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AQUACULTURE ASIA

Poor farmers culture tilapia intensively in Philippines

Seahorse biodiversity and conservation in India

Establishing post-tsunami rehabilitation information units

Simple herbal treatment for EUS

Role of immunostimulants

Red tilapia cage culture, Thailand

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Editor
Simon Wilkinson
simon.wilkinson@enaca.org

Editorial Consultant
Pedro Bueno

NACA
An intergovernmental organization 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
Email
simon.wilkinson@enaca.org
Website http://www.enaca.org

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Changes

Some changes are in store for the magazine in 2007. One of the most notable will be the incorporation of the NACA Newsletter as the news and events section within the magazine itself, with greater coverage of local news and events from research centres throughout the region. We will endeavor to increase the diversity of articles from different countries as well as to expand coverage of genetics and biodiversity issues; nutrition; and of mariculture issues to include more on non-finfish species. Additionally, new publications made available for free download on the website will be listed in a section the magazine to help our readers find them. So if you have a story to tell about aquaculture in your part of the world, particulary in relation to the above issues please download a copy of the Guidelines to Authors from the NACA website or request a copy by post or email.

The NACA website is also undergoing some modifications. The most substantial of these is the development of 'subportals' dedicated to particular topics. These sub-portals will filter out all the information and resources on major topics to help with specific interests find the information relevant to their needs. The first subportal to be released is on Genetics and Biodiversity, and is now accessible from:

http://www.enaca.org/modules/tinyd5/

Subportals on Marine Finfish Aquaculture, Shrimp Farming and the Environment and Aquaculture Certification (which will provide a summary of current aquaculture and fisheries certification schemes in addition to the normal news, publication and forum services) will be available by the end of the year, although subportals will eventually be developed for all NACA programmes.

We have also added a new Regional Lead Centre (RLC) section of the website for our RLCs in China, India, Thailand and the Philippines. This provides information about the major activities of each RLC and contact details for further information, as well as links to the websites of other participating research centres in the network, so it also serves as a contact directory for those with a website presence. If your centre is developing a new website please make sure we know about it and we'll include a link:

http://www.enaca.org/modules/smartpartner/

That's all for 2006. As this is the last issue I take this opportunity to wish you a Happy New Year and I'll see you in early 2007.

Simon Wilkinson

AQUACULTURE ASIA

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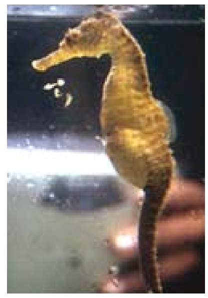

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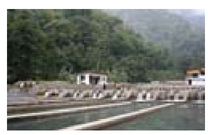

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Resources and biodiversity of seahorses and the need for their conservation in India

K.R. Salin[1] and Nair C. Mohanakumaran[2]

1. KVK, Regional Agricultural Research Station, Kerala Agricultural University, Kumarakom PO, Kottayam 686 566, Kerala, India, email salinkr@vsnl.com; 2. College of Fisheries, Panangad PO, Kochi 682 506, Kerala, India.

The family Syngnathidae includes some of the most fascinating fishes including seahorses, pipefishes and dragon fishes. Seahorses are usually found in shallow coastal, tropical and temperate seas of the Indo Pacific region at depths ranging from 20 to 150 metres. Apart from their use as a favourite group of ornamental fish, and dried curios, the greatest use of seahorses is that they are the major constituent of some of the most evolved traditional medicine systems of the world such as traditional Chinese medicine and its Japanese and Korean derivatives, Jamu medicine in Indonesia and folk medicine in the Philippines. The perceived medicinal properties of seahorses have led them to be extensively in traditional medicines as a treatment for a wide range of ailments including asthma, arteriosclerosis, impotence, incontinence, thyroid disorders, broken bones, skin ailments and heart diseases (Vincent, 1995).

Seahorses are exclusive predators of live prey; lacking teeth or a stomach, and possessing unusual grape-like gills. They are well known for their extreme and unusual body shapes such as horse-like heads, grasping tails, kangaroo-like brood pouch, independently moving eyes similar to those of a chameleon, and small fins emerging from slits in their bony external armour. They exhibit one of the most peculiar examples of paternal care, in which the male fertilizes and broods the eggs, which are produced and deposited into its pouch by the female during courtship and mating, and in turn delivers the hatchlings after a long period of pregnancy and labour. Seahorses are also ecologically important being major contributors to the nutrient dynamics in sea grass communities.

All seahorses belong to one genus *Hippocampus*, in which there are 34 species recognised all over the world (Lourie et al., 1999; Lourie & Randall 2003; Lourie et al., 2004; Project seahorse, online 2006). Seahorses can camouflage themselves through frequent colour changes and by growing skin filaments giving them a weedy appearance and helping them to merge with their surroundings, abilities that can also make it difficult to identify different species. Despite their small size, seahorses form a valuable fisheries resource in some areas and support a sizeable international trade. They can command very high prices and provide subsistence income for many fishing communities. The world trade of dried seahorses was estimated to be over 25 million individuals (more than 70 metric tonnes) in 2001, a great majority of them for use in traditional Chinese medicine (Project seahorse, online 2006). At least 77 countries or territories were known to sell or buy seahorses. The largest known net importers are China, Hong Kong, and Taiwan, while the largest known exporters are Thailand, Vietnam, India, and the Philippines.

Male seahorses are unusual in that they brood the eggs, which are deposited into their abdominal pouch by the female, and give birth.

The peculiar biology of seahorses and their primary use for traditional medicine and as aquarium fishes or curiosities rather than food, render seahorses vulnerable to habitat loss and capture in great numbers (Foster & Vincent, 2004), raising several issues of conservation. Although captive maturation and larval rearing of seahorses have been a commercial success only in Australia, the overwhelming proportion of the trade in seahorses for ornamental purposes is in wild-caught animals, with most of them coming from Indonesia or the Philippines for export to North America, Europe and Japan. Seven species of seahorses are listed as 'vulnerable' and one species *H. capensis* as 'endangered' on the 2006 IUCN Red List of Threatened Species (IUCN 2006). Another 26 species have been listed as "Data Deficient". The entire genus *Hippocampus* has now been added to Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES 2002; Mcpherson & Vincent 2004), which lists species not necessarily threatened with extinction at present, but that may become so unless trade in specimens of the species is controlled by permits. A minimum size limit of 10 cm has now been accepted that would permit reproduction and sustained trade in most species of seahorses taken from the wild and entering international trade (CITES, 2004). Hence of late, global research on seahorses has focused on conservation and management strategies of seahorse populations around the world.

Indian seahorses

India has a long history of trade on seahorses mostly originating from the southeast coast, especially the Palk Bay and Gulf of Mannar of Tamil Nadu state. Limited quantities of seahorses are also collected from the coasts of Kerala, Maharashtra and Karnataka. Palk Bay coast fishers target seahorses by diving while the landings in the Gulf of Mannar and Kerala are mostly by-catch from shrimp trawlers. A well-established seahorse trade prevailed until late 2001 along the south Tamil Nadu coast, as an alternate fishery to the declining resources of sea cucumbers along this coast. The landing of seahorses was more abundant in the Palk Bay region, the season varying according to the weather conditions. When the sea was rough during the northeast monsoon (October-December), it was difficult for the divers to go for fishing, and the catch mainly depended on by-catch from trawlers. The abundance of seahorses in Palk Bay might have arisen from an abundance of favoured habitat, whereas the Gulf of Mannar is relatively rocky offering a less suitable habitat.

Vincent (1996) reported the trade volume from India to be about 3.6 metric tonnes (1.5 million individuals) of dried seahorses per annum in 1995 while Salin et al. (2005) estimated the Indian seahorse trade to be 9.75 metric tonnes (2.65 million individuals) in 2001. Most of the catch was dried and exported to Singapore, Hong Kong and Malaysia in addition to some limited local consumption in folk medicine for treatment of asthma, fits and other illnesses. According to official estimates (Anon, 2003), about 2.53 metric tonnes of seahorses worth 1.5 million Rupees (US$ 40,000) were exported from India during 2000-01, mainly to Singapore, UAE and Hong Kong. This increased to 4.34 metric tonnes during 2001-02, worth 2.673 million Rupees (US$ 70 000), Chennai being the major port of activity. Apparently, the United Arab Emirates is only a transit point and most of the Indian exports are destined for Singapore or Hong Kong, countries with a sizeable population of ethnic Chinese communities.

Fishing crafts bringing by-catch of seahorses in Gulf of Mannar coast of India.

Seahorse fishery in Tamil Nadu coast

The seahorse trade in India was almost synonymous with the landing of seahorses from the Palk Bay and Gulf of Mannar coasts of south Tamil Nadu. Seahorses were also collected from areas near Tuticorin, Kolachel, Chennai and Pondicherry in this state. The Kolachel region near Kanyakumari appears to be a major centre for large sized seahorses of 13 to 18 cm. A minor quantity of seahorses was also available from the Cuddallore area near Pondicherry. The main landing centre near Chennai, Kassimedu had occasional landings of seahorses in the shrimp trawl by-catch. The major fishery occurred from May to October, with peak in the month of August, and the lean fishery during November to April.

Thondi coast is reported to be the major fishing area for seahorses in Palk Bay with a percentage share of 68% (1,368,579 individuals) in the total landings of seahorses from Palk Bay and Gulf of Mannar, while assuming that Palk Bay contributed 76% of the total landing from the southern coast of India in 2001 (Salin et al., 2005). Seahorse fishing at Thondi was carried out by diving fishers (to shallow depths of 3-3.5 m or sometimes even up to 10 to 13 m) who set out to the sea in small groups of 6 to 8 people in country boats (mainly to collect seahorses, sea cucumbers and gastropods such as *Murex*, *Xancus pyrum*), and by fishermen in small motorised country craft using thallu valai, which is a mini trawl net. There was apparently no significant difference in the quantum of the seahorses caught in either type of these crafts. Fishing in this region is restricted to six days in a week, with the motorised and non-motorised crafts engaged in fishing on alternate days. Fishing remained the mainstay of local livelihoods and was almost continuous throughout the year, even during the festival seasons, except when the sea was too rough to go out.

Male seahorses, identified by their brood pouch, were seen in the catch from Thondi throughout the year, suggesting that seahorses in general or at least a few species seen in Palk Bay were year round breeders, the major breeding season extending from June to September with peak between July and August (Salin, 2003). The sex ratio of seahorses collected from Thondi remained more or less the same, except during the breeding season when more males were seen in the catches.

Seahorse landings in Kerala

In Kerala, most of the small quantities of seahorses landed came from Sakthikulangara/Neendakara and Vizhinjam harbours as by-catch from shrimp trawlers. There is no organised fishery and trade of seahorses from any of the fish landing centres in Kerala. The stray catch obtained from country boats and gillnets, or ring seines, as well as by-catch from shrimp trawlers are the main source of landings. Seahorses obtained as by-catch often go unnoticed in many places and are dried for manure together with the stomatopod *Squilla*, other trash fish, small crabs, molluscs and other invertebrates, perhaps due to their small sizes or the emphasis being given more to the high valued shrimp obtained from trawlers. The segregation of a few seahorses from the huge heaps of by-catch is difficult and labour intensive.

Significant quantities of seahorses (1.6 metric tonnes or 561,418 individuals) were landed at Sakthikulangara/Neendakara harbour in 2001, the peak landings coinciding with the northeast monsoon rains in November (Salin et al., 2005). In the landings of Sakthikulangara, males were found to be 23.37% more abundant than females. Seahorses are occasionally collected at Vizhinjam harbour by country crafts such as Vallam and Catamarans and mechanized vessels which set out for gill netting. Seahorses were occasionally landed in Beypore and Puthiyappa fishing harbours in Calicut. They were found far off shore, and were believed

Hippocampus borboniensis.

Hippocampus spinosissimus.

Hippocampus.kuda.

Hippocampus trimaculatus.

Hippocampus fuscus.

Loss of critical habitat such as coastal reefs is a threat to seahorse populations.

to be associated with seaweeds mainly during the two monsoon periods when the sea became rough and water was turbid. Although there was no organised trade in Kerala, the local fishermen ascribed some medicinal uses for seahorses, which were dried, powdered, and mixed with honey as a local remedy for asthma. It was also believed by many fishermen that seahorses could prevent epilepsy or other similar disorders, if kept attached to the body as a talisman.

