ISSN 0859-600X

Volume 25 No. 1 January-March 2021

AQUACULTURE ASIA

Exotic trout fisheries in Uttarakhand

Fish pituitary gland collection and supply as a vocation

Reducing feed costs

Coral trout larviculture

Aquaculture Asia

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

Editor

Simon Wilkinson
simon@enaca.org

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.

Contact

The Editor, Aquaculture Asia
PO Box 1040
Kasetsart Post Office
Bangkok 10903, Thailand
Tel +66-2 561 1728
Fax +66-2 561 1727
Website http://www.enaca.org

Submit articles to:
magazine@enaca.org

AQUACULTURE ASIA

Register for the Global Conference on Aquaculture Millennium +20

Every ten years or so NACA and FAO organise a global conference on aquaculture, bringing together stakeholders from all walks of life and all over the world to meet, review issues and trends, and look at how we can guide the direction of the industry going forward. It is very much a development-oriented conference, in that it deals largely, although not entirely with global development trends and aquaculture in a developing country context.

The programme places emphasis on improving incomes for the poor, food and nutritional security, capacity building, gender equity and empowerment of rural communities. Of course, it also covers core technical issues such as aquatic animal health, feeds, innovation in production systems, along with overarching issues such as the environment and climate change.

We are counting down to this year's flagship event, the Global Conference on Aquaculture Millennium + 20, which has been rescheduled for 22-27 September. The conference will be offered in both online and offline modes. Presentations will be streamed live over the internet, and if circumstances allow, physical participation will also be possible in Shanghai, China.

Participation is free, so please consider registering online at the conference website:

https://aquaculture2020.org/registration/

If you would like an early sample of the programme, presentations of advanced (pre-final) versions of The State of World Aquaculture 2020 and six Regional Reviews have been recorded and are available online at:

https://aquaculture2020.org/reviews/

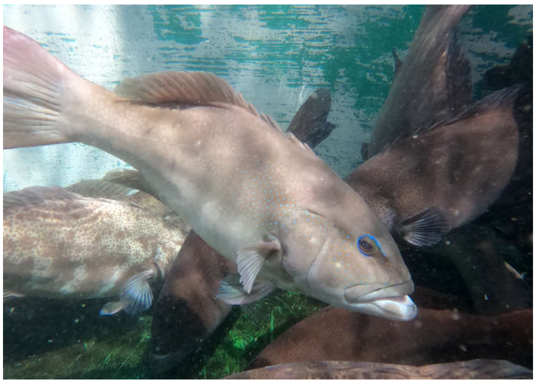
These reviews provide up-to-date information on the status and trends of the sector, at regional and global levels, developed from national, regional and global datasets, supplemented with expert opinion and literature review. The reviews are aimed to be of use to national governments, regional organisations,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

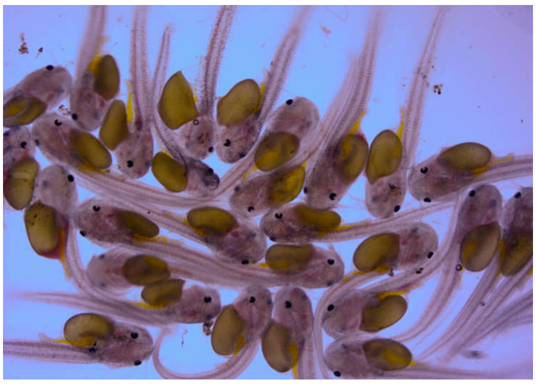
I look forward to seeing you there – whether online or in person.

Simon Wilkinson

AQUACULTURE ASIA

CONTENTS





Exotic trout fisheries resources and potentialities in Uttarakhand

Deepjyoti Baruah, Kishor Kunal, Ravindra Posti, N.N. Pandey, Jagdamba[1] and H.K. Purohit[2]

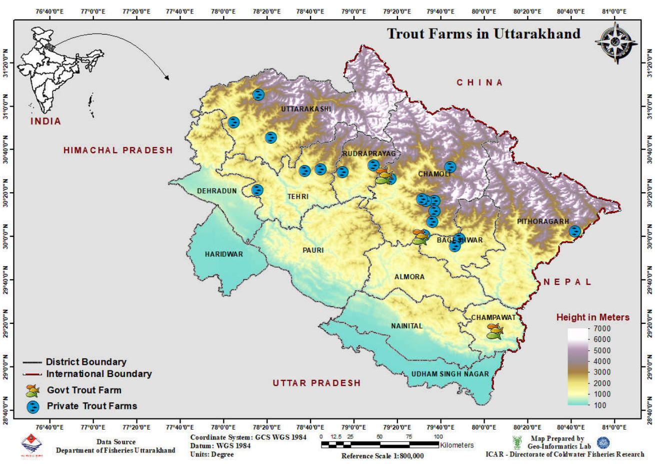
ICAR-Directorate of Coldwater Fisheries Research, Bhimtal-263136, Nainital, Uttarakhand; 1. Department of Fisheries, Gopeshwar-246401, Chamoli district, Uttarakhand; 2. Directorate of Fisheries, Badasi Grant (Dhanyari), Dehradun-248008, Uttarakhand

Above, below: Government trout farm and hatchery at Bairangana, Chamoli District.

Uttarakhand is the 27th State of the Republic of India, sharing international borders with China in the north; Nepal to the east; the Indian States of Uttar Pradesh to the south and Himachal Pradesh to the west. The State is divided into two divisions, Garhwal and Kumaon, covering seven and six districts respectively. The winter capital of Uttarakhand is Dehradun and the summer capital is Gairsain in Chamoli District. The State of Uttarakhand is often denoted as Devbhumi meaning the 'Land of the Gods' due to the existence of numerous Hindu temples and sacred shrines along the banks of the rivers of the State. The rivers of Uttarakhand are also reckoned to be holy in India, especially the river Ganga and Yamuna both of which have their origins in Uttarakhand State. Other well-known rivers in the State include Bhagirathi, Alaknanda, Nandakini, Pindar, Kosi, Mandakini, Ramganga, Kali, Nayar, Dhauliganga, Saryu, Bhilangna, Tons, Saraswati and the Gomati. Each of these rivers has their own religious as well as economic significance. Apart from the religious faiths and myths, these rivers along with their tributaries impose an allurement for those seeking adrenaline rush activities such as rafting, kayaking, trekking, zorbing and bungee jumping. Angling and riverside camping are other ways one can relish the rivers of Uttarakhand at their best.

Government trout farm and hatchery at Talwari, Chamoli District.

The topography divides the State into three altitudinal regimes: the mountains, the Bhabar and the Terai. The altitudinal variation provides a rich habitat for 125 fish species in the State of which 76 species fish are distributed in Garhwal region and 96 in Kumaon region (Sondhi, 2012). The salmonids in particular are mostly valued due to their superlative nutritional quality and sporting excellence in the temperate regime (Baruah, 2019). The two most important exotic salmonids found in India are the rainbow trout *Oncorhynchus mykiss* (Walbaum 1792) and brown trout *Salmo trutta*, Linnaeus 1758 thriving well in cold freshwaters of the Indian Himalayan Region. In Uttarakhand, the history of trout farming dates to 1910 when the eyed ova of rainbow trout were transplanted in the Government trout farm at Talwari in Chamoli District. In the beginning, trout was solely regarded as a sport fish and was less considered as an aquaculture avenue. But gradually, with the advancement in technical know-how on raceway farming practices, breeding and seed production, feed preparation and disease control



Map showing the distribution of trout farms in Uttarakhand.

Table 1: Major water quality parameters of trout farms and hatcheries of Uttarakhand.

Water quality parameters	Talwari	Bairangana	EFF Champawat	Private farms
Temperature (C)	6.2-6.5	6.4-7.7	11.2-14.3	8.5-14.6
pH	7.8-8.4	7.1-8.1	6.5-7.3	7.7-8.2
Dissolved oxygen (mg/l)	8.56-9.85	8.58-10.32	6.42-8.64	8.10-8.80
Total alkalinity (mg/l)	42-44	40-42	20-22	48-50
Total hardness (mg/l)	120-130	110-130	100-110	130-140
Ammonia (mg/l)	0.00	0.04	0.10	0.14
Nitrite (mg/l)	0.00	0.03	0.10	0.10
Nitrate (mg/l)	0.01	0.06	0.30	0.60

mitigations led to a transformation of the commercial trout farming scenario in the country. At present, the leading trout producing States in India are Jammu and Kashmir, Himachal Pradesh, Uttarakhand, Tamil Nadu and Kerala. The States of Sikkim, Arunachal Pradesh and Nagaland have also gained momentum in trout rearing in pursuance to meet the ever-increasing demand of trout by tourists. Commercial trout farming in Uttarakhand has advanced progressively during the last decade and has become a profitable occupation among the rural masses especially in the colder regimes where no other fish farming has possibilities. The rainbow trout here plays the most dominant role as a commercially important candidate species for culture in this hill locked Himalayan state of India. The present annual rainbow trout production in Uttarakhand is nearly 4 tonnes from the Government sector and 5 tonnes from the private sector as spoken by the fisheries officers of Govt. of Uttarakhand. Altogether, there are 27 trout farms and 336 raceways established in the State. The most trout farms are in Chamoli District accounting six that are privately owned and two operated by the Government sector.

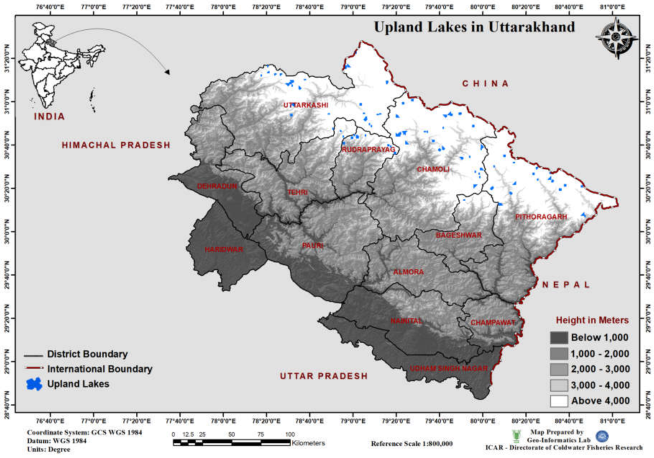
The major mode of distribution of this fish around the State is by eyed-egg transfer or fingerlings. The State has two well-equipped trout hatcheries under the Government sector located at Talwari and Bairangana in Chamoli District. The trout hatchery at Talwari is situated along the banks of a sub tributary of the Pindar River and has 28 rearing raceway units for rearing the brooders and seed production facilities with the capacity to produce 100,000 eyed eggs. The young ones are marketed to the growers of Dewal, Taal and Wan regions of the State. The trout hatchery at Bairangana is situated 15 km from Gopeshwar Township on the bank of snow fed Balkhila Gad. The hatchery has 700 brooders and produces approximately one million eyed ova each year. Altogether, 34 raceways are operational for the rearing of broodstock and alevins in the hatchery. The private farms seldom produce their own seed and therefore transport trout fingerlings from government hatcheries each year to stock in their raceways. The seeds are transported to places like Sutol, Urgam, Lwani and Ghat. Another trout seed production unit is situated at Experimental fish farm (EFF) at Champawat District along the banks of Chirapani Gad under the aegis of the ICAR-Directorate of Coldwater Fisheries Research. The Centre at present produces around 100,000 eyed ova and has a target to produce one million in the coming years. 2,800 brooders are maintained in four concrete raceways. The seeds are either used for their own research purpose or are distributed to the nearby villages such as Patti, Lohaghat, Reetha Sahib, Kathar and Madyoli for rearing as an avenue. In all the above hatcheries, the fertilised eggs are incubated in hatching troughs and remained undisturbed until the eyed stage is reached. The young ones are reared in fibreglass reinforced plastic (FRP) tanks of various dimensions based on the utility. However, young ones are also raised in concrete parallel channels along the rearing raceways at Bairangana and these have shown equal success compared to the FRP tanks. After hatching, the young pass through a series of morphological changes from sac fries or alevins to swim-up stage up to the fry stage when they are moved to outdoor grow-out facilities.

Rainbow trout is favoured in colder climatic conditions and are reared in concrete raceways on commercial lines. Access to qualitative and quantitative freshwater is the most important initial factor in deciding the suitability of a site for trout farming in order to achieve sound productivity and to mitigate disease.

