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Invasive apple snails in Brunei Darussalam

Spotted scat and pearl spot in India

Ornamental fish, India

Production of Tubifex

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NACA

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

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Genetic resources and anti-microbial resistance

At the 29th NACA Governing Council Meeting in the Maldives last month, three issues stood out as concerns amongst member governments: Health, genetics and anti-microbial resistance. Health is an ongoing concern but genetics and, in particular, anti-microbial resistance are increasingly high-profile issues.

While the observation that few genetically improved (selectively bred) varieties are used in aquaculture is well known, somehow it has never really gained a lot of traction in the region when compared to terrestrial agriculture, which is almost 100% based on selectively bred varieties that have improved production characteristics. It doesn't really matter whether you're shopping at a supermarket in a megacity or a rural farmers market, nearly all the produce you'll find is improved - except for the fish. The aquaculture sector is missing out on huge potential gains in production. While inroads are starting to be made, they are slow and generally being conducted by the private sector. Hopefully we will continue to see growing investment in this area in the future.

The conservation of aquatic genetic resources was also a conspicuous issue. Governments are moving beyond biodiversity concerns at the species level to recognise the value of genetic or population level biodiversity. Questions are being asked about the impact of restocking programmes on wild populations, and the value of wild genetic resources to the future of the aquaculture industry is gaining appreciation.

The use and, it has to be said, misuse of anti-microbial substances has become a burning issue. In particular, the development of microbes that are resistant to multiple drugs is of great concern, given the implications for both human and animal health. Nobody wants to live in a world where common infections are untreatable, but that is where we will end up if nothing is done. Multi-drug resistant microbes are already a reality in aquaculture.

Antibiotics have been a trade and food safety issue for a long time of course, but the main concern has historically been on food safety reasons. Regulation has chiefly focussed on the residue levels in end products, although the issue of resistance has been known for decades. However, the world is now starting to pay attention to the other consequences of antimicrobial usage. It may well be that the issue of anti-microbial resistance will overtakes residue limits as a concern.

Many governments are currently revisiting controls on the use of anti-microbial substances. It is almost certain that controls will be tightened, but enforcement remains a challenge. Another issue for the industry is the lack of veterinary supervision. While it is possible to use anti-microbial substances to treat sick fish in a responsible manner, realistically, how many fish farmers actually have access to a vet?

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Rearing of *Scatophagus argus* and *Etroplus suratensis* in coastal West Bengal, India

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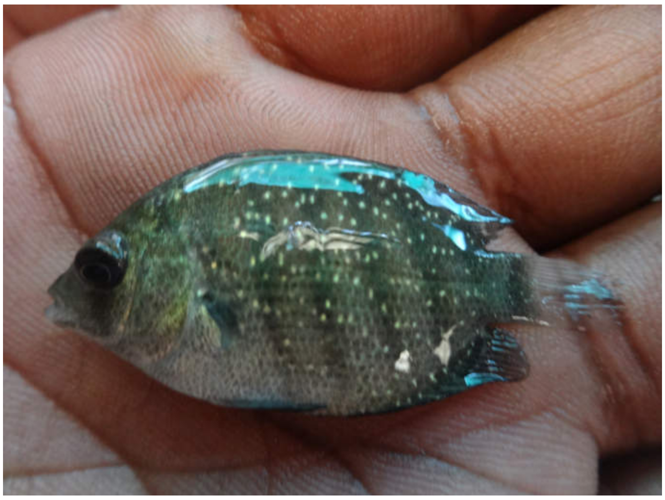
Spotted scat *Scatophagus argus* - a valued ornamental fish

The spotted scat or leopard pomfret *Scatophagus argus* (Perciformes: Scatophagidae) is a commercially-important fish found in the marine zone of Hooghly estuary in lower West Bengal, India from Diamond Harbour to Bakkhali, in the lower portion of tidal rivers, in large brackishwater impoundments or 'bheri' connected to estuaries and in seven other estuaries of Indian Sundarbans. Early stages of wild-collected spotted scat survive and exhibit good growth in low-saline brackishwater ponds (12ppt). Habitats preferred by *S. argus* such as estuaries and mangrove forests are characterised by wide fluctuations in physico-chemical water parameters. This sturdy fish has adapted to such ever-changing aquatic conditions and this tolerance has endowed it with some biological characteristics desirable in a cultivable tropical brackishwater finfish.

The species *S. argus, Terapon jarbua, Monodactylus argenteus, Odonus niger* and *Epinephelus diacanthus* are considered as important wild-caught indigenous marine ornamental fishes in India. In the ornamental fish markets of India, *S. argus* is popularly sold as 'Indian discus'. *S. argus* is a suitable candidate species for promoting as ornamental fish. It has heavy demand for aquarium purposes throughout the world and has a good market particularly at smaller body sizes. Wild seed are available for further rearing to produce marketable sized fish[1]. The common *S. argus* and red scat *S. argus arromaculatus* are the two colour morphs of *S. argus* which are popular among tropical fish-keeping enthusiasts. The Hooghly river spotted scat closely resembles normal *S. argus*. It was found to fetch higher price in the US aquarium trade. Boiled lettuce, soaked oatmeal porridge, aquarium plant *Nitella sp*, algae, water fleas and worms can be fed to scats in aquaria, and they can be maintained both in freshwater and marine aquaria. A brackishwater fish by nature, *S. argus* can easily adapt to freshwater aquarium conditions.

Scatophagus argus fry 10-12 mm. in length.



Close view of a pearl spot fry.

Like spotted scat, another brackishwater fish, pearl spot *Etroplus suratensis* (Perciformes: Cichlidae) commands high market value especially as an ornamental fish in West Bengal. The attractively coloured sub-adults of *E. suratensis* are sold in market as ornamental fish.

Pond rearing of spotted scat

Spotted scats sexually mature and breed in nearshore/ coastal waters. Advanced larvae migrate and enter estuaries during fry/early juvenile stage. The fry, black in colour, feed on microalgae and can be collected for stocking in culture ponds for the ornamental fish trade. Collection of fry and early juveniles of important brackishwater fishes such as spotted scat, Asian seabass and mullets from Hooghly and other estuaries in West Bengal is done using zero-mesh drag nets. *S. argus* fry 10-12mm (0.33 g; 15-20 days old) are available at Harwood Point (a ferry point on Hooghly River under Kakdwip PS) in the Hooghly estuary during March-September and again in November, with three peaks in March-April, June and November. At Ramnagar on the Ramnagar Canal in East Midnapore District, the two peak periods of its availability are April and September.

Joykrishna hatchery and fish seed farm, located on eastern bank of the Hooghly River estuarine zone is a unique site in West Bengal where juveniles and sub-adults of *S. argus* ('paayrachanda macchh' in local dialect) and *E. suratensis* ('muktogaccha macchh') are produced in brackishwater ponds for commercial utilisation as ornamental fishes. These are supplied to Hyderabad and other cities outside West Bengal and fetch high market price. The export price of *S. argus* and *E. suratensis* is US$14.9 / piece and US$8.25 / kg respectively.

In ponds, *E. suratensis* is mostly detritivorous and *S. argus* herbivorous in habit. *S. argus* fry are collected when the river water inflates during spring tide at times of full moon and new

Fry of Etroplus suratensis 24-36mm.

moon. In each of six properly-managed earthen chambers of 40 m² in area (8 m x 5 m) constructed in a series (salinity 10-14 ppt), 3,000-4,000 pieces of *S. argus* fry, procured @ Rs 0.50-0.80 / piece, are stocked. Water depth is maintained at 1.2-1.5 m. It takes 40-45 days to reach a harvestable size of 25-30 mm. If fry are stocked at a higher density, they will take 75 days to attain such a size, which are sold @ Rs 8-10 / piece. *S. argus* fry are also propagated in two brackishwater ponds of 440 m² each, where 12,000-15,000 pieces are stocked in each. After letting river water into the ponds and chambers during spring tide, it is treated with bleaching powder and other pre-stocking management measures are followed.

The '0' point 9904 CPF shrimp feed (dust) is fed to growing fry for the first thirty days @ 200-400 g/10,000 pieces daily. Thereafter boiled rice is used in small amounts. A formulated farm-made feed has been prepared, comprising rice bran 15%, mustard oil cake 20%, maize dust 20%, GNOC 10%, boiled pulses 5%, wheat flour 10%, rice dust 10%, fish meal 5%, vitamins B, C and minerals 5%. It feeds on periphyton deposited over palmyra leaves and bamboo poles. Every week, 2,000-2,500 pieces of *S. argus* juveniles of 'one rupee coin' size in local parlance, are sold from this hatchery to selected ornamental fish traders in Howrah District. The 45-48 mm stage, popular locally as 'nontaa (salty) snack biscuit' size, is also raised in ponds for sale.

Breeding and rearing of pearl spot

During March-April and June-July every year, breeding and seed production of *E. suratensis* is conducted in three brackishwater ponds 560-640 m² in area (16-18 ppt). Brooders of 50-100 g weight are stocked in the ratio 12 females : 15 males @ 600-700 fishes / pond. Palmyra leaves and, broken asbestos sheets are placed in ponds for egg attachment. Fishes have been found to breed within 40 days of stocking; 500-1,000 progeny are produced from each female. Pulverised ground nut oil cake and CPF shrimp feed in dust form is fed to the early stages, which attain 24-36 mm in 45 days of rearing from birth. Mustard oil cake is used to enhance zooplankton production in ponds.

In this hatchery-cum-seed farm, in every 640 m² pond, 6,000-8,000 *E. suratensis* fry are reared and harvested at 65-70 mm size in about three months, which is a sub-adult stage. Thin

Joykrishna hatchery at Kakdwip South 24 pgs West Bengal.

deposition of silt in pond bottom and partial growth of aquatic weeds is essential in *E. suratensis* ponds. In comparison to *S. argus, E. suratensis* are harvested at a larger size which is attractively coloured and fetches the best price in ornamental fish markets. In order to produce edible fishes, 900-1,000 fry are stocked / 640 m^2 pond and those attain 150-180 g at the end of one year. In every week, 250-500 pieces of E. suratensis fingerlings/sub-adults are sold from this site.