Biodiversity

Vincent (1996) identified three species from India - *H. fuscus*, *H. trimaculatus* and an unidentified, large-sized species from Kerala. Lourie (2003, pers. communication) suggested that there are at least five species of seahorses, in Indian waters viz. H. kuda, *H. spinosissimus*, *H. fuscus*, *H. trimaculatus*, and *H. Kelloggi*. Lourie et al. (2004) listed five species *H. fuscus*, *H. histrix*, *H. kelloggi*, *H. kuda*, *H. trimaculatus* and included *H. spinosissimus* to have suspected distribution in Indian waters. Salin et al. (2005) reported five species: *H. borboniensis*, *H. kuda*, *H. spinosissimus*, *H. fuscus* and *H. trimaculatus* from the southern coast of India. In Kerala only two species, *H. borboniensis* and *H. trimaculatus* have been reported. However, the *H. kuda* complex might contain several other species, which are difficult to identify, and the number of species might still be more (Vincent 1996).

Although *H. kelloggi* could not be identified from the collected samples (Salin et al., 2005), a morphotype similar to *H. kelloggi* in most characters was recognized, which lacked its major distinguishing feature of 39 or more number of tail rings. Also the seahorses available from Kerala were found to be of relatively small size, compared to those from Tamil Nadu coast. The large-sized seahorses are reported to be caught from the Kolachel region, located close to Kanyakumari and Kerala, which makes it probable that the large-sized seahorses reported by Vincent (1996) to have come from Kerala, might have in fact originated from the Kolachel region.

Species availability was found to vary with location. In the Thondi area, *H. borboniensis* dominated the catch with a share of 28% followed by *H. spinosissimus* (22%), *H. kuda* (21%), *H. trimaculatus* (14%) and *H. fuscus* (9%). A few doubtful morphotypes, which needed further studies to confirm their species status, represented the rest 6%. Individuals of mean wet length and weight 11.5 ± 2.36 cm and 6.89 ± 2.04 g respectively, contributed to the catch. In Kerala, the seahorse fishery of Chavakad was entirely of *H. trimaculatus* whereas in Sakthikulangara, Kochi, and Calicut, *H. trimaculatus* and *H. borboniensis* were present at ratios of 2.75:1, 4:1 and 4:1 respectively. The catch consisted of smaller sized individuals of mean length 8.0 ± 0.78 cm and mean wet weight 2.92 ± 1.61 g.

Three species of seahorses appeared particularly common and widely distributed in southern India, *H. borboniensis*, *H. spinosissimus* and *H. kuda*. These species occur in a majority of landings from the southeast coast, mostly from the target catch by divers. Along the Palk Bay coast, the shrimp trawl by-catch brought *H. trimaculatus* in great quantities. The species from Kerala coast also mostly comprised of *H. trimaculatus* followed by *H. borboniensis*. This confirms the observations of Vincent (1996) that the trawl by-catch from the south Tamil Nadu coast consisted of *H. trimaculatus* leading to the inference that *H. trimaculatus* is a species mostly occurring in deep waters. Further, almost all the landings of seahorses in Kerala came from shrimp trawlers, as by-catch.

The five species reported by Salin et al. (2005) apparently belong to three species complexes outlined by Vincent (1996). *H. borboniensis*, *H. kuda* and *H. fuscus* belong to the *H. kuda* complex, but there is every possibility that additional species would emerge from this complex upon more detailed studies, including genetic research. *H. spinosissimus* belong to the spiny seahorses that are grouped under the *H. histrix* complex. The *H. trimaculatus* complex include smaller deep-bodied and smooth seahorses, and further investigations are recommended to outline any other species under this group, particularly *H. fisheri* that have a representation in Indian waters. Lourie et al. (1999) had also cautioned that some of the species described might still be complexes, containing more than one discrete species and that required further research, using morphometric and DNA sequencing data.

Need for conservation of seahorses

Seahorses are vulnerable to degradation of their preferred sea grass, mangrove, and coral reef habitats, besides their depletion due to fishing for medicine, the ornamental fish trade and as souvenirs, with consequent impacts on the wild population. Among the seahorse species reported from India *H. spinosissimus*, *H. kuda* and *H. trimaculatus* are listed as vulnerable under IUCN Red List of Threatened species (IUCN, 2006). The seahorses in the south Tamil Nadu coast are subjected to relatively heavy fishing pressure (Salin et al., 2005), but their populations have not shown an alarming reduction over the years. In fact the individual size of dried seahorses has gone up from 2.5 g in 1995 (Vincent, 1996) to 3.7 g in 2001 (Salin, 2003). The reported annual catch of seahorses from India has also increased from about 3.6 - 4.8 metric tonnes in 1992 (Marichamy et al., 1993) and 3.6 metric tonnes (1.5 million individuals) in 1995 (Vincent, 1996), to 9.75 metric tonnes or 2.65 million individuals in 2001 (Salin et al., 2005), which means that there has been a substantial increase in seahorse landings along this coast, probably due to increased fishing effort in later periods. Although exclusive, large-scale mechanised fisheries for seahorses do not exist, incidental by-catch from shrimp trawling and other forms of net fishing is an important contributor to the seahorse trade in India.

The seahorse fishery had not been subject to any serious regulation in India, until 2001 when the government of India prohibited, by legislation, the collection and export of seahorses from the Indian seas, which substantially undermined the trade leaving thousands of poor fishers subsisting on the seahorse fishery in deep trouble. Seahorses (all syngnathids) were included on the prohibited list of fishes as per Notification S.O.665 (E) of the Ministry of Environment and Forest dated 11 July 2001, along with sharks and rays (all elasmobranchs) and giant grouper (*Epinephelus lanceolatus*). The Act makes seahorses a government property and prohibits their hunting and trade, and requires the possessor of the species to declare their stock to lawful authorities. It also entails the offences related to this species as ineligible for bail, so that a person indulging in an offence related to this species can be arrested without warrant and after prosecution can be convicted for up to a maximum imprisonment of seven years with a minimum fine of US $500 (Goenka 2005). The Export-Import Policy (2002-07) the government of India also prohibits the import or export of syngnathid species in India under the Export-Import (Development and Regulation) Act, 1991. This regulation is largely effective in India because of the absence of a domestic market, and the trade entirely based on export.

In many regions of the world where seahorses are abundantly caught, the fishers obtain a substantial share of their annual income from this activity. Seahorses comprise of up to 80% of the annual income of some subsistence fishers in the Philippines (Vincent 1996) or even up to 100% of the money earned during peak periods of seahorse catch in India (Marichamy et al., 1993). Therefore, conservation efforts should also consider the fishers and other stakeholders in the trade. There is need for a fully-fledged study on seahorse stocks to enable the establishment of reasonable fishing regulations. The conservation and management of seahorses is currently limited by the absence of data on the abundance and distribution of seahorse species in the region (Sreepada et al., 2002). Conservation measures of seahorses should take into consideration the unique features of their fishery so that both the trade and conservation of species are not unduly affected. It should include the popular strategies of fisheries management, such as closed seasons, and or establishing marine sanctuaries. Regulating or prohibiting the fishing of seahorses during the peak breeding season (at least during the month of August in Thondi) and regulation of fishing effort (the number of boats operating in peak season of availability and breeding season) could be resorted to. Efforts to save the hatchlings from pregnant males before they are sold in trade, similar to a novel community based management programme for sustainable seahorse fishery reported by Vincent & Pajaro (1997) in the Philippines, could also be considered.

Seahorses and many other species depend on their fragile habitats to survive. Attempts to diminish the impact of the trade on seahorse populations might be ineffectual unless protection and management are also sought for their vital sea grass, mangrove and coral reef habitats, which are being degraded and lost through a myriad of human interferences. The main habitat of seahorses in the Gulf of Mannar biosphere reserve is under severe stress from unregulated fishing, poaching of corals and seaweeds, targeted fishing for seacucumbers and to a large extent prawn fishing (Goenka 2005). An ongoing project (Sethu Samudram) to excavate a 300 m wide and 20 m deep shipping canal connecting the Palk Bay and Gulf of Mannar between India and Sri Lanka (Anon 2004a), with no serious environmental risk assessment, could fatally alter the floral and faunal characteristics in the area; an unimaginable catastrophe for seahorse populations.

The issue of shrimp trawl by-catch in India needs close scrutiny since it contributes to a substantial landing of seahorses on the Tamil Nadu and Kerala coasts (Vincent, 1996; Salin et al., 2005) and perhaps in most other marine states of India. CITES (2002) recommended a uniform minimum size limit of 10 cm for all *Hippocampus* species taken from the wild and entering international trade, which was put to effect by the 161 member countries of CITES in May 2004 (CITES, 2004; Anon 2004b), although Indonesia, Japan, Norway and South Korea refused to accept this. The minimum size limit would permit recruitment and help to increase pressure on shrimp trawlers reduce their by-catch of small fish. Possibilities of reviving the trade by enforcing similar regulations should be considered in the Indian context.

Aquaculture of seahorses could serve as a means of their conservation. Anil et al. (1999), Ignatius et al. (2000) and Salin et al. (2004) reported successful trials of seahorse captive rearing from different parts of India. Serious aquaculture efforts should be undertaken so that seahorses of different species could be reared under captivity and used for sea ranching in their preferred habitats. Adopting regulatory measures combined with protective strategies of their favourite habitats and mass scale aquaculture would help sustain the trade of seahorses, and save these valuable resources in the sea as well.

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Captive breeding of pangasid catfish *Pangasius pangasius* with Ovaprim - an attempt towards sustainable seed production and conservation of wild populations

U.K. Sarkar*, S.K. Paul, D. Kapoor, P.K. Deepak and S.P. Singh

*Endangered Fish Biology and Systematics Laboratory, National Bureau of Fish Genetic Resources, Canal Ring Road, Dilkusha, Lucknow – 226002, Phone: +91 522-244-1735; Fax: + 91-522-244-2403; E-mail: *usarkar1@rediffmail.com, nbfgr@sancharnet.in*

Pangasius pangasius, commonly known as yellow-tailed cat fish or pangas, are widely distributed in India, Pakistan, Bangladesh, the Malaya Archipelago, Java and Thailand. In India it is distributed from U.P. Bihar, West Bengal, Assam, Orissa, M.P., Andhra Pradesh, and Chennai, to the Bhaabani River in the south[1,2] and reported in all the east coast rivers from Ganga, Brahmaputra[3], Mahanadi[4], southwards to Godavari, Krishna and the Cauvery rivers. This fish has already established its importance as a profitable species in aquaculture in different parts of the country but due to the non-availability of seed, its culture potential has not been commercialized successfully.

At present, Indian fish farmers have directed their attention to other catfishes (*Clarias. gariepinus*, *P. sutchi*) due to the opportunity for short term profit, faster growth and cheap mode of feeding, irrespective of the potentially disastrous environmental effects of these exotic fish escaping, which is not compatible with native catfishes and may cause damage to native species in some states. It is therefore important to undertake studies on reproduction and artificial breeding of this valuable indigenous species. Moreover, *P. pangasius* is preferred by consumers due to its boneless flesh, good flavor and economic viability. In fact, there is much enthusiasm among the fish breeders and farmers of India for its artificial spawning and culture. There are reports that fish can grow up to 120 cm or more under favorable natural conditions[5] with a maximum reported size of 133.9 cm and 26.6 kg in weight[3]. Since it attains a good size, the fish also affords a good sport to anglers[6]. Unfortunately *P. pangasius* has suffered a reduced abundance in natural waters over the last ten years. In view of the increasing demand as an aquaculture species and as a priority species for conservation efforts were made to develop induced spawning of this giant cat fish under captivity.

Habitat

Pangas prefer to live in large rivers and estuaries, often undertaking a long range migration from the brackish estuarine waters to the upper reaches[3], however it is also found living in strictly freshwater such as in the Bhavani River. In the Gangetic system it occurs from the cold freshwater of Hardwar to saline tidal zone of West Bengal and Bangladesh. Young and adults are normally bottom dwellers of large rivers, estuaries, beels and baors and impounded freshwater tanks, where they enter along with the flood waters. Juvenile stages tend to inhabit tidal and brackish waters and are tolerant of salinity changes. While maturing and as adults they prefer fresh waters.

Fishery of *Panagasius pangasius*

Among the large cat fish, *Pangasius pangasius* forms a fishery of considerable commercial value in India. It constitutes a major fishery of the river Ganga, ranking first among all large sized catfishes landed in West Bengal from the estuaries[7]. In the Rajmahal Bhagalpur stretch of the Ganga Pangas is reported to gather in numbers within the shallow bays of the river where colonies of bivalves and gastropods thrive[3]. Peak months of catch are January to March and May to July. The river Mahanadi gives a considerable catch for the species. Pangas also predominate in the catch of the river Cauvery and Mettur reservoir, especially in the month of June and July. Pangas fingerlings constitute a major fishery during post monsoon months in the Hooghly estuary between Nabadwip and Kolkata[3]. As per CIFRI report a total of 77 kg of *Pangasius pangasius* were caught at selected centres on the north and south banks of River Brahamaputra at Jorhat and Dhubri landing centre in Assam, India[8]. The present authors have also collected many samples of *P. pangasius* (n=20) from the river Bhagirathi near Berhampur, West Bengal (unpublished).

