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AQUACULTURE ASIA

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The market for organic products has expanded rapidly in recent years with organically farmed aquatic products earning premium prices over conventional products. This international technical and trade conference will take a close look at the latest developments in organic aquaculture and sea farming, which is a significant contributor to organic aquaculture.

The accompanying INFOFISH/VIETFISH exhibition will feature exhibitors from all over the world in the fields of: aquaculture, seafood processing, import-export and equipment supply.

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The conference programme will include an in-depth analysis of the problems and potential of organic aquaculture. A wide range of topics will be discussed in the four sessions of the conference, including:

Industry Situation and Outlook: Latin American experience in organic aquaculture, with specific reference to Ecuador; Status of organic fish farming in North America; Organic aquaculture in Europe; Status of organic aquaculture in Japan; Organic aquaculture initiatives in Asia; Organic fish farming in Australia and New Zealand.

Production and Processing (Case Studies): Organic farming of salmon and trout; The Ecuadorean experience in organic shrimp farming; Organic shrimp farming in Vietnam; Mussel and oyster farming the organic way; Organic carp farming; Production and processing of Spirulina by organic methods, Economics of organic aquaculture; etc.

Markets and Marketing: Markets and marketing of organic aquaculture products in Europe; Markets and marketing of organic aquaculture products in USA; The Japanese market for organic aquaculture products; Markets for organic aquaculture products in Asia; Marketing of organically farmed aquactic products in Australia and New Zealand.

Technological Developments and Issues: Developing standards for organic aquaculture; The UK experience in developing standards for organic fish farming; The development of feeds for organic aquaculture; The processing of organically farmed products; Certification of organically famed aquatic products; Hatchery production and broodstock management; Labelling and product presentation of organic aquaculture products; etc.

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AQUACULTURE ASIA

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From the Editor's desk

Changes to Aquaculture Asia

As you have probably noticed the format of Aquaculture Asia been evolving over the last 12 months as we work hard to make improvements. I am happy to say that the bold new cover design, for which I thank the generosity of Khun Suthida Maleipan, caps off the evolutionary process at least for now.

The printed magazine has also gone black and white. Over the last year it has grown substantially with the addition of many new columns and features in each issue, and so have production costs. In the interests of keeping Aquaculture Asia accessible to the majority of readers I have adopted black and white production. The good news is that the 2003 subscription fees for Aquaculture Asia are correspondingly cheaper – a full 40% lower than the 2002 rates for the subscribers in the Asian region.

If you really want a full-color version of Aquaculture Asia, there's more good news. You can still have it - but only on CD. From January 2003, I will be producing a CD-ROM version of the magazine (in PDF format) as an alternative to the paper edition. An added incentive to subscribe to the CD version is that it will also carry a "Quarterly NACA Publications Update" - ie. you will get all our other publications from the preceding quarter included for free (also in PDF format). Tons more information for a lower price – we think it's a pretty good deal. The CD opens as a web page so its easy to use and the latest Acrobat Reader software is included (version 5). Contact me for subscription details or see the 'Aquaculture Asia page' on the NACA website www.enaca.org (where you can also download a subscription form and several trial electronic issues of the magazine for free).

There have been some developments in the catfish trade dispute between the US and Vietnam that I covered in my July-September Editorial "Who wants free trade". The United States Department of Commerce (DOC) has announced a preliminary ruling on the case, determining that that Vietnam has been illegally dumping catfish on the US market and will impose punitive tariffs of between 38-64% on imported fish fillets.

To recap, the dumping charge is vehemently denied by Vietnamese producers who point to lower production costs in Vietnam, a position that was supported by DOC investigations. However, the DOC bypassed their own findings by designating Vietnam as "a non-market economy for the purpose of US anti-dumping law", thereby retaining the option to impose punitive 'anti-dumping' tariffs. A final decision is not expected for some months. However, the tariffs on imported Vietnamese product will apply immediately.

Lastly, NACA extends its sympathies to the friends, families and crew of the Space Shuttle *Columbia*, lost with all hands on 1 February 2003. Possibly the ultimate symbol of human development, they inspired an entire world.

Simon Wilkinson

AQUACULTURE ASIA

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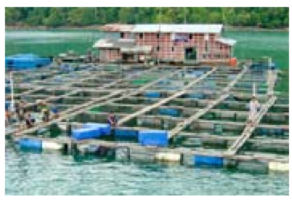

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Notes from the Publisher

As our partners see it

Pedro B, Bueno, Director-General of NACA, conceived of and was Editor of Aquaculture Asia for six years. He now writes from the vantage view of the Publisher.

We said it to FAO.

When then Chairman of NACA, Glenn Hurry, General Manager of Agriculture, Forestry and Fisheries Australia and I met with FAO's ADG for Fisheries Mr. Ichiro Nomura during the 24th COFI meeting in February 2001, Mr. Nomura asked how the TCP project on responsible movement of aquatic animals was doing. A meeting like we had – in the midst of a crowded COFI schedule — could not possibly go into details so we assured him it was doing very well. To touch on a broader issue, we added that the NACA governments are satisfied with FAO's collaborating with NACA in aquaculture development and aquatic resource management programs in the region, that FAO and other agencies' efforts in the region and their investments in aquaculture development programs go a longer way by partnering NACA, and that FAO provides a reassuring presence to other organizations in these partnerships. One message we strongly put across was that all projects that NACA implements are assured of continuity by being incorporated into the regional work program of the Organization, as with the Regional TCP project into the Aquatic Animal Health Programme. As such, the project builds on and adds value to other activities in the work programme on aquaculture development in the Asia-Pacific.

Now we'd like FAO to hear it from others.

Below are excerpts of letters sent to others and to NACA from OIE, an international intergovernmental organization; APEC, a regional economic cooperation; and ASEAN, a regional geopolitical association of nations, on the results of the "Assistance for the Responsible Movement of Live Aquatic Animals", a Regional Technical Cooperation Programme of FAO implemented in 21 countries of the Asia-Pacific by NACA:

World Animal Health Organization (OIE)

We are pleased to learn of the successful completion of the project and happy to note the recognition of OIE's contribution to its implementation. We are particularly pleased that the Asia-Pacific Quarterly Aquatic Animal Disease Reporting System (QAAD), which was started in 1998 under the programme, has now been firmly established and has garnered strong support from national governments for its continuation and further improvement.

As one of the partners with NACA in implementing the important activities of the movement management of aquatic animals in the region, I would like to congratulate NACA for the efforts provided to make the programme a huge success. The dedication and vision of those that provided leadership in managing and running the Aquatic Animal Health Programme, from FAO, NACA and OIE, had raised the profile of health in our region and elsewhere never before seen in the past. I applaud NACA's efforts to cooperate with other inter-governmental partners including FAO, OIE and SEAFDEC (Southeast Asian Fisheries Development Centre) as well as national organizations in wider activities for mutual interests in terms of sound development of aquaculture in the region, where more than 90% of aquaculture production in the world has been provided and thus where the importance of aquaculture has been recognized.