End note

Growing *E. suratensis* fry will not accept boiled rice as feed (unlike *S. argus*). Ornamental fishes like shubhangi, albino rengo and expensive varieties of gold fish and koi carp are also propagated in this hatchery in rectangular cement cisterns. Scientists at ICAR-Central Institute of Brackishwater Aquaculture, Kakdwip have helped in growth of this seed farm. One low saline pond (3-4 ppt) has been earmarked for polyculture of *E. suratensis* and Indian major carps, and another pond (6-8 ppt salinity) for culture of *Liza parsia, L. tade, S. argus* and *Penaeus monodon*. Giant prawn *Macrobrachium rosenbergii* juveniles must never be stocked in E. suratensis ponds. Brooders of *E. suratensis* and large-sized *S. argus* are maintained here in cement cisterns.

Recently few brackishwater fish farmers in Kakdwip and other coastal Blocks in South 24 Pgs District have endeavoured to produce juveniles/advanced juveniles of *S. argus* (30-48 mm size) for ornamental purposes. Juvenile spotted scat can fetch Rs 10-20 in retail markets and fetch higher prices in international markets. A small-scale farmer or self-help group can earn Rs 8,000-12,000 / month from rearing of brackishwater ornamental fishes such as *S. argus, T. jarbua, E. suratensis* (Prof. R. K. Trivedi, WB University of Animal and Fishery Sciences; personal communication). Fry collected from nature is stocked and reared in brackishwater ponds.

Close view of a juvenile spotted scat.

Larger sized spotted scat 75-80 g.

Nursery chambers for spotted scat.

If practices such as juvenile production of *S. argus*, pond breeding and rearing of *E. suratensis* are established with wider acceptance, it is expected that it will be a sustainable source of income for farmers and ornamental fish producers in the poor rural estuarine zone of coastal West Bengal and considerably contribute to rural livelihoods. The Freight-on-Board price of a pearl spot is US$0.35 in international markets. These fishes are yet to be fully exploited in aquaculture programmes. Freshwater pond aquaculture in the Indian Sundarbans and other regions in coastal West Bengal is often severely affected by cyclones and storm surges and the problem of saline water intrusion is encountered during the cyclonic depression period. In such situations, these ponds may be effectively utilised by farming of *S. argus, E. suratensis* and *M. rosenbergii*.

Juvenile Scatophagus argus at 25-30 mm length.

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Harvesting *Eurayle ferox (makhana)* from wetland *(beel)* fisheries of Assam

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Local boys with makhana fruits.

Euryale ferox (makhana)

Makhana, *Euryale ferox* (Nymphaeaceae) is a perennial aquatic herb with gigantic floating leaves that grows in still shallow water (0.2-2.0 m depth) with a rhizomatous stem deeply rooted in the sediments or mud by thick, fleshy root clusters[1,2,3]. Makhana is a nutritious dry fruit containing 0.1% fat, 76.9% carbohydrate, 9.7% protein, 12.8% moisture, 20 mg/100 g calcium, 90 mg/100 g phosphorus and 1,400 mg/100 g iron[4]. In Dhaka and Chittagong the seeds are very popular as food and medicine[5]. The plant has been known to the people of Assam as 'nikhori' and 'makhana' and has been reported from some beels of Assam[6]. Economically, no such expenditure is incurred on its cultivation in these wetlands as the seeds left over after harvest germinates subsequently as a crop for the next season.

The *makhana* wetlands *(beels)*

In India, *makhana* is particularly reported in north Bihar and lower Assam (62.86%) and the distribution, existence and potential of *E. ferox* in Assam is fragmentary as the aquatic cash crop grows wild in the state and is rarely cultivated in water bodies[7]. Ten such wetlands *(beels)* of the lower part of Assam in rural Kamrup District were investigated to witness the traditional practice of *makhana* harvest. The *beels* were under the jurisdiction of Assam Agricultural University (AAU) namely; (i) Rangai *beel* - 890 m^2 (ii) Bhaguwa *beel* – 2,346 m^2 (iii) Thaliputa *beel* (Part I) - 212 m^2 (iv) Thaliputa *beel* (Part II) - 417 m^2 (v) Balasari *beel* - 200 m^2 (vi) Bagheswari *beel* - 545m^2 (vii) Mandira *beel* – 1,175 m^2 (viii) Bidhanjika *beel* - 820 m^2 (ix) Tiplai *beel* - 537 m^2 and (x) Hogol *beel* - 860 m^2. The water area of these beels has been recorded during the dry period in winter season which becomes one mass of water body during the rainy season when fresh floods flow into the beels from the tributaries of river Brahmaputra. These *beels* are wide and spread out, irregular in shape and with a minimum depth of 1.5-3.0 m in the dry season. The *beels* are mostly leased out on a short-term basis as per AAU norms to the local *lessees* and *mohaldars* for fisheries purposes.

Fruit of makhana crop.

Identifying the *makhana* areas

The presence of makhana in the beels can be easily identified by its gigantic prickly floating leaves, which are green on the upper side and purple to red on the lower, thorny, oval or rounded with a diameter of 0.2-1.3 m. Flowers are violet-blue or red in colour. Petioles are prickly and deep green or pink. The fruit are round, spongy and prickly outside containing 12-20 seeds. The seeds are small, black, artillate and encrusted with a thick sheath around the white edible part inside. The plant was recorded to have best growth in old, perennial water bodies having thick layer of mucky bottom that is rich in nutrients; freshly excavated ponds with hard substratum are not suitable for this plant. These wetlands are normally poor in oxygen (below 4 ppm) and have a low pH due to the acidic soil; they also exhibit higher productivity of macrophytes and support a wider biodiversity of invertebrates. Makhana grows naturally in these wetlands, mostly in lower Assam along with other aquatic plants such as *Trapa natan* var. *bispinosa* (singori), *Nelumbo nucifera* (podum), *Nymphaea lotus* (boga bhet) and *Ipomoea aquatica* (kolmou), *Hydrilla verticillata, Ceratophyllum demersum, Utricularia spp., Potamogeton spp., Najas spp., Marsilea spp., Pistia stratiotes, Lemna spp., Salvinia cuculata*, and *Eicchornia spp.* etc. These plants are considered as biological indicators for favourable soil and water quality for *E. ferox* manifestation[4].

The *makhana* harvesters

The sowing and harvesting of makhana seeds is conducted by groups of migratory people belonging to the *Mallah* or *Sahini* community of Bihar. The lessee who takes the *beels* on lease for fish production assigns a middleman or a local person to supervise the harvest of makhana seeds. The migrants from Bihar take temporary shelter in the vicinity of the beels for 20-30 days until the seeds are completely harvested. The middlemen accounts the collected seeds with the help of the harvesters and the seeds are kept for sun-drying on the banks, which are later transported to Bihar for its further processing.

Method of operation

Harvesting of *makhana* is quite a cumbersome task and requires skill. The *makhana* seeds are usually fallen and scattered over the bottom of the *beels* and must be collected manually during the month of September-November. 10-12 skilled personnel are seen harvesting makhana at a time. The group surveys for a precise location of the fallen seeds within the beel on a boat. Once the location is confirmed, two persons among the group stay on the boat itself and the rest of the harvesters dive into the water to collect the seeds. Each one of them remains inside the water for a few seconds in each dive and sweeps the scattered makhana seeds with their bare hands over the soil surface to make a heap

Temporary shelter of the harvesters.

Mallah or Sahini community of Bihar.

Harvesters diving in search of makhana seeds.

A bamboo woven gaanja for sieving makhana seeds.

A lift net in operation in flood water.

of seeds underwater, marking the sites with long splits of bamboo or floating material above the water surface. It takes one to one and a half hours to sweep all the makhana fruit in one operation. The harvesters get back to the boat or swim back to the bank after the operation. As the harvesting is done in the colder part of the year, the harvesters take one to two hour rest intervals under the sun before the next harvest. During these intervals, one of the harvesters, recognised as master harvester, dives into the water several times to collect the heaps of makhana seeds in a cylindrical bamboo made drum commonly known as *gaanja*. The drum is woven with bamboo splits in such a way that the same works like a sieve. The mouth of the drum remains open whereas the base is closed by separate bamboo webbing. The base is slighter broader in diameter (100 cm) as compared to mouth (90 cm). The master harvester sieves the unwanted materials from the seeds by dipping and picking the *gaanja* with seeds in water several times. The seeds are brought to the bank of the beel to dry in the sun for several days. 80-120 kg of *makhana* seeds are typically harvested with 3-4 operations in a day as reported by the harvesters.

Fishes of the beels

Most of the fishes are indigenous and are commercially important as food and also with ornamental value. As the *beels* are of an open type, fishes are stocked naturally with flood water from the Jajjali River, a major tributary of the Brahmaputra. More than 40 varieties of fishes are harvested by the local fishers as an additional animal crop based on natural recruitment. In certain cases, the young of carps such as *Catla catla* (catla), *Ctenopharnygodon idella* (grass carp), *Hypophthalmichthys molitrix* (silver carp), *Labeo rohita* (rohu), *Cirrhinus mrigala* (mrigal) and minor carps are also stocked to fetch a higher return. Some of the groups of fishes identified are;

- Major carps – *Catla catla, Labeo rohita, Cirrhinus mrigala, Hypophthalmichthys molitrix, Ctenopharyngodon idella, Cyprinus carpio*.
- Minor and medium carps – *Labeo gonius, L. bata.*
- Catfishes and air-breathing fishes – *Sperata aor, Mystus spp., Clarias magur, Heteropneustes fossilis, Anabas testudineus.*
- Knife fishes - *Notopterus notopterus, Chitala chitala.*
- Murrels – *Channa marulius, C. straita, C. punctata, C. gachua.*
- Eels – *Monopterus spp., Mastacembelus spp., Macrogna-thus spp.*
- Freshwater prawns – *Macrobrachium spp.*
- Others – *Chanda spp., Rasbora spp., Badis spp., Devario spp., Nandus spp.,* tilapia and gouramies.