Experimental Fish Farm at Champawat District.

Concrete channels for trout seed rearing at Bairangana.

Trout fry at Experimental Fish Farm, Champawat in FRP trays.

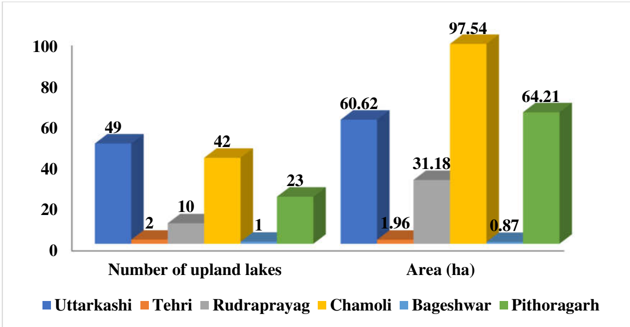


Distribution of high altitude lakes in Uttarakhand.

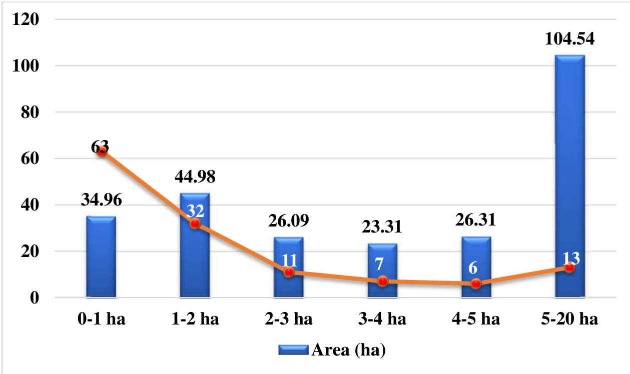
Therefore, the trout farms and hatcheries in Uttarakhand are located in a topography which ensures a perennial source of high-quality stream water year-round. The units of the trout farms and hatcheries are designed to have the best use of gravity for a convenient supply of water across the landscape. The water is mostly silt free except during the monsoon flow. Therefore, sedimentation tanks with buffers are provided in the government trout farms to retain the silt before water passes into the rearing and hatchery units. The other important factors for success of a trout farm in becoming a revenue generating centre are optimum temperature, pH, adequate dissolved oxygen, total alkalinity, hardness, and low ammonia, nitrite and nitrate levels in water (Table 1). The soil is not a major factor as the trout are cultivated in concrete raceways. The raceways are rectangular in shape

Raceway.

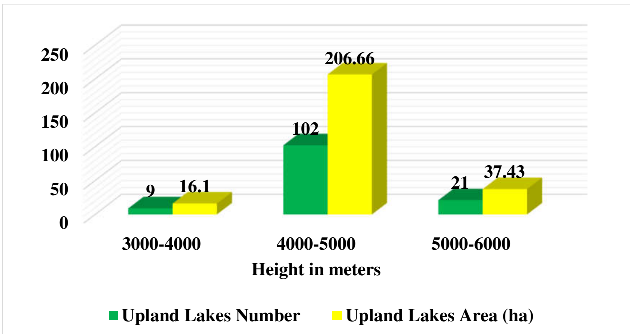
District-wise distribution of upland lakes in Uttarakhand.



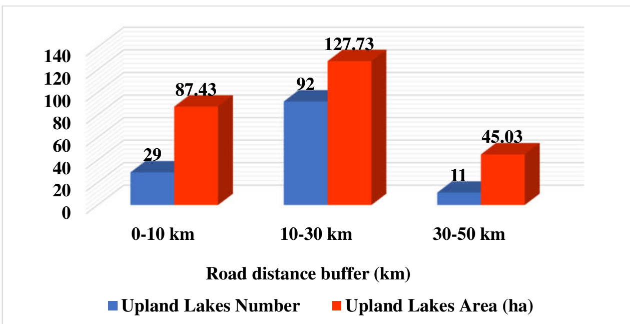
Size-wise classification of upland lakes in Uttarakhand.



Altitudinal-wise distribution of upland lakes in Uttarakhand.



Distribution of upland lakes according to the nearest road connectivity.



Trout raceways.

having an inlet pipe or channel at one end and an outlet at the opposite end fixed with wire mesh for overflow of water. A drainpipe or a drain channel is also provided at the bottom of the pond to facilitate the harvesting as well as in cleaning of the tank periodically. Both the parallel and serial type of raceways were observed which measured 15 x 3 x 1 m as standard dimensions maintaining a continuous water flow through them. The raceways are stocked with 45-50 fishes m^{-2} at Uttarakhand. Rainbow trout reaches a marketable size of 250-260 g usually in 12 months of rearing (Pandey and Ali, 2015). The stock is essentially graded four times during the rearing period in the initial year viz., at 2-5 g, 10-20 g, 50-60 g and >100 g, so as to ensure uniformity in growth. Periodical size grading and estimation of fish biomass determines the specific growth rates, feed conversion ratios and the production costs which are an essential requirement under better farm management practices.

Many of the aquatic resources with fisheries significance in Uttarakhand are still unexplored due to their remoteness in location and poor road connectivity. An effort has been made through application of GIS in determining potential sites suitable for trout farming and angling. Non-spatial data has further enhanced the development of suitability maps for understanding the actual land availability for cold water fisheries development in the State. Enumerating river resources reveals a total combined length of 10,928 km of river network in the State of which around 3,150 km has the potential to sustain suitable habitat for brown trout based on the criteria of elevation and the existing thermal conditions. These river resources have a temperature range below 16°C, delivered with clear and oxygenated freshwater (6.0-9.5 mg/l) and are surrounded by sparsely populated human habitation. Some of the important stretches of river and their upstream reaches harbouring brown trout have been reported

Interactive meet among scientists, officers and 300 fish farmers of Pauri Garhwal region of Uttarakhand.

Sedimentation tanks at Bairangana.

to include Nandakini, Pranmati Gad, Dhauli Ganga, Laisar Gad, Bhilangna River, Har Ki Dun, Pinder (Singh et al., 1983); Asiganga, Lake Dodi Tal, Balkhila Gad, and Madhu Ganga (Rawat et al., 2011). Applying the tools of GIS in the present communication showed the rivers Nandakini, Dhauli Ganga West, Laisar Gad, Bhagirathi, Bhilangna, Asiganga, Pranmati Gad, Bal Ganga, Badiyar Gad, Gomati, Balasuti, Pinder situated in the northern part of Uttarakhand can form potential grounds for brown trout. These river stretches may further be considered for establishing angling beats which can offer potential fishing spots for capturing brown trout on a catch and release basis. Although the seed production of brown trout in the state is very meagre, attempts has been made at the Bairangana hatchery to produce seed from 200 brown trout broodstock in recent years.

In addition, the State is also bestowed with 132 upland lakes covering an area of 260 ha and situated at an altitudinal regime ranging from 3,000-6,000 m MSL. The highest number of lakes is in the district of Uttarkashi whereas the largest area covered by these lakes is in Chamoli District. The minimum and maximum size of these lakes are 0.22 ha and 19.71 ha area respectively with an average size of 1.97 ± 2.54 ha area. There are 63 smaller sized lakes of 0-1 ha in the State whereas there are 13 of the largest sized lakes within the range 5-20 ha area. The largest number of lakes is situated at an altitudinal regime from 4,000-5,000 m MSL. 121 lakes cover 215.16 ha area are within the range of 0-30 km from road connectivity. The roads are considered as the major transport lines for carrying the basic inputs to the farm sites especially in the mountain regions. All these facts indicate the potentiality of the State in developing promotional based trout livelihoods among the rural folk dwelling amid the high mountains.

Overall, rainbow trout is a highly commercial food fish in the upland region of Uttarakhand and its farming has progressed steadily during the last decade and it has become the most profitable cold-water fish. Application of the tools of GIS has shown that the upland regions of the State situated above 2,000 m MSL with high potentialities for promotion of trout fisheries cover a land area of 1955 km^2; moderate potentialities cover 2,705 km^2 area and least potentialities cover 457 km^2 area. Altogether eleven districts have been found to have potentialities of which the districts of Almora (19.35%) and Pauri (19.26%) have shown the maximum potentialities followed with the districts of Dehradun (12.62%), Uttarakashi (12.09%), Chamoli (9.89%) and Pithoragarh (8.52%). Furthermore, the state being a tourist destination for many can be an added advantage for an easy access to the market, restaurants, riverside camps and homestays. The fish can be relished and prepared in many different forms such as boiled, smoked, steamed, and fried and their good taste and flavour can fetch higher market returns upon transport to nearby cities in frozen conditions. At the same time, brown trout has all the superlative qualities to become one of the most important sport fish and the seeds are being produced primarily to release them in the upland streams and lakes. A concerted effort from the researchers, anglers, hatchery managers and entrepreneurs can develop certain trout angling points together with other ancillary services and adventure sports inviting tourist worldwide to the State.

Diagnostic visit by scientists to evaluate a potential trout farming site, Chamoli.

References

Sondhi, S. (2012). Uttarakhand Nature Handbook, A guide for naturalists, eco-tourists and students. Uttarakhand Forest Department and Bishen Singh Mahendra Pal.

Singh, H.R., Joshi, C.B. and Prasad, R. (1983). The trout fishery of Garhwal: Present status, management problems and prospects. In: T.V. Singh and J. Kour (eds.). Studies in eco-develpoment: Himalayas, Mountain and Men. Print house, Lucknow. 273-288.

Pandey, N.N. and Ali, S. (2015). Rainbow trout farming in India: R & D Perspective ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, Bulletin No 23.

Rawat, M.S., Bantwanl, B., Singh, D. and Gusain, O.P. (2011). Status of brown trout (*Salmo trutta* fario L.) in Garhwal Himalaya with a note on it morphometric characteristics, Environment Conservation Journal, 12(3): 47-52.

Baruah, D., Ganie, P.A., Kunal, K., Posti, R., Chisi, K. and Yonggam, Tagi. (2019). Trout fisheries resources and potentialities in the Menchukha region of Arunachal Pradesh, Aquaculture Asia, 23(3): 30-39.

Scenario of captive production of *Clarias magur* in India

S. Ferosekhan, S.N. Sahoo, S.S. Giri and S.K. Sahoo

ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar - 751 002, Orissa, India

Carps are the main table fish amongst the fish-eating population of India, apart from catfish and prawns from freshwater production. Their availability in huge quantity in markets may be due to intensive research on their cultivation and its adoption by farmers for larger production. Further, the acceptable price also attracts consumers, contributing to fish as the preferred animal protein source in India.

The availability of catfish or prawns is limited as these are mainly obtained from fishing rather than aquaculture. There has been little change in this scenario in recent years as few farmers produce these fishes. However, *Clarias magur*, locally known as magur, is a well preferred medium sized catfish among Indian consumers. Researchers have intensively worked on this species under the “All India Coordinated Project on Air-breathing Fishes” during the early 1980s to popularise them among farmers. Difficulties such as shortages of effective inducing agents and the erratic response of females during induced breeding, low survival in different life stages, slow growth, and lack of effective feeds became a bottle neck for the wider adoption of this fish by farmers. Hence research institutions, fisheries departments of different states, universities and Krishi Vigyan Kendra (KVK) have undertaken research to simplify the technology and disseminate it among farmers over the last decade. This article summarises these attempts and describes the present level of its technology practiced in India.

Induced breeding

Maintenance of healthy brood fish is a prerequisite for successful seed production in captivity. Usually, this species attains maturity in one year and both sexes can be employed for breeding on reaching 100-150 g. It is always better to rear the brood fish in earthen ponds. As the water table goes up during monsoon months, collection of the catfish for breeding attempts becomes difficult in ponds. Hence it is better to collect the broodstock from culture ponds during the pre-monsoon month and rear them at 2-3 fish/m^2 in cemented tanks. The tank bottom may be provided with soil of 2-3 cm thickness to prevent injury when fish move along the bottom. The tank must bear inlets and outlets at the desired level for managing water level, with a complete drainage facility. These facilities are used to manage water quality or to drain for collection of entire stock. Continuous flow of water (two litres/minute) for a few hours is necessary during sunny days to avoid excessive water temperature, reducing the chance of stress in broodstock. A mixture of fish meal, groundnut oilcake, soybean meal and rice bran with vitamin and minerals, resulting in 30% protein level at 2-3% of the body weight, is fed to the stocked fishes. The tanks are replenished with water at fortnightly intervals to maintain hygiene. Many farmers also rear fish with feeding in small ponds and collect before induced breeding without transferring to cement tanks.