Feeding habit

P. pangasius is omnivorous. A good deal of differentiation has been mentioned by authorities in the diet composition of Pangas from different environments; however it is commonly held that molluscs form the primary food at various stages of life. While larval and post-larval fish feed on plankton and small insects the latter stages feed almost exclusively on molluscs of any kind where such foods are available in abundance[7,9]. *P. pangasius* has the ability to effectively control mollusc and helminth populations in ponds.

Research requirement

Though culture, breeding and larval rearing technology of the major carps has been well established for decades other non-conventional fishes of commercial importance, particularly cat fishes, have been largely ignored. In the long term it will be necessary to utilize India's vast water resources in a more productive way through the development of alternative culture systems with non-conventional fish species. There is increasing attention towards captive breeding and larval rearing of threatened freshwater fishes. *P. pangasius* has drawn attention as one of the potential and prioritized candidate species for aquaculture and captive breeding. There are many water sheds where major carp culture is not congenial or technically viable but these can be effectively utilized for culture of *P. pangasius*. Moreover consumer choice and acceptance relative to the major carps has to be taken into account for need-based culture of this species. A review of the literature shows that very few attempts have been made so far on captive breeding and stocking of this species in fresh water aquaculture systems. The successful breeding and seed production of *P. pangasius* could be alternatives to farmers since they grow fast.

Review of literature

A review of literature shows that limited and outdated information is available on cat fish breeding and culture and the promise towards large scale aquaculture of cat fish has yet to reach its potential.

Pangas is a fresh water seasonal spawner and its natural spawning season in the northern India is within June to August. Normally it breeds during the rains[6]. Unlike some bagrid and sisorid catfishes where genital papillae are present especially during the breeding months, the pangasid male and female are not usually visible externally, except during breeding months when mature male ooze milt with slight pressure on both side of the abdomen and females show a bulging abdomen with a wide genital opening. They do not ordinarily spawn in ponds, but breed in flooded rivers and adjoining areas, performing a long spawning migration but without ascending into small streams or tributaries far from the main rivers. They breed early in the monsoon within the channels of the main river[3]. There are different views regarding spawning location of pangas. Some reports indicate that this species spends its adult life in the rivers and migrates to estuaries for spawning[10], whereas others believe that pangas attains maturity in the estuary, then migrates and breeds in the freshwater with the young drifting into the tidal stretch of the river[3]. Fertilization is external and the species is highly fecund with females capable of bearing nearly 6,000,000 ova (195,000 per kg body weight of the fish[3]). Induced breeding of pond-reared pangas has been achieved in Thailand by using pituitary glands from another donor species (*Clarias batrachus*). However, in India induced spawning within captivity using synthetic Ovaprim has not been previously reported.

Protocols used for captive breeding

Collection of brood fish

Brood fish of *P. pangasius* (n=10, 6 male and 4 female) were collected from river Bhagirathi and feeder canal near Faraka Barrage in West Bengal, during April-May and were reared in a private fish farm of a progressive fish farmer at village Beldanga in the District Maldah, West Bengal. Brooders were collected by special dragnets locally called 'Mahajal' and were kept for 24 hours within a cage specially made by bamboo sticks (36 m^2). The average weight of the brooders was 6.0 kg. The cage was installed within the river not far from the bank. Live brood fish were transported to the fish farm using a three wheeler carriage using clove oil (0.01 ppm in transport water) to anesthetise the fish during the journey. The brooders were stocked in a medium sized earthen pond (1500m^3), where they were kept for 50 days for conditioning and acclimatization. Before stocking into tank the fishes were treated with potassium permanganate $KMnO_4$ solution. Brooders were fed twice daily at 5% of total body weight with rice bran (20%), mustard oil cake (25%), gastropods (15-20%) as the main food components. Fresh gastropods were collected from the river Bhagirathi and Ganga.

Breeding techniques

After 45 days brooders were raised from the stocking tank for induced spawning. As with clarid catfish only carp pituitary extract has been used as the agent for inducing spawning but considering the viability and success rate we used synthetic hormone 'Ovaprim' as an alternative agent for inducing four males (average weight 4.8 kg., length 75 cm.) and 2 females (average weight 6.2 kg., length 82 cm). A stimulatory dose of ovaprim at 1.0 ml/kg was injected intramuscularly to the males at the same time as females were injected with hormone at 1.0 ml/kg body weight. At about 8.30pm all the injected brooders were released into a bamboo cage (15m^3) installed within a pond that had a facility to intake bore water. Water circulation was provided after hormone administration to stimulate the spawners. The bright-pink colour of the female genital opening was one of the indications of the proper maturity of the female for stripping. The inside of the cage was covered with a fine mesh net to prevent escape of the eggs. Water temperature of the breeding pond was 30 ± 1°C, pH-7.9 ± 0.05, dissolved oxygen 4.07 ± 0.05 ppm, conductivity 671 mmhos/cm and average depth of the pond was 1.5 m.

Observations

Immediately after administration of Ovaprim no remarkable response was observed. After an hour and a half chasing movements began within the breeding hapa (bamboo cage) and continued at regular intervals. As the spawning period of catfishes are generally prolonged we examined the males after 18 hours and observed that males were not responding properly. Only few eggs were found to be fertilized mainly due to environmental factors. The survival rate of the fertilized eggs was poor. Variations in environmental temperature had strong effects on the effectiveness of the dose.

Since the males were not responding properly we applied a stripping method for fertilization. Males were dissected and fully mature testis was taken out and was minced in a grinder. Simultaneously, ripe female ovary was removed by dissection and eggs and milt were mixed with a feather in an enamel tray and water was added as per published methods[11]. The fertilized eggs were non adhesive, demersal and did not swell as is observed in carp. Fertilized eggs were incubated in a portable fiber glass hatchery. The diameter of water hardened eggs measured 0.98 to 1.21 mm. The blastodisc was observed after 30 minutes post-fertilization. The embryo showed twitching movements and the hatching process was completed within 25 hours after fertilization. However, the fertilization rate was poor and ranged from 10 to 20 %. The survival rate of the hatchlings were ranged from 20–25% at temperature ranges from 30 to 31° C. Temperature is an important factor for fertilization and hatching. Average fecundity estimated to range from 180,000 to 188,000 / kg body weight. The present study is a partial success on artificial spawning under captivity. The observations of this study suggest that *P. pangasius* can be bred under captivity. However, more experiments are suggested to be carried out in order to standardize the breeding protocols. Repeated trials and up scaling of the protocols are underway.

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Establishment of post-tsunami rehabilitation information units to facilitate coordination of effort in Thailand

Simon Wilkinson, NACA

The need for better information

The need for high-quality and timely information on post-tsunami rehabilitation activities has been widely recognised in high-profile consultations with donors, NGOs and concerned government organizations, such as the Joint Sub-committee on Post-tsunami Rehabilitation 'Task Force No. 3', and the Workshop on Fishing Communities and their Livelihoods in the Aftermath of the Tsunami, convened by the CHARM project of the Department of Fisheries.

One of the most common complaints of organizations providing rehabilitation assistance in the field is that there is a serious shortage of good information on which to base planning and decision making. This has lead to considerable duplication of effort, wastage or sub-optimal allocation of resources, and mismatch of assistance rendered with actual need. However, while the need for information is well recognised it is a fact that most donors have been very reluctant to fund information- or coordination-related activities, preferring instead to fund material aid.

Recent work by the Royal Thai Government and FAO has sought to redress this situation by improving the availability and management of information on post-tsunami rehabilitation activities. Two projects have operated in a parallel track, simultaneously building the capacity of:

- Local level authorities to collect high quality and standardised information on tsunami rehabilitation activities underway in the field;
- Provincial- and national-level authorities to collate, manage, analyse and disseminate information on post-tsunami rehabilitation activities to assist concerned organizations to plan their activities and facilitate coordination of effort; and
- The capacity of all players to exchange and aggregate data through a standardised approach.

Opening of the coordination meeting on progress in post-tsunami rehabilitation of the fisheries sector..

Work on the projects began starting with the fisheries sector, which was by far the most heavily damaged with heavy losses throughout the six affected provinces of Thailand. Work later expanded to cover the agriculture sector (inclusive of fisheries, forestry and livestock) in Phang Nga and Ranong Provinces, which suffered the majority (>80%) of agricultural losses.

DOF-FAO Post-tsunami Rehabilitation Information Unit for the Fisheries Sector

In March 2006 a national level meeting of NGOs, donors, development agencies and government organizations was held in Bangkok to discuss progress in post-tsunami rehabilitation of the fisheries sector and coordination issues. The consensus among participants was that the main barrier to coordination of effort was the general lack of information about the status of rehabilitation. Poor access to information had lead to:

- Frequent duplication of effort among organizations engaged in rehabilitation;
- Delivery of assistance that did not match actual needs;
- Poor allocation of resources, with some areas receiving too much while others received little or nothing;
- Concerns over the potential for assistance to impact on the long-term viability of the natural resource base, particularly in the fisheries sector.

A key message from participants was that access to good quality information on the status of rehabilitation activities would aid planning and allow resources to be allocated more efficiently, increasing the impact and benefit of assistance to affected communities. The kind of information participants most desired was basic data on 'who was doing what and where'.

A major outcome of the meeting was a recommendation to establish a Post-tsunami Rehabilitation Information Unit, based in the Department of Fisheries. It was proposed that the Unit provide key information services that would facilitate monitoring and planning of rehabilitation in the fisheries sector, including:

- Information on the status of fisheries resources, fishing capacity and the distribution of key fisheries inputs such as boats and engines to assist donors to make responsible decisions in providing assistance, due to concerns over the possibility of increasing the pressure on fisheries resources.
- A contact database of organizations providing rehabilitation assistance.
- A project database concerning rehabilitation activities that were underway or planned and their area of operation.

The next phase of the project involved the design and planning of an information system that would meet these needs:

- A set of indicators for monitoring progress of rehabilitation in the fisheries sector were developed in consultation with DOF.
- A simple data entry and analysis system was designed based on a standardised Excel spreadsheet.
- A 'functional statement' was also developed that outlined the role, organizational structure, operation and information outputs of the unit, along with staffing arrangements, responsibilities and time frames for unit activities.
- The transfer of the Andaman Forum website, a clearinghouse for tsunami rehabilitation information, to management by the Information Unit was negotiated with the CHARM project.
- A Working Group of key DOF personnel was established to oversee the operation of the unit and provide guidance.

Implementation of the project began with staff of the unit collecting data primarily through phone interview, with donors and NGOs identified through web searches, project reports, newspaper articles and discussion with other concerned organizations. As data collection was ongoing throughout the course of the project the staff of the Information Unit were given 'on-the-job' training in:

- Phone interview techniques, to facilitate the collection of relevant data from NGOs, donors and other government offices.
- Data entry using standardised data recording forms and spreadsheets.
- Record management and archiving of hard copy and electronic records.
- A one week course in website management and administration was also provided to staff from the DOF Computer Center, to enable them to take over maintenance and updating of the DOF-FAO Andaman Forum website.

This strategy proved quite effective for gathering information from the larger organizations providing rehabilitation assistance. However, the smaller organizations have less of a media profile and are more difficult to locate using such means, indicating the need for a local-level data collection strategy to supplement the efforts of the Information Unit in Bangkok. A training workshop in data collection was therefore held for field staff from the Fisheries Office in each of the six affected provinces. The objective of the workshop was to raise awareness of the Information Unit's activities and to establish a network of field officers that would assist in collection of local-level data for processing in Bangkok, according to a standardised format in line with the unit's planned information outputs.

By the close of the project DOF had assumed full responsibility for day-to-day operation and management of the Information Unit, both in terms of gathering and processing further information and disseminating the outputs, and in managing the DOF-FAO Andaman Forum website, which is available at **http://www.andamanforum.org.** Screenshots illustrating the major functions of the website are shown on page 14.

Participants in the coordination meeting in Phang Nga Province.

Provincial Post-tsunami Rehabilitation Information Units for Agriculture

The development of the Ranong and Phang Nga Agricultural Rehabilitation Information Units followed a similar process to that of the DOF-FAO Fisheries Rehabilitation Information Unit, but operating on a provincial rather than national scale. At the request of the Governor, the provincial Office of Agriculture and Cooperatives (MOAC) convened coordination meetings to discuss the status of rehabilitation involving NGOs and relevant government departments on 1 and 2 June 2006, respectively. Participants raised a very similar set of issues concerning a general lack of information on 'who was doing what where' and on the status of the natural resource base, indicating that this had lead to frequent duplication of effort and misallocation of assistance. Both meetings recommended that the MOAC establish an Information Unit that would provide information services to facilitate monitoring and planning of rehabilitation activities.