Economics

There is no established record on the economics of the makhana crop in Assam. The raw seeds are sold at the rate of Rs. 60 – 70 per kg in Assam. The collected seeds are usually transported to Bihar for their further processing and

Traps for installation in flood waters.

Local catfishes harvested from the beels.

the processed seeds are sold at the rate of Rs. 350 per kg in Bihar and other northern parts of India. The harvesters get a share of the harvest from their contractors based on the quantity of seeds reaching Bihar. The contractor also makes a deal with the *beel* lessee based on the harvest being made.

The rationale

Myriad *beels* of various dimensions are scattered throughout the lower part of Assam that are suitable for stocking and rearing useful aquatic flora and fauna of high economic importance under controlled conditions. The general people of Assam are largely unaware of the nutritious use of *makhana* seeds as relished by people in other parts of India and abroad as food items or for medicinal use. However, the raw edible part of the seeds are eaten by rural folk in interior villages as a casual food. Moreover, these *beels* can be profitably managed for fish culture as well as for growing water fruits, mainly makhana and singori. After the harvesting of the *makhana* crop, air-breathing fishes like magur *(Clarias magur)*, singhi *(Heteropneustes fossilis)*, kawai *(Anabas testudineus)*, goroi *(Channa spp.)*, mud eels *(Macrognathus aculeatum, Mastacembelus armatus, M. pancalus)*, small sized fishes *(Puntius spp., Trichogaster spp., Glossogobius giuris, Chanda spp., Oxygaster bacaila)*, and a few crustaceans, which generally get access and enter through the adjoining water bodies can provide nutritional security and additional income to the farmers without incurring any input cost towards fish seeds, fish feeds and zero level management in these beels. Therefore, providing advanced and organised marketing facilities, basic incentives to cultivators and new technology with processing plants to boost production will generate the interest of farmers in cultivation of makhana in Assam.

Local eels harvested from the beels.

A local auction market with the harvested fishes from the beels.

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Authors are also thankful to the makhana harvesters from Bihar, lessees, *mohaldars* and local fishers for providing the necessary information to document the traditional practice of *makhana* harvest and the associated fisheries scenario of the wetlands.

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Women selling molluscs in the local market.

Prospects of ornamental fish culture in seasonal water bodies of upper Assam

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Selling potential ornamental fish as food fish in upper Assam.

Ornamental fish keeping is an age old hobby. Ornamental fish are considered to be “living jewels” and are kept as pets in aquariums owing to their huge aesthetic value. Globally, fish keeping is the second most popular hobby in the world, next only to photography. It is a multibillion industry with a value of more than 10 billion dollars annually. Global export of ornamental fish is currently lead by Singapore followed by countries such as Japan, the Czech Republic, Thailand, Malaysia and Indonesia. USA is the leader in import of ornamental fishes.

India’s share of the international ornamental fish trade is marginal (<1%) but has been able to show consistent growth over the years[2,5]. Of the total fishes traded by India, approximately 85% are native ornamental fishes sourced from the Western Ghats and North East India, which are two major biodiversity hotspots region of the world, with Assam standing out as the major contributor.

Assam enjoys a favourable tropical climate and diverse landscape with huge resource potential. Despite having such vast resources, both in terms of natural water resources as well as rich fish diversity, the state lags far behind with respect to ornamental fish trade. A host of factors is undervaluing this potential venture of economic growth. Capture of wild, native ornamental fishes form the available resources has resulted in depletion of wild stocks. Anthropogenic problems such as habitat degradation, population explosion, overexploitation, pollution and destructive methods of fishing are also adding pressure on existing resources to meet the ever increasing demands of the region.

In this regard, the aquaculture of native fishes in seasonal water bodies can definitely play a crucial role to minimise the existing threats lingering upon the endemic and rare varieties of ornamental fish species. Seasonal water bodies are those aquatic resources that fill up on the onset of monsoon such as ephemeral streams, ponds, wetlands, roadside canals, paddy fields and ditches. While many of them dry up during the


A typical roadside pond which harbours many native ornamental fishes.

winter, some do not and expand once the monsoon season starts. Since the native fishes are well adapted to such water bodies, they can be tapped successfully to venture into the lucrative ornamental fish trade. This will not only minimise the existing threats to water bodies as well as fishes but will open up new sources of income through entrepreneurship development in aquaculture and allied sectors. Farming in these types of water bodies requires minimal effort and investment, which can be an added advantage.

Water resources of upper Assam

The upper Assam region, comprising the Dibrugarh, Tinsukia, Sivasagar, Jorhat, Golaghat, Majuli, Charaideo, Dhemaji and Lakhimpur districts, boasts a huge array of diverse water resources. The mighty Brahmaputra River and its tributaries are the principal water resources in the region. Data compiled by Department of Fisheries, Government of Assam (2014-15) reveals that the districts of upper Assam jointly occupy 13.37% ponds and tanks, 31.83% of beels, 18.02% of swamp and derelict water bodies, 32.90% reservoirs and 61.05% of forest fisheries of the total water resources of Assam. The monsoon rains start in April and peak in July, filling most of the water bodies in the region. According to the data from Indian Meteorological Department, the average rainfall received by the upper Assam districts is 332 mm in Dibrugarh, 329 mm in Tinsukia, 270 mm in Jorhat, 265 mm in Sivasagar, 217 mm in Golaghat, 413 mm in Lakhimpur and 327 mm in Dhemaji for the last five years (2012-2016) during the monsoon season and tends to remain more or less uniform at the same time period. Although high precipitation causes severe floods in most part of upper Assam, at the same time it opens up lots of opportunities in the fisheries sector. Inundation of lands and water bodies during flood leads to dispersal of native fishes, effectively stocking ephemeral water bodies as the flood water recedes. Also, the onset of monsoon creates a variety of micro habitats; ultimately leading to a rich repository of fish species[2]. The seasonal water bodies become a natural habitat for fishes, providing them with breeding and feeding grounds. The adaptation of native fishes to these water bodies makes their culture feasible and provides a rationale for the development of ornamental fisheries[7] and generates avenues for ornamental fish trade.

Ornamental fish resources of Assam

Divergent views regarding the total number of ornamental fishes has been recorded in Assam[2]. Srivastava et al. (2001) recorded 115 species of ornamental fishes from Assam. Working on the *beels* of upper Assam, Das and Biswas, (2005) reported 70 species of fishes with ornamental potential demanding commercial value in domestic and international market. Mahapatra et al. (2007) and Dhar and Ghosh (2015) enlisted 187 ornamental fishes from Assam out of total 250 potential ornamental fishes found in North East India. The major native ornamental fishes with good commercial value from the region include *Channa bleheri, C. aurantimaculata, C. stewartii, Leiodon cutcutia, Glossogobius giuris, Botia dario, Macrognathus pancalus, M. aral, Acanthocobitis botia, Danio rerio, Devario devario, Chaca chaca, Esomus danricus, Pethia gelius, Badis assamensis, B. badis, Trichogaster lalia, Xenentodon cancila* etc. to name a few. Of the total ornamental fishes reported, many of them are endemic to the region. The endemism of fishes leads to greater threats or vulnerability and hence requires immediate conservation strategies. Therefore, in this regard aquaculture in seasonal water bodies can play a very pivotal role in formulating conservation strategies for the threatened species along with prospects of generation of revenue.

Fish harvesting in a paddy field.

Prospects of ornamental fish culture in different water bodies

Almost the entire range of native fishes available in the state are dispersed during the monsoon season. The availability of this huge array of aquatic resources opens opportunities for entrepreneurship development in the fishery sector. Different water bodies can be selected according to the habitat and ecology of the prospective culture species. Culture of air breathing fishes such as *Channa gachua, C. aurantimaculata, C. bleheri, C stewartii, C. gachua, Anabas testudineus, Trichogaster fasciata, Heteropneustes fossilis, Clarias magur* and other such as *Nandus nandus*, *Trichogaster lalia, Badis badis* can be carried out in water bodies normally infested with weeds such as 'beels' (wetlands), ditches, roadside canals and swamps etc. as they can easily sustain in such water bodies. In this context, high value fishes such as *Clarias magur, Heteropneustes fossilis, Channa aurantimaculata, Anabas testudineus* can be preferred over other fishes as they command high market value amounting to Rs. 300-Rs. 400/kg in domestic market as food fishes along with their ornamental value. Similarly, the fishes that require relatively open access areas such as *Xenentodon cancila, Glossogobius giuris, Esomus danricus, Rasbora daniconius, Danio rerio, Macrognathus pancalus, Acanthocobitis botia, Mystus spp. Puntius spp.,* and *Chanda nama* can be cultured in open ponds, canals and paddy fields. It is important to note that most of the native food fishes, especially major and minor carps, are compatible with native ornamental fishes which can be cultured together to increase production further. Along with culture of the fishes, local traditional knowledge can be

A pond constructed in rice field environment.

Traditional duck cum fish farming in pond in upper Assam.

applied successfully in rearing, feeding, capture and management purposes of the aquatic resources. Such sustainable culture practice will not only decrease the existing pressure on the natural water bodies but will also pave the way for conservation strategies for both water bodies and native fish germplasm.

Scope for integrated fish farming

The advantages and success of integrated fish farming has been acknowledged globally. Since the region has abundant natural resources, it is often seen that different farm animals exist in rural households in the region thereby providing a huge potential of integrated farming of ornamental fishes in combination with other domestic animals. As the majority of households in Assam have access to ducks, pigs and other livestock, they can be integrated with ornamental fish culture which will boost rural economy as well as farm production. However, presently aquaculture in Assam is mainly focussed on major carp culture[7] and the paradigm should be shifted to include culture of small fishes to develop ornamental fish culture and trade in the region.