Back-yard flow-through hatchery made by a farmer for small-scale seed production.

Magur usually breed during the monsoon months of June-August. The fish are taken out of the broodstock tank or pond and kept separately in plastic containers for breeding operations. Males and females can be distinguished by secondary sexual characters. The abdomen of a gravid female is round and bulging with a reddish coloured button-shaped genital papilla and the males have elongated pointed papilla. They are either bred through hormone administration or through environmental manipulation.

Females are induced to breed through commercially available synthetic hormones, i.e., Ovaprim/Ovatide/WOVA-FH @ 1.0-1.5 ml/kg body weight. However, they can also be induced using the traditional carp pituitary extract at 30-40 mg/kg of body weight. The above hormones are injected into female fish on the dorsal side of the body during evening hours in a single injection schedule. The stripped eggs are fertilised artificially with sperm suspension. However, the males do not require hormonal administration.

Unlike carps and few catfishes (*Horabagrus brachysoma*, *Pangasius pangasius*, *Pangasinodon hypophthalmus*, *Wallago attu* etc), the males of this species do not ooze sperm during stripping and thus their testes are removed and macerated in normal saline solution (0.9% sodium chloride) to obtained the sperm suspension, which can be used within 24 hours at room temperature.

Females are stripped after a latency period of 16-17 hours and eggs are fertilised with sperm suspension. The fertilised eggs are then washed thoroughly and transferred to a flow-through hatchery. The eggs of this species are adhesive in nature and light brown eggs are considered good while opaque eggs are unfertilised. The fecundity of the species is low, at about 400-500 eggs/g of ovary weight.

The flow-through hatchery consists of a cemented platform on which plastic tubs are placed. A row of small tubs of 12 cm diameter with 6 cm height are placed under separate taps. Each plastic tub can accommodate 1,000-1,500 eggs. Water supply is provided from an overhead tank through a common pipe to all the tubs with individual control taps. Each tub has an outlet at a height of about 4-5 cm. Farmers have developed low-cost hatcheries for small-scale production using the same flow-through hatchery principle. Some farmers have also constructed rectangular cement cisterns with a drain line that may be used during continuous water flow or for complete drainage during harvest. They use these for dual activities such as egg incubation followed by seed rearing for 20-25 days.

An improvised hatchery system has also been developed at ICAR-CIFA, Bhubaneswar, for large-scale hatching, which is in use by farmers. The system consists of a circular FRP tank with inlets in the form of a duck mouth at the bottom of the tank, fixed at 45°. This system can accommodate about 50,000 fertilised eggs in a single operation with 60-80% hatching rate. The fertilised eggs are uniformly spread in the plastic tubs/circular container and a feeble current of water is provided to maintain optimum oxygen level. Some farmers also make use of the plant *Ichornia crasipe*, whose roots hold the fertilised eggs, and float them in the water tub till hatching. The hatchlings along with egg shells and broken roots are found in the bottom of the tank. It is difficult to separate them and long exposure in this environment leads to mortality of the tiny and tender hatchlings, a problem that is considered the main demerit of this system. The ideal temperature for hatching is between 27-30°C and hatching takes place within

Multiple use of cemented tank for large-scale egg incubation for hatching followed by seed rearing.

24-26 hours. The yolk sack of the newly hatched larvae is absorbed in 3-4 days. The hatchlings are transferred to circular/rectangular FRP containers for rearing.

The species can also be bred by providing a congenial environment in the paddy field. A continuous trench of 50 cm depth is dug out along the margin of the paddy fields and artificial pits are made inside it. Brood fish are released into the trench during December-January and fed with a mixture of fishmeal, groundnut oil-cake, soybean meal and rice bran at 2-3% of their body weight. During monsoon season (June-July), the trench is inundated with rain water, with further accumulation of water in the paddy field. The brood fish move in pairs and congregate in the pits to spawn there. The spent fishes go back to the trench when the water level recedes, leaving the fry behind in the pits, which are subsequently scooped out. A few farmers also allow the fry to grow further in the paddy field until the water level reaches a level suitable for fingerling production. Some researchers have also felt the limitations of successful egg laying in these types of environment.

It is possible for advanced breeding of this species prior to breeding season. The hormone treatment is given to the fish in the form of sustained hormone pellets, which are implanted

Bacterial infection in C. magur adult.

into the musculature. The hormone used is LHRHa @ 100 µg/fish, which is a super-active analogue of luteinising hormone releasing hormone or 150 IU hCG/female. The pellets are made of LHRHa or hCG in cholesterol base with a binder (gelatin and acacia gum). The pellets are implanted into the fishes during preparatory period of gonadal cycle. The above treatments bring about early maturity in fish, well in advance of the monsoon, which enables them to be induced to breed as early as in April. This application is limited to research to date during seed production of this catfish.

Larval rearing (larvae to fry)

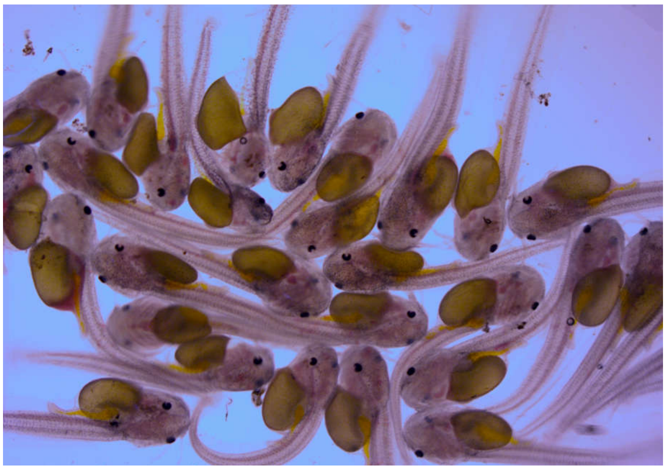
The larvae measure around 5-5.5 mm in length with a heavy yolk sac and must be reared for at least two weeks in the indoor rearing system. There is no necessity to provide feed during the first three days as yolk sac serves as stored feed. After its absorption, the hatchlings become longer with prominent barbels, jaws, operculum and gills. The quantity of feed depends on the density of the larvae reared in the container. Identification of acceptable feed and particle size matters a lot during rearing for increasing survival rate. Researchers and seed growers usually provide mixed zooplankton, Artemia nauplii or tubifex as larval feed apart from molluscan meat and egg custard. The above feed items contain 41-65% protein. Farmers often mix vitamin and mineral mixture in egg-custard during its preparation before feeding.

Organisms/particles ranging between 20-30 µm are ideal for initial feeding. Size can be increased gradually to 50-60 µm for 1-week old fry. The fry of magur develop a gregarious habit within a week and, being nocturnal and photo-negative in nature, they normally congregate in the corners of the rearing container to avoid light during day time. However, they fully disperse all over the container during night and as soon as they are exposed to light, they move to the corners in groups. The larval compound feed Starter-M has been developed for this species at ICAR-CIFA. Larvae of 8-10 days are fed after the gradual withdrawal of live feed. The feed is in powdered form, which is to be mixed with a little water to make it into a sticky dough. Small pieces of dough are put in several places of the rearing tanks for easy access of larvae to feed.

Since it is important to provide a congenial environment to larvae, the indoor rearing tanks are provided with continuous aeration and water exchange facilities. There is a chance of mortality and reduced growth of larvae due to poor environment as well as high stocking density during the indoor rearing phase. A stocking density of 1,000-1,500 larvae/m^2 is considered optimum for better growth and survival during indoor rearing.

Larvae being small and delicate require a good aquatic environment for survival and the depth of water in an indoor-rearing system plays a major role for optimum survivability. To optimise survivability, water management is an important aspect during rearing. Aerial respiration commences after 10-11 days and hence, aeration must be provided to the larval rearing tank. Accumulation of metabolites and unconsumed feed in the rearing containers pollute the environment and ultimately lead to oxygen depletion, disease and mortality. Therefore, it is advisable to replenish 70-80% of water on a daily basis to maintain 10-15 cm water depth.

Incubation of eggs.



Newly hatched larvae.

Two-week old magur fry.

The excreta of fry and decaying unconsumed feed under high-density rearing produce free ammonia (NH_3), ionised ammonia (NH_4+) and hydrogen sulphide (H_2S). Among these, free ammonia is toxic at low concentrations affecting gills and accessory respiratory organs and hydrogen sulphide causes stress to fry. Carbon dioxide in the environment may result in stress. CO_2, NH_3, NH_4 concentration levels up to 15 ppm, 0.05 ppm, 0.25 ppm, respectively, may not affect larvae, but may be dangerous if the level continues for a longer time. So vigorous aeration and frequent water exchange are required to get rid of this problem. Thus, the larvae grow to 30-40 mg during two weeks of rearing.

Fingerling rearing (fry to fingerling)

The fry thus reared in indoor systems are harvested and stocked in outdoor tanks for fingerling production. Usually, private and government hatcheries sell fry from two weeks old. Some farmers also extend the rearing period for another one to two weeks in the indoor system for better growth to get a higher price. This extended rearing in the indoor system engages the rearing tanks for a longer period, which reduces the operation period leading to lower production from a hatchery. Hence many farmers sell the fry or stock them in fingerling tanks to vacate the indoor tanks for a new round of production.

Cemented rectangular tanks are used for fingerling production. The fry are stocked up to 200 individuals/m^2 and fed with a crumble compound feed containing 30% protein. The rearing period continues for 6-8 weeks and the fingerlings grow to about 4-5 g. Some of the fingerlings show shooting behaviour during this period. It is wise to remove shooters to reduce size disparity among the fingerlings. A drastically reduced survival is also observed if shooters are not segregated.

The growth of filamentous algae in the fingerling tanks can occur due to low water height and nutrients from unconsumed feed. Intense growth of algae may restrict the movement of fish and may change the water quality. Hence periodic cleaning through netting may be beneficial during this stage.

Releasing fingerlings for growout culture.

Some farmers also construct rectangular polythene tanks for production of fingerlings instead of cement tanks, as the polythene tanks are less expensive.

Grow-out culture

Earthen ponds, stone pitched ponds and cemented tanks are all suitable for grow-out culture of magur, although it performs better in ponds compared to cement tanks during grow-out culture. Generally, a high density of 50,000-70,000 individuals/ha is recommended for culture of this fish. The density may be further reduced depending on the growing period of the area. Farmers usually buy seed from the seed growers. While transporting, there is a high risk of stress in the seed. The immediate release of these in pond for grow-out culture may lead to high mortality. Hence many farmers acclimatise the seed for 1 to 2 days before releasing them to culture ponds. Larger sized seeds (5-10 g) show good survival as well as growth during their culture. The fish are fed at 3-5% of their body weight with pelleted feed containing 30-32% protein, which is provided to fish in feeding baskets placed in different areas of the pond to reduce competition during feeding. Since this fish is an accessory air-breather, they normally come up to the water surface to gulping air. This kind of habit attracts predatory birds. Therefore, it is essential to cover ponds with nets to protect the fish. Magur attain a marketable size of 100-120 g during a culture period of about one year. Harvesting is done by complete dewatering and hand picking from culture ponds. A production of 2-3 tonnes can be achieved from one hectare of water.

Health management

Sustainable aquaculture production can only occur when fish are healthy and free from disease. The prevention of disease is an essential step for the successful operation of any hatchery system. Magur larvae are very delicate and susceptible to various diseases and stress. Because of the complexity of the environment, the different life stages of this catfish are susceptible to viral, bacterial, fungal and parasitic infections. Pond waters with high levels of organic matter may contribute to disease risk during magur culture. It is essential that farmers should be vigilant for early detection of behavioural changes or clinical signs and act earliest to prevent losses. Provision of optimum rearing conditions will increase survival of magur larvae.

Conclusion

Many farmers have taken up production of *C. magur* due to high demand for this catfish in the market. Many hatcheries have been established in the eastern states of India. Still there is a paucity of seed availability in terms of quantity as well as quality. This may be due to limitations in facilities available to farmers. Research institutions have placed emphasis in recent years on training new farmers and helping them to establish hatcheries. Seed production and culture technology of *C. magur* developed by ICAR-CIFA is in capsule form considering all the major activities for its wide adoption and successful farming. Hence, there is a greater hope for self-sufficiency in farmed production of this catfish in the near future.

