and *Labeo bata*, all separately, while that of *Puntius sarana*, *Puntius javanicus* and *Cyprinus carpio* are produced on a small scale.

Pituitary extract administered to brooder Cirrhinus mrigala.

Presently, out of a total of 125-130 functioning private carp hatcheries in Ramsagar Gram Panchayat owned by the same number of professional fish breeders, 30 are situated in close proximity at Hatibari and Barpetya villages and near or beside the Birai River where carp spawn production is done on a large scale. This cluster area is known by the name 'Gufu road'. These two villages are located beside Birai River, one of the main tributaries of Dwarakeswar River, that further forms one of the two major rivers in Bankura. Dwarakeswar River originates near Mukutmonipur in Purulia District. At the 'hatchery hub' in these two villages, there are presently 30 large carp hatchery owners - cum - large-scale carp breeders. All of these hatcheries have been accredited and registered by the West Bengal State Fisheries Department. Each outdoor hatchery comprises 4-7 circular concrete egg incubation-cum-hatching units. About 60% of the total spawn production in this Gram Panchayat is done every year in these two villages. In addition to above, a few other fish hatcheries work on a small scale in Hatibari, Barpetya, Hetamuya villages collectively. Sri Biswanath Dey, Sri Pintu Nayek, Sri Monosa Ram Dey are three such progressive fish breeders, amongst others, with whom author made on-site conversation. Gufu road will be an 'eye opener' site for many less-educated youths and aqua-entrepreneurs in adjacent states of West Bengal who are interested to do carp seed production. They will gain clear practical knowledge and encouragement if they visit there.

'Ramsagar-produced spawn' holds the fame of fast growth rate in fish culture ponds and high survivability. Rajendrapur-Battala fish seed market at Naihati, North 24 Parganas, is presently the largest fish seed wholesale market in eastern India and 70% of the seed sold here is supplied from villages in Ramsagar Gram Panchayat. But it is under-recognised. Many customers (fish farmers) in this market coming from different places in North and South 24 Parganas and Nadia districts (these places are nearer to Naihati than Ramsagar and good linkages exists with the former in terms of distance; the distance between two towns is 150-160 km) believe that all carp spawn available and meant to be sold here are produced in carp hatcheries situated at Naihati, which sometimes become more focused. According to Sri P. Nayek, it will be good if carp spawn produced at Ramsagar and sold at Naihati fish seed market are promoted under the name of Ramsagar-produced seed. Some fish farmers in these districts come to Ramsagar to procure carp spawn directly from people like Sri Biswanath Dey (Sri Dey), Sri Nayek and others.

Progressive fish culturists and fish breeders from each and every state in India (even from Gangtok, Meghalaya) have visited these two villages at Ramsagar Gram Panchayat. A considerable numbers of families and a large part of the inhabitants in Ramsagar Gram Panchayat are involved in carp spawn production commercially; this practice is expanding and developing as successful business enterprise and about 80% people in this Gram Panchayat depend directly or indirectly on carp spawn production business as source of livelihood. Customers within and outside West Bengal trust in the superior quality of Ramsagar-produced carp spawn. Jharkhand fish farmers have been buying spawn from here for the last 20-25 years.

Carp spawn packing and transportation from Ramsagar Gram Panchayat

Purba Medinipur is the leading district in production of table size major carp in West Bengal, and quite a few fish seed traders and fish farmers here procure carp spawn from Ramsagar. Seed goes to West Godavari, Rajahmundry, Ahmedabad, Pune and other districts in India by air from Dum Dum airport in Kolkata. Seed goes to all over West Bengal and all over India except Jammu and Kashmir, Himachal Pradesh, and a few north-eastern states, supplied to Andhra Pradesh, Madhya Pradesh, Chattisgarh and other states.

For long distance inter-district transport, and also to places in neighbouring states Odisha, Jharkhand and Bihar by roadway or railway (150-500 km; 3-8 hours journey), 25,000-35,000 carp spawn are kept in each oxygenated polythene packet containing 10-12 litres of water. For shorter distance transport of 25-40 km up to 100 km to adjacent districts, 50,000-70,000 are kept in each packet. Advanced hatchlings 48-60 hours old are preferred for long distance transport and normal 72–75-hour old spawn for shorter distances. A delivery vehicle (but not meant for it) such as Maruti Suzuki Omni can hold and transport 40-42 of such fish seed packets. Mini and larger-sized pick-up trucks (Mahindra Bolero pick-up van) with an open cargo area are also used. It takes 18-25 hours to transport carp spawn to places in Gujarat, Andhra Pradesh by train; the much faster air route is preferred which takes around 2 hours. In each cardboard carton containing oxygenated packet with 3 litres water, only 5,000-6,000 60 hour old spawn are kept and such cartons are dispatched to Dum Dum airport for aerial transport. A single medical-grade oxygen cylinder (46 litre capacity) can fill 280 spawn packets, each containing 10-12 litres of water.

Injection of oxygen into spawn packets.

Sri Tapas Bauri at Barpetya Notun Pally Perar Par is not a fish breeder but involved only in oxygen packing and transportation of carp spawn after buying the same from some hatchery owners, opined that a standard spawn measuring cup ('bati' in Bengali vernacular) of 135 ml water holding capacity holds 25,000-35,000 carp spawn. This measurement is normally followed while packing the hatchery-produced spawn for transportation. Thus two bati refers to 50,000-70,000 spawn (48-72 hours old). Sometimes the water is increased up to 15 litres in packets during long distance transport by road. Spawn contained in a single bati are divided into four parts in separate containers during aerial transport. Quite a few rural youths like Sri Bauri are seriously in such ancillary activities at these two villages, working in small temporary mud-built huts with thatched roof in fields.

According to Sri Dey, each such bati holds 35,000-45,000 carp spawn at its maximum capacity with the lowest possible amount of water, as it is sold to customers. At Sri Dey's hatchery site and of the others, one full bati carp spawn holding this much amount is kept in one oxygenated polythene packet during transportation during the night hours to Purba Medinipur or adjacent district, with 10 litres water in each. For such places, another larger bati is also sometimes used which is 1.5 times more voluminous than the previous one. In one packet, 1.5 bati carp spawn is sometimes kept, i.e., 80 packets received by a farmer of three species of Indian major carp will hold 120 bati spawn in total (approximately).

The 135 ml capacity spawn measuring cup ('bati') left and 1.5 times larger bati right.

Empty cement packets or bags (50 kg bags, INR 4-5 per bag) made of polypropylene polymer are used to wrap the oxygenated spawn-loaded polythene packets, one in each, during transportation within West Bengal. Auto showers, sprinklers, forced jets of water ejected from the metal mouth of rubber pipes – all are kept in constant operation over the egg incubation-cum-hatching pools as aeration devices until harvest of spawn and sale. In the early morning, the

Sri Tapas Bauri's cottage for carp spawn packing.

Shiromoni Express coming from Purulia arrives at Ramsagar station at 5.35am and carp spawn are individually loaded in cement bags in the vendor compartment for transportation to Purba Medinipur and Howrah districts on the train route. A daily super-fast deluxe night service bus 'Nightingale' going towards Kolkata city and Sealdah arrives at Ramsagar bus stop on the national highway at 4.00am. Spawn-loaded cement packets are loaded into the bus also, for transport to Kolkata. There is a special compartment in the Shiromoni Fast Passenger train (now Express) meant for transportation of carp spawn.