Entrepreneurship development through paddy cum fish culture

With more than 200,000 hectares of paddy fields in Assam, the development of paddy cum rice culture systems is a potential driving factor for economic growth in rural areas. High precipitation during the monsoon season in paddy fields creates ambient environment for propagation of native fishes which can be tapped for economic growth in ornamental fisheries. Currently, the indigenous farming system of capturing fishes in rice fields prevails in rural areas in upper Assam. Roadside canals, *nallahs*, ditches, wetlands, water-logged paddy fields and other seasonal water bodies are very common in the region. Such water bodies can be tapped successfully for culture of small colourful fishes instead of depending on nature for stocking and dispersal of fishes. Fishes adapted to environment of ponds and roadside canals can be utilised for revenue generation. It can be beneficial in comparison to other types of culture system as multiple resources can be cultivated together such as rice cum fish cum duck culture in the same niche. Practising culture techniques such as cage culture and pen culture in the wetlands and paddy fields can be an added advantage for further increase in fish production.

Empowerment of women

Women have been engaged in the fishery sector since time immemorial. It is a well-established fact that women are engaged consistently in different fishery related activities such as sorting, grading, processing, transporting along with marketing of fishes. Engagement of women can be a major boost to the lucrative ornamental fish industry, further supplementing total household income. There is also potential to earn income through preparation of feed, or through integrating ornamental fish culture into existing farming practices. In this regard, transfer of technologies for a wide range of aquaculture techniques from scientific laboratories to agriculture will be greatly helpful in entrepreneurship development and women's empowerment. Establishment of self-help groups and cooperative societies will open up new dimensions that will attract funding support from various government schemes. Successful implementation will enable women to increase household income and purchasing power, increase their status in the society, reduce poverty and better utilise available resources.

Funding agencies

A lot of emphasis has been given to culture of native ornamental fishes of northeast India. A host of national bodies such as NFDB, CIFA, MPEDA, NABARD and also state governments have been consistently providing funding support for the development of ornamental fish culture in the region. They can be approached for grants to set up tanks, breeding unit, marketing chain as well as other expenses. They also train fishermen about different aspect of aquaculture. CIFA in particular have been successful in demonstrating and providing training in culture technologies, integrated fish farming and ornamental fish breeding in the northereastern region of India. Hence, collaboration with these institutes and organisations will augment well for the fish farmers in the region.

Existing constraints

Due to many constraints, the ornamental fish trade in the region has remained very much nascent and untapped. Since more than 95% of the people in the region consume fishes, most native ornamental fishes are primarily utilised as food owing to high price of major carps that are imported from other states of India. Lack of awareness regarding ornamental fishes and their trade is another bottleneck. Consequently, existing fish hobbyists tend to prefer exotic fish varieties to readily available native ornamental fish varieties. Even though the region is endowed with diverse water resources, only capture fisheries persist with no inclination towards culture practices of ornamental fishes. The immediate implication is that most of the water bodies remain unattended and unproductive. Also, almost the entire shipment of ornamental fishes from the region is conducted by traders collecting directly

A seasonal roadside canal which can be utilised for culture of native ornamental fishes.

from the natural water bodies resulting in the depletion of the natural stocks and creating conservation threats as well. Protocols for captive rearing and supplementary feeding with pigment-rich food for locally available ornamental fish species is still a far cry from reality. All these factors together have had a negative impact on the growth of ornamental trade in the region.

Way forward to develop ornamental fisheries

Imparting sound knowledge regarding ornamental fish trade would be the first step towards successful ventures into this lucrative business. Every strata of the society in rural areas need to be educated and provided with technical guidance for sustainable utilisation of water bodies and fish germplasm that is essential for the conservation of the available resources in the region. Strict implementation of existing fisheries and forest acts applicable to fish catch and trade, use of fishing gears and other equipment, prevention of habitat destruction and destructive methods of fishing of native fishes would be immensely helpful in regulating unlawful practices. Furthermore, available breeding and culture techniques, fish management measures, identification and diagnosis of fish diseases and integrated farming techniques needs to be transferred to the fisher communities to encourage them to take part in culture of native ornamental fishes. State Government and other national bodies associated with aquaculture also need to step up their extension services for inclusive growth of ornamental fish trade in the region.

An example of unattended and polluted roadside ditch commonly seen which can be utilised for native ornamental fish culture.

Conclusion

Seasonal water bodies are a potential source of income generation in rural areas. Favourable climatic conditions and availability of huge array of aquatic bodies and fish fauna provides a bright scope for development of culture fisheries in the region. Still being in the nascent stage, culture of ornamental fishes in the seasonal water bodies has the potential to open up opportunities for local people to participate in the ever increasing global ornamental fish trade. A host of other culture practices can be done side by side along with ornamental fish culture. Successful implementation will open doors for income generation; increase returns on available resources; reduce poverty through entrepreneurship development, empower women and potentially contribute to the conservation of native fishes as well.

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Production of tubifex - a new dimension of aquaculture in feeding juvenile fish

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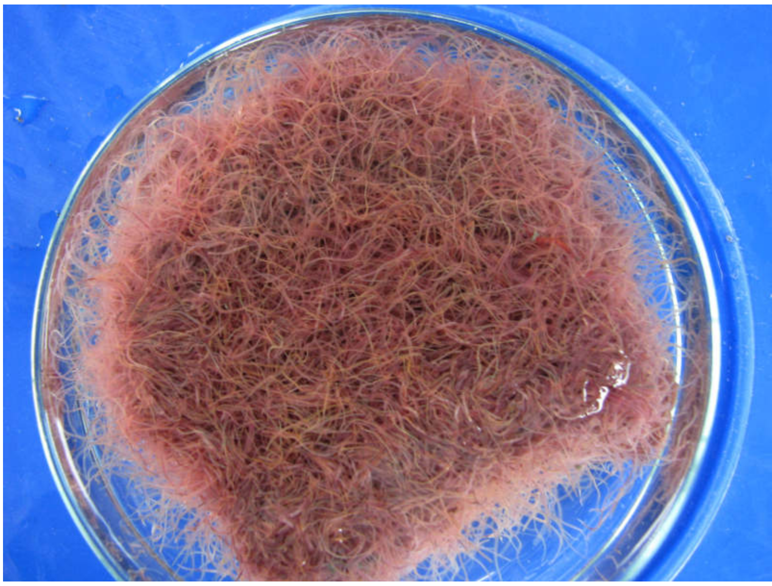
With the expansion of aquaculture, a variety of alternative, low cost feeds are being explored that are cheap to produce. Farmers are in need of appropriate food for spawn, particularly those of catfish species such as *Ompok* spp., *Mystus* spp, *Pangasius* spp., *Clarias* spp., and others such as climbing perch, *Anabas* spp. and murrel, *Channa* spp.

The use of sludge or 'tubifex' worm, *Tubifex tubifex*, as a live food for juveniles has been long practiced in farmers' fields. Behavioural studies have shown that catfish instinctively prefer to accept those food items which are easily detected and captured while swimming, moving or having any type of motility in the water bodies. Larvae are believed to be visual feeders adapted to capture moving prey. Also, the movement of live food is likely to stimulate larval feeding responses. Varieties of ornamental fish are commonly fed with tubifex worm. Tubifex worm is an important food item to freshwater intensive aquaculture throughout the world because of its high caloric value. Significantly, larvae of *Clarius batrachus* feeding upon tubifex had a higher survival rate and ten times more additional growth than those fed formulated fry feed. In such circumstances, a sincere effort is needed to develop the technique suitable to get a reliable supply of tubifex worm to be used as fish food at a large scale to sustain aquaculture, at least to catfish and ornamental fish farming.



Tubifex in a petri dish.

Fish farming and food

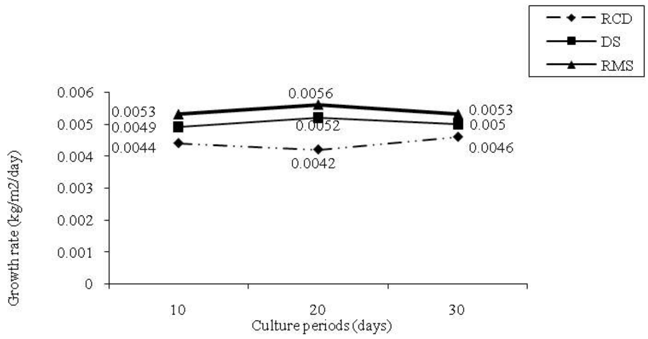
Ornamental fish farming has been recognised as an important trade internationally. Culture of catfish, murrels and climbing

A view of rectangular FRP tanks used for tubifex culture.

Harvesting tubifex.

Harvesting tubifex with nylon net.

perch are in array, particularly in Indian markets. These fishes, known as wild species, are now in demand due to their rich nutritional value, fewer bones, consumer preference and easy digestibility. Their increasing demand to consumers has attracted the attention of farmers for their extensive production. Present day aquaculture is drifting towards the culture of these fishes. With substantial nutritional properties, these fishes can easily be processed for preparation of a variety of value added products and different food items through the process of fortification. Fish farmers are aware of the commercial aspect of these fishes. Farmers need two basic items for their culture: (i) quality seed and (ii) suitable food for rearing of juveniles. Tubifex worm is one of the preferable live foods to feed them.



Growth rate (kg m^{-2}day^{-1}) of tubifex biomass treated with different wastes at 10, 20, 30 days culture.

Why tubifex culture in captivity

Tubifex is found growing naturally in flowing water, particularly in sewage-fed water canals and in open drains. Tubifex has hitherto been supplied from collection of its population from such habitats. During summer, most of the open drains become dry and tubifex becomes scarce with market price becoming so high that common farmers are unable to afford it. There are also some problems in the collection of tubifex from the natural environment: (i) its collection is a most cumbersome task; skilled people can do it from very difficult zone, with risk of skin infection, (ii) lack of tubifex worm purity, and (iii) chance of transmission of fish pathogen from sewage fed water channels. Culture of tubifex in captivity is necessary to meet demand, provide a reliable supply and to assure human and animal health.