Strategies to reduce feed cost by improving gut health and nutrient utilisation of fish in aquaculture

G. Sathishkumar[1], U. Bhavatharaniya[3], N. Felix[2], Amit Ranjan[1], and E. Prabhu[2]

1. Institute of Fisheries Post Graduate Studies (IFPGS), TNJFU, Vaniyanchavadi, Chennai; 2. Directorate of Incubation and Vocational Training in Aquaculture (DIVA), TNJFU, Muttukadu, Chennai; 3. Central Institute of Fisheries Education, Mumbai. Email: n.felix@tnfu.ac.in

Feed is an important input that involves nearly 60% of the total production cost in commercial aquaculture. Hence, nutritionally balanced and cost effective diets play a large role in deciding the return from an aquaculture venture. The quality of nutrients is determined by their source, ie. the ingredients used in diet formulation which in turn determines the feed cost.

Protein is the most expensive component in compounded feed because protein-rich ingredients are typically costly and their inclusion in aquaculture diets has a significant role in overall feed costs. In aquaculture production, fishmeal is usually regarded as the main protein source in formulated feed owing to its high protein content, excellent amino acid profile, low carbohydrate level, high digestibility and its palatability. During the past decades worldwide fishmeal demand and supply has been greatly affected leading to higher costs. To find a solution, nutritionists are searching for alternative ingredients that have a reasonable price and nutritionally balanced amino acid profile to meet the requirements of cultured fish. In commercial aquaculture practices overall growth depends upon the gut health of the animal and nutrient utilisation. Hence, this article discusses the various strategies to reduce the feed cost by promoting gut health and nutrient utlilisation.

Alternative sources of fishmeal in aquaculture feeds

Animal by-products, due to their high protein and low carbohydrate content, balanced amino acid profiles, lack of anti-nutritional factors and palatability can be considered as alternate feed ingredients to fishmeal. Ingredients of plant origin such as aquatic weeds, legume seeds, various oilseeds and cakes, leaf meals, leaf protein concentrates, and root tuber meals may also be used in aquaculture feeds as they also contain high protein levels and may be locally available at a cheap price.

Hurdles in utilisation of plant-based ingredients in fish feed

Some studies have shown that plant-based ingredients are able to fully or partially replace fishmeal without affecting the growth performance of farmed fish and shrimp species due to presence of high protein, with the added benefit of a low cost per kilogram of protein compared to fishmeal. However, some plant-based ingredients can be nutritionally complicated with an unbalanced amino acid profile or low nutrient digestibility and bioavailability. They may also contain anti-nutritional factors or nonsoluble carbohydrates.

Most plant-based ingredients are deficient in some essential amino acid, such as lysine or methionine. For example corn gluten meal is an alternative protein source to fishmeal in some feeds. It has a 60% crude protein content but it is limited in lysine and contains a lot of nonsoluble carbohydrate. Soy protein is also an important plant-based protein source, but is deficient in some essential amino acids, essential minerals and contains anti-nutritional factors such as phytic acid, which is tightly bound to essential minerals such as P, Ca, K, Cu, Mg, Fe, Zn and protein. Phytic acid mainly reduces the bioavailability of phosphorus. Additionally, other anti-nutritional factors such as tannins and protease inhibitors hinder protein digestibility because they reduce the proteolytic enzyme activity (these inhibitors mainly act by binding with chymotrypsin and trypsin). Tannins are present in a wide variety of plant ingredients.

Lectins or haemaglutinins cause a reduction in absorption of nutrients from the gut and alimentary canal of organisms. Gossypol is also an important anti-nutritional factor present in cotton seed, which forms a complex with protein and may lead to deficiency of methionine and lysine amino acids.

Oxalates forms complexes with some essential minerals like calcium. Oil cakes including rapeseed and mustard contain glucosinolates, which inhibit the uptake of iodine by the thyroid gland.

Mimosine is another anti-nutritional factor present in ipil-ipil. Mimosine is an unusual amino acid, structurally it is like tyrosine and is an antagonist to other amino acids and affects the thyroid gland.

Non-starch polysaccharides

Non-starch polysaccharides (NSP) are are polymers of hexoses and pentoses (galactose, glucose, xylose, mannose, etc) and are not easily digestible in fish. NSP comprises up to 90% of the plant cell wall (cellulose, hemicelluloses and pectins). Cellulose is a basic structural component of the cell wall. Xylan is the most common hemicellulose and represents the major non-cellulosic cell wall polysaccharide in plants. Cellulase enzyme breaks β-(1,4) linkages in cellulose, but since fish lack this enzyme the utilisation of cellulose is low in most fish.

Some conventional methods such as heat treatment, soaking in water, germination and de-hulling methods can effectively inactivate anti-nutritional factors in plant feed stuffs but increase cost and time required for feed preparation. Some anti-nutritional factors are heat stable. So the following sustainable approaches are proposed to effectively reduce the problems of plant-based ingredients and finally reduce feed costs in aquaculture.

Sustainable approaches to overcome the hurdles

Approaches that can be used to improve nutrient utilisation and reduce feed cost include:

- Probiotic approach - to modulate the gut microflora using selected bacteria.
- Prebiotic approach - specific nutrients promoting the development of selected bacterial strains.
- Supplementation of exogenous enzyme - to improve digestibility.
- Supplementation of essential nutrients - to overcome specific nutrient deficiencies of ingredients (such as essential amino acids, vitamins, minerals and fatty acids).
- Supplementation of chemo-attractants - stimulate appetite and palatability.
- Other feed additives (acidifiers and mycotoxin binders) – digestibility enhancers.

Fish gut microbiota.

The fish gut contains a microbial community of aerobic and anaerobic bacteria, yeast and fungi. Fish gut bacteria can be divided into autochthonous (able to colonise in the gut) and allochthonous (considered to be free living). The microbial composition largely depends on the nutritional status of the fish. Mostly, protease enzyme-producing bacteria are present in carnivorous fish, whereas amylase- and cellulase-producing bacteria are present in herbivorous fish. Autochthonous bacteria produce endogenous digestive enzymes that are helpful for the digestibility of feedstuff.

Many studies have isolated useful enzyme producing bacteria from the different fish species. Cellulose-degrading microorganisms convert cellulose into a simple molecule of glucose. Phytase-degrading bacteria increase the bioavailability of phosphorus and other minerals. Tannase enzyme degrades tannins into inactive forms of tannic acid and xylanase enzyme hydrolyse xylan into xylase molecules.

Gut microbiota as a bio control agent: A probiotic approach

Probiotics are defined as live microorganisms, when administered in sufficient amounts, that confer a health benefit to the animal. So the use of enzyme-producing indigenous microbiota can be a form of probiotics. Probiotic organisms may confer health benefits to the host by improving feed digestibility through the supply of exogenous enzymes and degradation of complex components of the feed that are otherwise hard to digest. Probiotics may produce antagonistic compounds against pathogens, so they may be used as alternative to antibiotics. Moreover, probiotics are able to be grown in low pH and bile salts affect the fish gut.

Fermentation: An approach for bio-processing of feedstuffs

Fermentation is based on use of microorganisms that can exhibit a benefial role, if reared under specific conditions. Fermentation can increase the crude protein and decrease the content of crude fibre, anti-nutritional factors and toxic contents in feedstuffs. Fermentation improves the availability of vitamins, protein solubility and amino acid profile as well as increasing the palatability. Bacterial strains (*Bacillus* sp., *Enterococcus* sp., *Lactobacillus* sp.), yeast (*Saccharomyces* sp.), and fungal cells (*Aspergillus* sp) can be used in fermentation of feedstuffs. Bacterial cells obtain energy by converting carbohydrates (glucose or lactose) into lactic acid. Yeasts degrades complex carbohydrate into glucose, ethanol and carbon dioxide.

Supplementation of exogenous enzymes

Supplementation of exogenous enzymes enhances the digestibility of plant feedstuffs through hydrolysation of complex carbohydrates and inactivation of anti-nutritional factors. So they act to increase the nutrient availability and digestibility of proteins, carbohydrates and phosphorus content. Carbohydrase includes all enzymes that catalyse a reduction in the molecular weight of polymeric carbohydrates, which aids easy digestion. In fish feed, more than 80% of supplemented carbohydrase are xylanase and glucanase. Other commercially available carbohydrase include α amylase, β mannanase, α galactosidase and pectinase. When the presence of specific digestive enzymes seems to be very low or non-existent in fish, supplementation with exogenous enzymes will increase the bioavailability of

Table 1. Non starch polysaccharides present in plant feed stuffs (Source: Sinha et al., 2011).

Category	Monomeric residue	Linkage	Plant feedstuffs
Cellulose	Glucose	β-(1 → 4)	Cereals (barley, corn, wheat) and legumes (soybean, cottonseed, rapeseed/canola, lupin)
Arabinoxylans	Arabinose & xylose	β-(1 → 4) linked xylose units	Cereals (rye, rice, barley, corn, wheat, oat, sorghum)
Mixed linked β-glucans	Glucose	β-(1 → 4) and β-(1 → 4)	Barley & oats
Arabinans	Arabinose	α-(1→ 5)	Cereal co products
Galactans	Galactose	β-(1 → 4)	Sugar bean meal, Sugar beat pulp
Arabinogalactans (Type-I)	Arabinose & galactose	β-(1 → 4)	Grain legumes
Arabinogalactans (Type-II)	Arabinose & galactose	β-(1 → 4)	Rapeseed cotyledon

carbohydrate and minerals. Mostly, enzymes are inactivated at high temperature (95°C). So, exogenous enzymes are mixed with oil and sprayed onto the feed.

Acidifiers

Generally, agastric fishes do not have an acidic pH due to the absence of a stomach. Most enzymes like phytase act at an acidic pH. To overcome such problems acidifiers are used to enhance the activity of enzymes, which in turn improves digestibility. Many organic acid feed additives are supplemented to the diets because of their antimicrobial effects. Mostly, the acidifiers used are organic acids (short chain fatty acids). Organic acids are low molecular weight aldehyde-containing compounds with one or more – COOH groups. Organic acids, such as acetic, butyric, citric, formic, lactic, propionic, malic, and sorbic acids and their salts have been used as acidifiers in animal feeds (NRC, 2011). Organic acids are available on the market in a variety of forms such as adsorbates (liquid acids or mixtures of acids adsorbed onto a solid), salts (usually solids, except for ammonium propionate and ammonium formate which are liquid). Organic acids are applied directly into feedstuffs and compound feed. Liquid acid blends are sprayed onto the feed, whereas solid acids and acid salts are added directly or via special pre mixtures. The mode of action of organic acids in the intestinal tract involves two different actions:

- The pH-decreasing action of organic acids in the stomach and small intestine through delivery of H+ ions contributes to an improved activity of digestive enzymes.

- They inhibit the growth of gram negative bacteria through the dissociation of the acids and production of anions in the bacterial cells.

The use of acidifiers can be an efficient tool to achieve sustainable, economical and safe fish and shrimp production.

Phytogenics

Phytogenics are products originating from the leaves, roots, tubers, fruits or spices of herbs and other plants. Phytogenics are available either in solid, dried and ground forms, and as extracts or essential oils. The active ingredients of these products (eg. phenolics and flavonoids) can lead to stimulation of the appetite, increased antimicrobial action, direct reduction of gut bacteria, stimulation of gastric juices, enhancement of immune system, anti-inflammatory responses or may have antioxidant properties. The antimicrobial mode of action is considered to arise mainly from the potential of hydrophobic essential oils to intrude into the bacterial cell membrane, disintegrate membrane structures, and cause ion leakage. The garlic extract allicin (diallyl thiosulfinate) is used for bacterial disease control and immunostimulation of cultured fish. Essential oils extracted from rosemary also seem particularly interesting due to their high concentration of components such as carnasol and carnosic acid, which have high antioxidant properties. In addition, peppermint and cinnamon also seem to be possible candidates to be used as phytochemical feed additives in aquatic species to improve growth performance, fish health status and to reduce microbial challenge in the gut.