Before the COVID-19 lockdown period, a great numbers of fish farmers carrying carp spawn in large aluminium hundi (with continuous surface water splashing with right and left palm) and oxygenated cement bags could be found in early morning at Ramsagar railway station, frequently numbering more than local passengers availing the train service. For a fish breeder, each polythene packet costs INR 8-10. Before transportation, for the convenience of customers, oxygen-inflated cement bags carrying carp spawn are marked as yellow bags for *C. catla*, white bags for *L. rohita* and white bags with blue knots of durable string for *C. mrigala* (supposedly). When felt necessary, oxygenated packets are filled with glucose water before introducing carp spawn into it. Polythene packets are loaded inside cardboard cartons for long distance transport.

Hatchery structure at Barpetya and Hatibari villages

Both Birai River water and/or 60-90 m deep underground water are pumped using electric motors and submersible pumps (shallow tube wells) respectively and taken into carp hatchery complexes for storage and use. Concrete rectangular chambers and earthen ponds of 120-280 m^2 area and 0.9-1.0 m water depth serve as reservoirs to hold the brooders. Water is pumped from the river to concrete water reservoirs, and passed into each of the concrete and circular carp egg incubation-cum-hatching chambers or cisterns (familiar Chinese model) kept in operation, where fertilised eggs are placed. Each of the largest egg incubation-cum-hatching units has a 6.1 m outer diameter and produces 180-220 bati (each 135 ml capacity) spawn in one single operation of a particular carp species, which becomes ready for harvest and packing. In comparison, smaller units each of 4.6 m diameter produce 90-150 bati spawn. Water from the central outlets of egg incubation-cum-hatching units is released into the river, where it is made available to local agriculturists to irrigate their vegetable farming lands free of cost. Carp broodstock ponds of hatchery owners are generally located 2.5-3 km distance from the hatchery proper.

In the main fish breeding and carp spawn production season that lasts from 15th March till 15th July every year, 200-300 bati carp spawn are produced every day on average from all egg incubation-cum-hatching units in one hatchery. In the 30 hatcheries, spawn production continues till end of July every year but is extended till end of August in other hatcheries. Injected brood fishes of both sexes of a particular carp species are released in small-sized 60-140 m^2 earthen or concrete water bodies (breeding chambers) having 1 m depth. Broodstock harvested from ponds are maintained for a brief period before injection in such concrete impoundments

Water-filled packets at hatchery site ready for holding spawn.

Putting spawn inside polythene packets during daytime.

Oxygenating spawn packets.

with continuous aeration. Fish breeders have made and run the artificial sprinklers and auto-shower systems over egg incubation-cum-hatching pools and fish breeding chambers using simple indigenous technology. The single dose of fish pituitary extract is administered and induced only to 50% of the male fishes in a single operation by some progressive fish breeders and are released with non-injected male fishes; this is sympathetic breeding. Neither overhead water storage tanks nor circular concrete carp breeding pool (Chinese

Oxygenated spawn packets ready to be loaded on the Shiromoni Express train at Ramsagar station.

structure) exist in hatcheries here at Ramsagar. All circular egg incubation-cum-hatching pools have been constructed and operate at 1.22 m below ground level whereas, contrastingly, they are constructed above ground level at Naihati.

Sale price of carp spawn

Towards the middle and end of fish breeding season (from 3rd or 4th week of May till July), the sale price of a bati of *L. rohita* and *C. catla* spawn separately varies from INR 350-200 and INR 400-200 respectively. If carp spawn producers like Sri Dey and others are unable to meet customers or carp spawn purchasers (fish farmers) directly in other districts of West Bengal, then they contact intermediary persons first; these persons provide the spawn to customers known to them. Such persons, of which there are 350-400 in Bankura District, have become members of a co-operative society at Ramsagar. According to Sri Dey, in the 2nd week of March, i.e., in the beginning of season, spawn is sold to customers @ INR 900-1,000 per 135ml bati (retail price). These customers have direct contact with fish breeders here. But in Malda and other districts, people like Sri Dey sell spawn to customers via intermediary 'media' persons @ INR 1,500-1,800 per bati (including carrying cost), who receive 20% commission per bati. Thus Sri Dey gets INR 1,250-1,400 from the sale of one bati spawn to such customers. From a publication[2], we come to know that twenty years back during 2002 and little earlier, spawn was sold from Ramsagar Gram Panchayat @ INR 250-300 per bati, price falling to INR 100 per bati towards the end of season in early September. There were approximately 150 carp spawn producers using Chinese cisterns (egg incubation-cum-hatching pools).

Indian major carp spawn ready for transportation in cement bags.

Largest egg incubation-cum-hatching pools.

Natural breeding of carps

Bankura is pioneer in respect of production of fish seed of major carps by simulating natural conditions in captivity, with continuous aeration by means of overhead sprinklers[3]. After hormone injection to prospective brooders, natural breeding of carps is allowed in small earthen (some breeders say 'bundh-like') impoundments provided with water sprinkler structures. From earthen squarish or rectangular 40-120 m^2 breeding pools, fertilised eggs of a single species of carp are obtained, collected using drag-type mosquito net. Fertilised eggs are released in small rectangular 20-40 m^2 earthen hapa enclosures for incubation and hatching with no water circulation, water is intentionally and controllably made turbid to keep eggs in a suspended condition in the water column. Also, eggs are kept safe in this manner in summer months with higher water temperatures. Grown-up spawn are harvested from these rectangular mud egg hatching pits or hatching hapa using a large soft cotton cloth. In the natural carp breeding process, fertilised eggs are mostly transferred to familiar circular egg incubation-cum-hatching pools.

The earthen square-shaped carp breeding chambers with 1 m water depth (also called earthen breeding hapa) have a gentle slope at its base from one end to the other with 0.30-0.37 m more water depth towards lower end (slope). Earthen chambers have slope and embankment on four sides like that of a pond, here natural breeding or natural spawning of carps take place. After completion of one breeding (fish spawning) operation and collection of fertilised eggs of a single carp species, the entire water mass is drained out but prior to that, water (10-15 cm depth) is made turbid by pulling a thick log or tree trunk 1.5 m long and 20-15 cm diameter kept pressed over the bottom soil. This sweeping of soil and water mass is done manually and repeatedly, which helps in removal of deposited shells of fertilised and unfertilised carp eggs (if any) and undesirable organic matter accumulated over the bottom soil. Breeding or spawning of injected carps is also carried out in 40-120 m^2 small squarish or rectangular chambers having a concrete base and four sides (walls), no embankment or side slopes. These chambers also have a gentle flat slope at the base from one end to another. Some fish breeders refer to it as 'bundh breeding area'.

Mud hatchery pits are a traditional device for hatching fertilised carp eggs in Bankura (discussed above) which are dug in series, 1.5 x 1 m^2 each, and the inside plastered with red soil. During the twitching stages of embryos, fertilised eggs are collected from bundh structures and put into the hatching pits. But presently this technique is not much used.

Removal of egg shells from natural carp breeding chamber.

Sri B. Dey's small-sized egg incubation-cum-hatching pools.

Care of carp broodstock

After one spawning operation, spent fishes are harvested from square-shaped earthen and concrete fish breeding chambers, placed in water-loaded hundi (30-45 cm open mouth diameter aluminium vessel used for transporting fish spawn, fry and broodfishes, capacity 25-28 litres), loaded and carried in indigenous open loader tricycle motor trolley and released into broodstock ponds (4,000-10,000 m^2) of hatchery owners located 2.5-3 km from the hatchery proper. These vehicles and hundi also carry selected healthy brood fishes of both sexes from these ponds for release in fish breeding units at the hatchery site 4-6 hours before preparations for pituitary extract injection. Only well-matured major carps weighing 1,800-4,000 g are used as brooders (100-300 g for *Labeo bata*).