The Governors of Ranong and Phang Nga accepted these recommendations. Operational models and organisational arrangements for the Information Units were developed in discussion with the provincial MOACs,

Coordination meeting in Ranong Province, FAO DRR Mr. Konuma (centre) and the Deputy Governor Mr. Boonsong Techamaneesatit (centre-right in white shirt).

with final endorsement by the Governors. Assistance provided by FAO included:

- Development of a detailed 'functional statement' describing the role, organizational structure, operation, information outputs and staffing arrangements of the Information Units.
- Development of standardised indicators for monitoring rehabilitation of the agriculture sector.
- Two training courses and mentoring in information processing and record management for MOAC staff that would operate the Information Units.
- Practical training in information collection for around 50 district (field) staff of relevant provincial technical departments, including Agricultural Extension, Fisheries, Livestock, Land Development and National Parks.
- Essential computer equipment to support the operation on the Information Units.

Both the Phang Nga and Ranong Information Units have just begun operation as the necessary organizational arrangements and training have just been completed, and are currently engaged in their first round of information collection.

Linkages between the Information Units

The adoption of standardized rehabilitation indicators for the agriculture sector was a deliberate decision made by all parties in order to allow information to be exchanged between provinces and aggregated at a higher (national) level. For example, local-level fisheries data collected by the Ranong and Phang Nga Information Units can be immediately used by the DOF-FAO Information Unit in Bangkok without further processing or extrapolation.

To maintain ease of access to information, the Phang Nga and Ranong Information Units have agreed to publish the information they gather on the DOF-FAO Andaman Forum website (see screenshots on following page), which was set up as a clearinghouse on post-tsunami rehabilitation shortly after the disaster. However, each unit will also undertake its own dissemination activities (particularly with regards to non-electronic dissemination) within its own jurisdiction.

Conclusion and lessons learnt

The successful establishment of Post-tsunami Rehabilitation Information Units will provide an ongoing framework for sharing information on rehabilitation activities at both the provincial and national level. Development of the units required considerable parallel investment in activities to build capacity of authorities at the local, provincial and national levels. Some of the key lessons we have drawn from our experience in establishing the information units are:

- Developing an information system takes time and requires a long-term perspective. It is necessary to build on existing institutional frameworks in order to sustain activities after the project funding ends.
- Getting information from the field to the end user requires that capacity be built at all levels in the 'information chain' from local to provincial to national.
- Gaining the support and understanding of top tier management prior to implementation is essential to ensure that staff will have the mandate and resources they need to undertake the activity.
- The 'human' issues are the most difficult challenge in implementing an information system. A substantial commitment to training and raising the awareness of participating staff is required for success; the technical issues are relatively simple by comparison.
- Staff resistance to the introduction of new technology can be very high. Simple and familiar tools such as Excel often prove more effective in the field than technically superior but more complex relational databases.

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- Strengthening Coordination and Assessment of Fishing Resources and Inputs Provided by Tsunami Emergency Relief (OSRO/THA/505/CHAR).
- Regional information management and co-ordination on strategies for early recovery of agriculture in coastal regions in Indonesia, Maldives, Sri Lanka and Thailand affected by tsunami (OSRO/RAS/503/CHA).

The funding support for these projects is gratefully acknowledged.

Thailand tsunami information for fisheries and agriculture: www.andamanforum.org

The home page lists the latest contacts, projects and reports.

The contact directory lists donors & NGOs by category.

The project directory lists activities by province & category.

Project descriptions indicate activities and area of operation.

Contact descriptions include phone, fax and email details.

Peter Edwards writes on

Rural Aquaculture

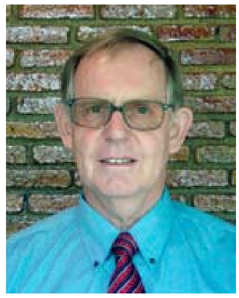
Poor farmers culture tilapia intensively in ponds in Central Luzon, Philippines

A farmers's son with a tilapia caught from a typical small-scale tilapia pond.

Overview

Central Luzon, a major lowland agricultural region, is also the major area for pond farmed tilapia in the Philippines. It is the third most populated region in the Philippines with a population density of 422 persons per km^2.

A major finding of the Asian Development Bank (ADB) Special Evaluation Study (SES): "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction" is that just less than half (43%) of the surveyed small-scale households farming tilapia in ponds in Central Luzon were below the poverty line. The majority of tilapia farmers (68%) fed their fish intensively with commercial pelleted feed, obtaining yields of 8-9 tonnes per ha per 3-3.5 month cycle. Only a quarter of the farmers (27%) combined use of pelleted feed with pond fertilization and feeding rice bran; and very few (2%) relied solely on natural food production to feed their fish. Most farmers (92%), however, used fertilization prior to the start of the culture cycle.



Peter Edwards is Emeritus Professor at the Asian Institute of Technology where he founded the aquaculture program. He has nearly 30 years experience in aquaculture in the Asian region. Email: pedwards@inet.co.th.

Methodology

A total of 248 households were surveyed in the 2003 study: An equal number of tilapia farmers (or adopters); and non-adopters (or small-scale rice farmers). For the purpose of the study, small-scale tilapia farmers were defined as those using ponds of a maximum of 1 ha total area; and non-adopters had rice farms of a maximum of 3 ha. Rice farmers were selected as non-adopters since many tilapia farmers previously farmed rice and had converted their rice fields into tilapia ponds. Adopters and non-adopters were selected from the same villages.

Livelihood assets

Human capital

The majority (86%) of small-scale tilapia farmers as well as non-adopters (79%) were owner-operators with the remainder lessees, caretakers or share-croppers. However, the two surveyed groups differed in many attributes although their households both had about five members. Tilapia farmers were younger and had completed more years of high school education. Their average length of experience in tilapia farming was relatively short (4.7 years) compared to the 30 years experience of non-adopters in rice farming although about 39% of tilapia farmers were previously rice farmers. Among farmers owning land, tilapia farmers had an average larger landholding than non-adopters, 2.5 versus 1.3 ha, respectively. Most heads (89%) of tilapia farming households had more than one occupation; about half (46%) reported

Feeding tilapia with commercial pelleted feed.

tilapia farming as their primary occupation with major secondary and other occupations being rice farming (21%), vegetable farming (12%) and livestock raising (12%) as well as driving, vending/trading, office employment and carpentry. Some 36% of tilapia farmers continued to grow rice in separate plots on their farm.

Natural capital

Access and tenure rights are required for farming tilapia and tilapia farmers had access to land either through ownership or lease. Land ownership was through both inheritance and purchase. Tilapia farmers allocated 0.5 ha to fish ponds and 2.9 ha to rice or vegetables. Most tilapia farmers (89%) obtained a reliable water supply from groundwater from deep wells, lessening water-related conflicts with rice farmers who depended heavily on irrigation from surface water.

Social capital

Access to sources of knowledge and information, training and advisory services facilitated tilapia farming. Most farmers (82%) traced the origin of their tilapia farming practices to their own province, disseminated through an informal network of farmers government agencies and private sector hatcheries and nurseries. More than two-thirds of farmers had received training from government, including Central Luzon State University and hatcheries and feed suppliers. Most tilapia farmers (82%) were not affiliated with any livelihood association.

Physical capital

About 94% of all respondents owned their dwelling but tilapia farmers overall were relatively better-off than non-adopters in terms of ownership of physical capital. The houses of the former were more sturdy in terms of construction materials and more had refrigerators, telephones/cellular phones and gold jewellery. However, almost all members of both groups owned TVs and electric fans and had a water-sealed toilet.

Financial capital

Most small-scale tilapia farmers (66%) were self-reliant using their own funds to farm fish. Most of the tilapia farmers receiving financial assistance (34%) obtained it from feed suppliers (51%) and relatives/friends (20%). As feed comprised about 72% of the cost of tilapia production, some farmers borrowed feed from feed suppliers to reduce their cash outlay. The feed cost was payable on fish harvest with a small feed cost markup.

In terms of financial returns, tilapia farming was 5-6 times more profitable per ha than rice farming but was much more capital intensive and risky, especially due to floods, poaching and predators.

The mean contribution from tilapia farming to total household income was 39% with farmers also drawing an average of 29% of their income from rice and 6% from vegetables. In contrast, non-adopters derived 66% of their total income from rice and 9% from vegetable farming.

Transforming processes

Output markets

Marketing tilapia was relatively easy for most farmers, most (77%) selling to wholesalers/assemblers with

Papaya and cattle grazing grass on a pond dike on a multi-component farm.

A farmers's daughter and son with tilapia caught for lunch.

the rest selling to retailers, consumers and brokers. Wholesalers/assemblers mainstreamed the harvests from the small-scale tilapia farmers live in aerated tanks to large consumer markets. This was facilitated by physical infrastructure such as roads, transport and communications.

Labour and employment

Tilapia farming provided self-employment for farmers and their family members as well as outside employment for poor caretakers and labourers who were unable to establish their own ponds. Tilapia farmers also hired seasonal labour to prepare ponds and harvest fish. Tilapia grow-out also had backward (hatcheries/nurseries; feed manufacture and marketing) and forward linkages (harvesting, post-harvest handling, processing, marketing) which also absorbed labour.

Supporting services

Tilapia farming in Central Luzon has benefited enormously from research, training and extension from government institutions and universities. Furthermore private seed and feed suppliers advised farmers on appropriate practices as well as improving their products which has contributed to the rapid commercialization of the tilapia sector. The survey showed that the most important providers of advice to small-scale tilapia farmers were other farmers (49%), government (35%), friends (30%) and relatives (27%). Input suppliers such as feed dealers (30%) and hatcheries (10%) also transferred information.

Tilapia broiled over a fire for lunch.

Crisis and coping strategies

Less than half of the tilapia farmers reported a crisis in the last 12 months. The main crises experienced by some farming households were natural calamities such as typhoons (41%), drought (27%) and floods (19%). Other types of crisis which upset household cash liquidity were family illness (40%), financial loss (28%) and death within the family (14%). To cope with crises, households mainly used their savings (64%) or borrowed from friends and relatives (45%) but a few borrowed from money lenders, pawned jewellery, sold livestock or mortgaged their land. Crisis depleted financial resources sufficiently in some instances to stop tilapia farming.

Conclusions

Tilapia pond farming is a profitable livelihood that contributes to reducing poverty in Central Luzon, but obstacles to entry must first be overcome. Access to livelihood assets, together with robust markets (input, output and labour markets), available services, facilities and infrastructure, and supportive policies and institutions are vital channels of effects for poverty reduction.

In Central Luzon, several channels of effects have facilitated tilapia pond farming:

- access to land (through land ownership and lease arrangements with guaranteed tenure rights);
- reliable water supply and water pump ownership;
- access to working capital (from family savings and/or from external sources, such as feed suppliers, relatives, friends, and financiers);
- availability of infrastructure and other related facilities (roads, transport facilities, and communication facilities);
- access to markets and positive financial returns from tilapia farming;
- dissemination of improved tilapia breeds through various hatcheries; and availability of commercial feed; and
- provision of training, extension and related services by private and government organizations.

The mainstreaming of harvests from small-scale tilapia farms into larger consumer markets has brought about direct benefits. From the survey results, small-scale farmers feel better off now than 5 years ago in terms of cash income from tilapia farming, employment and consumption, and anticipate further positive changes in the next 5 years.

The survey indicated that tilapia has become an important fish in the diet of tilapia farming and non-fish farming households alike with declines in consumption of milkfish and round scad and native freshwater fish. Milkfish traditionally has been the most popular and widely farmed fresh and brackish-water fish in the country; and round scad traditionally has been the most popular and affordable marine fish for the poor. Thus, the poor are benefiting from the availability of tilapia as an affordable fish as about 43% of the tilapia farmers and 71% of the non-adopters fell below the provincial poverty line.

There is considerable scope for further growth of tilapia pond farming in Central Luzon, given a rapidly growing population/consumer base, positive returns from tilapia farming, availability of agricultural land and water, access to improved tilapia breeds and commercial feed, availability of farmer financing, existence of tilapia processing facilities and continuing public-private linkages in the industry. Lowering production costs, particularly feed costs, through less dependence on fishmeal-based feeds, along with reducing vulnerability to risks and changing economic conditions, are the major future challenges.