Mycotoxin binders

In commercial aquaculture feed production the usage of plant-based proteins instead of fishmeal, leads to contamination by mycotoxins. Mycotoxins are secondary metabolites produced by different species of fungi that have the potential to reduce the growth and health status of aquatic organisms. There are a number of options to prevent or reduce the risk of mycotoxin contamination such as careful selection of raw materials, maintaining good storage conditions for feeds and raw materials, and using feed additives. Aluminum silicates, clay and zeolitic materials, are the most commonly applied group of mycotoxin binders.

Chemoattractants

Plant feeds generally have lower palatability than fishmeal. So, chemoattracts can be used to increase feed consumption by fish. Commercially, both natural and synthetic chemoattractants are used. Krill meal, anchovy fishmeal, byproducts of squid meal, fish solubles, fish hydrolysate (tuna hydrolysate, squid hydrolysate), poultry meal, blood meal, hydrolysed feather meal and some herbal plants are used as natural chemoattractants in fish feed formulations. A mix of free amino acids (alanine, arginine, glutamine, glycine, isoleucine, serine, taurine, betaine, proline), nucleotides and nucleosides are examples of synthetic chemoattractants also used in feeds.

Conclusion

Formulated feed is very important in aquaculture production. In formulated feeds fishmeal is usually considered the primary source of protein and it is the main factor in overall feed production cost. Plant-based feedstuffs as an alternative to fishmeal have been a focal area of research globally but the presence of deleterious anti-nutritional factors associated with plant-based ingredients and nutritional deficiencies have limited their use. The various strategies discussed in this article can be adopted to bring down feed costs and improve nutrient utilisation in fish.

Table 2. Type of commercial feed enzymes and target substrates.

Enzymes	Target substrate	Target feed stuffs
β-glucanases	β-glucan	Barley, oats and rye
Xylanases	Arabinoxylans	Wheat, rye, triticale, barley, fibrous plant materials
α-galactosidases	Oligosaccharides	Soybean meal, grain legumes
Phytases	Phytic acid	All plant-derived ingredients
Proteases	Proteins	All plant protein sources
Amylase	Starch	Cereal grains, grain legumes
Lipases	Lipids	Lipids in feed ingredients
Mannanases, cellulases, hemicellulases, pectinases	Cell wall matrix (fibre components)	Plant-derived ingredients, fibrous plant materials

Fish pituitary gland collection and supply as a vocation in West Bengal, India

Subrato Ghosh

122/1V, Monohar Pukur Road, P.O. Kalighat, Kolkata – 700026, West Bengal, India. Email: subratoffa@gmail.com

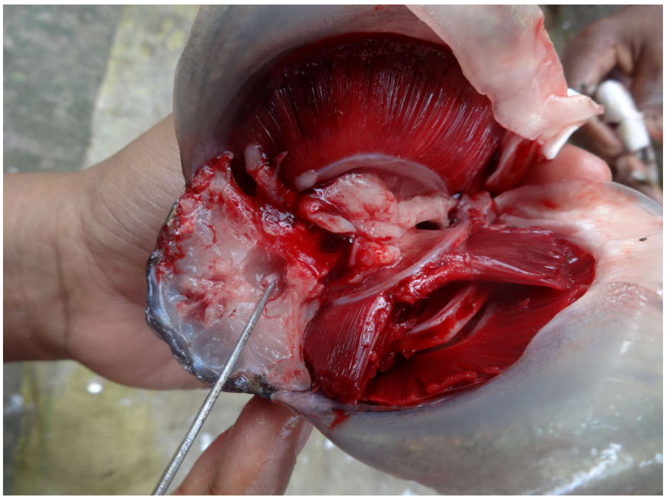
Healthy L. rohita spawn supplied to farmers.

In India, West Bengal is a pioneer state and leads in hatchery-oriented induced bred seed production of major carps. Healthy carp fry production, the stockable size in rearing ponds for raising fingerlings, amounted to 22,691 million in West Bengal in 2018-2019 and carp spawn production increased to 15,002 million in 2012-2013 from 2,000 million in 1982. Good quality seed (spawn and thereafter fry) of pure varieties of carp dictates the success of grow-out culture and table fish production. It is the most important input in freshwater fish aquaculture and culture-based fisheries in India, facilitating growth and expansion. From every 5 million major carp spawn stocked in well-managed earthen nursery ponds, 1.5-2.5 million fry are produced in 15-18 days.

Widespread adoption of the hypophysation technique for carp breeding started in the mid-1970s in West Bengal and other states and established steadily. Most major carp breeders and hatchery owners in West Bengal today prefer fish pituitary gland (ie., hypophysis) as inducing agent (hormonal injection) over commercially available synthetic hormones. Hormones stored and secreted in the fish pituitary gland cause spermeation and ovulation in mature carps and release of gametes effectively in hatchery conditions. The pituitary glands of mature fish are gathered by professional collectors in retail fish markets for carp breeding, and sold to hatchery owners.

Tools of a pituitary gland collector.

In West Bengal, a greater concentration of fish hatcheries is found around Naihati Village in Barrackpore-I Block, North 24 Parganas District, which in the 1970's had three hatcheries, but has now become a major concentration of fish seed production in India. Ramsagar Village in Onda Block, Bankura District, is also a well-known site for commercial carp hatcheries. In early 2015, 596 functional fish hatcheries existed in the private sector in West Bengal. In August 2016, the West Bengal Fisheries Directorate published a directory with contact information for 454 private sector major carp seed hatcheries, another five under the Fisheries Directorate and 33 carp seed farms (for fry and fingerling production)[1].



Position of foramen magnum in C. catla head (300 g).

Pituitary gland collection

In retail fish markets in Kolkata city proper, suburbs and neighbouring districts, pituitary glands are collected by trained and professional persons from the foramen magnum region (large posterior aperture of fish skull) of the heads of major carps ≥1 kg in size. Prior to sale, fish sellers remove major carp heads with a strong native knife ('bonti') at a fixed distance from the body. As the posterior part of cranium is cut, sufficient space is left to remove the brain and collect the pituitary gland. After drilling the bony portion carefully with a short sharp knife, collectors remove a small lump of grey matter and fatty tissue from the region and set it aside. A 15 cm long needle is inserted through this opening and the pituitary gland located and removed with the blunt (bent) end of the needle. Then small opening is then smoothed over and the head returned to the seller for sale.

Hatchery owners obtain pituitary glands preserved in acetone from markets in Kolkata, Kalna and Naihati. Glands are supplied to hatcheries at Naihati, Kalyani, Ramsagar, Balagarh, Pandua, Kalna, Kaliagarh (in Bankura, Hooghly, North 24 Pgs and Purba Bardhaman districts in West Bengal)[2]. A survey covering 149 major markets in 20 districts of West Bengal estimated that a total of 8-9 million pituitary glands are collected by local youths at the onset of monsoon until its peak, sold at INR 5-8/piece[3].

Alcohol preserved fish pituitary glands.

Activity of pituitary gland collector Bachchu Dey

Sri Bachchu Dey, residing near Sealdah Koley market and aged 56, has been collecting fish pituitary glands professionally since 1982 as his main means of livelihood. He does mass-scale pituitary gland collection himself in the semi-crowded and quite noisy Lokarmat-Sishumangal fish retail market in south-east Kolkata every day from 7.30am-11am; his trained assistants also collect glands for him from the Manicktala and Ananda Palit Chorgarod fish markets in north-central Kolkata. Sri Dey's workplace is 7-8 km from home. He collects 160-200 pituitary glands daily from different fishes, viz., *Labeo rohita*, *Catla catla*, *Ctenopharyngodon idella*, *Hypophthalmicthys molitrix*, *Pangasianodon hypophthalmus*, *Sperata seenghala*, *Rita rita*, *Lates calcarifer* (4-6 kg), *Nibea soldado* (bhola bhetki) from 10-12 fish sellers, neither disturbing them nor buyers. Major carps as donors of quality pituitary gland weigh between 900 g – 3 kg and *C. catla* sometimes weigh even 6-8 kg. Demand for pituitary glands is highest during the monsoon months until the end of August, the carp spawn/fry production season.

Pituitary gland from a mature C. catla of 1.3 kg.

Until 1988, every fortnight for six months a year, he travelled 80-100 km from home and supplied pituitary glands to a hatchery at Kulgoria Choti, Sibdurga hatchery, and Nabodar hatchery in Galsi-II Block, Purba Bardhaman District. Pituitary gland collection and supply has become his year-round activity since 1990. Presently middlemen/agents collect pituitary glands from his doorstep which are supplied to established hatcheries at North 24 Parganas and Bankura districts. From September, on demand, he collects pituitary glands from *Cyprinus carpio* as it breeds during winter. Until 1987, he paid INR 0.50 to fish sellers for each fish head he collected from, which was sold for INR 2.50-3.50. In his words, the pituitary glands of 2.5 – 3 kg carps appear as lentil grains, bigger than smaller sized fishes. Presently he pays INR 2.00 for every fish head; and sells pituitary glands @ INR 8.00/piece. He gets INR 5.00, 6.00-7.00 and 10.00 for each pituitary gland if segregated by size before selling. Collecting in 30 ml amber-coloured glass vials containing 100% alcohol, he returns home, exchanges the alcohol, remove impurities from the glands, counts and stores them at 4°C. Alcohol is exchanged once in 12-15 hours until the glands are collected from him, in lots of 1,000-2,000 each time.

Two different sizes of pituitary glands in separate vials.

Combining the three markets, Sri Dey's daily collection is 550. For every 200 pituitary glands, he pays INR 400 and earns INR 1,500 daily. Bearing expenses for tiffin, fuel for motorcycles, etc., he makes a profit of INR 500 and above daily from the sale of 200 pituitary glands, i.e., ≥ INR 15,000/month. He can minutely distinguish alcohol-preserved pituitary glands of major carps from those of large catfishes; collected both from donor ice-preserved fresh imported fishes and fresh local ones of proper size. He collects 4-5 pituitary glands/minute holding fish heads upside down on his left palm. Pituitary glands are placed on his lower left arm just after collection, 5-10 collectively dipped inside vials before they start drying and enzymatic decomposition of gonadotropin begins. Screwcaps are tightened to avoid contamination with water.

Activity of Md. Ali and the price of fish heads

Md. Zulfikar Ali, aged 34 at Talsa village under Dighra-Manikberia GP, Habra-II Block, North 24 Parganas has been doing pituitary gland collection since 1998, which he supplies to fish breeders on demand during June-July. Working for six hours

Selection of pituitary glands in fish hatchery for injection.

Pituitary gland suspenson after homogenisation.

in forenoon daily in local fish markets, he earns INR 8,000-9,000/month. He gives a certain amount to sellers from whom he collects fish heads. Sri Dey, Md. Ali and others involved in pituitary gland collection, preservation and marketing also collect glands from large Indian major carps bought at homes in at times of occasions like marriage ceremonies. According to Md. Ali, the potency of alcohol-preserved pituitary glands remains for 2-3 years at 4°C in airtight phials, with routine change of alcohol. Fish pituitary glands from West Bengal are also transported to hatcheries in Andhra Pradesh and Tamil Nadu.

Pituitary glands weigh 5-6 mg (wet weight) and 9-10 mg collected from 1-2 kg and 2-3 kg *L. rohita* respectively. An experienced worker easily manages to collect 50-60 pituitary glands per hour[4]. With practical experience, this work seems easy. A beginner (entrepreneur) in carp spawn production will require 100 mg of pituitary gland for every 10 kg female brooder in a single operation in a hatchery in four months (breeding season)[5]. The same females are induced to breed 3-4 times in a season. For every male and female *L. rohita*/*C. catla* of 2 kg size, around 24-36 mg of pituitary gland are required per breeding operation. The author observed that in Kolkata retail markets, a 750 g head of a large *C. catla* or that of *L. rohita*, or 650 g head off a 3.6 kg fish normally sold @ INR 80/kg to general buyers/consumers. The same weighing 300 g off a fresh 1.3 kg *C. catla* in district markets will cost INR 28-30. Heads of *L. rohita* 800-1,000 g are sold @ INR 15-20/piece at times of bulk availability. For 800 g *L. rohita* or *C. catla*, the head weighs around 200 g and is normally sold @ INR 50-60/kg. For 3.0-3.5 kg fish, with a head weighing 800 g the price can reach INR 100/piece. A 400 g head off a 1.5 kg *C. catla* sold at INR 30-32.