"I applaud NACA's efforts to cooperate with other inter-governmental partners including FAO, OIE and SEAFDEC...as well as national organizations in wider activities for mutual interests in terms of sound development of aquaculture in the region".

Please accept our congratulations to the NACA organization and continued support to the various systems that are now being put in place. We hope that NACA, FAO and OIE's collaboration, in cooperation with other regional partners, will assist regional countries in addressing the issues on health management that are confronting the aquaculture sector and that will hopefully benefit the fish farmers and the farming communities which are dependent on this sector.

Teruhide Fujita
Regional Representative
OIE Regional Representation for Asia and the Pacific
Tokyo

Asia-Pacific Economic Cooperation (APEC)

Several years ago, in response - among others - to the severe impacts of outbreaks of shrimp virus in Southeast Asian economies, NACA undertook a TCP project that is having far-reaching impacts. Before NACA staff framed a science-based solution, the risk of shrimp virus hung heavy over aqua-culture production that otherwise was expected to make a growing contribution to the GDP's of Asian economies. Since a virus outbreak could destroy an entire year's shrimp production, a science-based method of detecting the presence of shrimp virus and of preventing its spread was essential.

Using TCP funding, NACA developed the technology. But rather than just publish the results of the study and move on, NACA sought to build the capacities of the developing economies that would be least able to sustain the economic hardship of a shrimp crop failure. The NACA work led to the development of simple, easy to use but scientifically valid procedures for virus detection. And it gave officials and shrimp farmers confidence in the methods and in their application, so that producers now actually support testing to detect virus and control measures to prevent the spread of virus. Governments now employ science-based rules with the same objectives, thus achieving an APEC objective of facilitating trade.

NACA could have stopped there. But, through the APEC FWG, NACA saw the possibility of an even wider application of the techniques it had developed.

In 2000, NACA convened an APEC workshop in Puerto Vallarta, Jellico, Mexico, in an effort to explain the new procedures and concepts to APEC economies in Latin America. With assistance from FAO, and participation by OIE, NACA engaged not only APEC economies, but also FAO members from Latin America. NACA has gone forward to catalyze, through a genuine "South-South dialogue," widespread interest among Latin American shrimp producers in applying the techniques developed through the initial TCP NACA work.

"I know of no other TCP project with the potential for such widespread benefits, including animal health, sustainability of aquaculture, enhanced trade, and product quality".

In 2002, NACA and FAO organized a follow-up workshop in Mazatlan, Sinaloa, Mexico. Support for the science-based techniques developed through the TCP-funded NACA project continues. The participants contemplate a number of follow-on activities. The participants in the Mazatlan meeting agreed to a series of actions, including the possible establishment of a NACA-type center of sustainable aquaculture expertise for the Americas.

Clearly the products of the original TCP funding have catalyzed actions by the target group of FAO COFI members in Southeast Asia. And now NACA is helping that target group of shrimp producing countries share the benefits of the original project with other shrimp producers in Latin America. This project is one of the best examples of what APEC refers to as "ecotech." Ecotech is that form of technology transfer that has both environmental and trade benefits. In this case, it is especially commendable, because developing economies in one part of the world are sharing technology with developing economies in another part of the world.

I know of no other TCP project with the potential for such widespread benefits, including animal health, sustainability of aquaculture, enhanced trade, and product quality.

H. Stetson Tinkham
US Department of State, Washington DC, USA
Lead Shepherd, Fisheries Working Group
Asia-Pacific Economic Cooperation (APEC)

Association of Southeast Asian Nations (ASEAN)

We wish to congratulate NACA and its regional partners for the successful completion of the project, Assistance for Responsible Movement of Live Aquatic Animals".

ASEAN has witnessed through various invitations to participate in some of the activities of the regional program the progress and further development of the program including the long list of follow-up actions resulting from the TCP. ASEAN's participation in the Final Workshop of the TCP held in Beijing in 2000 paved the way for ASEAN's direct involvement in some of the follow-up activities particularly in the development and implementation of the National Strategies on Aquatic Animal Health as a major component of the Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy. The 'Technical Guidelines' was endorsed as an ASEAN policy document during the 9th Meeting of the ASEAN Working Group on Fisheries held in September 2001 in Bali, Indonesia. The progress was also reported to the 23 rd ASEAN Senior Officials Meeting and to the ASEAN Ministers on Agriculture and Forestry in October 2001 in Medan, Indonesia.

We are also pleased to report that the 'Technical Guidelines' was endorsed by the ASEAN SEAFDEC Fisheries Consultative Group (FCG) during the development of the 'Regional Guidelines for Responsible Fisheries in Southeast Asia-Responsible Aquaculture'. The two relevant statements are: "State should support the implementation of the 'Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing: Consensus and Implementation Strategy' with emphasis on phased implementation based an national needs', and 'The National Strategies on Aquatic Animal Health Management in the Technical Guidelines ' should be integrated into the national aquaculture development plans of States in the region. States should provide funds for its implementation".

During the ASEAN-SEAFDEC Millennium Conference "Fish for People" held in Bangkok, Thailand in November 2001, support to the implementation of the 'Technical Guidelines' was re-emphasized.

On behalf of the ASEAN Secretariat and the ASEAN member governments, we wish to reiterate our commitment to actively participate in the follow-up activities resulting from the regional program in collaboration with NACA and other regional organizations involved in sustainable aquaculture development. The regional program has proved that through regional cooperation, a solid platform for the development of regional policies that will assist countries in undertaking responsible health management as a shared responsibility can be established.

Dr. Somsak Pipoppinyo
Assistant Director of Economic & Functional Cooperation
ASEAN Secretariat, Jakarta