Advantages of tubifex culture

Tubifex is also known as sludge worm since it is found growing naturally in sludge loaded with organically rich substances. It grows in a wide spectrum of habitats, with a high level of biological oxygen demand. Its survival is, however, ensured because it is a very hardy organism and can withstand very low oxygen concentrations. On the other hand, there is a variety of wastes and by-products emanating from agricultural-based industries. These wastes along with cattle dung are available in huge quantities from dairy plants, rice mills, distilleries, breweries and food processing plants, etc. There is ample scope to utilise these wastes as nutrients to support the growth of tubifex. Culture of tubifex provides scope to utilise these wastes as food resources.

Harvested tubifex.

Procedure of culture

Selection of wastes

Waste substances were selected based on the easy availability and convenient distance of spective plant units from the Regional Research Centre of CIFA, Kolkata. Raw cattle dung, dairy sludge and rice mill sludge were collected and brought to the wet laboratory of the centre. Known as a suitable organic manure traditionally used in aquaculture, raw cattle dung was used as a food resource after decomposition with water before its use. Dairy sludge was considered as potential food resource in this experiment. After processing of different milk products, dairy effluent is drained out and stored in a large container exposed to the direct sunlight to avoid contamination. This semi-solid substance, stored oxidised dairy effluent, was collected from Metro dairy plants. Rice mill sludge is utilised as organic manure in paddy fields. Rice mill plants produce waste effluent after par boiling of paddy grain. The waste effluent is drained out into marshy places for its temporary storage. Organic substances from the waste effluent are suspended, resulting in a dark brown thick layer of organic matter that was utilised in this experiment.

Experimental design

Three time periods such as 10, 20 and 30 days were conducted separately for this production. Raw cattle dung, dairy sludge and rice mill sludge were tested in respective treatments, each with three replicates. A total of nine FRP tanks were established for each time period, with the 10 day period tests carried out initially, followed by 20 and 30 days. Each tank (2.4 m x 0.67 m x 1.0 m) was manufactured in a specific design with both inflow and outflow facilities. Inflow systems were made with a hole in the width side of tank whereas the outflow system was made in the floor of the opposite side. The hole of outflow was raised to 10 cm height through a plastic pipe adjusted with it. The inflow system was connected with a common PVC pipeline with individual regulatory tap to control water flow. Water was supplied at 0.75 litres per minute initially to avoid the erosion of base media, later raised to 1.2 litres per minute continuously.

Base medium, inoculum, and food substances

The floor of each tank was covered with soil mud containing sand, silt, clay and organic manure. The mud used as base medium was sieved through fine mesh nylon net in order to eliminate coarse and rough materials and allowed to be consolidated, with thickness of 2.0 cm. 100 g of tubifex @ 62.5 g per square metre was inoculated uniformly in each FRP tank covering the entire area. Wastes were applied as feed in each tank two hours after application of inoculum. Each waste (dry weight basis) was applied @ 4.0 g per gram of tubifex on a daily basis. 4.0 kg (4 g of waste × 100 g of inoculum × 10 days) of each waste was utilised for each treatment in 10 days culture. However, for 20 and 30 days culture, the amount of feed provided to the tubifex was adjusted every tenth day based on tubifex sampling in the FRP tanks.

Harvest of tubifex

Tubifex was harvested after the specified time period. Water from each tank was drained via the outflow system. The base media was segmented into five to six parts. The entire content of each part was put in mesh nylon net and washed with water. In the process, base media was sieved through the nylon net, leaving behind tubifex biomass within. Biomass was then collected and put in a beaker with fresh water. This process was continued until the entire biomass of each tank was harvested.

Evaluation

Production

Tubifex biomass production in all the three treatments was found significantly ($P<0.05$) different within respective culture periods. Net biomass production of all three experiments showed that rice mill sludge had the highest efficiency, with dairy sludge the second best and raw cattle dung the poorest.

The most efficient culture period was found to be 20 days of culture for both dairy sludge and rice mill sludge fed treatments ($P<0.05$), producing the most biomass. The growth rate of the same treatments declined thereafter, which was recorded at 30 days culture. On the contrary, the growth rate in the raw cattle dung treatment after 20 days of culture was found to be the poorest ($P<0.05$), but 30 days culture was the most efficient for the dung treatment ($P<0.05$).

Composition of tubifex

Carcass composition (% w/w basis) of harvested tubifex showed that rice mill sludge fed tubifex contained the highest amount of protein (6.38), crude lipid (3.02) and ash (2.98), followed by dairy sludge (protein 5.87, crude lipid 1.29, ash, 2.58) and raw cattle dung (protein 4.02, crude lipid 0.85, ash, 2.43) fed tubifex, respectively.

Tubifex culture – few important issues

Waste substances

Different workers have conducted tubifex culture using mustard oil cake, wheat bran, soybean meal, lettuce leaves and cow dung. All of these resources used as food substances for tubifex culture have substantial market price and need to be procured. The majority of fish farmers want

Dr. Meena Kumari, Former DDG (FY), ICAR observing tubifex production.

cheap substances which are easily available. Farmers find difficulties when any resource utilised for fish culture is costly one. However, both dairy sludge and rice mill sludge are easily available in huge amounts in respective production units and have also been found to be effective food substances for production of tubifex. Use of the waste substances is economical since no monetary transaction is involved.

Duration

Tubifex is considered as an essential food item. The duration of culture is an important factor for obtaining desirable product with optimal quantity in convenient time. The present experiment advocates 20 days as an ideal period for obtaining optimal production of tubifex subject to utility of dairy sludge and rice mill sludge as food substances. Comparatively, this experiment shows that the best yield is achieved despite the reduction of a number of days in culture purposes, particularly in dairy sludge and rice mill sludge treatments. Longer culture periods can lead to lower growth rates. The shorter duration brings advantages like less time required for management in the production system, along with other recurring expenditures.

Conclusion

Tubifex is an important fish food for spawn rearing. This needs to be produced by utility of suitable methods that are economically viable. Two important matters are to be considered for this production system. The easy availability of resources used as food substances for biomass production; poultry litter and other by-products may be tested subject to their ready availability in adequate quantities and non-toxic nature. A short culture duration also important to minimise use of labour and reduce risk, and to maximise yield and save water and electricity.

Invasive apple snails (*Pomacea* spp.) in Brunei Darussalam: Current status and management in irrigated transplanted rice fields

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Invasive apple snail egg masses on vegetation along an irrigation canal, Brunei Agricultural Research Centre, Brunei Darussalam. (Credit: Norkhadijah binti Haji Latip).

History and spread

Freshwater invasive apple snail (*Pomacea* spp.), family Ampullariidae, was first recorded in 2009 at the Wasan Paddy Plantation Area, Brunei Muara District, Brunei Darussalam. However, it was not introduced intentionally with a definite purpose; unlike in other ASEAN countries, where they were deliberately introduced for food aside from the aquarium trade (Cowie et al, 2017). Communities in Brunei Darussalam have never recognised *Pomacea* spp., as a food source, although there are several other snail species which are considered as traditional gastronomies. Two species of Pomacea namely, *Pomacea canaliculata* and *Pomacea maculata* have been recorded from Malaysia (Yahaya et al, 2006; Hayes et al, 2008; Arfan et al, 2014; Yahaya et al, 2017). *P. canaliculata* and *P. maculata* have commonly been referred to as golden apple snails, often without clarifying specifically which species, or if both, were involved, or indeed simply assuming it to be *Pomacea canaliculata* (Cowie et al, 2017). For clarity, this article avoids this ambiguous common name designation.

In Sabah, these snails were first sighted in Keningua in the early 1990s, and in Sarawak they were reported in Ba Kelalan in the Limbang Division in 1997 (Teo & Nur, 2017). Brunei Darussalam is right next to Sabah and surrounded by Sarawak, East Malaysia. Therefore, their accidental introduction is likely from a neighboring country.

The Fourth National Report Convention on Biodiversity, Brunei Darussalam, Forestry Department (2010) simply lists Golden Apple Snail, *(Pomacea canaliculata)* and Black Apple Snail *(Pomacea insularus)*, as invasive alien species, with no details. In addition, the use of common terms “Golden Apple Snail” and “Black Apple Snail”, and “insularum” (junior synonym of *maculata*), incorrectly spelled as “insularus”, which added further confusion to the species identity.

A preliminary checklist of the freshwater gastropods of Brunei Darussalam has been documented by Ng et al, (2015). Based on the examination of one empty Pomacea shell collected along edge of mangrove forest on Pulau Bedukang, they

Dead invasive apple snails in the newly transplanted rice treated with synthetic molluscicide, Wasan Rice Plantation Area, Brunei Darussalam. (Credit: Siti Amaniah binti Haji Awang Besar).

could not verify it as either *Pomacea canaliculata* or *Pomacea maculata* (Ng et al, 2015). Exact species determination based on the shell alone is difficult (Hayes et al, 2012).

Therefore, it is very difficult at this time to pinpoint the exact pathways, source of introductions, and the number of *Pomacea* species that have invaded Brunei Darussalam, unless preserved specimens are examined using molecular and morphological approaches (Hayes et al, 2008). Identification of invasive species is one of the most fundamental needs when attempting to manage them (Joshi et al, 2017).

Rice cultivation in Brunei Darussalam

Rice is cultivated in two types of areas, namely irrigated and non-irrigated (rain fed) areas. Farmers in irrigated areas practice double cropping while farmers in non-irrigated areas produce only one crop per year which is in the main season. The main season spans September to February, whereas the off-season is usually from April to August. In 2016, the total rice cultivation area was 1,013 ha where 427 ha were irrigated, while the remaining 586 ha were rain fed. The majority of the farmers practiced transplanting methods either using mechanical transplanters or manual transplantation. However, there are a few farmers who practice direct-seeding methods either by dibbling, broadcasting or using drum seeders. Since more than half of the area is non-irrigated and depends greatly on rainfall, the rice planting and harvesting months varies within a year with the changing weather conditions. The most common rice varieties planted and their average yield/ha are as follows: MRQ76 – 4mt/ha/season and Laila – 3mt/ha/season in irrigated areas, while in rainfed areas, BDR5 – 2mt/ha and traditional landraces such as Pusu, Adan and Bario – 1mt/ha are used. Total rice production expenses per hectare are about BND 5,476.25 (USD 4,102). An estimated revenue in each cropping season/ha is BND 4,800 (USD 6,384) for the irrigated areas and BND 1,600 (USD 2,128) for the rainfed areas. The Government of Brunei Darussalam through the Department of Agriculture and Agrifood buys the paddy from the farmers at BND 1.60/kg under the Paddy Buyback Scheme. After milling, the rice is sold to the public at BND 1.25/kg.