Such large-sized carps are maintained as brooders with proper feeding and water quality management. Paddle wheel aerators used in many broodstock ponds. For them, a home-made supplementary feed comprising ground nut oil cake, soyabean meal, maize meal, de-oiled rice bran, fish meal, boiled rice, wheat flour, boiled lentil pulses, common salt and vitamin-mineral mixture is used to form dough balls in perforated bags kept suspended in the water column. It costs INR 30 per kg. During 9.00-10.00am every day, 100-150 kg of such feed is provided to every 10 tonnes of broodstock carps, i.e., @ 1,000-1,500 g per 100 kg fish. During 4.00-5.00pm of same day, commercially available floating pelleted broodstock feed (INR 50 per kg) is used, 50 kg for every 10 tonnes of fish. Newly excavated or re-excavated ponds (water bodies), done by fish breeders themselves or with the initiative of the Block Development Officer, Onda Development Block and 100% financial support from Government, serve as broodstock fish ponds in villages under Ramsagar Gram Panchayat. Sri Dey maintains large carp broodstock population of 55 to 60 tonnes. Like others, he replaces and exchanges the major portion of his own broodstock fishes of both sexes from a distant place almost every year. Only 2–3-year-old fishes used for injection, brooders are bought by Sri Dey @ INR 225 per kg. Major carps above 3 years in age are no more used for induced breeding and spawn production.

Part of egg incubation-cum-hatching pools of Sri B.Dey.

Sri P. Nayek's egg incubation-cum-hatching pools.

End note

Since 1950, the residents of Ramsagar Gram Panchayat have taken up fish seed production as one of their major means of livelihood generation, although at that time they used traditional methods for obtaining major carp seed from natural freshwater bodies like river tributaries, canals, and

Simple water sprinkler system in earthen fish holding chambers.

beels. The introduction of induced breeding methods helped them to produce spawn on a large-scale. Small ponds excavated in this Gram Panchayat under the MGNREGA programme are used by some fish breeders to hold brood fishes and/or use them for natural spawning and spawn production of major carps[4]. Two widely recognised and significant fish seed markets of the country viz, Naihati and Bankura, are functional in West Bengal within a distance of around 200 km, catering to the needs of the whole country. A large number of hatcheries are concentrated around Naihati and Bankura as seed producing clusters[5].

Presently about 6,000-8,000 people are involved directly or indirectly with this fish seed production business at Ramsagar Gram Panchayat, including trolley drivers, oxygen cylinder suppliers, hatchery labourers (who administer hormone injection of fishes, feed broodfishes, and conduct other kinds of work and monitoring), carp spawn packers, hatchery technicians, polythene packet and empty cement bag suppliers, cardboard carton suppliers, intermediary persons and customers in Bankura and adjacent districts; also those who do fish netting from ponds to get broodfishes, sieving and harvest of fertilised eggs from small squarish earthen or concrete carp breeding chambers and transfer to egg incubation-cum-hatching chambers. Many local village women make polythene packets of specific sizes from large polythene sheets required for carp spawn transportation, do

Overhead water sprinkler in fish holding pools.

cleaning of used cement bags for reuse, and pack oxygenated polythene spawn packets into cardboard cartons for long distance transport. Financially challenged youths take part in ancillary activities.

Sri Dey and others advise their customers to prepare their nursery ponds properly before spawn stocking by killing medium-sized predatory fishes and also aquatic insects,

Broodfish ready to be loaded and transported to hatchery site.

Harvesting spawn from egg incubation-cum-hatching pool.

Water-swollen fertilised eggs of major carp.

using soap-oil emulsion. Commercial products such as Butox and Cleaner may be used against insects but soap-oil emulsion is safer.

People form adjacent Gram Panchayats of Onda Block come to Ramsagar for work in fish hatcheries. Under each of large fish breeders like Sri Dey and others, 15-30 people work for income. Some of them are permanent labourers, and some are recruited as contractual and daily labourers mainly in the four-month long carp spawn production season. Sometimes customers cannot be present at hatchery site in proper time to receive carp spawn and they cancel previously-placed purchase orders due to sudden storms and natural calamities (and typically express unwillingness to buy and stock spawn in such weather conditions). In such circumstances, Sri Dey and others face monetary loss. Prediction of about-to-occur cyclonic storms or heavy rain in the next 2-7 days is declared in the news but customers have already placed orders much before that date. Carp spawn cannot be kept inside circulating water columns of egg incubation-cum-hatching pools for more than 75 hours from birth. In such unwanted conditions, those unsold spawn are transferred to local small-sized earthen ponds. The demand for carp spawn from customers is heavy during mid-March every year for people like Sri Dey and some others, 500-550 bati of spawn have to be produced per day per hatchery. Then 10-15 persons work, day and night, in one hatchery to produce and fulfil this demand. It is a fifty-year long tradition of induced fish breeding and carp spawn production at Ramsagar Gram Panchayat. In West Bengal, production of fish seed has been increasing as it has not only a good market within the state but also outside the state[6].

Sri Dey has 14 broodstock ponds each of 4,000-10,000 m^2 in area. He has been producing seed for the last 32 years. He received the 'Best fish seed producer' award from the Minister of Fisheries, Government of West Bengal in January 2019 and the State-level 'Krishak Samman' award from Hon'ble Chief Minister of West Bengal in March 2019. The Bankura District carp spawn producers' welfare society ('Bankura Zilla Machh Dimpona Utpadok Welfare Samity') was formed in 1985 with almost all the 130 carp hatchery owners as members. This co-operative aims to resolve the usual minor and major problems (poaching of brood fishes, putting up genuine problems or matter to local or State-level administration for consideration, etc) faced by member fish breeders. It fixes the standard price of sale of Ramsagar-produced carp spawn per bati, applicable to all carp hatchery owners in this Gram Panchayat. Sri Dey and Sri P. Nayek are its Governing Body members.

Sri Dey also owns a semi-indoor mini hatchery system with five small-sized circular and semi-squarish type egg incubation-cum-hatching units of 2.14 m outer diameter each (for circular structures), a overhead water reservoir and pond 140 m^2 in area. It is beside his home, 4,000 m from his main outdoor hatchery site. About 50-60 bati of spawn (60-75 hours old) of major carps is obtained from each of such new model of egg incubation unit in one operation.

Sri Dey and Sri Nayek expressed concern about the bad conditions of the 2-3 km reddish earthen link road between their hatchery proper and the carp broodstock ponds. Fish become stressed and even die sometimes during their transport to the hatchery site on tricycle motor van/trolley, which cannot ply smoothly. Perhaps these hard-working and honest carp hatchery owners will be able to gain more prosperity with prevention of loss in their income and will continue to sustain the livelihoods of hundreds of associated people if obstacles are removed from their way.

Acknowledgement

The author is particularly grateful to Sri Biswanath Dey, Proprietor, Maa Bhubaneshwari Fish Hatchery at Barpetya Village, Ramsagar Gram Panchayat for spending much time with author and patiently narrating and explaining the details of carp spawn production process at Ramsagar.

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Spawn packets ready for transportation by bus.

Below: Small concrete rectangular chambers for maintaining hatchlings.