Production and Grow-out of the Black-Lip Pearl Oyster *Pinctada margaritifera*

I. Lane, C. Oengpepa and J. Bell

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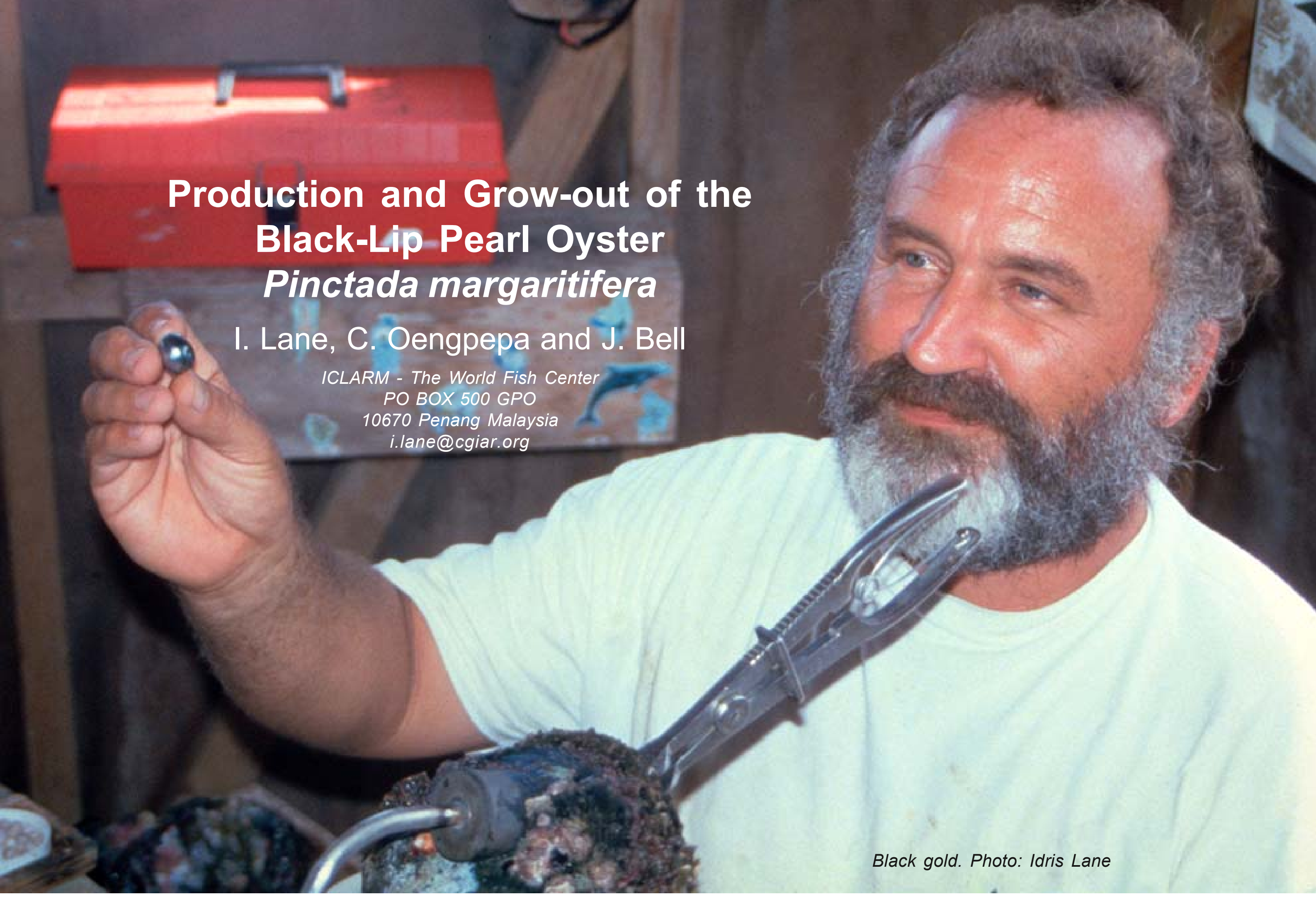

Black gold. Photo: Idris Lane

Black pearls

Black-lip pearl oysters (*Pinctada margaritifera*) are widespread throughout the Indo-Pacific region, where they have traditionally been used for food, ornaments, jewellery, tools and fish hooks. However, the major benefits of black-lip pearl oysters today come from their use in the culture of "black" pearls.

Culture techniques for black pearls were first developed in the Pacific in French Polynesia where the industry grew quickly to create major export earnings estimated at US$200 million in 2000. Cook Islands later developed an industry that is now worth US$5 million. Due to the success of pearl farming in French Polynesia and Cook Islands, other Pacific countries such as Fiji, Tonga, Marshall Islands and Solomon Islands are looking to develop a black pearl industry. Australia has also been attracted to the production of black pearls as a way to increase pearl production that is otherwise restricted through licence limitations that exist for pearls produced from the silver-lip pearl oyster (*Pinctada maxima*).

Recent increases in production of black pearls, particularly in French Polynesia, have caused a decline in prices. Average prices for Tahitian pearls fell from US$77 per gram in 1986 to US$13 per gram in 2000, although prices for the best quality pearls have remained stable. Measures to counter reduced financial returns to growers in French Polynesia include greater emphasis on quality pearl production, and restrictions on the marketing of lower quality product. The industry is also encountering other problems. For example, over-stocking of the major pearl producing atoll in Cook Islands has led to disease. This is now being addressed by limiting the number of oysters that can be stocked in the lagoon. It is now clear that while there are still many places in the Pacific Islands and Australia with the potential to produce black pearls, the size of the market, and local growing conditions, are affecting production. Further increases in production will need to be matched to market demand, and greater emphasis will need to be placed on pearl quality, oyster husbandry and efficiency.

In this paper, we briefly outline the methods that are being used in countries like Solomon Islands to collect and grow black-lip pearl oysters to pave the way for development of black pearl farming.

Supply of juvenile oysters or spat

The cheapest and simplest method of obtaining juvenile blacklip pearl oysters (spat) for grow-out is to collect them from the wild. This is possible if there are sufficient numbers of broodstock on the reefs to produce large numbers of spat. Efficient collection is also dependant on locating aggregations of spat. If wild broodstock are scarce, and / or spat concentrations cannot be found, it is possible to produce the juvenile oysters in a hatchery. This is technically more difficult and expensive than wild spat collection, but can produce large numbers of juveniles. Further details of these two methods of obtaining spat are set out below.

i) Wild spat collection

Spat collectors are placed in the sea to provide a surface for settlement of spat once they complete their pelagic (floating) stage. The collectors can be made from a variety of materials, ranging from old onion bags, rope and shademesh to commercially produced spat collector "ropes". The collectors are attached to a subsurface longline placed at a depth of 3 m, within the general depth range at which spat normally settle on shallow reef areas. Where crabs and *Cymatium* spp. gastropods also settle on the collectors, spat should be removed every three months to minimise losses to these predators. The settlement of spat is seasonal and the most efficient times for collection need to be determined beforehand by a monthly spat collection or gonad sampling programme.

Checking shademesh spat collectors for juveniles oysters. Photo: Idris Lane.

ii) Hatchery spat production

Fecund oysters are induced to spawn by either thermal shock, temporary desiccation, addition of gametes (i.e. sperm) to the water, injection of the gonad with a chemical stimulant or bathing in UV-treated water. Once spawning is initiated, male and female oysters are placed in separate containers for the collection of gametes. Eggs are then fertilised with sperm at a rate of 1-5 sperm per egg.

Inspecting spat collectors on a longline. Photo: Mike McCoy

The fertilised eggs are stocked in indoor culture tanks at 30-50 per ml with aeration, which aids circulation and prevents settlement of eggs at the bottom of the tanks. The tanks should be cleaned and the water changed every second day. This process involves draining the tanks and removing the larvae by sieving. Antibiotics may be required during the incubation period (day 0) to prevent bacterial infections invading the tanks and causing a "collapse" of the larvae culture.