Impact of invasive apple snails

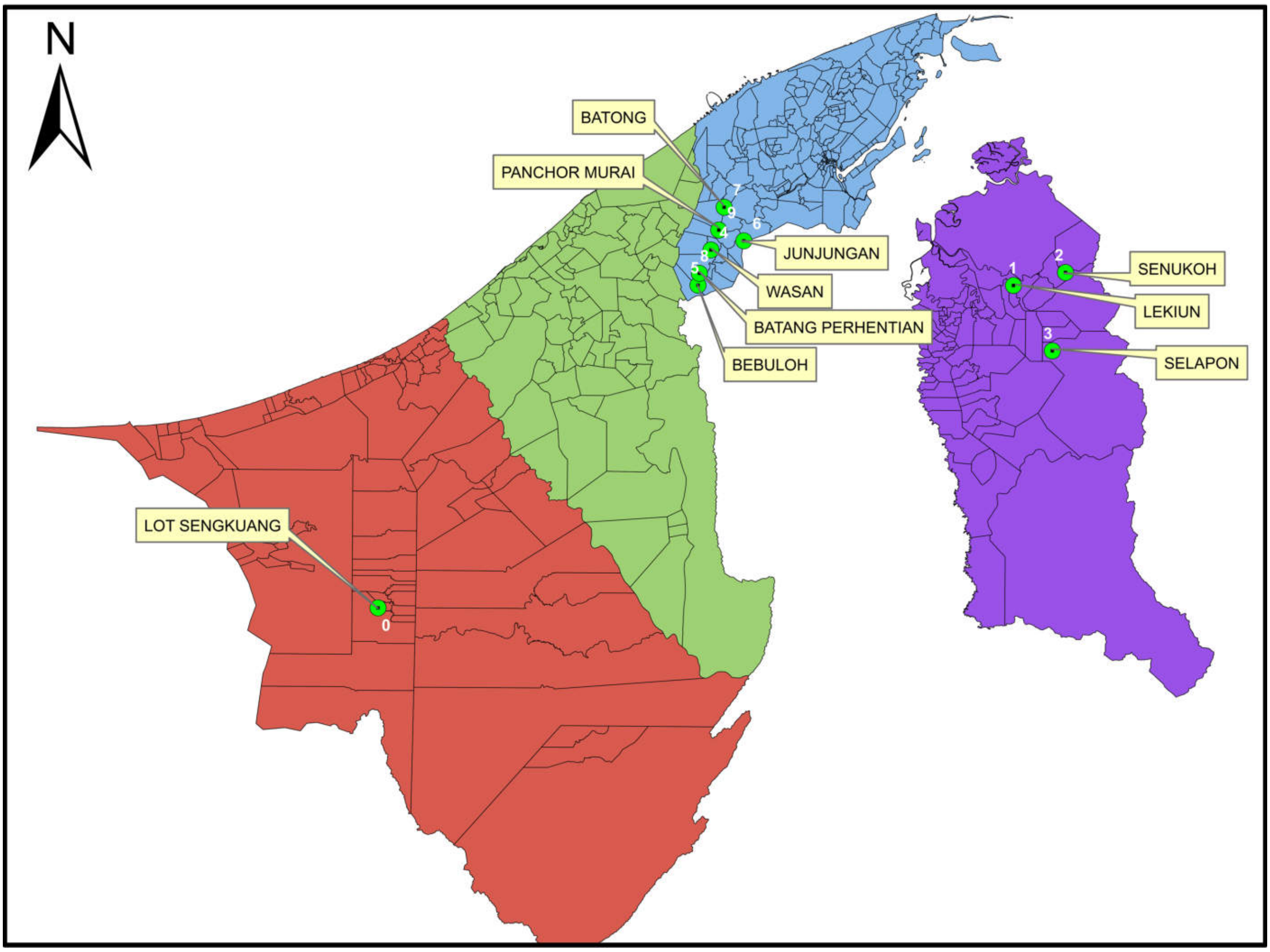
Since its first reported occurrence in Wasan Rice Plantation Area, Brunei Muara District, Brunei Darussalam, there has been no systematic surveys or crop loss analysis to determine the rice areas invaded and destroyed. However, snails are present in all rice fields of four districts and estimated to cause 10-20% damage/ha to newly transplanted rice.

Control of invasive apple snails

The main infested areas are located on the east side of the country, which are mainly irrigated, and where the molluscicides are used. Molluscicides registered in Brunei Darussalam are niclosamide ethanolamine (traded by Bayer Company, Malaysia as Bayluscide in 250g package costing BND 46.00) and metaldehyde (traded by Hwa Hong Trading, Malaysia in 500g package costing BND 1.60-4.50), of which niclosamide is used in rice fields at the rate of 0.315kg/ha, and metaldehyde (Trade names: Siputox, Racun Siput Berbutir), on vegetables and fruit farms at 15-20 kg/ha, but it is likely some rice farmers would have also used metaldehyde in paddy fields. Both molluscicide formulations are sold under Government Incentive Program and the annual estimated average volume was 90.25 kg, based on the Government Agricultural Input Scheme records from 2013-2015. The expenses for crop protection products, are estimated to be BND 400.00/ha, with farmer average spending of about BND 50.00 for molluscicides. Most molluscicides are applied twice per season, during the first month after transplanting, when snails devour young rice seedlings.

Conclusions

Invasive apple snails have spread across both irrigated and rainfed rice areas in Brunei Darussalam since they were first detected in 2009, causing serious crop losses and



Map of rice growing areas in Brunei Darussalam.

increasing reliance on the use of synthetic molluscicides. Aside from direct rice damage, the other negative impacts on non-target fauna and flora including human health and the environment is still unknown. Thus, long-term control and containment is needed to reduce ecological and economic losses. International collaboration with infested countries in ASEAN region is needed for accurate species identification, and for better understanding of invasion biology in order to develop effective ecologically sustainable snail management integrated approaches.

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Aquaculture: A new trend and a big opportunity in Sindh, Pakistan

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Pakistan is an agricultural nation, with 70% of the population living in rural areas and engaged in the agriculture and fisheries sectors. In recent times, food security has become a major issue and challenge with the rapidly increasing global population anticipated to reach 9.6 billion people by 2050. As a result, poverty, unemployment and hunger are likely to remain pressing issues. The situation is alarming and has raised great concerns for governments and development agencies. With regards to foodfish, there is only one viable option, namely aquaculture, which is likely to play a significant role in mitigating the aforesaid concerns and meeting the increasing global demand for food.

Fish plays an important role in the diet of the people worldwide. It is a very rich source of essential nutrients and animal protein. A deficiency of dietary protein in humans leads to malnutrition, weakness, high infant mortality and health problems with the eyes, liver, kidneys, bone breakage and memory loss. This situation can be tackled by increasing food fish production through widely introducing, practicing and promoting community based fish farming in the hook and corner of the country. Aquaculture is a very viable method of food (protein) production, about seven times more efficient than cattle production, four times more efficient than pork, three times more efficient than raising pigs and one and a half times more efficient than raising chickens. Therefore increasing the consumption of fish is, relatively speaking, a good alternative for food security. Fish provide an essential source of income and contribute to reducing poverty in many parts of the developing world. The growth in aquaculture has been identified as a key driver in boosting the global per capita consumption levels of fish.

In Pakistan, Sindh Province is very rich in aquatic resources and has a strong irrigation network based on the Indus River, canals, barrages, reservoirs, lakes, waterlogged areas and village ponds. Beside this, the land of Sindh is very fertile for fish farming and therefore the majority of fish farms are located in Thatta, Badin and Dadu districts through which the Indus River passes. Badin and Thatta have waterlogged floodplain areas which are very suitable for fish farming. About 6,000 fish farms with an average size of 5-10 ha are functionally operating across the province and employing 20,000 people in this industry. Finally, the province and its districts have the greatest potential and huge opportunities for the sustainable aquaculture growth and development.

Farmers after facing immense agricultural problems, now are considering the aquaculture is the best alternate option for them. Aquaculture is a fast growing industry and is attaining a great significance in most of the rural villages of Sindh.

A new trend has been developed among the majority of land owner-farmers, so called agriculturists, who give their preference to convert and utilise their lands for aquaculture farming/production. From their point of view, it provides high yields and profit in less time with low physical and financial input and management; it also offers a good future and potential for small farmers. In the current environmental conditions, it is a relatively low risk and highly profitable business famously practiced throughout the province.

Carps are one of the most farmed groups of fish throughout globe. Commercial pond carp culture has significantly expanded and is now widely practiced in Sindh. It has been considered a very popular aquaculture production method by which different carps species are commonly cultured together in the earthen ponds in a polyculture system, which is relatively environmentally friendly. It is observed that most of fish farmers practicing carp aquaculture are selecting, rearing and harvesting indigenous freshwater species of Indian major carps such as, thela *(Catla catla)*, rohu *(Labeo rohita)*, morakhi *(Cirrhinus mrigala)* and common carp *(Cyprinus carpio)* along with exotic Chinese carps namely grass carp *(Ctenopharyngodon idellus)* and silver carp *(Hypophthalmichthys molitrix)*.

As a result of carp farming, farmers have been getting high profits and successful high fish production from their ponds, which are properly sited and built with careful assessment of water availability, quantity, quality, pond fertilisation, stocking, feeding and harvesting. One reason for the success is that farmers have been gathering scientific information, improving their knowledge and enhancing their capacities to practice commercial aquaculture.