Seahorse aquaculture: A new paradigm of commercial activity

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Seahorses are unique charismatic livebearers that come under the genus *Hippocampus* spp. These flagship species are easily identified with their distinguishing features such as a horse-shaped head, large eyes, curvaceous trunk, and monkey-like prehensile tail. They are widely distributed in tropical and temperate waters (mostly in the Indo-Pacific region) and different species can tolerate a salinity range of 6-35 ppt. Seahorses are highly in demand for traditional medicines and curio trade purposes in the dried form and live ones are popular in the marine ornamental aquarium trade. As a result, they are vulnerable to overfishing. Since over-exploitation of these charismatic species has resulted in a drastic reduction in their natural populations, aquaculture of seahorses on a commercial scale may help to reduce pressure on wild stocks.

History of seahorse aquaculture

The seahorse *Hippocampus trimaculatus* was first bred in captivity in 1957 at Shantou Mariculture Test Farm, Guangdong Province, South China. From 1970 onwards, serious efforts were made to breed seahorses on a commercial scale in China. During the 1970's and 80's, Australia, Japan, and Venezuela conducted breeding experiments and rearing of seahorses in small-scale systems at research institutes and public aquaria. During the 1990's, considerable expansion of commercial seahorse aquaculture was evident in Australia, USA, and New Zealand, particularly for the big-bellied seahorse, *H. abdominalis*. The large scale culture of syngnathids spear-headed the recognition of the potential of seahorse aquaculture in 1995. South-east Asian countries conducted two workshops in 1998 to promote seahorse culture. In the last decade, extensive research has been done on different varieties of seahorse. Based on the recent studies, researchers suggested that seahorses can also be cultured in the integrated eco-aquaculture systems in a sustainable manner (Zhang and Vincent, 2018).

Global and Indian scenario of seahorse Aquaculture

Increasing demand of seahorses in international arena for ornamental and medicinal purposes has led to commercial culture of the seahorse. There are seven species (*Hippcampus abdominalis*, *H. barbouri*, *H. breviceps*, *H. comes*, *H. ingens*, *H. kuda*, and *H. reidi*) are which are accounting more than 99% of the culture and are traded throughout the world. Australia and New Zealand have developed significant centers for seahorse aquaculture.

There is a huge potential for farming seahorses in India, as there are vast resources found along the Gulf of Mannar and the Gulf of Kutch regions. It also provides an option of livelihood or additional income to the fisherfolk / self-help groups in the coastal belt besides promoting the marine ornamental industry. However, since seahorse farming is otherwise banned in India, research work on seahorses has been restricted to only four institutes within India, namely the:

- Central Marine Fisheries Research Institute, Cochin.
- Centre for Advanced Study in Marine Biology, Annamalai University, Tamil Nadu.
- Marine Biological Research Station, Ratnagiri.
- Maharashtra and Aquaculture Laboratory, CSIR-National Institute of Oceanography, Goa.

Seahorse captive breeding and rearing efforts from the above-mentioned institutes and various researchers from India are summarised in Table 1. Sadly, fishermen still rely on the wild by-catch for market and trade since culture technology of seahorse is not yet commercialised.

Biology of seahorses

Seahorses have distinct morphological characteristics such as a horse-like head positioned at a right angle, a long tubular snout with no teeth, no scales, a body with a series of bony plates and a prehensile tail. They have relatively large eyes, and small, circular openings to the gill chamber. The pelvic and caudal fins are not present in adult seahorses and the dorsal fin helps in propulsion. These species have a reduced anal fin, and the two small pectoral fins are used for stabilisation and steering. Because they are so slow-moving, sea horses are highly vulner-

Table 1. Seahorse captive breeding and rearing research in India.

Species	Author	Institute
H. kuda	Anil et al., 1999	ICAR-CMFRI, Cochin
H. kelloggi	Balasubramanian, 2002	CAS, Tamil Nadu
H. kuda	Naik et al., 2002	MBRS, Maharashtra
H. kuda	Salin et al., 2004	ICAR-CMFRI, Cochin
H. trimaculatus	Murugan et al., 2009	CSIR-NIO, Goa
H. kuda	Pawar et al., 2012	CSIR-NIO, Goa
H. trimaculatus	Murugan et al., 2013	CAS, Tamil Nadu
H. spinosissimus	Pawar et al., 2014	CSIR-NIO, Goa
H. kuda	Murugan et al., 2017	CAS, Tamil Nadu

able to predators and so they can camouflage themselves to match their surroundings. Seahorses are ambush predators, and primarily consume live and mobile prey types such as zooplankton, small crustaceans (amphipods), but also fish fry and other invertebrates. They also ingest smaller organisms that fit into their snout. They take close care of their offspring. Courtship behaviour takes hours to days, and then the mature female transfers its eggs to the male brood pouch known as a marsupium. The male secretes sperm into its pouch and then the eggs are fertilised externally, and embryos begin to develop. Soon after the gestation period, the male ejects the tiny, independent swimming seahorses to the surrounding environment.

Production of seahorses

Production cycle

Brooders are raised in indoor tanks and fed with lipid and vitamin-rich diets for maturation. During mating, male fertilises and broods the eggs which have been produced and deposited into its pouch by the female. After a period of 9-45 days of gestation, the fully developed young seahorses are ejected from the pregnant males. One day old fry are thereafter stocked in the indoor tanks and fed with live feed such as copepods or enriched *Artemia* nauplii. After 30-40 days, the juveniles are fed with frozen *Acetes*, *Mysis* or adult *Artemia* and are reared either in indoor tanks or outdoor sea cages. Once the juveniles become adults after 3-6 months, they are conditioned for breeding and the cycle continues. The other marketable size is adults of 10 cm, which are traded for traditional Chinese medicine, curios and marine aquariums in the domestic/international markets (Figure 1).

Currently, there are two types of production systems practiced globally, which are as follows:

Intensive monoculture system

The broodstock obtained from wild are kept in indoor tanks and fed with a diet containing vitamins A, C and E. During spawning season, females transfer around 200-2,000 ripe eggs to the pouch of the males. Embryo development takes place in this pouch in 10-20 days at the optimum temperature range of 26-28°C. The fry are fed with copepods, enriched rotifers and *Artemia* nauplii from birth to 40-days old age. After 40 days of rearing of the fry, the seahorses are transferred to outdoor cages and stocked @ 500/m^3. As they grow stocking is reduced to 200/m^3 by the end of the rearing period. During the grow-out period, they are weaned to frozen feed (*Mysis* and *Acetes*) twice a day. All the seahorses are harvested by net with a 40 cm diameter and 1 mm mesh size. After harvesting, seahorses are placed in oxygenated tanks and transported live for sale to exporters.

Integrated aquaculture system

IMTA (integrated multi-trophic aquaculture): Seahorses are cultured with shrimp / oyster in this system (Figure 2). Shrimp are benthic and feed on detritivores present at the bottom of the pond and the oysters are placed close to the surface of water and feed on phytoplankton. Seahorses are farmed inside cages and feed on zooplankton. In this way, the seahorse culture is synergistic with the production of shrimp and oysters, improving profitability.

Figure 1. Seahorse production cycle.