Further information

The study on which this column is based is available on the ADB web site and as a printed book with the title "An Evaluation of Small-scale Freshwater Rural Aquaculture Development for Poverty Reduction", which may be obtained from:

http://www.adb.org/Documents/Reports/Evaluation/sst-reg-2004-07/default.asp?p=opereval

Also listed at one Fish:

http://www.onefish.org/servlet/CDSServlet?status=ND04MTU1MS4yNDk2MDomNj1IbiYzMzlkb2N1bWVudHMmMzc9aW5mbw~~#koinfo

For a hard copy contact: Njoman George Bestari, Senior Evaluation Specialist, Operations Evaluation Department, Asian Development Bank, Email: nbestari@adb.org, Tel: (632) 632-5690, Fax: (632) 636-2161, www.adb.org.

Simple herbal treatment for epizootic ulcerative syndrome in murrels (snakehead)

M.A. Haniffa, M. Dhanaraj, C. Muthu Ramakrishnan and R. Arthi Manju

Center for Aquaculture Research and Extension (CARE), St. Xavier's College (Autonomous), Palayamkottai – 627 002, Tamil Nadu, India.

Outbreaks of an ulcerative disease characterized by mycotic granulomas in aquaculture practices are an important limiting factor to production and trade of fresh water and estuarine fishes of South and Southeast Asia (Macdonald, 2001). This disease, known as Epizootic Ulcerative Syndrome (EUS), is mainly caused by a highly invasive aseptate and specific slow-growing fungus originally described as *Aphanomyces invadens* (Willoughby et al., 1995) and now listed as *Aphonomyces invadens* in the index of fungi (Lilly and Roberts 1997). Over the past two decades, EUS has had a serious effect on tropical fisheries resulting heavy economic losses (Das 1994, Biswas et al., 2002). A large number of reports are available on possible association between EUS changes and seasonal factors, such as rainfall and flooding, and water quality parameters such as low temperature, low pH and low dissolved oxygen levels. A diverse group of biotic agents viz; viruses, bacteria and cutaneous ecotoparasites may cause skin lesions which are subsequently colonized by *A. invadens* and ultimately lead to EUS (Lilley et al., 1992.).

More than 100 fish species have been affected by EUS and the most severely affected ones in natural outbreaks are generally air-breathing fishes (Roberts et al., 1994) especially the snakehead. The snakehead (family Channidae), commonly called murrels, have a good market value due to their excellent taste, low fat, fewer intramuscular spines and medicinal qualities (Haniffa and Marimuthu 2004). EUS is very common in both northern and southern India and has spread through rivers, reservoirs and paddy fields to neighbouring states.

Diseased striped murrels (*Channa striatus*) and spotted murrels (*Channa punctatus*) length 20-24 cm and weight 350-400g were purchased from the local market, Tirunelveli District. The infected individuals were separated and were transported to Centre for Aquaculture Research and Extension Aquafarm. Most of them showed lesions and deformed fins on the upper side and a few showed reddish spots on the bottom side and bulging white eyes. These diseased murrels were reared in cement tanks (3m x 1m x 1m) and were fed on semi moist feed (Haniffa et al, 1999).

A number of wound healing techniques viz., spraying chemicals into ponds and/or adding antibiotics in the feed have been previously described. For instance Rehulka (2000) treated rainbow trout while Harikrishnan et.al., (2003) attempted *Cyprinus carpio* using such methods. Anon (1993) noticed that the application of neem leaves and turmeric paste prevented the spread of infection and promoted the survival and growth of the fish. Another medicinal herb commonly available in tropical countries is *Aloe vera*. This plant directly assists the body's immune system by killing or preventing the replication of bacteria, viruses and fungi that invade wounded tissues and prevent healing. In addition, *Aloe vera* is an anti-oxidant and serves as a popular aid for treatment for burns, itching and minor cuts. Scar formation is also prevented in the healing wound when Aloe vera is applied (Lewis and Elvin-Lewis, 1997).

In order to treat the diseased murrels two types of pastes viz., neem paste and *Aloe vera* paste were prepared for the present study (Table 1).The ingredients were ground finely using glycerine and water to create a mixture. Neem leaves and turmeric were added in a 4:1 ratio for the preparation of neem paste and Aloe vera gel was used for the preparation of the second paste.

Twenty diseased striped and spotted murrels of equal weight (350-400g) with moderate lesions were taken from the cement tanks and divided into two groups each with 10 individuals. Neem paste was applied topically on the whole body of the first group while aloe paste was applied to the second group. They were kept undisturbed in plastic troughs (capacity: 40 litres) for 15 minutes. After that they were introduced into the cement tanks (3m x 1m x 1m). The treatment was given twice per day and continued for 10 days.

Every day fishes were taken from the rearing tanks and observed for wound healing and after that the treatment was repeated. Meanwhile the rearing tanks were cleaned and supplied with well oxygenated water from a nearby bore well. Water quality parameters recorded were: pH (7.83+ 0.28), salinity (2.07+ 0.02 ppt), dissolved oxygen (9.4+0.30 ml/litre) and ammonia (0.26+0.02 ppm).

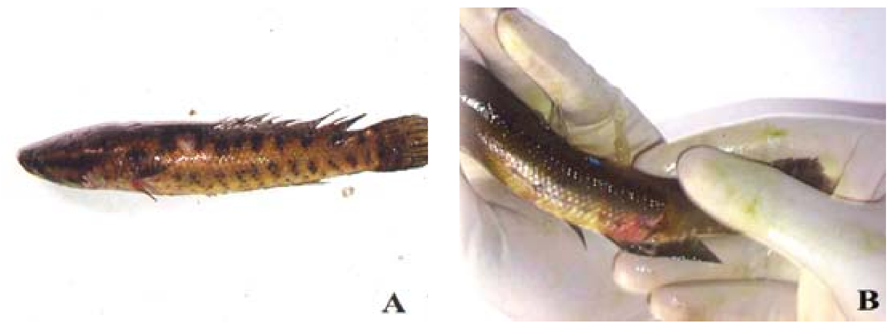
When compared to aloe paste, neem paste was more effective. In the case of

A & B: EUS affected spotted murrel showing abdominal lesions.
C: Medicinal herb Aloe vera.

Xeropthalmia affected spotted murrel.

A&B: Topical application of neem paste to treat EUS-affected striped murrel.
C: Neem paste being applied to xeropthalmia-affected spotted murrel.

A: Partial recovery of xeropthalmia on third day of treatment.
B: Complete recovery of xeropthalmia on sixth day of treatment.



Wound healing in spotted murrel (A) and striped murrel (B).

Table 1: Composition of the neem and aloe pastes.

Neem paste		Aloe paste	
Neem Leaves	12g		
Turmeric	3g	Aloe gel	10g
Glycerin	6ml	Glycerin	5ml
Distilled water	5ml	Distilled water	2ml

Complete recovery from EUS in striped murrel (A) and spotted murrel (B).

neem paste treated individuals complete wound healing was noticed on the 6th day of the treatment, whereas aloe paste treated murrels showed slower recovery and all the external wound disappeared on the 8th day of treatment. Diseased murrels with bulging eyes (xerophthalmia) showed recovery on the 3rd day after neem paste treatment and eye became normal on the 6th day, whereas aloe paste treated xerophthalmic *C. punctatus* became normal only on the 8th day.

The present study suggests that medicinal herbs can play a significant role in treating fish diseases. Fish farmers can practice this indigenous technology to treat EUS in air–breathing fishes.

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DNA vaccination and prophylactic measures in aquaculture health management

Dr. A.S. Ninawe

Director, Department of Biotechnology, Government of India, Block – 2, C.G.O. Complex, Lodhi Road, New Delhi – 110003. E-mail: ninawe.dbt@nic.in

Rapid expansion and intensification of aquaculture have been accompanied by increased incidence of disease outbreaks. Among infectious diseases, those of viral origin have often caused heavy damage to aquaculture production with some estimates that ten percent of all cultured aquatic animals are lost due to infectious diseases alone. No treatment is available for viral infections and the rapid onset of disease in farms usually requires destruction of the infected stock and a clean start. Vaccines have long proven their efficacy in herd protection, but in the aquaculture industry, they are at a relatively early phase of development. Most of the commercially available vaccines protect fish against bacterial diseases and are simply made of inactivated bacterial preparations applied by either immersion or injection with an oil adjuvant.

Currently no vaccine is available against parasitic pathogens, and very few are available against viruses. Several vaccine formulations have been tested under laboratory conditions, but did not prove to be commercially viable because of their prohibitive cost of production, insufficient protection or lack of safety. Thus, current health management strategies are still focused mainly on prevention.

Several DNA vaccines for human use are in various stages of development and validation trials to determine their efficiency and safety are in progress. In aquaculture, several trials of DNA vaccines are underway, especially for control of viral pathogens in cold water fishes. Of the different vaccines developed against various viruses, DNA vaccines against infectious haematopoietic necrosis virus (IHNV), which infects salmon, has been commercialized.

In India, attempts are being made to screen a large number of *Aeromonas hydrophila* strains from different areas for their outer membrane proteins to examine if these are conserved and could be used in development of vaccines to protect against infection caused by diverse *A. hydrophila* serotypes. *A. hydrophila* is cloned and expressed in *Escherichia coli*. Work on immunogenicity of the proteins, the protective nature of immune response and the duration of immune response in Indian major carps – *Catla catla*, *Labeo rohita* and *Cirrihinus mrigala* are being attempted.

Advantages of DNA vaccines and immunization

The approach of vaccination through DNA is promising, as experiments showing an immune response to plasmid-encoded antigens of infectious pathogens were published in the literature several years ago. Being a very promising technology, it has caught the attention of scientists working in the field of vaccine development. A report published in 1991 showed the expression of a reporter gene in carp muscle after injection of plasmid DNA, several years before DNA vaccines were demonstrated in fish. For aquatic organisms, as for other farmed animals, DNA vaccines offer several advantages over classical antigen vaccines viz. live attenuated, whole killed and subunit vaccines. They are relatively inexpensive and easy to produce, as all DNA vaccines require identical production process. DNA based immunization has immunological advantages over traditional methods of vaccination. As shown with mammals, they can induce strong and long lasting humoral and cell-dependent immune responses without boost, similar to that conferred by live vaccines, but without the risk of inadvertent infection. In fish, much less is known about the immune responses following plasmid injection, but there is no indication that it will be very different from what has been observed with other animals.

Multivalent vaccines can also be easily prepared by mixing together different plasmids, or including more than one antigen-encoding gene in a single vector for collinear expression, which will further reduce the cost of production. In addition, DNA is a very stable molecule, and does not need to be maintained in a cold environment during shipment or storage. The cloning approach allows vaccines to be rapidly modified if needed. These factors contribute to make DNA vaccines very attractive to fish vaccine manufacturers. Finfish such as carps and catfish have a specific immune response and therefore, it is possible to develop vaccines for these fish against bacterial pathogens. Recombinant protein and DNA vaccines have better chance of success in aquaculture, since technology for mass production can be developed and DNA vaccines might induce long lasting immunity with single dose of vaccination.

Vaccine development approach

Vaccination has been shown to be the best method of preventing infection not only in humans but also in important agricultural animals. In the case of organisms of importance in aquaculture, this has not been so successful with classical vaccination programmes. Thus, development of vaccination methods and their proven effectiveness is new line of health care technology for organisms of importance for aquaculture. *Aeromonas* could be one of the best choices being its ubiquitous nature as it infects many fish species of commercial importance in warm water Indian species. Gene coding for proteins showing good protection is attempted for development of DNA vaccines. The useful genes are likely to be cloned in a eukaryotic expression vector and the immunogenicity will be tested in a controlled environment using a water recirculation system. The extents of immune response, duration of immunity and cross protection against various serotypes are under evaluation. The aim is to develop a universal 'all-fish' DNA vaccine vector having a constitutive 5' promoter and 3' un-translated regulatory region of gene, and a region of sequence which has multiple cloning sites. It is proposed to develop a product, namely an 'all-fish' DNA vaccine vector for fish, which can be isolated from fish genome thus avoiding the regulatory prohibition and consumer resistance to genetically modified organisms. The vector developed could be used for all commercially important cyprinid fishes. The efficiency of the vector will be determined for Indian major carps using the antigen originated from *A. hydrophila* as a test system.

In salmon aquaculture, commercial and polyvalent vaccines are available for various bacterial pathogens. Efforts are being made in India to develop viable technology for vaccinating Indian major carps against the most common bacterial diseases, hemorrhagic septicemia and ulcerative diseases. The experience gained in useful vaccine development, field trials and scaling up of technologies is an added advantage that can help in reducing production losses due to diseases problems. The extent of protection induced against various serotypes of *A. hydrophila* are also being evaluated in Indian labs such as the Centre for Biotechnology, JNU, New Delhi and College of Fisheries, KVASU, Bidar. These labs are actively engaged in vaccine development for Indian major carps and catfish species.