Freshwater/inland fish farming is under the control of the provincial fisheries department who supply seed, operate hatcheries, provide extension services and facilitate interest free loans, and collect primary data. The department also promotes community based fish farming through extension manuals, brochures, case studies, exposure visits and by organising capacity building workshops and seminars with aim to practice and promote fish farming on modern methods and techniques based on scientific technology. In this connection, many fish farmers are connecting with the department to get assistance to expand aquaculture operations in their respective areas. The contribution of inland fish production from aquaculture to the country's GDP is growing yearly, with production increasing from 142,724 to 185,000 tonnes during 2012 to 2016.

Aquaculture as part of fisheries plays a modest role in increasing the national economy of Pakistan. Therefore, the main objectives of community based aquaculture development turn around ensuring food security, improving the financial status and well being of rural farmers and their families, reducing poverty and malnutrition, increasing export earnings and creating employment opportunities through expansion of the industry. This can be possible by utilising empty state land for aquaculture purpose and moreover improving the sustainability of our waters in terms of freedom from pollution, overfishing and ecological degradation so that, many benefits can easily be obtained for poorest people whose dependency is often based on these resources.

Aquaculture Production of Pakistan										
Year	**2016**		**2015**		**2014**		**2013**		**2012**	
Culture type	Production (tonnes)	%	Production (tonnes)	%	Production (tonnes)	%	Production (tonnes)	%	Production (tonnes)	%
Freshwater	185,000	99.93	151,055	99.92	148,266	99.92	148,008	99.92	142,724	99.92
Marine	123	0.07	119	0.08	115	0.08	112	0.08	108	0.08
Total	185,123		151,174		148,381		148,120		142,832	

Source: FAO-National Aquaculture Sector Overview Pakistan

Finally, the author urges provincial and federal government to drive their serious attention, invest resources and assist farms to implement good practices in planning, management and providing guidance to further expand the industry on a large scale as to further utilise the significant area of unexploited water bodies for sustainable community based aquaculture throughout Sindh Province, with a view to increasing the economic benefits for the national economy and for reduction of poverty and improved wellbeing among communities at the local level.

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NACA Newsletter

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29th Governing Council Meeting held in Malé, Maldives

NACA's 29th Governing Council Meeting was held in the Maldives capital, Malé, from 26-27 June, with attendance by fifteen member governments, the Regional Lead Centres for China, India, Iran and Thailand, the Food and Agriculture Organization of the United Nations (FAO) and the Southeast Asian Fisheries Development Center (SEAFDEC).

The incoming Chair, Dr Shakeel Hassan, Senior Biologist for the Marine Research Centre, Ministry of Fisheries and Agriculture, welcomed participants to the Maldives. The outgoing Chair, Dr Md. Goljar Hossain, Director General of the Department of Fisheries, Bangladesh, made introductory remarks. China was elected as Vice Chair for the meeting.

The meeting was opened by Dr Mohamed Shiham Adam, Maldives. The Director General of NACA, Dr Cherdsak Virapat, presented a gift to the Government of the Maldives, which was received by the Hon. Shah Ismail, Deputy Minister. The Hon. Adam Haleem, Deputy Minister, presented delegates and partner organisations with a souvenir.

This was the first official NACA meeting in the Maldives, since it became a member in 2014, and also the first time that most of the delegates had visited the country, affording participants a fascinating glimpse of a very different lifestyle in the archipelago, and a very different development context.

Members discussed priority issues for the year ahead and opportunities to collaborate. As always, animal health issues continue to be a challenge, but the usage of anti-microbial substances in aquaculture and the consequent development of anti-microbial resistance were considered to be an issue of great concern, given the potential impacts on human health.

Many members are currently taking stock of practices in the aquaculture sector and ramping up awareness campaigns to encourage responsible usage of chemicals and alternatives such as better management practices, aimed at improving the health status of animals and reducing risk of disease naturally. This work is happening as part of a coordinated effort across all livestock sectors and the human health system as well.

Aquatic genetic resources were also a hot issue. There is increasing awareness of the need to improve management of genetic resources. There are massive unrealised gains to be had through the development of genetically improved varieties with superior production characteristics, or even simply through avoiding inbreeding depression. The conservation of wild aquatic genetic resources is also gaining attention, with increasing awareness of the potential impacts of stock enhancement programmes, particularly on threatened species. FAO informed the meeting that the first global report State of the World's Aquatic Genetic Resources for Food and Agriculture is being readied for publication, based on reports from 92 governments that collectively represent around 96% of global aquaculture production.

There was widespread support for continuing work on the development of culture-based fisheries; prior work undertaken years ago in Lao PDR under Prof. Sena De Silva's initiative continue to spread organically as neighbouring villages take up the practice after observing the benefits. Members have also made substantial progress in revising legal frameworks governing aquaculture, notably in Thailand, to improve the basis for regulating the industry. There was renewed interest in strengthening cooperation in mariculture development, with the Maldives offering considerable opportunity for exchange.

A key recommendation from the meeting was to investigate the possibility of convening a global "Aquaculture +20" conference to take stock of the sector, building on the previous series of development-oriented conferences beginning with the "Kyoto conference" in 1976, the "Millennium conference" held in Bangkok, 2000, and the "Aquaculture 2010" conference held in Phuket.

On behalf of the members, NACA wishes to thank the Government of Maldives and the staff of the Marine Research Centre and Ministry of Fisheries and Agriculture for their kind assistance in organising the meeting and excellent hospitality and hosting arrangements.

Proceedings of the Emergency Regional Consultation for Prevention and Management of Tilapia Lake Virus in the Asia-Pacific

Since 2009, tilapia aquaculture has been threatened by mass die-offs in Israel and Ecuador, caused by a novel Orthomyxo-like (RNA) virus named tilapia lake virus (TiLV). This has been reported as a newly emerging virus that causes syncytial hepatitis of tilapia (SHT). As of 2016, countries affected by this emerging disease included Israel, Ecuador, Colombia and Egypt. In 2017, Thailand and Taiwan, Province of China confirmed the presence of the virus among farmed tilapia, which was also causing mass mortalities. These were the first reports of the disease in Asia-Pacific Region. In response to this, NACA released a disease advisory as part of an awareness programme in the region. The advisory has been widely disseminated to all NACA member countries, partner institutes and other interested parties in the region and beyond. Moreover, FAO has circulated a special alert on TiLV, OIE published a technical disease card, while WorldFish prepared a TiLV Factsheet and CGIAR published a TiLV Literature Review (please see the link below to download these publications).

As tilapia is a highly important aquaculture species in the region, it is highly necessary to contain the disease in affected countries, and to prevent its spread to major tilapia-producing countries in the region. As such, countries in the region should be able to harmonise efforts in preventing the entry of the pathogen through stricter quarantine and biosecurity measures.

In this regard, an Emergency Regional Consultation for Prevention and Management of Tilapia Lake Virus in the Asia-Pacific was undertaken to discuss and plan actions on the overall prevention and management of the disease. The Consultation focused on the following:

- Implementation of proper quarantine and biosecurity measures, as well as responsible movement of live tilapias within the country and across the region.
- Strengthening of diagnostic capacities as well as active surveillance of the disease.
- Formulation of recommendations on the sanitary measures for disease prevention.
- Emergency preparedness for countries not yet affected by the disease, considering the capacity of each country.

As tilapia is a common food for many people in the region, especially among rural communities, emergency preparedness will make a big impact in the management of this emerging threat for tilapia aquaculture.

Keynote presentations covered the overall status of tilapia aquaculture in the region, major diseases affecting cultured tilapia, an overview and status of TiLV in the region (and the world), the role of trade in the spread of transboundary aquatic animal diseases, and risk assessment and biosecurity as preventive measures in the spread of the disease. Status of and plans of action for management of TiLV in eight countries in the region were also presented and discussed. These included China, India, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Viet Nam. The panel discussion dealt with relevant issues on the management, prevention and control of TiLV including the formulation of a regional plan for prevention and control of TiLV; research gaps and priorities; surveillance and reporting; listing in OIE; and the way forward.

Based on the presentations and panel discussions, recommendations were made to further understand and manage TiLV in the region. For disease surveillance and diagnosis, a standard diagnostic test is still needed. There is also a need to set up two working groups to deal with TiLV investigations, one for national surveillance and another for the development of standard operating procedures for biosecurity. Understanding the genetic variations of the virus, carriers (sub-clinically infected fish) and susceptibility of other fish species to the virus are also important. Similarly, research studies should focus on validation of diagnostic tests (study of coinfection of virus and bacteria; survival of virus in frozen sample; abundance of virus in muscle tissue; the relationship between host and pathogen; phylogenetic analysis of different strains; and susceptibility of marine ornamental fishes). It is also necessary to know whether the virus is already present in the natural aquatic environment, and to identify the root cause of the disease. As the clinical signs appear to be non-specific which causes confusion, it might be worthwhile to pay attention to several areas including unbalanced "complete" feeds which might cause nutrient deficiencies, and environmental parameters that might trigger disease outbreak and proliferation of the virus.

The proceedings and other documents mentioned are available for download from:

https://enaca.org/?id=986

NACA signs MOU on cooperation with the Bangladesh Shrimp and Fish Foundation

An agreement on cooperation between NACA and Bangladesh Shrimp and Fish Foundation (BSFF) was signed in May. BSFF is a non-profit business support foundation dedicated to the growth of the fisheries and aquaculture sector of Bangladesh with regards to economically, socially and environmentally sustainable development. The ultimate objective of BSFF, in common with that of NACA, is to reduce poverty and improve economic development.

BSFF conducts research, studies and training in collaboration with public, private, regional and international organisations. In particular, BSFF provides support to improve and sustain the shrimp and fish based industry in Bangladesh, related export growth, food security and consumer needs, and environmental sustainability.

Through signing the MOU, both parties have agreed to collaborate on promoting better management practices, traceability, genetic improvement of shrimp, aquatic animal health and climate change issues. The organisations will facilitate technical exchange of information and personnel necessary to implement these activities.