Fish pituitary gland supplier Tapan Ghosh

Sri Tapan Ghosh, aged 59 at Goalafatak, near a hub of carp hatcheries at Naihati, has long experience in supplying pituitary glands to hatcheries. In addition to local supply, he visits Maharajganj and other villages in Gorakhpur and Charbagh districts, Uttar Pradesh, once in three weeks, distributing 20,000-25,000 of alcohol-preserved pituitary glands to the owners of 60-70 hatcheries. The faint brick colour of pituitary gland is retained if they are properly washed and preserved, otherwise they will turn whitish, Sri Ghosh mentioned in a conversation recently. He segregates pituitary glands of 2.0-2.5 mg (from 1.5 kg *L. rohita*/*C. catla*) and 4-5 mg (from 3.5-4.0 kg fish) separately, with 500 and 1,000 of larger and smaller size respectively in each of 10 ml vials. Large vials contain 7,000. Supply season ends in September, but he collects every month. In the early 1980s, he sold 80,000-85,000 pituitary gland in every season; INR 0.50 had to be paid for each fish head to sellers. Then pituitary gland collectors working under Sri Ghosh were paid

Sri Ghosh with some of his pituitary gland stock.

Author with Sri Debnath.

INR 1.20/pituitary gland and sold by him for INR 1.50-1.80 each to 15-18 fish hatcheries established around Naihati in villages namely Madarpur, Awalsiddhi, Ramchandrapur, Hamidpur, Shibdaspur. In 2020, he paid INR 10-12 for each collected pituitary gland and same sold at INR 15-16. pituitary glands were sold at a higher price in the COVID-19 induced lockdown period due to lower supply of larger major carps in market and high demand for pituitary gland. During 2012-2016, his cost and selling prices were INR 4.50 and INR 5.50-6.00/pituitary gland respectively.

Since early 2018, he sold 300,000-320,000 pituitary gland/season and normal sales are 35,000-45,000/month, with customers even at Raipur, Chattisgarh. He gains INR 1.50/pituitary gland, excluding expenses incurred. In the off-season of early November 2020, he bought glands @ INR 7.00-8.50 for stock. The pituitary gland of *Cyprinus carpio* has high potency and the fish remains gravid all year round, he stated and travels by himself to collect glands already gathered by 15 people working in retail fish markets in Bardhaman and Midnapore districts, also in Odisha. He first supplied pituitary glands to hatchery owners outside West Bengal in Darbhanga District, Bihar in 1996; he explained that pituitary glands harden once dipped in alcohol, but extracted brains do not and preserved pituitary glands do not disintegrate nor become soft when pierced by a needle. Emphasising that there are no alternatives to pituitary gland, Sri Ghosh opined that spent brooder carps attain a 'ready-to-be-bred' stage once again in the same season if pituitary gland is used as inducing agent instead of synthetic hormones and if the fish are maintained properly. Such females spawn twice (*C. catla*) or thrice (*C. idella*, *L. rohita*, *H. molitrix*). Many hatchery owners prefer to buy pituitary glands even if the price is high. With encouragement of renowned fish breeder the Late Nilratan Ghosh earlier on collection and supply of pituitary glands to fish hatcheries, Sri Ghosh became proficient in this business-oriented activity, working faithfully with determination even after death of his only son in 1994.

Large-scale business of Ratan Debnath

Sri Ratan Debnath at Vill. Purbo Methermathpara, Block Haringhata, Dist. Nadia is one among very few dominating large-scale business people and wholesale suppliers of fish pituitary gland in West Bengal, operating since the year 2000. He collected 200-300 pituitary glands/day initially on his own; presently 18-20 persons work directly under him as paid gland collectors, supplying him with 2,000/day from an equal number of retail fish markets in Asansol, Katwa, Nabadwip, Chakdah, Krishnanagar, Gobardanga, Ranaghat, Habra, Bongaon and other towns and Taratala, Behala, Patipukur, Kestopur markets in Kolkata. In addition to this, 5-6 independent collectors supply part of their take to him. Sri Debnath pays INR 1.50-2.00 for each fish head to major carp sellers and INR 5.00-6.00 to his workers for every pituitary gland collected. Retail fish pituitary gland sellers buy it from him in bulk (≥5,000 /person) once in every 6-12 days, smaller ones for INR 7.50-8.00 and larger for INR 10.00-12.00 individually, which are supplied to 80-100 hatcheries in Chattisgarh, Bihar, Assam in addition to reputed fish hatchery owners in districts of West Bengal. He makes a profit of INR 0.50-2.00/pituitary gland and his monthly collection is 60,000-70,000 (sometimes reach 0.15 million combining all assured sources) and same is sold. Demand peaks from March to August every year and he maintains sufficient pituitary gland stock (0.10-0.15 million) at home at 4°C during other months, with fortnightly change of alcohol. In addition to small glass vials, he maintains stock in 120 ml vials containing 6,000-10,000 in each, depending on individual size. Only 3,000 pituitary glands of Rita rita, larger than major carps, make up every such vial.

Sellers bought pituitary gland from Sri Debnath at a high price (INR 22-25/pituitary gland) during the recent COVID-19 induced lockdown period, compared to INR 5.00-6.00/pituitary gland during 2005-2015. He developed a drying technique of fish pituitary glands; material is supplied to hatcheries in Bangladesh and elsewhere @ INR 10,000/g and same is the price of dusted form of pituitary glands, which he prepares and sell as 1 g vials. He pays advance money to fish sellers for one year in all markets in different locations of West Bengal from whom his collectors get the material; all deliver their collection (made during 7.00-11.00am) to him every day. His 24-year-old son, an arts graduate and trained in pituitary gland collection on-field, is one of them.

End note

During the early part of May 1958, scientists at the Pond Culture Division of the ICAR-Central Inland Fisheries Research Institute, Barrackpore collected over 100 pituitary glands of maturing major carps from the Kolkata fish markets. The same was done by scientists at the Allahabad Research Centre, Jhansi with 4-6 times more in number during June-July 1958 (Source: ICAR-CIFRI Annual Report, 1961). Since the mid-1970s, trade in pituitary gland collection from mature carps has flourished in the Howrah fish market. The heads of fish in breeding season were offered to pituitary gland collectors for INR 2.00-3.00 and same returned to fish sellers after collection. This market served as donor fish for pituitary gland collectors in West Bengal and neighbouring states[6]. At the then Cuttack Research Station of CIFRI in the late 1950s and 1960s, pituitary glands collected from the Kolkata fish markets from well-preserved iced donor fishes found fully potent for induced breeding work, though fresh fish were preferred[9].

In fish hatcheries in Bangladesh, pituitary gland hormone has tripled in price since the COVID-19 crisis started (Source: Field Notes on Impacts on aquaculture and fisheries in Bangladesh in times of COVID-19; fish.cgiar.org).

In 964 Government accredited and registered carp hatcheries in Bangladesh produced 610 tonnes of carp spawn annually via hormonal injection of pituitary gland extract. About 40-50 kg of pituitary gland was required to produce this volume of spawn. Material inputs from Kolkata, ie., dried pituitary glands from food fish markets, were supplied to major fish seed production centres at Jessore District, Bangladesh[7]. Pituitary glands of mature major carps are items of higher biological research and of practical demonstration at undergraduate / postgraduate level, and are indispensable to commercial fish hatcheries, providing a means of livelihood generation and an important contribution to fish culture.

In the chapter 'Fish breeding and reproduction' of a Bengali book on fish culture authored by Prof. Bana Bihari Jana, it was mentioned (when translated into English): 'These days cut heads of large-sized major carps are found to be sold in fish markets in West Bengal and some middle-aged persons with little effort to collect pituitary glands from these heads'. The author read it in 1998-1999 during undergraduate studies but did not appreciate then the importance of this activity as profession. Young people assisting fish sellers/traders in retail markets may gain additional income if they collect pituitary glands from major carps for hypophysation. With a reasonable charge, people involved in fish dressing may begin pituitary gland collection as a promising entrepreneurial activity. One person/retail fish market in Kolkata and other places, can be involved in other income-generating activities after 11.30 am. Pituitary glands can be collected, preserved, and stored quite in advance of fish breeding season. The total number of registered fish retailers in Kolkata is 2,407 and there are 98 registered fresh fish retail markets in the same number of municipal wards. The majority of these serve as a major source of pituitary gland supply during fish breeding season. There were separate pituitary gland collectors, who paid INR 0.50 /pituitary gland to retailers[8]. This activity does not reduce market value of fish heads.

According to a survey made by West Bengal Government officials during 2016-2017, the total number of renowned and established fish retail markets in Kolkata is 145, with at least another 1,200 non-registered retail markets in Kolkata and outskirts with 8-10 fish sellers in each. Pituitary gland collection is not possible in wholesale fish markets. After some experience is gained, a worker can easily collect pituitary glands from fish heads without either causing any injury to the pituitary gland or damaging the fish head[9]. Some onlooking buyers/consumers in local marketplaces in West Bengal consider pituitary gland collection from major carps as an improper activity and disfavour it, but, according to afore-mentioned persons with whom author conversed during October-December 2020, there is nothing suspicious about it; large-sized carp heads without pituitary glands may be unhesitatingly bought and cooked as a special Bengali dish at home and consumed safely.