From day 2-18 larvae are fed twice a day with a mixture of 3 or 4 species of cultured micro-algae. At day 3, when the larvae are veligers, stocking density is reduced to 5 per ml. At day 5-6, larvae are moved to larger 2,500-3,000 litre culture tanks and the stocking density reduced to 3 per ml. By day 8-10, the larvae have metamorphosed to the early umbo stage and by day 12 they have a fully developed umbo. At day 16-18, "eye spots" become distinct and spat collectors (the same as are used in the sea) are then hung in the culture tanks. The stocking density is reduced to 1 per ml on day 20, and by day 21-23 the pentigrade stage should be visible on the spat collectors. By day 25-28, the spat collectors with the attached spat are transferred to the sea for grow-out. The collectors are left inside plastic trays or lantern nets and the spat allowed to grow until they are 5mm or greater in length, at which time they enter the juvenile grow-out phase.

Growout of juveniles

The wild or cultured spat are put into intermediate grow-out systems i.e. glued into plastic trays, placed in panel nets etc., and are cleaned regularly to reduce fouling and remove predators. Once the oysters are 50-60 mm shell length, they are removed from the trays/panel nets and transferred to the main grow-out system. This usually involves one of several methods, including ear-hanging on rope chaplets, or placing the oysters in panel or pocket nets, suspended from either surface or subsurface longlines. The oysters may need to be cleaned of fouling organisms at 4-6 weekly intervals, although at some sites there is minimal fouling and the oysters will not require cleaning. The density of oysters should be reduced as they grow by increasing the spacing on and between the rope chaplets or panel nets. When the oysters reach 90-120 mm they can be "seeded" with the shell nucleus and a graft of mantle tissue to create a cultured pearl.

Black-lip oyster juveniles glued into tray. Photo: Idris Lane

Seeding of adults

Suitable adult oysters should be conditioned, i.e. mildly stressed, to remove excess gametes during the 5-6 weeks before seeding to improve the success of the grafting operation. Immediately before the seeding, fouling organisms are removed from the oyster's shell and the oyster is "pegged" open to create room for the technician to do the operation, which involves the use of a "graft" of mantle tissue and a shell "nucleus". The graft is cut from a sacrificed oyster that has good inner shell colour(s). The nucleus is a round bead made from the shell of a freshwater mussel. The operation itself consists of making an incision in the gonad of the oyster and then inserting a piece of mantle followed by the nucleus (placed on top of the graft). In a successful operation, the cut heals and the grafted mantle tissue grows around the nucleus to form a "pearl sack". Mother-of-pearl (nacre) is then deposited on the nucleus. Consecutive layers of mother-of-pearl result in a cultured pearl after 18-24 months.

After the operation, the shells are kept ventral edge down and handled carefully with each oyster being placed in a catch bag. The oysters are then either ear-hung on ropes or placed in panel nets and carefully transferred to grow-out lines as soon as possible. After 4-6 weeks, the oysters are checked to see if they have "vomited" the nucleus (which is caught by the catch bag). The catch bags are then removed. Any oysters that have vomited the nucleus, or are dead after the operation, are removed from the grow-out system. The 4-6 weekly cleaning cycle is resumed (if necessary) for the next 18-24 months, after which there is a second operation to remove the pearl. At this time, suitable oysters, i.e. those that have produced good pearls, may be re-seeded with another nucleus to produce another pearl. For this second operation, there is no need for a graft of mantle tissue as the pearl sack has already formed and will continue to produce mother-of-pearl to coat the new nucleus.

Pearl in situ in dissected back-lip oyster. Photo: Idris Lane

Overview

The culture of black pearls has great potential to create new livelihoods for coastal communities adjacent to coral reef habitats in the Indo-Pacific. The non-perishable and small size of the high-value product makes this form of aquaculture suitable for even the most remote locations, as demonstrated by the success of the industry in French Polynesia and Cook Islands.

However, the high costs involved in employing pearl-seeding technicians means that farms need to produce the required percentage of high quality pearls to be successful. Enterprises that do not pay attention to pearl quality are doomed to failure. Another factor that needs to be considered when assessing the opportunities to create livelihoods through pearl farming is that farms need to produce sufficient oysters to attract technicians to do the seeding operation. The minimum number of oysters needed to attract and engage a good technician is around 5,000-10,000. Farms of this size are often beyond the means of small-scale operators and so the development of an industry in the first instance will usually involve attracting an investor prepared to operate a medium to large scale farm. Coastal villagers will then benefit by collecting spat, growing them to adult size, and selling them to the main farm. Over time, once technicians have begun to visit a large farm regularly, smaller farms can then be established by local entrepreneurs who are able to make additional contracts with the technicians servicing the major farm(s).

Suggested reading

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Diver checking catch bags on black-lip oyster longline. Photo: Idris Lane

Breeding of carps using a low-cost, small-scale hatchery in Assam, India – A farmer proven technology

S.K. Das

Associate professor, Assam Agricultural University, College of Fisheries, Raha, Nagaon, Assam, India- 782 103.

In the last three decades the Indian fish seed production industry has recorded a remarkable growth. From earthen "pit" hatcheries used for hatching eggs there has been a tremendous development in incubation techniques. The most large-scale commercial hatcheries of today are of Chinese type wherein all activities such as raising the brood stock, breeding and spawn rearing is undertaken. The improved technologies of breeding, hatching and rearing have increased the fish seed production of the country significantly in recent times. A large number of hatcheries have been designed in India for breeding and hatching of carps eggs since the first successful induced breeding of these fish in India in 1957[1].

Rural fish seed production through small-scale hatcheries continues to be a focus of attention in many developing countries. The wider implications of the role of small-scale hatcheries to provide fish seed for farmers in rural areas and the future of public sector involvement are gaining increasing importance. In an earlier attempt we successfully introduced a small-scale hatchery using locally available cheap resources for poor farmers in rural Cambodia[2]. The hatchery comprised of a human powered bicycle pump to access a deep bore well, water jars, a breeding pool and hatching jars.

Privately operated hatcheries can be expected to play an increasing role in providing the basic input - fish seed for rural fish production. However, documentation of small-scale hatcheries in terms of their development, production methods and profitability is scanty.

A three year long participatory small-scale rural aquaculture project was undertaken between 1998-2001 with a basic objective to introduce small-scale fish culture to homestead ponds of a tribal area in Assam, India. During the second year of operation, it was realized that unless the basic input i.e. fish seeds were made locally available, aquaculture would remain a remote fantasy for these resource-poor farmers. Therefore, a low-cost carp hatchery was designed commissioned at a village, Palasaguri near Amsoi in Nagaon district with active participation of the target farmers.