Aquaculture in China: Success Stories and Modern Trends

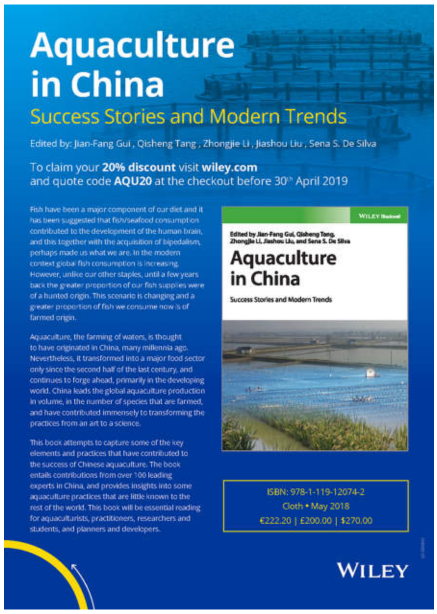
Fish have been a major component of our diet and it has been suggested that fish/seafood consumption contributed to the development of the human brain, and this together with the acquisition of bipedalism, perhaps made us what we are. In the modern context global fish consumption is increasing. However, unlike our other staples, until a few years back the greater proportion of our fish supplies were of a hunted origin. This scenario is changing and a greater proportion of fish we consume now is of farmed origin.

Aquaculture, the farming of waters, is thought to have originated in China, many millennia ago. Nevertheless, it transformed into a major food sector only since the second half of the last century, and continues to forge ahead, primarily in the developing world. China leads the global aquaculture production in volume, in the number of species that are farmed, and has contributed immensely to transforming the practices from an art to a science.

This book attempts to capture some of the key elements and practices that have contributed to the success of Chinese aquaculture. The book entails contributions from over 100 leading experts in China, and provides insights into some aquaculture practices that are little known to the rest of the world. This book will be essential reading for aquaculturists, practitioners, researchers and students, and planners and developers.

To order the book please download an order form from:

https://enaca.org/?id=987



Quarterly Aquatic Animal Disease Report, October-December 2017

The 76th edition of the Quarterly Aquatic Animal Disease Report contains information from 14 governments. The foreword discusses the outcomes of a Stakeholder Consultation on Progressive Management Pathway to Improve Aquaculture Biosecurity, organised by the Food and Agriculture Organization of the United Nations, Mississippi State University and the World Bank. The report is available for download from:

https://enaca.org/?id=988

Gender in Aquaculture and Fisheries 2018: Early registration closing soon!

The 7th Global Symposium jointly organised by Gender in Aquaculture and Fisheries Section of the Asian Fisheries Society and Asian Institute of Technology (AIT) will be held at AIT, Bangkok during 18-20 October 2018. GAF conferences endeavour to explore the expanding horizons of gender dimensions in aquaculture and fisheries, while highlighting the need for expanding gender inclusiveness and equity.

Renowned researchers from around the world will present papers on various topics related to gender issues in aquaculture and fisheries policy and practice and will also deliver plenary and keynote addresses.

The conference provides a platform for the dissemination of current knowledge and exchange of information among all those involved in the fisheries and aquaculture industries.

We look forward to participation from everyone involved in fisheries and allied industries, including researchers, academics, students, entrepreneurs and fishers to make this event a great success.

All presenters are required to register in order to secure your presentation slots. We strongly advise you to take advantage of the early bird discount rate. Online registration can be made at the GAF website. Please note, there will be no further extension of the early bird registration deadline after 15 July 2018.

A few more rooms are available at the venue hotel. Please check the accommodation page and book early to avoid disappointment.

Should you need further information, kindly contact the Conference Secretariat: info@gafconference.org, or visit the conference website at:

https://www.gafconference.org/register.htm

International Training Course on the Biology and Pathology of Penaeid Shrimp

The Center for Excellence for Shrimp Molecular Biology and Biotechnology (Centex Shrimp) will organise this training course from 10-21 September, 2018.

Tailored to those involved in shrimp research, you will learn from the very best in the field about major and emerging shrimp diseases, shrimp farm management, gross inspection and molecular diagnosis of shrimp infectious diseases.

You will have opportunities to try your hand in a series of practical sessions, including anatomical inspection using digital slides, nucleic acid detection, and many more.

For those wanting to experience the “real” shrimp farming, the course will include an excursion to a local shrimp farm, so that you can see for yourself the nooks and crannies of farm operations and talk face-to-face with experienced farmers.

And if that leaves you wanting more, a two-day optional trip to Surat Thani is available to visit one of the most successful shrimp farms in Thailand.

Registration is open until 20 August. For more details, please email sccentexshrimp@mahidol.ac.th, call on +66 2 201 5871 or visit:

https://enaca.org/?id=991

Apply now: ASEAN-India Research Training Fellowships

Fifty fellowships are available for young scientists and researchers under the ASEAN-India Research Training Fellowship Scheme (AIRTF), to study at Indian academic and R&D institutions. The fellowships are for a period of up to six months and include travel and financial support.

The fellowships are intended to build capacity among young ASEAN researchers in science and technology and to further strengthen the bond between India and ASEAN member states. Fellows will have the opportunity to conduct research under the guidance of a host scientist in India in order to advance their own research capabilities while fostering scientific and technological cooperation between ASEAN and India.

Applicants must be nationals of ASEAN member states, under 45 years in age and hold a Masters Degree in science, technology/engineering, medicine or allied disciplines. The area of research must be ASEAN-centric and aligned with the ASEAN Plan of Action on Science, Technology and Innovation, which includes the agricultural sciences. For more information, or to apply online, please visit the ASEAN-India website:

http://www.aistic.gov.in/ASEAN/aistdfFellowship

EURASTiP Exchange Programme Grants

The EURASTiP Exchange Programme provides opportunities for industry, researchers and educators from Europe and south-east Asia to connect and gain new perspectives while sharing innvovative ideas to help develop long term partnerships. Bursaries of up to €3,000 per exchange are available (subject to eligibility criteria) to support international innovation and collaboration.

The deadline for applications is 20 September 2018. Eligible NACA member states include Bangladesh, Cambodia, Indonesia, Lao, Malaysia, Myanmar, Philippines, Thailand and Vietnam.

EURASTiP is an EU-funded H2020 project promoting multi-stakeholder contributions to international cooperation on sustainable solutions for aquaculture development in south-east Asia. For more information about the programme and how to apply please visit:

http://www.eurastip.eu/exchanges

Urgent action on risks to aquaculture workers needed, study finds

Health and safety within the global aquaculture industry is widely overlooked – despite the sector posing a great risk to workers, according to University of Stirling-led research.

The project found the world's estimated 18 million aquaculture workers regularly contend with "highly hazardous" conditions and workplace injury and disease risks are high.

While some aquaculture workers are highly trained and in secure jobs globally, most are from vulnerable populations in precarious work, including women, indigenous people, children, seasonal workers, migrant workers, rural and remote workers.

Unfortunately, occupational safety and health (OSH) hazards may at times also be associated with other labour exploitation issues, such as forced labour, child labour, debt bondage, discrimination, and denial of rights to association and collective bargaining negotiations and labour agreements.

However, it added that "many risks remain either neglected or unaddressed" due to gaps in knowledge, as well as limited independent analysis of prevention and risk reduction strategies.

Professor Andrew Watterson, of the Occupational and Environmental Health Research Group at Stirling, coordinated the project, involving a number of international partners. He presented the findings during a keynote speech at the International Fisheries Safety and Health Conference, in Canada, today.

Professor Watterson, of the Faculty of Health Sciences and Sport, said: "Our research found many gaps in our global knowledge of the working conditions of the world's 18 million aquaculture workers; the hazards they face; the injuries and diseases they suffer; and the risk management systems used to protect them.

"Independent analysis of prevention and risk reduction strategies adopted is limited. This emerges in all the national and regional profiles compiled for this report."

He added: "Aquaculture occupational health and safety is frequently marginalised or lost by government, industry and sometimes labour organisations. This contrasts with the wider importance and funding given to production, cost, food safety, sustainability and wider environmental issues within the sector."

The research also found that the human, social and economic toll of poor health and safety within the industry is either known to be or likely to be "considerable" for workers directly through occupational injuries and illnesses, and indirectly through low wages, long hours, job insecurity and poor welfare and social security.

Launched in December, the desk-based project looked at issues along the primary aquaculture supply chain, in marine and freshwater locations. The report includes discussion of the hazards of stock-holding units like ponds, racks and cages – as well as feeding, harvesting, processing, and transport of produce. It also explored workplace injuries in the sector relating to machinery, tools, boats, vehicles, drowning, falls, electrocution and bites.

Despite the gaps in knowledge, the team found that, in some parts of the world, practical solutions now exist to remove or reduce many sectoral risks.

"Policies and practices based on good regulations, monitoring and enforcement underpinned by effective industry, community, and labour engagement, research and knowledge transfer appear to have been successfully adopted in some countries and some production systems," Professor Watterson said.

The study found codes on occupational health, human rights, and "decent work" programmes from the International Labour Organisation and Food and Agriculture Organisation (FAO), of the United Nations, could be effective ways of addressing and raising weak standards.

Professor Watterson said: "These programmes, if linked to relevant ministries – such as labour, health and social security – may be able to contribute to progress."

He added that successes identified included: (i) workforce OHS agreements with European aquaculture companies operate in developing countries such as Ghana; (ii) extension services work well in some US states; (iii) technological innovations and hazard assessment in Norway linked to regulation, (iv) Canadian technology innovations have succeeded in reducing hazardous exposures, (v) changed South African occupational health and safety management have improved practices, (vi) Scottish and UK tripartite body initiatives have improved knowledge exchange.

The team included Lissandra Cavalli, from Brazil; Mohammed Jeebhay, South Africa; Rebecca Mitchell, Australasia and New Zealand; and Barbara Neis, Canada.

The project was funded by the FAO of the United Nations, and administered by the International Union of Food, Workers.

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