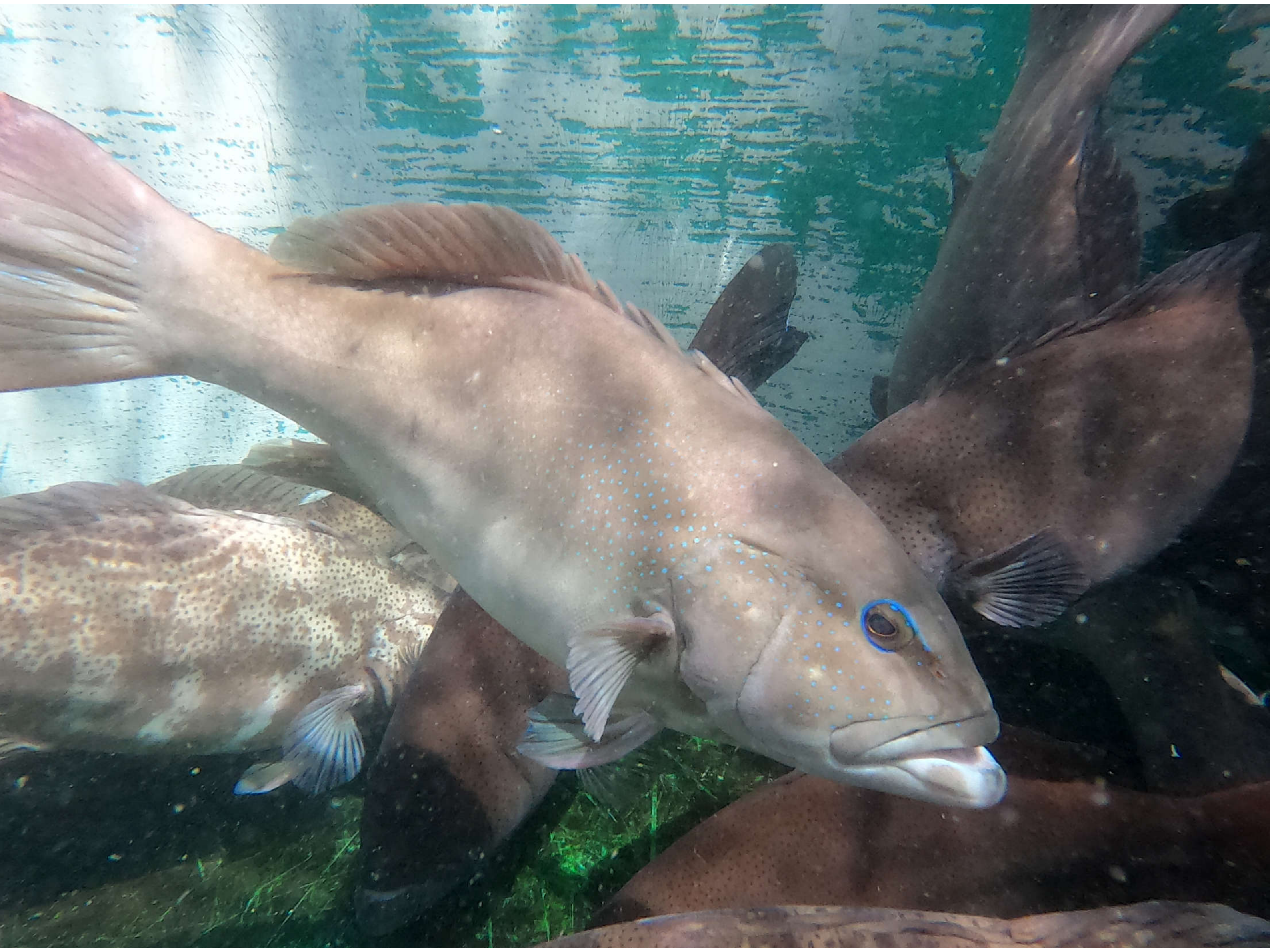
References

1. Jana, P. K. 2016. Directory of fish hatchery and seed farms in West Bengal. Directorate of Fisheries, Government of WB publication: 1-186.
2. Milwain, G. K., Little, D. C., Kundu, N. and Immink, A. J. 2002. Overview of fish seed production and distribution in West Bengal. Institute of Aquaculture, University of Stirling and Institute of Wetland Management and Ecological Design, Kolkata publication, Working Paper 7: 1-79.
3. Riddhi Foundation and Business Brio. 2015. Tradable bioresources of West Bengal. West Bengal Biodiversity Board publication: 75-94.
4. Piska, R. S. and Naik, S. J. K. Freshwater Aquaculture Paper-I. State Institute of Vocational Education and Board of Intermediate Education, Lahari Publications, Hyderabad: 1-29.
5. Biswas, K. P. 2003. Madhyam sikkhiter jonno swanijukti prokolpo - machher dimpona utpadon (in Bengali). Krishi, matsyo chass o posu-paloner maddhomey swa-uparjon o swanirbhorota (Self-employment and income generation through agriculture, pisciculture and livestock farming), RI District 3290 Kolkata publication: 84-88.
6. Singh, B. N. 2000. Four decades of research in maturation and induced breeding of cultivable fishes. In. B. N. Singh, V. R. Chitransi and K. Gopakumar Ed., Fifty years of fisheries research in India, ICAR, New Delhi publication: 21-73.
7. Costa-Pierce, B., Desbonnet, A., Edwards, P. and Baker, D. 2005. Urban Aquaculture. CABI Publishing, London: 39.
8. Srivastava, U. K. 1984. Inland Fish Marketing in India. Indian Institute of Management, Ahmedabad study series, Concept Publishing Company, New Delhi, VII: 41-44.
9. Chaudhuri, A. B. 2008. Aquaculture Beyond 2000 - New Horizons. Daya Publishing House, New Delhi: 21-114.

Coral trout *Plectropomus leopardus* aquaculture research and fingerling production in Indonesia

Yasmina Nirmala Asih, Sudewi, Afifah Nasukha and I. Nyoman Adiasmara Giri

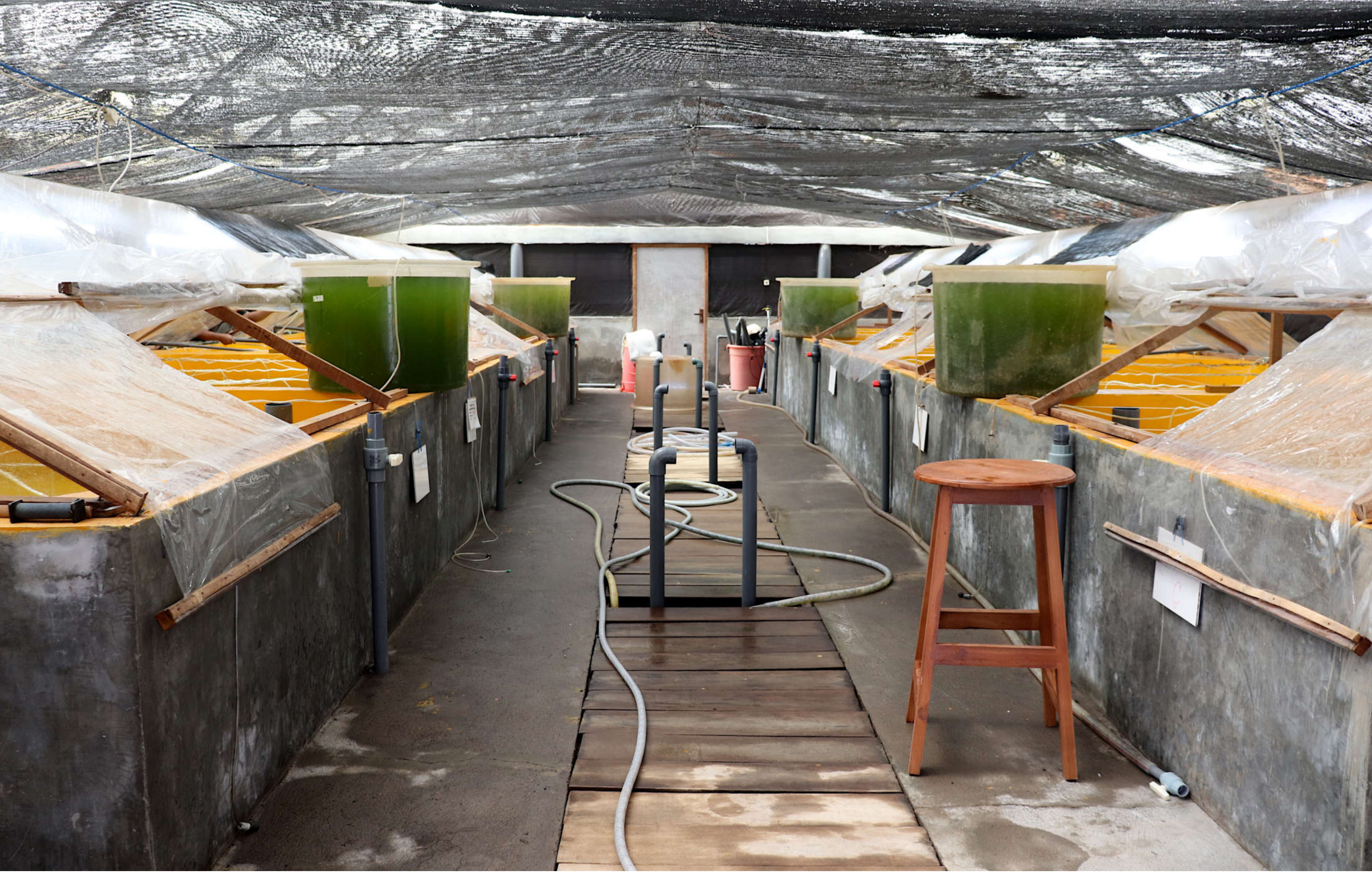
Institute for Mariculture Research and Fisheries Extension (IMRAFE), Gondol, Buleleng Bali, Indonesia



Coral trout broodstock.

Coral trout *Plectropomus leopardus* is an emerging exported grouper commodity in Indonesia. The demand for coral trout fingerlings has been increasing considerably in recent years, particularly from the central area for grouper hatcheries in Bali, even during the current pandemic situation. Mostly, coral trout fingerlings are exported to Taiwan Province of China or locally distributed to Eastern Indonesia for grow-out culture in sea cages. However, fingerling production as the main key for sustainable aquaculture has not been well established compared to production of fingerlings for other grouper species and hybrids.

The value of coral trout is acknowledged to be the highest among grouper commodities. The price of hatchery-produced coral trout fingerlings is around 4-5 times higher than that of hybrid grouper. The total length of fingerlings determines their price, which ranges (per centimetre) from IDR 1,800 to 2,000 in the hatchery. The market size of fingerlings for nursery segmentation starts from 3 to 5 cm, meaning for a 3 cm fingerling the price can be as high as IDR 6,000. The limited availability of fingerlings contributes to their high price, but it is also due to the longer duration required to produce fingerlings from eggs. It takes approximately 65 days to produce a 3 cm fingerling, whereas for hybrid grouper it only takes 45 days.



Grouper hatchery.

Developing coral trout fingerling production technology will benefit the marine aquaculture sector. The Institute for Mariculture Research and Fisheries Extension (IMRAFE), formerly known as the Gondol Research Institute for Mariculture, has been researching this species. The results of fingerling production are quite promising, as shown by the increasing number of fingerlings produced as well as the survival rate from larval rearing. In 2019, IMRAFE produced 107,000 coral trout fingerlings with total lengths of 2.3-2.7 cm, 50 days after hatching, which took approximately two weeks more to reach market size of 3 cm. By continuously improving the larval rearing technique, particularly with regard to water and feeding management, survival increased from 2% in 2017 to 12% in 2020. As far as the authors are aware, this is the highest survival reported for mass-scale coral trout larval rearing.

D50 coral trout fingerlings gathered in containers for grading.

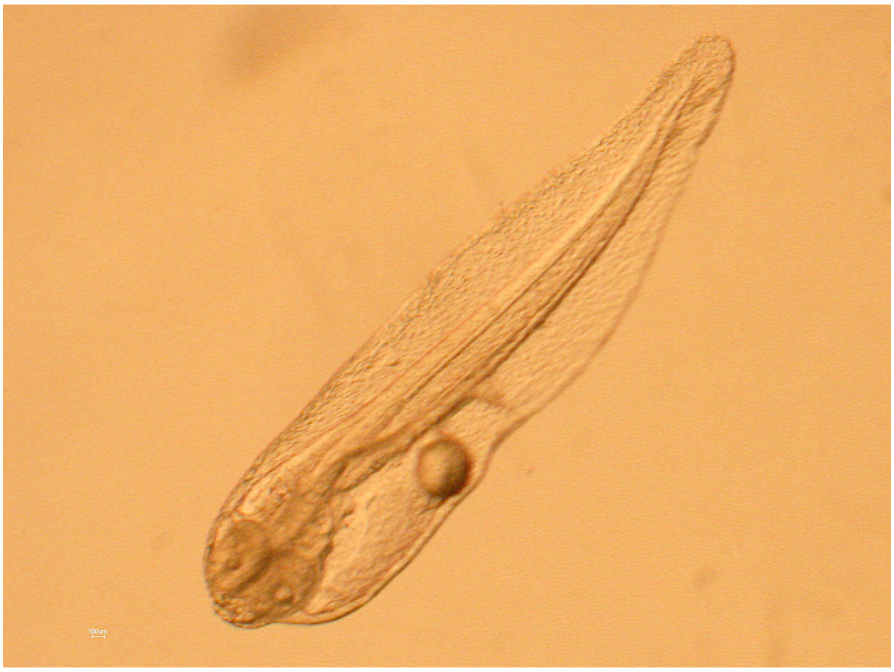
Research topics for developing the technology were mostly focused on feeding and environmental management, particularly in enhancing live feed and water quality. The protocol of larval rearing is quite similar to the standard protocol for grouper fingerling production. However, the rearing of coral trout larvae is notoriously more ‘difficult’ than that of other groupers, since coral trout larvae are more easily stressed than tiger or hybrid grouper. As a comparison, the total length of coral trout day 1 is 1.92-2.17 mm, which is smaller than ‘cantik’ hybrid grouper (*E. fuscoguttatus* x *E. polyphekadion*) at 2.49-2.56 mm. Also, the mouth gap for first feeding of coral trout is relatively small at 103.19 ± 35.77 µm compared to ‘cantik’ hybrid grouper at 125 µm.

Grading.

Larval rearing protocol

At IMRAFE, eggs are obtained from natural spawning of coral trout brood stock confined in round concrete tanks. For fingerling production, eggs are stocked in concrete tanks with rounded corners and a yellow colour with a density of 10 eggs/litre in a closed hatchery. The volume of tanks is approximately 6,000 litres with 1 metre depth. Seawater is sand filtered and sterilised with UV light prior to stocking of eggs and water exchange. To increase light intensity and photoperiod to 15 hours light : 9 hours dark, fluorescent lights are installed above the tanks.

Nannochloropsis sp. are added in the rearing water as green water and live feed consists of rotifers, copepod nauplii, artemia nauplii, and mysids. Formulated diet is incorporated into feeding on the same day as the first siphoning. Water quality parameters, particularly dissolved oxygen (DO) and temperature are regularly monitored to adjust aeration rate and air circulation should it be required. The level of DO and temperature should be maintained above 5 ppm or 80% saturation and 27.5-30 °C. To maintain water quality, water exchange is started from 5% on D5 and increased gradually to 15% on D12 and to >25-100% from D22 onwards. Siphoning is conducted daily from D12. Feeding and water exchange management are illustrated in the accompanying tables.