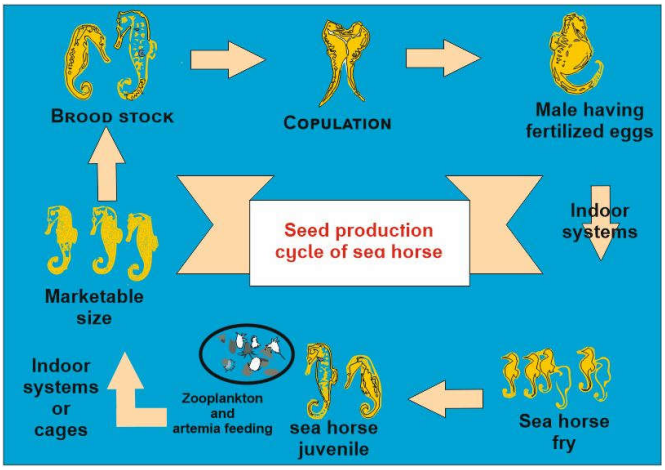
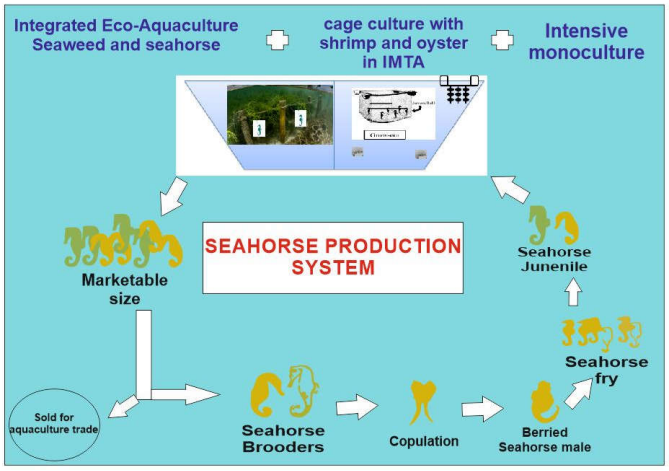


Figure 2. Seahorse production sytems.



Integrated eco-aquaculture: Seahorses are cultured with seaweed (Figure 2). Seaweed provides a holdfast and a prey growth environment for the seahorses, besides also controlling the water quality. Seaweeds not only provide convenient and abundant prey but also adjust the light intensity in the system since the seahorse is dependent on its vision to capture prey and needs a certain light intensity in the system.

Diseases and control measures

The major diseases which infect seahorses are vibriosis and mycobacteriosis. Vibriosis can be treated by application of antibiotics or vaccines. Gas bubble disease is another condition where gas becomes entrapped in the brood pouch and subcutaneous layer of the tail segment, which may be due to gas supersaturation or infectious agents. This can be treated by aspiration and antibiotics respectively. Apart from these, cultured species are vulnerable to infections caused by fungi, cestodes, marine leeches, trematodes, microsporidians and so on. Good husbandry practices and prophylactic measures can reduce the risk of disease significantly.

Conclusion

Seahorse culture is a new avenue in aquaculture which can help to reduce pressure on depleted natural populations. By adopting integrated multi-trophic aquaculture and integrated eco-aquaculture systems, populations of various species of seahorse may be enhanced in the shallow marine aquatic habitats of tropical and temperate waters. Besides taking up its commercial farming, researchers and farmers around the world need to address issues of market access and trade to build a well-managed and sustainable business.

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Mixed infections in tropical freshwater fish culture systems: A potential emerging threat for successful aquaculture

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The world population is growing steadily and predicted to reach up to 9.7 billion by 2050. To feed the ever-increasing world population, fish is an important source of nutrition. Fish not only serves as a source of protein but also contain other essential vitamins and minerals, and is considered a healthy food.

Aquaculture is an age-old technology initially began with a backyard pond-based extensive mode of culture, and today has reached the level of an industry with high intensification. Advanced technologies such as biofloc culture and recirculation-based super-intensive aquculture systems are becoming more common.

With intensification there is also an increase in the stress load on fishes, which ultimately suppresses the immune system and leads to disease, morbidity and mortality. Diseases are a major issue in aquaculture that commonly account for 10-15% of production losses. The aquatic environment contains many opportunistic pathogens and fish are frequently infected by a range of parasites, bacteria, viruses, and fungi. When the fish body is challenged by physical, chemical or biological stress factors, these opportunistic pathogens gain the upper hand and cause disease. In most incidences of disease, the involvement of two or more pathogens are often seen, which in turn complicates diagnosis and treatment. In our earlier surveillance-based study, we recorded that mixed bacterial-parasitic infections as being 10.50% of total disease incidences, while mixed parasitic infection was 37.80% of all parasitic cases (Sahoo et al., 2020). Further, parasites constituted 74.88% of total disease incidences in the same study, which was conducted from 2014-2018 in eastern India. The parasite infections were not usually directly detrimental, but they cause severe physiological distress to the host animal which invites other pathogens such as bacteria, viruses or other parasite(s) to infect further. However, mixed or co-infections aggravate the stress load on fish and thus lead to cause mass mortalities in different culture environments.

Above, below: Mass mortality due to stress induced by multiple infections with erratic isolated swimming of fish in the pond.

Here we present a few case studies on mixed infections in aquaculture systems, which may become more common in future due to changing climatic patterns and associated adverse impacts on water quality. Mixed infections seem to be a big challenge to diagnostic laboratories and health specialists in terms of providing a correct diagnosis and treatment.

Case 1: Mixed parasitic infections in larval Indian major carps

Farm location: Giringo, Balipatna, Khordha, Odisha

A pond size of 0.15 ha with water depth of 2 m was stocked with 0.80 million Indian major carp spawn for fingerling production. A continuous mortality of up to 15,000 for 5 days with clinical signs of surfacing, anorexia and high mucus mount on gills was noticed from day 20 of culture. The farmer incurred a direct loss of INR 10,500/- (US$ 142). Infected moribund fish were bought to the laboratory for investigation. The fish were found to be infected with myxosporideans, *Trichodina* sp. and *Dactylogyrus* sp. under microscopic examination of damaged gills. No other bacterium was isolated from the kidney tissue. The fish were provided with anti-parasitic treatment, and the mortality was stopped.

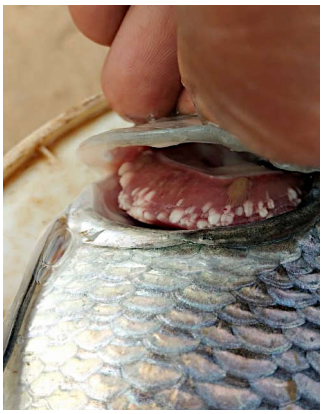
Case 2: Mixed bacterial and parasitic infections in grow-out of Indian major carps

Farm location: Kurangsasan, Baranga, Cuttack, Odisha

A pond size of 0.61 ha with water depth of 2 m was stocked with 5,000 fingerlings (~100 g) and recorded mortality of fish continuously for two days. The fish, weighing on average of 200-500 g, showed sluggishness, anorexia, surfacing and haemorrhages over the body before death (twenty in two days). The moribund fish were bought to the laboratory for further investigation. The fish were found to be infected with myxosporideans, *Trichodina* sp., and *Aeromonas hydrophila* was also isolated from the kidney tissue. Treatment measures using formalin and Sokrena WS (Di-Decyldimethyl Ammonium Chloride of Virbac India) were able to prevent further mortality and the fish were cleared of infection within a week.

Above, below: Mixed parasitic infection in fry stage of fish.

Mixed parasitic (below on gill tissue) and bacterial infections (haemorrhagic ulcer on body) in carps.