Health measures in shellfish aquaculture

Disease is one of the main factors limiting the survival, growth and production of shellfish, especially white spot syndrome virus (WSSV), which causes around US$ 125 million in losses annually in India. In Southeast Asian countries, WSSV has created a great global challenge due to its significant economic impact and has attracted a lot of research interest. The primary goal is to protect farms in the coastal belts from this virus through early diagnosis, which could aid in preventing the spread of the virus to healthy shrimp.

The disease is characterized by white spots in the exoskeleton of infected shrimp. The WSSV is enveloped and elliptical in shape and around 66 X 112 nm in size, and the nucleocapsid of WSSV is cylindrical in shape (420 X 68 nm) with one end flat and other pointed, having a pattern of opaque and transparent striations arranged perpendicular to the long axis of the nucleocapsid.

DNA-based diagnosis is made feasible by optimizing the conditions for the extraction of viral DNA from the tissues of infected shrimps and identifying the infection by PCR based approaches such as nested and single tube semi-nested PCR. Simple immunodiagnostics with viral proteins are being developed that are convenient to farmers in their operations. Researchers have identified 18 kDa predominantly expressed protein in the infected shrimps and the protein is being used for antiserum production in mice and rabbits, which could help in detection of WSSV infection from the tissues of infected shrimps in field samples using techniques such as latex-based agglutination with a high degree of consistency. The technology is being transferred to a aquaculture biotech company for developments of DNA and protein based diagnosis of WSSV infection in shrimp. The technology to generate viral recombinant proteins from WSSV is being attempted to develop techniques including expression of prophenol oxidases, penaedins and other microbial peptides in shrimps using molecular techniques such as RT PCR and in-situ hybridization in shrimp tissues. Experimental models for testing vaccine candidates against WSSV infection in shrimp and vaccination strategies with recombinant proteins and other immunostimulants are under development. Such models can be generated for other shrimp diseases and may lead to the development of micro-vaccination technologies in shrimp.

Developments in the health sector

In aquaculture healthcare formulations, pharmaceutical companies are entering in India and concentrating exclusively on their core competency to develop a wide spectrum of products for water quality management, nutrition, treatment of diseases and immuno-modulators for aquaculture. These products are available domestically and are widely accepted by farmers. "Water stable" microencapsulated coated products and "gels" for aquaculture have been introduced to reduce leaching of ingredients into the water. The aquaculture service sector is also producing and selling various formulations including iodine, B.K.C sanitizers, zeolite, vitamin mixtures and probiotics for treatment of pond bottom and pond waters. As antibiotics are banned, manufacturers' attention has been drawn on the use of probiotics with introduction of 'beneficial' bacteria to facilitate bioremediation and reduce incidence of disease. Newer sanitizers have been introduced to address the problems of loose shell and white gut and immuno-modulators such as 1-3D beta glucan have also been adopted to boost natural immunity. However, the development of vaccines of various types and protection of culture species from pathogenic aggression can also boost immunity.

Vaccine delivery technology

Oral vaccination is the most preferred method for vaccination in aquaculture. However, currently used oral vaccines give poor and inconsistent immune response and protection to fish, mainly due to destruction of vaccine in the stomach before reaching the immune responsive areas of the hind gut and lymphoid organs. A model biofilm of *A. hydrophila* - a pathogen of carp - was employed for oral vaccination of carps. Significantly, very high antibody titre and protection for an extended duration were reported with biofilm vaccine, as compared to that with free cell vaccine. Better performance of biofilm was demonstrated by antigen localization in gut, spleen and kidney by monoclonal antibody based immunofluorescence.

As an alternative to costly artificial feeds, a simple strategy is needed for enhancing endogenous heterotrophic food production development in ponds, which involves introduction of biodegradable plant substrates such as sugarcane bagasse and paddy straw into ponds along with a low dosage of manure to maintain appropriate C:N ratio to favour biofilm development. The technology is expected to be cheap and attractive and suitable for indigenous aquaculture species, especially carps and catfish. Carp reared in biofilm promoted ponds have been reported to show higher antibody titer and resistance against ubiquitous secondary pathogen like *A. hydrophila*. The strategy is being promoted by Indian workers.

Development strategy

Marine and brackish water aquaculture in India is presently limited to culture of shrimp and finfish, which are popular in other Asian countries but still have not fulfilled their market potential in India. Attempts are required to develop aquaculture and hatchery technology for marine and brackishwater species with a proven package of environment, health measures and technology for breeding, larval rearing, pond culture. The introduction of new culture practices should be accompanied by appropriate health management strategies to facilitate sustainable production. This could include:

1. Development of vaccines for important infectious diseases and vaccine delivery systems including immersion for use in larval baths and through feed pellets.
2. Development of a vector for use in Indian major carps as DNA vaccination tool and use of an 'all-fish' construct, reducing consumer apprehension to GMOs.
4. Development of nucleic acid and protein-based diagnostic methods and their field evaluation to protect fish against fish viral pathogens by adopting different delivery systems of vaccination in hatcheries and farms.
5. Isolation and characterization of different viral pathogens using established fish cell lines to form a model for isolation of fish viruses using fish cell lines.
6. Development of simple diagnostic methods and vaccine for various fish viruses.
7. Creation of scientific database on pathological aspects of fish viruses and their characterization.

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The role of immunostimulants in fish and shrimp aquaculture

Vishal S. Jadhav[1], Sajid I. Khan[2], Milind M. Girkar[2] and Madhav J. Gitte[2]

1. Wockhardt Ltd., Bandra, Mumbai, India; 2. Department of Aquaculture, College of Fisheries, Ratnagiri, India

With no effective remedies against most viral infections, immunostimulants can become powerful tools to control fish and shrimp diseases. In this article, the authors provide a overview of the efficacy and limitations of immunostimulants to help users make informed choices.

In recent years, problems with diseases have emerged as constraints to the growth of aquaculture. Increased disease occurrences and in particular the uncontrolled movement of live aquatic animals have resulted in the transfer of pathogenic organisms among countries. The shrimp culture industry of India as well as other Southeast Asian countries has suffered significant economic losses due to these viral and bacterial epizootics.

Attempts to control or prevent such devastating outbreaks using conventional antimicrobials and other chemotherapeutants have been generally unsuccessful. The uncontrolled and repeated use of antibiotics to treat bacterial infections has in some cases led to the development of antibiotic resistant pathogens.

Considering the potential threat of diseases on one hand and the potential human and animal health issues associated with misuse of antibiotics, disease management aspects should concentrate on environment-friendly, preventative methods such as immunoprophylaxis.

Immunostimulants are chemical compounds that stimulate the nonspecific immune system when given alone or the specific immune mechanisms when given with an antigen, thereby rendering animals more resistant to microbial and parasitic infections.

Immunostimulants can be grouped under chemical agents, bacterial preparations, polysaccharides, animal or plant extracts, nutritional factors and cytokines (Sakai, 1999).

Synthetic chemicals

Levamisole is a low cost broad spectrum anthelminthic used for the treatments of nematode infections in man and animals. Cuesta et al. (2002), Findlay et al. (2000) and Anderson et al. (1989) have recommended application of levamisole as immunostimulant in fish. Hybrid stripped bass had better disease challenge when fed with 100-500mg/kg of levamisole (Li et al, 2004).

FK-565, a peptide related to lactoyl tetrapeptide (FK-156) isolated from cultures of *Streptomyces olivaceogriseus* has been shown to be active against *Aeromonas. salmonicida* infections in rainbow trout. (Kiato and Yoshida, 1986).

Bacterial derivatives

Muramyl dipeptide (MDP) derived from *Mycobacterium* has an immunostimulatory effect in fish. It showed increased phagocytic activity, respiratory burst and migration activities of kidney leucocytes as well as resistance to some bacteria (Kodama et al., 1993). Intraperitoneal injection of MDP showed increased resistance in rainbow trout to *A. salmonicida* (Kodama et al., 1993).

Lipopolysaccharide (LPS) is a cell wall component of gram-negative bacteria. Red sea bream *Pagrus major* injected with LPS showed enhanced macrophage activity. It can also stimulate hemocytes proliferation, enhance phagocytic activity as well as the microbicidal activity of shrimp (Karunasagar et al., 1996).

Freund's Complete Adjuvant (FCA), is a mineral oil adjuvant containing dead *Mycobacterium butyricum*. Coho salmon injected with FCA increased protection up to 450 times against *A. salmonicida* challenge (Oliver et al., 1989). FCA-injected rainbow trout appeared to show increased protection against furunculosis, vibriosis and redmouth disease (Adams et al., 1988).

Of the Vibrio bacterin (vaccine made from killed Vibrio bacteria), Vibrio anguillarum bacterin is the most successful vaccine used for salmonid fish. This bacterin acts as an immunostimulant in shrimp as they do not have specific immune responses (Itami et al., 1989). Sakai et al. (1995) reported that rainbow trout immersed in Vibrio anguillarum bacterin solution increased protection to Streptococcus sp. infection. The immunostimulatory effect of Vibrio bacterin was reported in Penaeus japonicus given immersion bath (Itami et al., 1989).

Chitin is a polysaccharide forming the principal components of crustacean and insect exoskeletons and the cell wall of certain fungi. It stimulates the macrophage activity and increases the resistance of fish to certain bacteria. Yellowtail injected with chitin alone showed increased protection against

How do immunostimulants work?

Immunostimulants increase resistance to infectious disease, not by boosting specific immune responses, but by enhancing non-specific defense mechanisms. Therefore there is no memory component and the response is likely to be of short duration.

Use of these immunostimulants is an effective means to increase the immunocompetency and disease resistance of fish and shellfish. Research into fish immunostimulants is developing and many agents are currently in use in the aquaculture industry.

Pseudomonas piscicida (Kawakami et al., 1998).

Chitosan is a de-N-acetylated chitin, with immunostimulatory effects in fish. Brook trout, injected or immersed in chitosan solution showed increased protection against *A. salmonicida* infection (Anderson and Siwicki, 1994).

EF 203 is the fermented product of chicken eggs. The oral administration of EF203 to rainbow trout stimulates the activity of leucocytes such as phagocytosis and increased protection against *Streptococcus* infection (Yoshida et al., 1993).

Glucans are the most common immunostimulants used in aquaculture. There are several types of glucans e.g. Yeast glucan, peptide glucan, β-1,3 glucan. β-1,3 and β-1,6- glucan are prepared from the cell wall of baker's yeast. These glucans are reported to enhance nonspecific defense mechanism and improve overall health, growth and general performance of fish and farmed shrimp (Raa, 2000).

Tiger shrimp immersed in yeast glucan solution (0.5 and 1 mg/ml) showed enhanced protection against *Vibrio vulnificus* infection (Sung et al., 1994). Thompson et al. (1995) reported that rainbow trout injected with yeast glucans showed enhanced resistance against *V. anguillarum* infection.

Animal and plant components

Animal extracts from some invertebrates have immunomodulatory effects. An extract from the marine tunicate, *Ecteinascida turbinata* (Ete) and a glucoprotein fraction of water extract from abalone *Haliotis discus hannai* (Hde), are reported to act as immunostimulants (Sakai, 1999).

Glycyrrhizin is a glycosylated saponin, containing one molecule of glycyrretinic acid, which has anti-inflammatory and anti-tumor activities, mediated by its immunomodulatory activities (Sakai, 1999). Rainbow trout injected with Hde (water extract from abalone) showed enhanced phagocytic and natural killer (NK**) cell activities, and showed increased survival against *V. anguillarum* infection (Sakai, 1999).

Quil A saponin, a soybean protein, acts as immunostimulant. Protein bound polysaccharide (PS-K), spirulina, acid peptide fractions from fish protein hydrolysate were also reported to act as immunostimulants (Duncan and Klesius, 1996). Rainbow trout treated orally with soybean protein showed increased leucocyte activities such as phagocytosis and production of superoxide* (Sakai, 1999).

Dietary components

Dietary vitamin C is essential for normal growth and for several physiological functions in most fishes. High levels of dietary vitamin C are reported to increase protective immune response in some fishes. Vitamin C is reported to increase resistance to *Edwardsiella tarda* and *E. ictaluri* infection in channel catfish. Vitamin E is also reported to act as an immunostimulant in Atlantic salmon fed orally (Hardie et al., 1990).

Hormones, cytokines, and others

The growth hormone (GH) and prolactin (PRL) directly affect immunocompetent cells (macrophages, lymphocytes and NK cells) and are reported to act as immunostimulants (Kajita et al., 1992). GH given to rainbow trout increased the production of superoxide anion in leucocyte (Sakai, 1999). Sakai also reported that the addition of prolactin to chum salmon, induced lymphocyte mitogenic response.

Cytokines are polypeptides or glycoproteins which act as modulators in the immune system. The existence of several cytokines has been reported in fish. These can be used as immunostimulants (Secombes et al., 1996). It has given immunostimulaory effect in Japanese flat fish (Sakai, 1999).