Coral trout larvae D1.

Coral trout larvae D6.

Feed management	Larvae age (days)																	
	2	3	4	7	9	10	11	12	13	14	15	16	17	20	25	30	40	50
Nannochloropsis	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		
Rotifers	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Copepod nauplii			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Formulated diet								■	■	■	■	■	■	■	■	■	■	■
Artemia nauplii														■	■	■	■	■
Mysids																	■	■

Water exchange	Larvae age (days)																	
	1	3	5	7	9	10	11	12	13	14	15	16	17	20	22	30	40	50
5-10 %			■	■	■	■	■											
10-25 %								■	■	■	■	■	■	■				
>25 % gradually to 100%															■	■	■	■
Siphoning								■	■	■	■	■	■	■	■	■	■	■

Coral trout larvae D12.

Coral trout larvae D25.

First grading is conducted on D50 when most of the larvae have fully metamorphosed into fingerlings. Prior to grading, rearing water should have been flowed thoroughly for at least 2 days. Grading is performed manually by grouping fingerlings based on their length and removing deformed individuals, which are rarely found in fingerlings of less than 5 cm.

Smartphone app improving smallholder shrimp farming practices in Bangladesh

Winrock International is implementing a five-year project in Bangladesh to improve production and trade of farmed marine shrimp and freshwater prawns, with 250,000 farmers and other industry businesses targeted.

Winrock is a USA Not-for-Profit development organisation and the Bangladesh project - called “Safe Aqua Farming for Economic and Trade Improvement (SAFETI)” - is funded by the United States Department of Agriculture.

SAFETI is introducing improved farming methods to the country’s shrimp and prawn farmers and has developed a mobile phone app as one way to support them. The Shrimp Farming BD App contains information on improved technologies - from pond preparation through to harvest - and has a calculator that farmers can use to work out the quantities of chemicals, feeds and other inputs they need for their pond. Also incorporated is a Frequently Asked Questions (FAQ) page where users can find answers to common questions with a single click: and they can send specific technical questions to SAFETI specialists online and receive an answer back within hours. The app can also be used to post news messages, and a link to market prices is planned.

The app can be downloaded from the Google Play Store and then used online or offline. It is only available in Bengali language, but already has 14,000 users, including some in the neighboring Indian State of West Bengal. Under the COVID-19 conditions this year, it has been particularly valuable as a support to Bangladeshi smallholder shrimp and prawn farmers, and will serve them as a remote learning resource well into the future.

NACA Newsletter

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

ISSN 0115-8503

Volume XXXVI, No. 1
January-March 2021

2020 Global Conference on Aquaculture

Aquaculture for food and sustainable development

Registrations are open!

We are pleased to announce that registration for the Global Conference on Aquaculture Millennium +20 (GCA +20) is now open.

Recognising the critical role of a diverse aquaculture sector for food security and poverty alleviation, the expectation for aquaculture to fill the increasing global fish supply and demand gap, the need to exchange information and experiences, and the importance for a common vision and appreciation on how to achieve the sustainable growth of this food sector, FAO, at the request of its Members, is organising the Global Conference on Aquaculture Millennium + 20 in collaboration with the Network of Aquaculture Centres in Asia-Pacific (NACA) and the Ministry of Agriculture and Rural Affairs (MARA) of the People's Republic of China.

Originally planned for October 2020 and postponed due to the COVID-19 pandemic, the GCA will now be held from **22–27 September 2021** in Shanghai, China.

GCA +20 will be the fourth in a series of development-oriented conferences that have shaped global aquaculture: Kyoto (1976), Bangkok (2000) and Phuket (2010). Under the theme "Aquaculture for food and sustainable development", the GCA +20 aims to bring stakeholders from government, business, academia and civil society together to identify the policy and technology innovations, investment opportunities and fruitful areas of cooperation in aquaculture for food and sustainable development.

A key output from the GCA +20 - *The Shanghai Consensus* - will highlight the principles and strategic pathways to maximise the contribution of sustainable aquaculture in achieving the Sustainable Development Goals and meeting the pledge of "Leaving no one behind".

Interested participants are invited to complete the application form and the conference Secretariat will inform registrants as to the status of their application in due course.

The GCA +20 will be a hybrid conference; registration will allow attendance of conference **in-person or virtually**, with the indicated preference taken into account to the extent possible. The maximum number of in-person participants will have to be capped, in close consultation with the host and in line with the latest advice from health authorities.

The GCA is open to all interested stakeholders, including from government, academia, private sector and civil society. Women and youth (35 years of age or younger) are strongly encouraged to apply. Kindly note that registration is free.

Register online at:

https://aquaculture2020.org/registration/

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

Ahead of the Global Conference on Aquaculture Millennium +20, a series of webinars were organised on various topics relevant to the sustainable development of aquaculture.

The first of these was a presentation of advanced (pre-final) versions of The State of World Aquaculture 2020 and six Regional Reviews during the week of 26–29 October 2020.

These reviews, listed below, provide up-to-date information on the status and trends of the sector, at regional and global levels, developed from national, regional and global datasets, supplemented with expert opinion and literature review:

- Regional Review of Aquaculture in Asia and the Pacific.
- Regional Review of Aquaculture in Europe.
- 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
- Regional Review of Aquaculture in Latin America and the Caribbean.
- Presentation of The State of World Aquaculture 2020.

The reviews can be of pertinent interest and use to national governments, regional organisations, policy-makers, aquaculture farmers and other aquaculture value chain actors, investors, civil society organisations, research and training institutions as well as the general public.

These webinars were convened by FAO, in partnership with the Network of Aquaculture Centres in Asia-Pacific and the World Fisheries Trust.

For each review, a presentation of key messages was followed by a panel discussion. Question and answer sessions provided opportunity for interested parties to comment on the reviews, ahead of their final publication.

Video recordings of the webinars are available at:

https://aquaculture2020.org/reviews/

Quarterly Aquatic Animal Disease Report, April-June 2020

The 86th edition of the Quarterly Aquatic Animal Disease Report contains information from fifteen governments. The foreword provides a discussion of a webinar on decapod iridescent virus 1 (DIV1), held on 20 August 2020. The report is available for free download from:

https://enaca.org/?id=1123

Webinar: International Forum of Aquaculture in Silk Road Countries

A free webinar on aquaculture in silk road countries was held from 24-25 November. The theme of the forum was Sustainable Aquaculture Development: Response Strategies Towards Post-pandemic. 264 people from 22 countries attended the lectures and participated in the discussions.

The webinar addressed issues including measures of sustainable development of aquaculture, advanced models and successful experience of sustainable development of aquaculture, and response strategies as we move towards the post-COVID-19 period. Selected presentations included:

- Green development of aquaculture in China.
- Mitigation strategies for COVID-19 impacts on fish and aquatic food systems.
- Systematic prevention and control technology for important *Vibrio* diseases in shrimp culture.
- Innovation in microbial management for more sustainable aquaculture.
- Leveraging aquaculture development for post-COVID economic recovery.

The full programme is available for download from the link below. Video recordings of the presentations will be made available online in due course: https://enaca.org/?id=1125

The webinar was organised by:

- Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences ("Belt and Road " Training Base for Mariculture Technologies, Ministry of Agriculture and Rural Affairs of the People's Republic of China).
- The NACA Secretariat.
- The Mariculture Chapter, China Society of Fisheries.
- The Marine Aquaculture Committee, China Rural Special Technnology Association.
- The Qingdao Municipal Marine Development Bureau.
- Laboratory for Marine Fisheries and Food Production Processes, Pilot National Laboratory for Marine Science and Technology (Qingdao).
- Key Laboratory of Sustainable Development of Marine Fisheries, Ministry of Agriculture and Rural Affairs of the People's Republic of China.
- Qingdao Society of Fisheries.

NACA would like to thank our colleagues in China, particularly the Yellow Sea Fisheries Research Institute for their work in development of the technical programme and for generously sharing their technical expertise.

World Fisheries Day Lecture Series, 20 December: Biosecurity - the concept to guarantee the sustainable development of aquaculture

NACA's Director General Dr Jie Huang give a virtual lecture on "Biosecurity - the concept to guarantee the sustainable development of aquaculture".

The presentation was given as part of the World Fisheries Day 2020 Lecture Series, hosted by the ICAR-Central Institute of Freshwater Aquaculture, India.

The lecture, presented on 22 December, featured Special Remarks by Dr C.N. Ravisankar, Director of ICAR-CIFT.

The Organiser was Dr S.K. Swain, Director of ICAR-CIFA, and the Coordinator was Dr S.S. Giri, Head, FNP Division.

A video recording of the lecture is available at:

https://fb.watch/2YQx_SlbJ0/

Webinar: Beauty and the Beast: Important Parasites of Fish

A free webinar on important parasites of marine and freshwater fish was held on 9 December 2020 and attended by 479 people from throughout the region.

The webinar was organised by the Fish Health Section of the Asian Fisheries Society.

Topics and speakers were:

- Parasites of freshwater fish.
  Dr Andy Shinn, BMK Asia.
- Sea lice problem in marine fish aquaculture in the Philippines.
  Dr Erlinda R. Cruz-Lacierda, University of the Philippines Visayas.
- Neobenedenia: Can we innovate to successfully manage this parasite in sea cages?
  Dr Susan Gibson-Kueh, James Cook University - Singapore.
- Marine leech: From life cycle to control measures.
  Dr Kua Beng Chu, Department of Fisheries, Malaysia.

Second Online Training on Mariculture Technology for the Asia-Pacific Region: Aquaculture Biosecurity

Aquaculture biosecurity has been accepted as a mainstream approach to reducing the risk of infectious disease in aquaculture.

FAO and OIE stress the importance of biosecurity in the sustainable development of aquaculture. Together, they are developing guidelines and recommendations to enhance aquaculture biosecurity systems at national and on-farm levels.

During earlier training courses and webinars, participants expressed their interest in further courses in aquaculture biosecurity and related capacity building, technology, and modernisation of the industry.

In response, the "Belt and Road" Training Base for Mariculture Technologies and FAO Reference Centre on Aquaculture Biosecurity and AMR in YSFRI (Yellow Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences), and NACA co-hosted the Second Online Training Program of Mariculture Technology for the Asia-Pacific Region from 15 to 20 December 2020.

The course focused on aquaculture biosecurity and related technologies at the international, national, and on-farm levels. Lectures were given by experts from FAO, OIE, NACA, YSFRI, and industry. 264 people participated from all over the world.

Lectures included:

- Guidelines on aquaculture biosecurity.
- Diagnostic methods for the detection of AHPND.
- Operational training in rapid detection for aquaculture pathogens.
- The progressive management pathway for improving aquaculture biosecurity.
- Development of a contingency plan for shrimp acute hepatopancreatic necrosis disease.
- Theory and framework to establish biosecurity plans for aquaculture.
- Diagnosis and pathogenicity of IHHNV.
- Biosecurity for broodstock multiplication centers: The concept to maintain SPF shrimp.
- Shrimp culture management vs biosecurity issues and options.
- Systematic prevention and control technology and the practice of important *Vibrio* diseases in shrimp culture.
- Quality management system for aquatic animal diagnostic laboratories.

A Q&A session on "Implementation of Progressive Management Pathways to Improve Aquaculture Biosecurity (PMP/AB)" promoted by FAO at the national level and "Practice of biosecurity at the farm level and application of the PMP/AB approach" was held during the course, with some additional presentations and a discussion session with participants.

Selected lectures from the course will be made available online in due course.

Network of Aquaculture Centres in Asia-Pacific

Mailing address:
P.O. Box 1040,
Kasetsart University
Post Office,
Ladyao, Jatujak,
Bangkok 10903,
Thailand

Phone +66 (2) 561 1728
Fax +66 (2) 561 1727
Email: info@enaca.org
Website: www.enaca.org

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

More online offerings to come in 2021

2021 will see NACA experimenting with more webinars, training courses and audio and video production, to be delivered online.

While our opportunities to record field activities and interesting innovations in aquaculture systems will remain limited for the time being, we will endeavour to make recordings of technical presentations from during our online webinars and training courses available online.

This is intended to assist those living in different time zones, who may be unable to attend the live sessions, and to serve as training and reference materials on an ongoing basis.

Upcoming online activities will be advertised on the NACA website, Facebook, LinkedIn and Twitter channels. Please consider following or subscribing in order to keep informed!