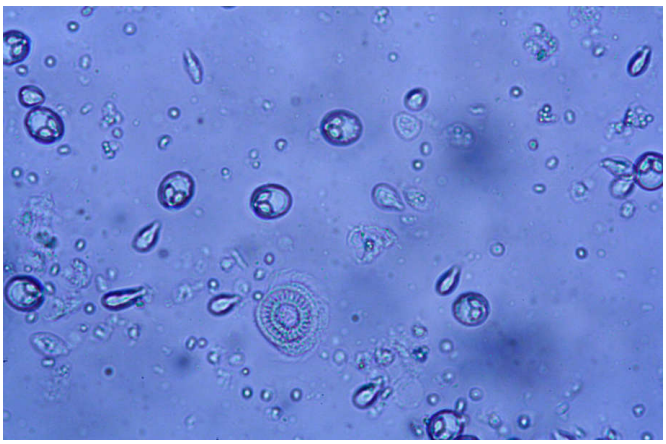


Case 3: Mixed recurrent parasitic infections in grow-out of Indian major carps

Farm location: Bhusandpur, Tangi, Khordha, Odisha

A recurrent infection with mixed parasites was observed in an Indian major carp grow-out pond of 6.47 ha. The fishes showed clinical signs of damaged gills, surfacing and anorexia. During September 2016, moribund catla and rohu samples were diagnosed for mixed parasitic infections with the presence of *Dactylogyrus* sp., *Trichodina* sp. and myxosporideans in gills and lice (*Argulus* sp.) on the body. The farmer was advised to use an antiparasitic drug and subsequently the disease was controlled. Again, during December 2016, 200-250 fishes died in the same pond with clinical signs of haemorrhages, surfacing and gill damage. Diagnosis revealed that the fish harboured the same parasites in gills in addition to the involvement of one bacterium i.e., *Aeromonas hydrophila*, which was isolated and identified using molecular tools from kidney tissue. The farmer was advised to use medication and the infection declined, and mortality was stopped. The pond was completely harvested during December 2016. Again, during early January, 2017, the pond was stocked with fingerlings of Indian major carps and after just 15 days of stocking, a sporadic mortality was noticed. The fish were found to contain a heavy load of myxosporidean cysts in the internal organs such as the spleen, liver and kidney along with presence of *Dactylogyrus* sp. and *Argulus* sp. Anti-parasitic drugs were advocated, and the mortality was controlled. The prolonged winter during 2016-17 might be one of the possible predisposing factors for recurrent parasitic infestations.

Above, below: Mixed parasitic infection on gills and internal organs.



Case 4: Mixed parasitic infections along with fungal infection in juvenile *Anabas testudineus*

Farm location: Rahandia, Bhadrak, Odisha

A large-scale mortality was noticed in biofloc culture of Anabas raised in six 100,000 litre tanks stocked at 180,000 fish/tank). Within a span of one week the mortality reached 15,000 fish (size ~100 g) in spite of proper biofloc manage-

ment at the farm level by the farmer. A loss of INR 750,000/- (US$10,140) was incurred because of the mortality. Clinical signs include pale colour of gills, white ulcerative patches on the body, and red spots near the operculum. On examination, the moribund fish were found to be infected with myxosporideans and *Dactylogyrus* sp. Further, fungal elements were also noticed on skin scraping examination. No gross changes in internal organs were found and also the kidney was free of any bacterium upon bacteriological examination. The floc was discontinued and the fish were shifted to isolation tanks for symptomatic treatment to get rid of the infection.

Infection and mass mortality of Anabas in biofloc tank.

Case 5: Co-infection with bacteria and parasite in koi carp

Farm location: Ornamental unit, Kausalyaganga, Odisha

Mortality was noticed in 90 koi carp stocked in a cement tank. The infected animals showed clinical signs of anorexia, haemorrhages on body, high mucus built up on gills, and sluggishness in movement before death. In total seven fish had died when they were bought to the laboratory for examination. The fish were found to be infected with a heavy load of *Dactylogyrus* sp. on gill squash examination and Staphylococcus epidermidis was isolated from kidney and spleen tissues of the infected fish. Further, symptomatic treatment as able to control the mortality in the farm. Fish were free from carp edema virus on PCR. Gill flukes might have played primary role in causing stress and mortality, besides allowing secondary bacterial infection to further aggravate the condition.

Mortality of koi carp due to co-infection of bacteria with gill flukes.

Case 6: Co-infection with bacteria and parasites in catfish

Farm location: Ekchahalia, Pipili, Puri, Odisha

A pond of 0.80 ha with water depth of 2 m stocked with 8,000 numbers of African catfish (*Clarias gariepinus)* along with Indian major carps was recorded mortality in catfish, only. The moribund fish showed marked sluggishness, surfacing and haemorrhages over body before death. Within five days, 300 fish had died of the infection. The fish were diagnosed to be infected with *Staphylococcus aureus* along with a heavy load of myxosporideans on the gills through PCR and microscopic examinations. Symptomatic treatment with parasiticide and disinfectant was able to control the mortality successfully in the farm.

These are few examples of mixed infections which are cited here. Similar types of cases are increasing day by day, not only in freshwater aquaculture systems but also in brackish water aquaculture involving multiple etiological agents. For example, infections with multiple viral etiological agents such as white spot virus, monodon baculovirus and hepatopancreatic parvovirus (Manivannan et al., 2002) and/or with EHP (*Enterocytozoon hepatopenaei*), an intracellular microsporidian (Thamizhvanan et al., 2019) in shrimp are becoming common problems in most of the shrimp producing countries in south east Asia.

Mortality in catfish due to co-infections with bacteria and parasites.

Conclusions

The cases of co- or mixed infections in freshwater fish farming systems are increasing day by day. It is quite often difficult to pinpoint a single etiological agent as a root cause of infection in a mortality event. Similar mortality events are not uncommon in any culture system, particularly in ornamental fish farming. Validating Koch's postulate with single organism most of the times failed to create similar infection upon experimental challenge to establish the primary etiological agent in those mortality events. Earlier we also noticed large scale mortality in goldfish farming with Cyprinid herpes virus-2 along with *Aeromonas hydrophil*a (Sahoo et al., 2016). Further, Swaminathan et al. (2016) noticed carp edema virus infection in koi carp along with co-infection of *Dactylogyrus* sp. and opportunistic bacterial presence in internal organs. Similarly, our laboratory also recorded co-infection of carp edema virus with *A. hydrophila* in a mortality event in koi farming (Sahoo et al., 2020).

Climate change and transboundary movement along with system diversification and intensification are the major factors in the emergence of co- or mixed infections in fish farms. Researchers or health management officials need to be more cautious in disease diagnosis as ultimately this may decide the success of control of infection and effective health management. The mere presence of a parasite or any other opportunistic bacteria or virus may aggravate stressful conditions in the host in a culture environment leading to large scale mortality. Hence, proper care must be given for practising better health management at the farm site along with quality seed stocking. Intermittent use of probiotics and immunostimulants may be practiced in these situations to have a hand on effective management.

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New reviews of aquaculture now available online

We are pleased to announce that the FAO Reviews of Aquaculture have been published online at the FAO website, including the six regional reviews and a global synthesis. The reviews were developed and published in conjunction with the Global Conference on Aquaculture Millennium +20 (GCA+20), which was co-organised by NACA. The reviews are:

- Global Aquaculture Synthesis.
- Regional Review of Aquaculture in Asia and the Pacific.
- Regional Review of Aquaculture in Europe.
- Regional Review of Aquaculture in Latin America and the Caribbean.
- Regional Review of Aquaculture in the Near East and North Africa.
- Regional Review of Aquaculture in North America.
- Regional Review of Aquaculture in Sub Saharan Africa.

Each regional review and the global synthesis contain nine chapters:

- Social and economic background.
- General characteristics of the sector.
- Resources, services and technologies.
- Aquaculture and environmental integrity.
- Markets and trade.
- Contribution of aquaculture to food security and social and economic development.
- External pressures on the sector.
- Governance and management of the sector.
- Aquaculture contribution to the FAO strategic objectives.