Lactoferrin which consists of a single peptide chain with a molecular weight of about 87,000 and possessing two Fe-binding sites per molecule is widely distributed in the physiological fluids of mammals. It can act as an immunostimulant in fishes (Amberuso and Johnston, 1981). Its immunostimulatory effect was reported in rainbow trout.

Advantages of immunostimulants

- Particularly suitable for boosting immune system.
- Effective against a number of opportunistic pathogens.
- Useful at times of known stress such as transportation and vaccination.
- Enhance immune response to conventional vaccines.
- Safe and non-toxic.
- No resistance problems.
- Environment friendly, fully biodegradable.

Immunostimulant application

The use of immunostimulants can protect fish from several infectious diseases and decrease mortality rates, however fish cannot be protected against all infectious diseases by immunostimulants. Fish receiving immunostimulants show increased resistance against infection by bacteria such as *Vibrio anguillarum*, *V. salmonicida*, *Aeromonas salmonicida* and *Streptococcus* sp., viral infections such as IHN (Infectious Hematopoetic Necrosis) and yellow-head (YHV) disease, and parasitic infections such as microsporidia (*Loma morhua*) and Sea-lice. Positive effects of immunostimulants against many bacterial infections such as *Cytophaga* (= *Flexibacter*) infections have not been reported.

Immunostimulants do not increase resistance against *Renibacterium salmoninarum*, *Pseudomonas piscicida* or *Edwardsiella ictaluri* infection. These bacteria are resistant to phagocytosis and can survive within macrophages. As already indicated, the main immunological function increased by immunostimulants is the activity of phagocytic cells. However, macrophage-resistant bacteria may escape from activated macrophages and thus in these situation immunostimulants do not appear effective against such infections. (Sakai, 1999).

Timing

The timing of the administration on immunostimulant function is a very important issue. Usually, the most effective timing of antibiotics is dependent on the occurrence of disease and they cannot often be used prophylactically due to risk of fostering of drug-resistant bacteria.

It is recommended to use immunostimulants particularly in situations known to result in stress (handling, acclimatization, high stocking density culture) and in larval phases when animals are more vulnerable to infectious diseases (Raa, 2000). When immunostimulants are used as prophylactic measures, then it should be applied before the outbreak of disease to reduce disease-related losses.

Route of administration

Injection of immunostimulants can produce strong non-specific response. However, this method is labour intensive, relatively time consuming and becomes impractical when fish are too small. It is only applicable for larger juveniles and adults intended for high value purposes such as broodstock or genetic stock.

Immersion produces a lesser non-specific immune response, but is more cost effective than injection. It requires crowding of stock for the immersion bath, and therefore increases the handling of stock animals, possibly increasing stress levels. Macrophages and hemocytes have the possibility of being activated in very young larval stages of fish and shrimp.

In the field, it has proven to be very effective in raising the survival of post larvae during acclimation to ponds and its use has become common in many farms. During treatment, post larvae are immersed in the immunostimulant suspension. A two-hour minimum exposure is generally recommended for immersion treatments.

Oral ingestion produces good non-specific immune response and can be the most cost effective method of administration. These can be achieved by top dressing. Here the purified immunostimulant is applied to the surface of the feeds. This is similar to top dressing antibiotic powders using a fish oil coating. This technique tends to produce variable results depending on how well the immunostimulant adheres to the feed.

Adding to feeds is undoubtedly the most cost-effective method to provide good non-specific immune system support. Immunostimulants can be incorporated directly into any feed formulation and used for feeding animals. This method is non-stressful and allows mass administration regardless of fish size.

Another method to introduce immunostimulants for oral ingestions is by bio-encapsulation. Purified immunostimulant can be fed to live organisms, which ingest the immunostimulant. They are then fed to shrimp or fish larvae that might not otherwise accept non-animated feeds.

Doses

Immunostimulants increase the immune responses and enhance protection against pathogen, which raises the question of dose-dependency. The effects of immunostimulants are not directly dose dependent, and high doses may not enhance but may inhibit the immune responses.

Additional effects

It is reported by several authors that there is relationship between immunostimulation and growth promoting activity. When immunostimulants were used

Immune defenses

There are two basic immune system types in animals. One is the specific immune system where memory of some specific chemical characteristic of pathogen is biochemically retained within the host cellular system. The other is the non-specific immune system, where no cellular memory system is retained, but where cellular defense system respond to specific types of molecules found on the surface cells of many pathogens such as bacteria, fungi and also some viruses (Dugger and Jory, 1999).

Fish

The fish defense system is basically similar to that described in mammals. For cellular defense systems, teleosts have phagocytic cells similar to macrophages, neutrophils and natural killer (NK) cells, as well as T and B-lymphocytes. Phagocytic cells such as macrophages of fish treated with immunostimulants shows increased phagocytosis. Lymphocytes are activated and antibody production is also increased by the immunostimulants.

Shrimp

The nonspecific or innate immune system is regarded as the first line of defense in the shrimp. Broad immunostimulation in shrimp is accomplished by the activation of the non-specific immune system cells called hemocytes. The hemocytes must get activated to work against pathogens. Activated hemocytes produce a whole sequence of metabolic changes, resulting in the production of a series of cytokines and other critical compounds, which helps in regulating the immune system within the shrimp body. Immunostimulants are used for this activation of the hemocyte in shrimps thus enhancing non-specific immune response (Dugger and Jory, 1999).

in shrimp, the shrimp showed better growth and feed conversion rates along with immune enhancement (Boonyaratpalin et al., 1995). Thus, there may be a close relationship between growth and immunostimulation.

Conclusion

There are mainly three methods to control fish diseases: vaccination, chemotherapeutics and immunostimulants. Both immunostimulants and vaccines are used to prevent infectious diseases. However, it must be noted that we cannot expect the marked or long term effects observed with vaccines to occur with immunostimulants.

Although immunostimulants may be used for treatment of some infectious diseases, they are not as effective as many chemotherapeutics. On the other hand, antibiotic-resistant bacteria can prevail in the aquaculture environment and the treatment of disease using chemotherapeutics has thus become more difficult.

With an intrinsic capability to work against many pathogens through improving and enhancing non-specific defense, immunostimulants may be able to compensate for the limitations of the use of chemotherapeutics and vaccines. Thus, with a detailed understanding of the efficacy and limitations of immunostimulants, they may become powerful tools to control fish and shrimp diseases.

*Superoxide: oxygen which supports cellular respiration is reduced to the superoxide anion O2-, acting against the infection

**NK cells: Natural Killer cells are non phagocytic cells, which weaken the infected cell's plasma membrane, causing water and ions to diffuse into the cell.

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Red tilapia cage culture in central Thailand

Ben Belton, David Little & Jimmy Young

The Nile tilapia (*Oreochromis niloticus*) is arguably Thailand's most important cultured fish. Total production reported by the Department of Fisheries in 2003 was 98,300mt; about 30% of recorded freshwater fish production (DOF, 2005). The true extent of tilapia culture is severely under-reported however, and annual production could be well in excess of 200,000mt (Belton, 2005). Although tilapia is traditionally considered a low value species the Thai market is becoming increasingly segmented. The introduction and widespread uptake of commercial monosex tilapia fry production from the mid 1990s enabled production of large all male fish (>400g) which appealed to affluent consumers and commanded higher retail prices than smaller mixed-sex fish. More recently, the growth of intensive red tilapia (*Oreochromis* spp.) cage culture promoted by Charoen Pokphand (CP) has created a new premium product, production and marketing of which is markedly different than that of mixed and monosex Nile tilapia. This article reports on the nature and extent of red tilapia cage culture in Central Thailand.

The history of red tilapia in Thailand

Red tilapia has been available for culture in Thailand since the mid-1980s when the Department of fisheries (DOF) developed a strain at the Ubon Fisheries Station. The fish performed well and there was considerable interest in its commercial potential but marketing attempts failed because its pale appearance when dead was unappealing to consumers. CP began the first major commercial attempt to produce red tilapia in Thailand in 1994-1995, developing a strain for export to the USA that could grow well in abandoned brackish water shrimp ponds on the upper Gulf of Thailand.

Freshly prepared red tilapia, Rangsit Market, Pathum Thani.

Although domestic markets were not CP's initial focus, the combination of several factors created a climate favourable to domestic production and consumption. The company experienced difficulty in fulfilling export orders and began work on a cage culture system through joint trials with DOF in 1996. These developments coincided with the economic crisis which reduced the spending power of middle class consumers who typically favored expensive marine fish. Red tilapia provided a somewhat cheaper substitute, and innovative live marketing made it possible to retain the fish's attractive colour and obtain a premium price. The strain was granted the name "Plah Taptim" (ruby fish) by the King of Thailand and following a concerted campaign promoting live sale through restaurants the product's popularity grew rapidly.

Contract and independent cage culture

CP initiated a form of contract farming, the first of its kind in Thailand for a freshwater fish, supplying fry and feed to franchised aquatic feed dealerships which oversaw the remainder of the production cycle. Dealerships nursed fry to stockable size, sold feed, and harvested and marketed fish when they attained 600g or more. This system proved attractive to potential market entrants as cage culture techniques were very simple to learn and feed dealerships provided initial technical support. The activity appeared predictable and relatively risk free for farmers because all fish over 600g were purchased at a set price upwards of Bt40($0.97)/kg. Dealerships offered

Red Tilapia Cages, Khlong 13, Pathum Thani Province.

feed on credit, although given sufficient capital framers prefer to purchase outright because of the lower costs entailed and credit is no longer always offered.

Farmers contracted to CP have reported problems with inconsistent availability of fingerlings and delayed harvesting at times of oversupply which disrupt production cycles. Some farmers also believe the company's feed costs to be excessive or have been able to obtain more than the guaranteed price by selling fish to independent middlemen. As a result, farmers have begun to produce red tilapia independently using fry or fingerlings sourced from smaller hatcheries and nurseries, arranging marketing through middlemen, and feeding cheaper catfish pellets. Independent and contract production both offer advantages and disadvantages, although contract farming is usually more convenient for producers as it is not necessary arrange harvesting or locate buyers for their fish. Independent farms produce an estimated 20% of cage cultured red tilapia, suggesting that the convenience of the contract system offers a comparative advantage.

Production

Typical cages are composed of steel frames covered with polypropylene mesh and attached to buoyancy aids, with an average volume of 62.5m³. They can be constructed by the farmer from materials costing in the region of Bt7,000 ($170)/cage. Although we interviewed farmers maintaining up to 100 cages, ownership of between four and 25 cages is the norm. This makes startup costs for medium sized cage farms favourable to land based operations generating comparable returns as construction of ponds is relatively expensive (around Bt75,000 ($1840)/Ha). Cages are located in public water bodies, most commonly rivers and canals. Large operations with absentee owners employing fulltime staff exist, but the vast majority of farmers take advantage of free access to water close to where they live.

Fish are all-male and stocking densities range from 1,500-2,500/cage depending on cage dimensions and the availability and size of fingerlings. Because of lower survival rates Red tilapia fry are significantly more expensive than Nile tilapia fry: Bt0.5 ($0.012)/0.25g for red tilapia fry, Bt0.3 ($0.007)/0.25g for Nile tilapia fry. Farmers often nurse fry in earthen ponds for several weeks to the preferred stocking size of 25-50g to reduce costs. 25g fingerlings sell for around Bt2 ($0.049) each. Growout periods average four months, with yields of around 1tonne per cage typical. Feed accounts for the greatest portion of variable costs, at Bt20,000-30,000 ($490-735)/cage/crop. CP feed is around 20% more expensive than other brands, retailing for Bt20-22($0.49-0.54)/kg. Some farmers use cheaper alternatives such as hybrid walking catfish pellets but are often limited in their ability to do so by contracts with feed dealerships.

The uptake of cage culture has been rapid, with promotion by word of mouth following establishment of demonstration farms by feed dealerships, and most production occurs in localized clusters. Although the cost of cages and feed is a significant barrier to market entry it is common for farmers to begin production with a small number of cages and reinvest profits in expansion. In Prachinburi province (and undoubtedly in other areas of Central Thailand) the popularity of cage culture has been fortuitous for feed businesses struggling following the collapse of inland shrimp farming, although the transition may be a difficult one for former shrimp farmers due to issues of location and limited capital.

Feeding time, Bang Pa Kong River, Ban Sang, Prachinburi Province.