A low-cost, small-scale carp hatchery developed under the study

The hatchery is a concrete structure and was designed based on the same Chinese hatchery principle with little modification to suit the local conditions. The overhead tank, breeding pool, hatchery pool and spawners tanks are integrated into one unit. It is possible for a circular tank to function also as an egg incubator, a hatching tank and a fry rearing tank[3]. The overhead tank has a

Participating farmers are engaged in fish seed production using the low-cost hatchery

Farmers working on the low-cost hatchery

capacity of about 5,200 liters. An average water flow of 9.7 liters per minutes is maintained in the hatchery although a water-flow speed of 50-60 liters per minute is generally recommended in carp hatcheries[4]. In the portable circular hatchery system a water flow of 8-10 liters per minute is maintained. In the glass jar hatchery, each with a capacity of 6.35 liters, the rate of water flow is kept around 600-800 ml/min for the eggs of Indian major carps and 800-1,000ml/min for eggs of grass and silver carps[5]. Through several trials it was observed that a 5 HP diesel pump with a delivery pipe of diameter 3 inch requires only about 10 minutes to fill the overhead tank of the hatchery developed under the present study. The diameter of the breeding cum hatching pool is 1.92 meter and in one batch about 8 kg of brood fish can be placed in it for induced breeding. A detachable circular hatching ring of 60cm diameter, made of iron is placed inside it during incubation. A nylon net/screen is fitted and stretched tightly on its outer surface. The ring is detached during the breeding operation. The mesh size of the screen used in the hatching ring is 1/80 inch, which prevents escape of eggs and spawns from the pool. The breeding cum hatching pool is provided with bottom inlets for water circulation and a circular perforated pipe fixed around the top margin of the pool for artificial rains. The unit also has three spawner tanks of 80cm in diameter and cm in height each to rear the hatchlings for a few days. About 800,000 eggs can be incubated at one time using this low-cost carp hatchery. The recommended spawning space and egg incubation density in a carp hatchery are around 3kg/cubic meter and 700,000/cubic meter respectively[6]. A convenient size of a breeding tank is around 2 meters in diameter and 1 meter deep which will hold about 1,800 liters of water[3]. Breeding and hatching operations can be carried out in about 30 batches in a breeding season lasting for about 120 days[7]. According to this observation, about one crore (10 million) eggs can be obtained in one batch (spawning pond 8 m diameter and incubation pond, 3.6m diameter).

In our trials we used the standard method of induced breeding with ovaprim hormone for seed production of various carps using the rural model carp hatchery described above. Ovaprim was injected in a single dose to both the sexes. The injected fishes were released in the spawning pool for egg laying. Later, the brood fishes were removed from the spawning pool with the help of a scoop net. The inner hatching ring was placed inside the spawning pool for incubation of fertilized eggs. A mild water flow is maintained during the period of incubation through the bottom inlets and through perforated circular water pipe fitted along the top margin of spawning pool. Breeding response was classified as complete, partial or no spawning based on the volume of residual eggs released on application of pressure on the abdomen. The fertilization rate was calculated by examining a minimum of three samples from each breeding experiment.

Outcomes

Altogether six trials of carp breeding were undertaken during June-July, 2000. Five different carp species were tried for induced breeding trial viz. *Labeo rohita*, *Cirrhinus mrigala*, *Hypophthalmichthys molitrix*, *Putius javanicus* and *Labeo calbasu*. Results of the experiments, which returned encouraging spawning results, have been summarized in the Table 1. Several dosages of ovaprim hormone were tried in this experiment. It was observed that most carp fishes responded well at a dose ranging between 0.40 to 0.60 ml per kg body weight. *Labeo calbasu* responded only partially at dose lower than 0.30ml/kg body weight. However, a dose of 0.3 ml / kg body weight of Ovaprim was sufficient for complete spawning in case of *Puntius javanicus*. Complete spawning of *Puntius javanicus* has previously been achieved with a single dose of 0.35 ml/kg ovaprim[9]. Earlier Nandeesha et al[11] recommended a dose range of 0.40 – 0.70ml/kg ovaprim for most carp species in India.

The small-scale hatcheries have several advantages. First of all they can be constructed with low investment and the return can be obtained in a short period of time. Small size enables the farmers operate the hatchery with less labor and manage it effectively. Land and other infrastructure facilities requirement are also low as it is small in size. And lastly the small-scale hatchery shall enable the seed producers to induce spawning of fish species separately for quality seed production, as the broodstock requirement is lower.

Lessons learnt

1. The low-cost, small-scale carp hatchery developed under the present study was operated successfully in the farmer's field, thus it is a farmer proven technology.
2. On an average 84% fertilization and 77.71 % hatching were recorded in the carp seed production using this hatchery.
3. The breeding pool can also be utilized as hatching pool with minor modification as suggested in this experiment to reduce the overall construction cost of a carp hatchery.

4. An average water flow of 9.7 liters/ minute was found sufficient for carp breeding in the small-scale hatchery developed under the present study.

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Table 1: Experimental results

Fish species	Fish Weight (Kg)	Hormone Dose (ml)	Spawning result	Response time	Fertilization (%)	Hatching (%)
Rohu	F 175	0.10	Complete	9.5 hours	99.0	97.0
	F 150	0.075	Complete			
	M 160	0.05				
	M 215	0.05				
Mrigal	F 250	0.12	Complete	9.5 hours	99.0	97.0
	F 260	0.13	Complete			
	M 220	0.06				
	M 250	0.06				
Mrigal	F 250	0.10	Complete	7 hours	93.0	88.0
	F 175	0.10				
	M 200	0.05				
	M 200	0.05				
Rohu	F 300	0.15	Complete			
	M 250	0.05				
	M 200	0.05				
Silver Carp	F 700	0.35	Partial	9 hours	73.0	62.00
	F 950	0.40	Complete			
	F 900	0.40	Complete			
	M 600	0.15				
	M 700	0.20				
	M 900	0.20				
Silver Carp	F 2000	0.90	Partial	11 hours	45.00	28.0
	M 1500	0.50				
	M 900	0.20				
Java Puthi	F 1000	0.30	Complete	7 hours	92.0	88.0
	M 500	0.10				
	M 500	0.10				
Calbasu	F 300	0.08	Partial	7.5 hours	87.0	84.0
	F 400	0.15	Complete			
	M 400	0.08				
	M 450	0.08				

Fertilization, soil and water quality management in small-scale ponds

Part II – Soil and water quality management

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Suitable bottom soil condition and high quality water are essential ingredients for successful pond aquaculture. Some problems with pond soil and water quality are related to site characteristics. Bottom soils may have undesirable properties such as potential acid sulfate, high organic matter content or excessive porosity. The water may be of poor quality, viz, highly acidic, rich in nutrients and organic matter, high in suspended solids or polluted with industrial or agricultural chemicals. However, even if a good site is available large inputs of nutrients and organic matter as a result of feeding very often lead to poor water and bottom soil conditions. Therefore, soil and water quality problems are common in aquaculture ponds, and many methods are used for the purpose of improving pond soils and water.