The reviews are available for download from the link below.

https://www.fao.org/fishery/regional-aquaculture-reviews/reviews-2020/en/

You are welcome and invited to share the reviews widely through your networks.

Video presentations of the reviews, including expert panel discussions and question and answer sessions, are also available from the GCA+20 website at:

https://aquaculture2020.org/regional/

Post-doctoral scholarships for women in STEM at the University of Stirling

The University of Stirling has been awarded funds by the British Council to provide funding for four Early Academic Fellowships for Women in STEM. These fellowships will be 6-12 months in duration.

The scholarships are post-doctoral awards, available to eligible candidates from South Asia, for women that have recently been awarded their PhD (0-12 months postdoctoral) and wish to have a research experience at a UK university or research institution, converting their doctoral work into publications or other academic outputs, and establishing new research relationships.

The scholarships are to run during academic year 2022/23.

Eligibility

The scholarships are available to women who are passport holders and permanent residents of India, Pakistan, Bangladesh, Nepal and Sri Lanka.

Applications

For further information please visit the University of Stirling website at the link below. The deadline for submissions is **31 March 2022**:

https://www.stir.ac.uk/scholarships/natural-sciences/british-council-scholarships-for-women-in-stem-post-doctoral-level/

Research breakthrough seen to curb shortage of 'poor man's fish'

Report by Rex Delsar

A scientific breakthrough at a research center in the Philippines might finally be the long-term solution to the perennial shortage of round scad (*Decapterus* spp.), known as the "poor man's fish" in the country.

In a world's first, researchers successfully spawned the round scad *Decapterus macrosoma* in captivity at the Southeast Asian Fisheries Development Center, Aquaculture Department (SEAFDEC/AQD) in Tigbauan, Iloilo, marking a critical milestone towards farming the fish, locally known as *galunggong*.

Round scad is considered a staple fish in the Philippines with over 202,000 metric tons harvested by commercial and municipal fisheries in 2020 according to government statistics. However, the haul could not keep up with market demand leading to increasing prices, now reaching $5 to $6 a kilo, and controversial moves to import the fish amid closed fishing seasons.

"Our breeders have been spawning continuously since December last year until this February, and we now have thousands of galunggong in different larval to early juvenile stages at our hatchery which we hope to further grow to market sizes to prove that we can farm galunggong," revealed SEAFDEC/AQD chief Dan Baliao in an interview last Feb. 28, 2022.

Round scad (Decapterus macrosoma) breeders feeding on krill during an experiment at SEAFDEC/AQD. Photo by EV Antolino.

Some of the world's first captive-bred round scad, 48 days after hatching, at SEAFDEC/AQD in Iloilo, Philippines. Photo by JF Aldon.

Researcher Ma. Irene Cabanilla-Legaspi said they started collecting wild breeders off southern Iloilo and Antique in 2020 as part of a Government of Japan-funded project at SEAFDEC/AQD, the same research center responsible for groundbreaking studies on breeding milkfish in the 70s and 80s.

After collecting round scad breeders onboard commercial fishing vessels and through fish traps, Cabanilla-Legaspi's team transported them to SEAFDEC/AQD's headquarters in Tigbauan and stocked them in fish tanks to prepare them for spawning.

It was the breeders they caught in August and October 2021 that began laying eggs in December 2021, and continued to produce good eggs through February 2022. Though still in an early experimental stage, they already have fingerlings in the hatchery that are more than 50 days old.

'Very fast' growth

"We observed that the fish were growing very fast. When they reach 20 days old, they have a very fast growth and we can obtain 2.5-centimeter round scad in 25 days," Cabanilla-Legaspi said. Although trials in the hatchery are still few, SEAFDEC/AQD scientist Dr. Leobert de la Peña noted that the round scad fry also have "very high survival" compared to other marine fish being grown at SEAFDEC/AQD, reaching as much as 20% survival 25 days after they hatch.

Meanwhile, the SEAFDEC/AQD team will continue to collect broodstock from the wild for more experimental runs that will also cover studying the fish's larval development, reproductive development, feeding habits, and the formulation of hatchery, nursery, and grow-out procedures.

"We hope our attempts to grow galunggong will proceed quickly. We are excited to roll out the technology and promote the culture of galunggong so prices may become more affordable as farms can surely augment the catch from the wild," Baliao added.

SEAFDEC/AQD deputy chief Dr. Sayaka Ito also noted that round scad is a potential export product for the Philippines as it is now being imported by Japan as otsumami, a kind of snack or finger food.

The research on round scad is under an umbrella program at SEAFDEC/AQD that aims to develop aquaculture technologies on new aquatic species that also includes kawakawa (mackerel tuna) and flathead lobster. The main goal of the research program is to close the life cycle of these species in captivity and to develop production techniques for hatchery, nursery, and grow-out.

News provided by:

Southeast Asian Fisheries Development Center, Aquaculture Department (SEAFDEC/AQD)

SEAFDEC is a regional treaty organisation, with 11 member countries, and is tasked with promoting sustainable fisheries and aquaculture in Southeast Asia. Its Aquaculture Department (AQD) is based in Iloilo, Philippines.

Free online aquaculture courses

Five free online aquaculture courses are now available on the platform OpenLearn Create. The courses are outputs of the EU GAIN project (Green Aquaculture Intensification in Europe). The courses are:

- Introduction to the GAIN project and courses - developed by Ca' Foscari University of Venice.
- Sustainability of aquaculture products - developed by the University of Stirling.
- Sustainable Aquafeeds - developed by SPAROS.
- Valorisation of aquaculture wastes: An approach to the circular economy - developed by CSIC with contributions from ANFACO-CECOPESCA, Salten Havbrukspark and Waister AS.
- Precision aquaculture.

The courses are self-paced and intended for people actively engaged withaquaculture production, seafood value chains, certification schemes and policy organisations, but are also of interest to students and academic audiences.

To sign up for courses visit the OpenLearn Create website:

https://www.open.edu/openlearncreate/course/index.php?categoryid=502

"Fishing for Life 2022"

South and South-East Asian Conference on Small Scale Fisheries and Aquaculture, 19-20 September 2022 at the Ocean University of Sri Lanka

In celebrating the Year of Artisanal Fisheries and Aquaculture-2022, as declared by the United Nations, Sri Lanka Forum for Small Scale Fisheries (SLFSSF) is organising a conference under the theme "Fishing for Life", which will be an international conference covering the South and South-East Asian region. This will be organised in partnership with Sri Lanka Association for Fisheries and Aquatic Resources (SLAFAR) and the Ocean University of Sri Lanka (OCUSL). The event will be held during 19-20 September 2022, in virtual format due to the Covid-19 pandemic situation.

The conference aims to bring to light, the important contribution made by artisanal and small scale fisheries to food supply, nutrition, employment, poverty alleviation and wellbeing of the people in the region, while at the same time, unearthing issues of governance failures, including social injustices emerging from the process of blue economic development. It is expected that the conference will yield an outcome having implications for effective management measures to be adopted, to secure sustainable artisanal and small-scale fisheries and aquaculture sub-sectors in the region.The organisers decided to invite you to share the conference flyer and information among your networks and empower the participation.

Conference themes include: Sustainable use of resources; Impact of policy, technology, trade and development on SSF; Poverty, rights and rural aquaculture; Gender issues in SSF; Governance and management of SSF; and Implementation of SSF guidelines.

The conference is organised with the SLFSSF in partnership with the Sri Lankan Association of Fisheries and Aquatic Resources, and the Oceans University of Sri Lanka.