Marketing

The vast majority of cage-farmed red tilapia is marketed live. This contributes to its premium product status. Off-flavour is considered less prevalent in cage cultured fish than those from greenwater systems and this contributes to consumer perception of the fish as a high quality product. Cage-raised red tilapia are generally marketed close to where they are produced, at traveling markets where fresh fish are cooked in front of the customer, and through restaurants which keep the fish alive in tanks. The fish is particularly popular at meals held to celebrate Buddhist festivals, and demand is greatest at periods such as Thai New Year when there are numerous festivals and public holidays. At these times demand can exceed supply and farmgate prices of up to Bt60 ($1.47)/kg are possible. By contrast during July and August, when there are few festivals and at the end of the rainy season when wild fish are abundant, farmgate price can fall to as little as Bt30 ($0.74)/kg. Farmers respond to market price by increasing or temporarily ceasing production, contributing to seasonal fluctuations in production levels. Industrial pollution in rivers and canals and *Streptococcus* outbreaks can be severe during the dry season (March and April) as a result of low flows and high water temperatures, leading to a corresponding decline in production over this period. Average farmgate prices recorded at Bangkok fish market remained constant at Bt40 ($0.98)/kg between 2002 and 2004, indicating an overall balance in levels of demand and supply from year to year for this period (FMO, 2005). Farmer perceptions indicate that prices have trended slightly downwards in the last two years however, and it is no longer common practice for feed dealerships to guarantee prices in advance, suggesting that the expansion of cage culture may have peaked.

Live fish are kept in aerated tanks prior to sale.

As harvesting of cages at most farms is staggered there is rarely direct competition between feed dealerships apart from during seasonal periods of oversupply. Independent farmers rely on middlemen to market their crop as the fish must be transported in pickup trucks modified to carry water. Most fish are delivered to large wholesale markets such as Talad Thai and Ang Thong Fish Market where they are retained in aerated tanks prior to sale to retailers. Red tilapia are particularly popular in North and Northeastern Thailand, where large Nile tilapia are also commonly grown in cages for live sale at traditional 'wet' markets. A recently launched CP subsidiary company, AQFresh, provides seed and feed and harvest and marketing services to direct to farmers, thereby bypassing feed dealerships. Other feed companies such as Thai Lux have also entered into contract production using models similar to the one developed by CP.

Producer livelihoods

Farmers' experiences of red tilapia cage culture vary. Some report it offers a secure and modestly profitable livelihood, requiring as little as one hour of labour per day, and find it possible to break even in the event of sub-optimal crops and prices. Others, particularly those with small numbers of cages, often struggle in the event of low market values or high mortality. The minor labour effort required means that the activity fits comfortably with a variety of livelihoods, and can help to diversify livelihood portfolios. Cage farmers come from diverse backgrounds, including agriculture, retail, construction and the civil service. For many the activity is a secondary one, but a significant percentage of farmers have abandoned previous occupations such as rice or shrimp farming because of the favourable returns to effort which cage culture offers.

Conclusion

Red tilapia cage culture has become an increasingly significant activity since 2000. Mariojouls et al (2004) suggest that cage production of red tilapia is in the region of 30,000mt/year. A senior CP employee substantiated this estimate on the basis that the company produces 120 million red tilapia fry annually, with 1 million fry generating 250mt of marketable size fish. This equates to 10% or more of total Thai tilapia production, and a greater proportion by value.

During periods of high demand, CP lacks the capacity to supply enough fry due to seasonal effects (e.g. low egg production during the cool season) and lack of suitable broodstock. This slack is partially taken up by numerous independent hatcheries and nurseries which supply around 20% of fry and fingerlings. The market niche occupied by live red tilapia is finite however, and expansion may have peaked as low farmgate prices and declines in production at times of oversupply appear to be increasingly prevalent. Farming in public water bodies also limits the activity's expansion to some degree as it is largely impractical for individuals who do not live in close proximity to them. Pollution and disease outbreaks appear to be increasingly problematic, particularly during the dry season, and may ultimately threaten the sustainability of the activity in some locations.

Red tilapia cage culture is most usefully seen as distinct from conventional Nile tilapia culture. Indeed, many consumers still fail to recognize the fish as belonging to the same species. The activity has made a striking contribution to the diversification of Thai aquaculture in an extremely short space of time, and exemplifies the nation's dynamism in this field. With this in mind, it will be interesting to see what the future holds. There is no good technical reason why red tilapia for live sale cannot be raised in more bio-secure pond monocultures, perhaps on a reduced commercial diet. This option while potentially cheaper for producers and consumers has yet to take hold and CP is unlikely to promote an activity with potential to reduce its feed sales and control over the production process. Nevertheless, should production and marketing of high quality red tilapia in ponds prove profitable Thailand's highly entrepreneurial (aqua) culture will ensure that farmers soon move in this new direction.

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Quality improvement of farmed fish in Iranian markets

Gholam Reza Shaviklo

Expert on Food Processing & Quality Control, Iranian Fisheries Organization (SHILAT), shaviklo@gmail.com.

Iran is a large and rapidly developing country and its pattern of supply and demand may be expected to change markedly in the near future. The aquaculture industry is currently the most important sub-sector of fisheries in Iran and its rapid development has attracted considerable attention in recent years.

The Government of Iran aims to increase the production of animal protein to meet domestic needs, especially through the fisheries sector. Since the potential increase from marine capture fisheries is limited, aquaculture is considered as a sector with good potential to contribute towards this aim. More than 90% of aquaculture production in Iran comes from fresh water culture, mostly of Chinese carp and rainbow trout. This issue is expected to increase through the promotion of better farming systems, introduction of new technologies and species, training of farmers, application of good quality inputs such as feed and seed and quality improvement of farmed fish.

Placing product on the market

Farmers sell their harvests directly to wholesalers while some sell their products through agreement at the time of stocking or before harvesting. Carps are usually marketed when they reach 1-2 kg per piece through the main markets. However most of the trout is usually marketed at 250-350 gr per piece, mainly through the retail markets. Fish farmers or wholesalers deliver fish in trucks or covered pickup vehicles to urban centers. Icing of fish is critical in this stage which is not followed by many of farmers.

Market expectations for farmed fish

In Iran, the consumption of fisheries products has increased over the last twenty years and this expansion is expected to continue over the next decade particularly in urban areas and inland provinces. Local markets have become increasingly concerned about the quality of farmed fish.

Marketing usually begins with an assessment of what the market expectations are for table fish. These must be established before beginning the harvesting process in order to assure a long-standing and profitable business venture.

Consumers of aquaculture products and fish processing experts have identified their expectations of farmed fish products. These expectations are classified as follows:

- Product quality and safety: The product should be handled carefully throughout the harvesting and distribution chain to preserve the highest quality and safety;
- Product availability: The farmed fish products should be available when they are needed. Farmed fish are usually placed on the markets during the autumn and winter months but with use of different methods of processing availability could be extended throughout the whole year;
- Size control: Farmers must produce uniform sized products to meet distributor and consumer expectations. Carps of around 1 kg per piece, and rainbow trout around 250g per piece are preferred by many markets;
- Price stability: Stability of the product's price is identified as one of the criteria in marketing development;
- Product diversification: People want to increase their quality of life through access to a diverse choice of food that is easily prepared at home and presents value for the family as a whole. This means that the retail business will have to offer new and improved value added fish products that are suitable for use at home.

Marketing of Chinese carps, Tehran.

Fillets of Common Carp.

Optimal market solutions

Studies of the market structure for farmed fish have not been given much attention in Iran and so it is important to examine marketing concepts related to carp and trout culture with respect to the pre and post-harvest activities in farms, processing plants, and markets. Some ways that farmers can ensure the quality of their product and market it effectively are suggested below:

To insure as long a shelf-life as possible the quality control of the product must be addressed early in the production phase. At regular intervals, the farmer should monitor the evisceration loss, the flesh texture, color and taste, and the general appearance of the fish. During the 7 to 10 day period before the fish are sent off for distribution and processing they should be kept in a clean water situation and not fed. This practice will deliver at least five product enhancing benefits:

- Flesh firmness will increase through reduction in the intramuscular fat content;
- Potential oxidative rancidity will be reduced, again by reduction of the intramuscular fat content;
- Evisceration loss will decrease;
- Flesh contamination potential will be reduced through reduction of viscera;
- Off-flavour of flesh that fish may have acquired from the pond water conditions will be reduced.

During this process, there will be some weight loss and its quantity should be determined by the farmers. Nonetheless, the weight loss will not very important because of increased product quality.

At the time of harvest fish begin a series of post harvest changes.

- Chemically, anaerobic pathways metabolize energy reserves.
- Microbiologically, bacterial numbers begin to rise with subsequent chemical changes.
- Enzymatically, autolysis proceeds from the gut, outwards.

Depending on how far these post harvest changes have progressed, the consumer can purchase a vastly different product ranging from one that is very fresh to one that is at the end of its shelf life. Using ice is the best and cheapest way to keep fish fresh as it is the ideal cooling medium with a large cooling capacity for a given weight, plus it is cheap and is able to cool the product effectively.

Farmers undertaking quality assurance measures or adhering to quality standards should establish a regional or provincial logo to be placed upon each fish box or package of farmed fish product that can serve to indicate assurance of adherence to an established quality control program.

Each fish box or package should have "harvested" or "processed" and "distributed" dates before it leaves farms or processing plants. From a shelf life expectation point of view insertion of this information on a product is important to help track the time from the product leaving the farm or processing plant and being received in the retail market.

There should be some mechanism for people who are, for example, not satisfied with the quality of their purchase, to register their concern(s) and to receive some degree of satisfaction. Usually a less-then-desirable quality of fish means a loss of future purchases by the affected customer.

A wider variety of value added products should be developed and test marketed. Such products could include those that are complete meals coming in a ready to eat package. Modified atmosphere packaging systems are available that require no refrigeration or freezing or use of preservatives. Such systems include packing of product in nitrogen (rather than air) and extended shelf life may be available for some products of up to 18 months. The flavor of such products is generally considered by expert opinion to be acceptable, if not fully equivalent to that of a similar freshly prepared meal.

Production of value added items is very important for market development of farmed fish. It seems that the aquaculture industry can capture an increased share of this market by making use of some innovative food technology and marketing. Some value added farmed fish products are as follows:

- Whole, gutted fish packed in PE/PP bags;
- Whole, gutted fish in modified atmosphere packaging (MAP) for chilled retail cabinets;
- Boneless fillets, with or without skin, packed in bulk for the counter or in MAP or vacuum retail format;
- Fillet portions and steaks, mainly in MAP lidded-tray formats;
- Fillet with flavored toppings for microwave or oven cooking;
- Carp / trout burger in frozen format;
- Smoked carp / trout packed in vacuum format;
- Sausages manufactured from carp surimi.

Conclusion

In Iran aquaculture is a developing industry, and studies on marketing farmed fish products is required especially in post harvest activities, price stability, fish availability, fish quality and development of value added products.

Per capita consumption of fish in Iran is extremely low though variable, and fish consumption ranges from less than 1 kg to more than 25 kg. The Iranian Fisheries Organization (SHILAT) has introduced a programme to increase fish consumption in the inland provinces. A population near to 70 million people makes the domestic market for fish potentially large in Iran. Hence, improvement of farmed fish quality is critical for further development of this industry and to fulfil the aim of increasing fish consumption by the people of Iran.

Trout farms producing from clear mountain waters of Iran produce fish of exceptional taste.

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LEILINATURE

LEILINATURE Alga Feed Additives

Pure Natural Products with International Standard

LEILINATURE alga feed additives are pure natural feed additives from Sargassum and Laminaria. Our raw materials are selected from South China Sea and the sea area of Mindanao, the Philippines, far from pollution. These series products are rich in natural minerals and vitamins necessary to aquatic animals and contain fucoidan, natural bioactive hormone and growth promoter (UGF), etc.

LEILINATURE Alga Feed

Pure Natural Alga Meal

Contains 60 minerals, 12 vitamins, seaweed bio-active substances and full range amino acids for aquatic animals;

Helps to get more favorable taste and increases feeding intake;

Improves animal' s production capacity and product quality and increases meat feed ratio;

Be good bond and supplement of feed.

LEILINATURE Double Health

Natural Alga Nutritional Additive

Decrease mastitis rate, improve conception rate, prolong lactation period;

Improves animals' immunity and resistance to irritability;

Prevents and cures animals' deficiency symptom caused by lack of vitamin and mineral;

Inhibits the growth of penicillium, staphylococcus aureus and salmonella etc.

LEILINATURE Fucoidan

Natural Alga Bio-active Substance

LEILINATURE Fucoidan is a complex sulfated polysaccharide with high biological activity;

Effectively prevents and cures infectious disease caused by virus and bacterium for aquatic animals, especially white spot syndrome virus for shrimp;

Effectively prevents and cures respiratory disease for poultry;

Decreases animal's dependence on antibiotics and has no interference with other antibiotics while application together.

more active
more healthy

LEILI NATURAL PRODUCTS CO., LTD.

Tel:0086-10-68910657

Fax:0086-10-68910221

Email:info@leilinature.com

www.leilinature.com