Water quality management

Fish are in equilibrium between potential disease organisms and their environment. Changes in this equilibrium such as a deterioration in water quality (environment) can result in fish becoming "stressed" and vulnerable to disease. It is, therefore, very important to know something of the water quality parameters and their management that have influence on growth and survival of aquatic organisms.

Dissolved Oxygen

The optimum dissolved oxygen (DO) content of pond waters should be in the range of 5 mg/l to saturation level for good growth of fish. Aeration is a proven technique for improving dissolved oxygen availability in ponds. However, in heavily aerated ponds where aerators are positioned around the edges to create circular water flow, strong water currents can cause severe erosion of pond bottom. Mineral soil and organic matter particles eroded from peripheral areas settle in the central part of the pond where water currents are weaker. Therefore, a method of aeration that does not erode soil and produces water movement over the entire pond bottom instead of just around the periphery is needed.

Temperature

Temperature sets the pace of fish metabolism by controlling molecular dynamics (diffusibility, solubility, fluidity) and biochemical reaction rates. Under otherwise favorable conditions, the optimum temperature range for many 'coldwater' and 'warmwater' fishes are 14-18C and 24-30C, respectively. Water temperature can be adjusted to optimum levels in controlled systems such as hatcheries. It is difficult to adjust water temperature in large water bodies. Operation of aerators during calm and warm afternoons helps to break thermal stratification of ponds by mixing warm surface water with cool subsurface water. The planting of trees on pond banks to give shade will reduce stratification but at the same time, reduces the beneficial effects of wind mixing and restricts sunlight needed for photosynthesis, which can reduce the productivity of the pond.

Turbidity

Turbidity is the result of several factors including suspended soil particles, planktonic organisms and humic substances produced through decomposition of organic matter. Turbidity is measured by Secchi disk visibility. Optimum Secchi disk visibility of fishponds is considered to be 40-60 cm. Turbidity resulting from plankton is generally desirable. However, heavy blooms limits heat and light penetration thus reducing the effective volume of the productive zone. Turbidity due to suspended soil particles can be controlled by manure application of 500-1000 kg/ha, gypsum application of 250-500 kg/ha or alum application of 25-50 kg/ha.

Ammonia

Fish are very sensitive to unionized ammonia (NH_3) and the optimum range is 0.02-0.05 mg/l in the pond water. Normally in the case of high dissolved oxygen and high carbon dioxide concentrations, the toxicity of ammonia to fish is reduced. Aeration can reduce ammonia toxicity. Healthy phytoplankton populations remove ammonia from water. The addition of salt @ 1,200-1,800 kg/ha can be used to reduce the toxicity of ammonia in water. Formalin may also be used to reduce ammonia. Biological filters may be used to treat water for converting ammonia to nitrite and then to harmless nitrate through nitrification process.

Nitrite

Under normal conditions the nitrite concentration of fish ponds is negligible as the ponds are kept well oxygenated. In hatcheries, control may be accomplished by installing biological filters and addition of chloride ions (through addition of salt). Effective removal of organic wastes, adequate aeration, and correct application of fertilizers are the methods to prevent the accumulation of nitrite to toxic levels in pond culture.

Hydrogen sulfide

Freshwater fish ponds should be free from hydrogen sulphide. Fish lose their equilibrium and become to sublethal stress at concentrations of 0.01 mg/l of hydrogen sulphide. Frequent exchange of water is practiced to prevent building up of hydrogen sulphide in the water body. Also, if the pH of water is increased by liming the toxicity of hydrogen sulphide is reduced. Potassium permanganate is also used (6.2 mg/l) to remove hydrogen sulphide (1 mg/l) from water.

[*Editors note:* Care is required in application of potassium permanganate as excessive amounts can kill phytoplankton leading to oxygen depletion as it decomposes. For more information on use of potassium permanganate see 'Aquaculture fundamentals' in the April-June 2002 edition of Aquaculture Asia – or you can download the back issue from the NACA website www.enaca.org].

pH

pH is a measure of hydrogen ion concentration in water and indicates how much water is acidic or basic. Water pH affects metabolism and physiological process of fish. pH also exerts considerable influence on toxicity of ammonia and hydrogen sulphide as well as solubility of nutrients and thereby water fertility. The generalized effects of pH on fish is generalized below.
The best way to counter water pH problem is to lime the pond to increase the soil pH to greater than pH 6, total alkalinity and the total hardness to greater than 40 mg/l as calcium carbonate.

Calcium carbonate (calcite) $CaCO_3$, Dolomite-$CaMg(C0_3)_2$, Calcium hydroxide (slaked lime)-$Ca(OH)_2$ and Calcium Oxide (quick lime)-CaO are the liming materials generally used. Liming should be carried out a few weeks before addition of fertilizers and stocking of fish. Agricultural gypsum ($CaSO_4$) is applied, to correct total hardness without affecting total alkalinity when total hardness is low and total alkalinity is high to control very high afternoon pH. It may also be applied to correct alkaline pH.

pH	Effect
4	Acid death point
4-6	Slow growth
6-9	Best for growth
9-11	Slow growth, lethal to fish over long period of time
11+	Alkaline death point

Total alkalinity

Pond waters with a low alkalinity (less than 20 mg/l) as $CaCO_3$, have a very low buffering capacity and consequently are very vulnerable to fluctuations in pH, for example, during rainfall and phytoplankton blooms. Such fluctuations may be directly harmful to fish populations. Ponds with alkalinity greater than 300 mg/l may also be unproductive because of limitation to carbon dioxide availability at such high concentrations. The ideal range of total; alkalinity for freshwater fish is 60-300 mg/l as $CaCO_3$. Low alkalinity ponds can be treated with lime.

Total hardness

Total hardness for freshwater fishponds should be greater than 40 mg/l as $CaCO_3$. This concentration of hardness helps to protect fish against harmful effects of pH fluctuation and metal ions. Ponds with low hardness can be treated with lime.

Carbon dioxide

Freshwater fishponds should contain a low concentration of free CO_2 (<8 mg/l). However, repeated aeration of water and increasing the pH of water by hydrated lime (calcium hydroxide) can control high carbon dioxide concentration. Experiments have shown that 1.0 mg/l of hydrated lime can remove 1.68 mg/l of free CO_2.

Bottom soil management

The role of bottom soil in determining productivity of a pond is well documented. The production of various primary food organisms depends largely on the availability of different nutrients. Dynamics of availability of most of these nutrients, in turn, is determined by the condition prevailing in the bottom soil. Considering this significance bottom soil is designated as the chemical laboratory of a pond. However, suitable soil quality problems are common in aquaculture ponds, and therefore, many methods are used for the purpose of improving pond soils.