To register or obtain further information, please visit the SLFSSF website at:

https://slfssf.org/

Reported Aquatic Animal Diseases in the Asia-Pacific Region during the Third Quarter of 2021

Report by E.M. Leaño

Senior Programme Officer, Aquatic Animal Health, NACA

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 third quarter of 2021. The following diseases were reported:

Finfish Diseases

- Infection with *Aphanomyces invadans* (EUS): India in green chromide (Etroplus suratensis).
- Viral encephalopathy and retinopathy (VER): Australia in farmed barramundi (*Lates calcarifer*) and giant grouper (*Ephinephelus lanceolatus*), and wild orange spotted grouper (*E. coioides*); and New Caledonia (affected species not specified).
- Infection with red seabream iridovirus (RSIV): India in molly (*Poecilia* sp.), dwarf gourami (*Trichogaster lalius*), three-spot gourami (*T. trichopterus*), and angelfish (*Pterophyllum* sp.).
- Enteric septicaemia of catfish: Vietnam in pangas catfish (*Pangasianodon hypophthalmus*)
- Carp edema virus disease (CEV): New Caledonia (affected species not specified).
- Infection with Tilapia lake virus (TILV): India in tilapia (*Oreochromis niloticus*); and, Philippines in tilapia (juveniles and adults).

Molluscan Diseases

- Infection with abalone herpesvirus: Australia in wild green lip abalone (*Haliotis laevigata*) and black lip abalone (*H. rubra*).

Crustacean Diseases

- Infection with white spot syndrome virus (WSSV): India in whiteleg shrimp (*Penaeus vannamei*); Philippines in PLs and juveniles of tiger shrimp (*Penaeus monodon*) and whiteleg shrimp (*P. vannamei*), and broodstock of mudcrab (*Scylla serrata*); and, Vietnam in *P. monodon* and *P. vannamei*.
- Infection with infectious hypodermal and haematopoietic necrosis virus (IHHNV): Philippines in tiger shrimp (*P. monodon*; PL), whiteleg shrimp (*P. vannamei*), and Indian prawn (*P. indicus*).
- Acute hepatopancreatic necrosis disease (AHPND): Chinese Taipei in tiger shrimp (*P. monodon*); Philippines in PLs and juveniles of whiteleg shrimp (*P. vannamei*); and, Vietnam in *P. vannamei* and *P. monodon*.
- Infection with Infectious Myonecrosis Virus (IMNV): India in whiteleg shrimp (*P. vannamei*).
- Hepatopancreatic microsporidiosis caused by *Enterocytozoon hepatopenaei* (EHP): India in whiteleg shrimp (*P. vannamei*); and, Philippines in PLs and juveniles of tiger shrimp (*P. monodon*), and juveniles of whiteleg shrimp (*P. vannamei*) and Indian prawn (*P. indicus*).
- Infection with decapod iridescent virus 1 (DIV-1): Chinese Taipei in freshwater crayfish (*Cherax quadricarinatus*).

Amphibian Diseases

- Infection with Ranavirus species: Chinese Taipei bullfrog (*Lithobates catesbeianus*).
- Infection with *Batrachochytrium dendrobatidis*: New Caledonia (affected species not specified).

Other Diseases

- Bangladesh reported Infection with *Staphylococcus* sp. in gulsha (*Mystus cavasius*) and Infection with *Aeromonas* spp. in stinging catfish (*Heteropnuestes fossilis*) and koi (*Cyrpinus carpio*), while Hong Kong SAR reported Infection with Infectious Spleen and Kidney Necrosis Virus (ISKVN) in Sabah hybrid grouper (*E. fuscoguttatus* x *E. lanceolatus*).

Historical reports

Previous / historical QAAD reports are available for download from the NACA website at:

https://enaca.org/?id=8

Shrimp 2022: INFOFISH World Shrimp Trade Conference and Exhibition

"Recovery through resilience and innovation"

World aquaculture production attained an all-time record high of 114.5 million metric tonnes (MMT) in live weight during 2018 with a total farmgate sale value of USD 263.6 billion, where Asia contributed significantly (66%). Three major shrimp species viz. whiteleg shrimp (52.9 MMT), black tiger shrimp (8 MMT) and giant river prawn (2.5 MMT) constituted 67.54% of the global crustacean production (93.87 MMT) (SOFIA 2020). Despite lower demand from the hotel, restaurant and catering sector due to COVID-19, the retail demand for fresh and frozen shrimp increased worldwide. Industry analysts suggested that shrimp production moderately increased in Ecuador and Indonesia but reduced in India, Thailand, Malaysia, and Bangladesh compared to 2019. Higher production drops were observed in China than other Asian countries. (GLOBEFISH 1st Issue 2021).

COVID-19 had an unprecedented impact on all nodes of the value chains, while simultaneously being the catalyst for some far-reaching changes that in many cases are likely to be permanent. At the same time, products, logistics, sales channels, marketing strategies and consumer behaviour have all been fundamentally affected by the economic and social turmoil that has taken place since the initial lockdowns in early 2020. Although these changes have been accompanied by heavy financial losses in many cases, they have also created a more resilient seafood sector and extensive new market opportunities. Newly developed distribution channels, products oriented towards home consumption, and operational adaptations are likely to remain key features of the industry, increasing the ability of businesses to respond to future crises of a similar nature and opening new routes for innovation. A similar tight supply is expected in 2021 for several key species. (FAO Food Outlook, June 2021).

The INFOFISH WORLD SHRIMP TRADE CONFERENCE AND EXHIBITION, the 6th Global Shrimp Conference of its kind, will be held virtually for the first time ever considering the uncertainty posed by the COVID-19 pandemic. SHRIMP 2019 Bangkok attracted more than 200 delegates from 26 countries as well as exhibitors. SHRIMP 2022 has been transformed virtually with the theme Recovery through resilience and innovation although you will experience the same interactive sessions, networking opportunities and showcase the shrimp brands as well.

SHRIMP 2022 will bring together all the key stakeholders (Broodstock Suppliers, Farmers, Feedmillers, Feed additive manufacturers, Health Management Product Suppliers, Disease Diagnostic Service Providers, Equipment Suppliers, Processors, Packaging Solution Providers, Traders, Exporters & Importers, Investors, Innovators, Academia, Policy Makers, Media, IGOs, NGOs, Certification Bodies, and Competent Authorities etc. around the globe throughout shrimp value chains.

Don't miss this opportunity to be part of the biggest shrimp conference, updated on the major shrimp markets, innovative solutions, explore one-to-one business contacts, showcase brands and also to learn about the recovery pathways towards a resilient and sustainable industry.

For more information or to register, please visit the conference website at:

https://shrimp.infofish.org/

Tuskfish CMS v2.0.3 available

A new version of the software that powers the NACA website, Tuskfish CMS, is available for free download.

New features

- PHP 8.1 compatibility.
- Support for embedding external Youtube videos via link (you can change the template to support other video services if you want).
- Added sitemap generation function to Settings.
- Added a 'minimum views' preference (before displaying the view counter).
- Added live character counter to meta description field, so you can see when you are approaching Google's 160 character soft limit.

Maintenance

- Updated templates to Bootstrap 5 compatibility.
- Updated third-party libraries to contemporary stable versions.
- Fixed occasional 'database locked' error under high load conditions.

Tuskfish CMS is open source software published under the GNU General Public License V2. Get it from:

https://github.com/crushdepth/tuskfish2/archive/refs/tags/2.0.3.zip

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