Texture

The nature and the properties of the parent material forming the soil determine the soil texture. Many important physico-chemical properties influencing the fertility of fishponds are influenced to a great extent by the relative proportion of the different size fraction of the soil. An ideal pond soil should be too sandy to allow leaching of the nutrients or should not be too clayey to keep all the nutrients adsorbed in it. When the pond is constructed on sandy soils, then heavy doses of organic manure are essential to control seepage loss of water. In general, the dose of raw or composted farmyard manure varies from 10,000-15,000 kg/ha/yr.

Soil acidity

Soil may be acidic, alkaline or neutral. The ideal range for soil is pH 6-8. The water passing over acid soil tends to be acidic with low alkalinity and hardness. High concentration of metal ions particularly aluminum and iron also may be present. Acid ponds do not respond well to fertilization.

Liming is the only way to improve water quality in ponds with acid soils and it is the pH of the soil that must be corrected for lasting effect, rather than the pH of the water. Recommended rates of application of lime ($CaCO_3$) at different soil pH is given below.

Soil pH	Lime (mt/ha) $CaCO_3$
6.0-7.0	0.3-0.5
5.0-6.0	0.5-1.0
4.0-5.0	1.0-1.5
3.0-4.0	2.0-4.0

Acid sulfate soils

Acid sulfate soils from mine spoils and coastal mangroves contain high levels of pyrite (FeS_2 1-6%). As long as sediments containing pyrites are submerged and anaerobic they remain reduced and change little. However, as they are drained and exposed to the air, oxidation results and sulfuric acid is formed.

Sulfuric acid reduces the pH of the water when pond is filled. In ponds the problems with acid sulfate soils usually originate in pond dykes. Pond bottoms are usually flooded and anaerobic, so sulfuric acid does not form. However, dykes dry and sulfuric acid formed during the dry period enters pond in run off water after rains. Acidity on dykes can be controlled by liming (0.5-l.0 kg/ square meter) and establishing good cover with an acid resistant grass species.

A procedure for rapid reclamation of ponds with acid sulfate involves drying and filling of the soil to oxidize pyrite, filling the pond with water and holding till water pH drops to below 4 and then draining the pond, repeating the procedure until the pH stabilize at a pH above 5 and then liming the pond with 500 kg of calcium carbonate per hectare.

Bottom soil oxidation

Dissolved oxygen cannot move rapidly into water-saturated soil, and pond soils become anaerobic below a depth of few millimeters. Aeration and water circulation are beneficial in improving bottom soil oxygenation, but the surface layer of soil may still become anaerobic in intensive fish culture ponds. When the redox potential is low at the soil surface (anaerobic conditions), hydrogen sulfide and other toxic microbial metabolites diffuse into the pond water. Sodium nitrate can serve as a source of oxygen for microbes in poorly oxygenated environments the redox-potential will not drop low enough for the formation of hydrogen sulfide and other toxic metabolites.

Drying pond bottoms

When pond bottom are dried between crops, evaporation of waters from soil pores and cracking of the soil enhances aeration and favors microbial decomposition of soil organic matter. Excessive drying makes soil too dry for microbial activity, so a drying period of 2-3 weeks usually is adequate. Tilling of dry soil with a disk harrow also can improve aeration, but tilled bottoms of aerated ponds should be compacted before refilling to reduce the tendency for erosion.

Some other treatments for sustainable pond productivity

Nutrient removal

It is possible to precipitate phosphorus from pond water by applying sources of iron, aluminium or calcium ions. These ions precipitate phosphate as insoluble iron, aluminium or calcium phosphates. Alum (aluminium sulfate) and ferric chloride are commercially available sources of aluminium and iron respectively. Alum is cheaper and more widely available than ferric chloride. Gypsum (calcium sulfate) is a good source of calcium, because it is more soluble than liming materials. Treatments rates of 20-30 mg/l of alum and 100-200 mg/l of gypsum have lower phosphorus concentration in pond waters. Alum is acidic and more suitable for use in waters of 500 mg/l total alkalinity and above. Gypsum is better for use in low alkalinity waters.

Phytoplankton removal

Algicides are used to reduce the abundance of phytoplankton in intensive fish culture ponds. Copper sulfate is recommended for reducing phytoplankton abundance and the abundance of blue green algae in particular. The usual recommendation is to apply a dose to copper sulfate equal to 1/100 of the total alkalinity. The best approach to phytoplankton control is to regulate nutrient inputs by moderate stocking and feeding rates, but it may feasible to use alum or gypsum to precipitate excessive concentrations of phosphorus.

Chlorination

Hypochlorus acid and hypochlorite (free chlorine residuals) are responsible for the disinfecting power of chlorine products in pond water. But, chlorination of waters containing fish or prawn is both dangerous and unbeneficial. It is possible to disinfect bottoms of empty ponds and water in newly filled but unstocked ponds by applying chlorine products. When this is done, enough chlorine should be applied to overcome the chlorine demand and provide 1 mg/l or more of free chlorine residual. The residuals will detoxify naturally in a few days so that ponds can be stocked safely.

Water exchange

There are reasons to exchange water in specific instances, such as to reduce salinity, to flush out excessive nutrients and plankton or to reduce ammonia concentrations. However, daily water exchange usually does not improve water quality in ponds, and pumping costs are a liability. Ponds are highly efficient in assimilating carbon, nitrogen and phosphorous inputs not converted to fish or prawn flesh, but if water exchange is great, these substances are discharged from ponds before they can be assimilated. Thus, the pollution potential of aquaculture ponds increases as a function of increasing water exchange. From both economic and environmental perspectives, water exchange should only be used when necessary.

The best method for preventing soils and water quality problems in aquaculture ponds is to select a site with good soils and an adequate supply of high quality water and to maintain moderate levels of prawn and fish production. If this is done, liming, fertilization and aeration can prevent most soil and water quality imbalances. However, in some instances, sedimentation basin may be needed to prevent ponds from filling in and water exchange may be required periodically. In intensive aquaculture ponds, bottom soil treatment such as drying and liming between crops, phosphorous precipitation, turbidity removal and oxidation of bottom soils with sodium nitrate may be beneficial. Some treatments are either ineffective or potentially hazardous to the stock.

Therefore, proper pond management is the key to sustainability in aquaculture, and enhancing sustainability of pond aquaculture can improve soil and water quality in ponds and reduce the volume and pollution potential of pond effluents. Proper procedures for pond management will improve environmental conditions, sustainability and profits.

Fisheries and Aquaculture Activities in Nepal

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Fish production in Nepal

Nepal lies between India and China. The country touches with India at its southern, western and eastern borders, while the northern boundary is with China. In the south the altitude is about 50 metres above sea level, while at northern end the elevation goes up to the highest peak 8848 m (Mt. Everest) of the world. Being landlocked, the country is deprived of any oceanic resources and overwhelmed by mountains, which comprise about 83% of the total area of 147,181 sq. km. Approximately, 5% of the total area of the country is known to be occupied by different freshwater aquatic habitats[1] where some 186 fish species are reported to thrive[2]. In general, the aquatic habitats and fish species can be viewed as prospects for fisheries and aquaculture development in the country. This also implies that aquatic resources located at different altitude and climatic zones can offer potential for different fisheries and aquaculture activities in Nepal.

Fishing is traditional in Nepal but modern aquaculture techniques for fish production started with the introduction of exotic carps in the early 1950s. To utilize fish resources about fourteen state owned fish farms were established in different parts of the country during 1960-65, where spawning and seed production technologies of carp (*Cyprinus carpio*, *Ctenopharygodon idella*, *Aristichthys nobilis*, *Hypopthalmichthys molitrix*, *Labeo rohita*, *Cirrhinus mrigala* and *Catla catla*) were successfully developed in the warm southern region. At present, technology of subsistence carp farming in ponds has been widely disseminated in the southern part of the country. However, it is necessary to improve productivity by increasing our understanding and increasing inputs In the 1960s, attempts to introduce trout in the country failed, perhaps due to inadequate technical and management skills. Rainbow trout (*Onchorynchus mykiss*) was later introduced in Nepal in 1989 from Japan[3]. Now, trout can be successfully propagated and the farming practices are slowly disseminating among the farmers in the mountains.

Fishery

The Directorate of Fisheries Development (DOFD) under the Department of Agriculture is one of the main Government organizations for fisheries and aquaculture development. National production was 33,270 metric tonnes of fish in 2001/01 through capture fishery and aquaculture. The data reveal that about 49% of total production is achieved by capture fishery (Fig 1 and Fig 2), where both exotic and indigenous species are caught from different water bodies. It is mostly in the mid-hill lakes and reservoirs where exotic carp contributed higher in capture fishery. However, in rivers and streams the catch of indigenous fish is high as these waters have only very rarely been stocked with exotic fish.

Among the fishes reported from Nepal about 90 species are known from the mountains[4]. It is speculated that this high fish diversity in the country is due to the diverse agro-ecosystem zones providing suitable habitats for different fish species. Since the natural fish stocks may deplete rapidly due to over fishing, and aquatic pollution, efforts should be made for conservation of habitats and fish species by educating local communities. A migratory eel *Anguilla bengalensis* is also found in rivers, lakes and ponds of hill regions. Native fish are known to be disappearing at an alarming rate due to damming, over fishing, destruction of habitats, chemical and physical water pollution[4,5]. Further studies on native fish populations, their catch and socio-economics of fisher communities depending on fishing can give foresight to develop strategies to sustain and develop the capture fisheries in the country.

Traditional fishing and fisher folk

Traditional fishing is carried out by different methods using cast net, gill net, loop, line and hook and basket[5]. Some unconventional fishing has emerged in recent years using explosives, electricity, and poison, which is destroying the aquatic life indiscriminately. In Nepal, about 142,000 males and

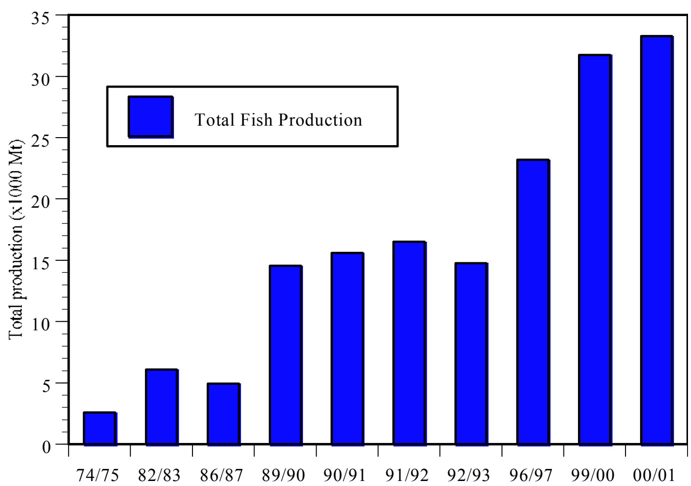

Figure 1

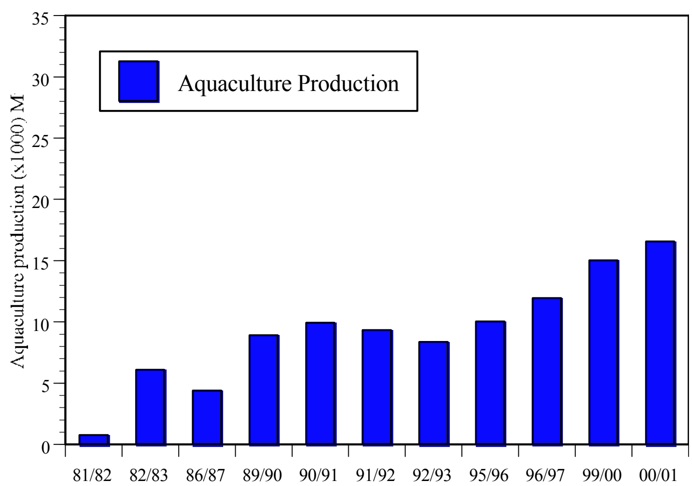

Figure 2

223,000 females depended on subsistence capture fisheries in rivers, lakes and swamps during 2000/01[7]. In the 1980s, people engaged in fisheries were estimated to be about 80,000 (Swar 1980). The recent dramatic increase in the population engaged in capture fishery probably reflects the unemployment due to increased population in the country. Water bodies in Nepal are usually uncontrolled for local access, and usually, the poorest most deprived people are known to harness nearby natural resources such as water bodies or forest for their livelihood. Nowadays, most forests are managed through a community approach involving local inhabitants, for conservation as well as for the benefit from the forest. However, rivers and few natural water bodies have yet been managed in such a way and most remain a "free-for-all".

A few lakes in the mid-hills have been stocked with cultivable carp for increased production as strategies to reduce the fishing pressure on thinly populated native species without losing the fisher's employment and income opportunities, until measures for conservation practices of locally vulnerable species are developed. The capture fishery also includes rivers, streams, rice-fields, and swamps. However, rivers and streams were never viewed for commercial aquaculture production or development as recreational fishing grounds. Development of fish sanctuaries for commercial recreational places such as wildlife resorts might help to conserve fisheries resources.

By tradition, Nepalese society has distinctly identified ethnic communities for fishing, which, entirely depend upon fishing and water related occupations such as boating and fishing net mending as a family profession. However, with few exceptions, such traditional occupations are not financially rewarding enough for sustaining a family. The ethnic communities involved for fishing traditionally are the Jalari or Pode, Majhi, Malaha, and Bote. They live in villages near the water resource. The fishing occupation within the caste system by tradition can be attributed both to abundant water resources in the country, and honoring fish as a valuable food resource in past. In general, all communities in the country accept fish as delicious food and considered auspicious among many communities.

Setting the nets on Lake Rupa, Pokhara

Fish diversity and conservation is one of the neglected areas of research and development in fisheries sector. For conservation of the aquatic life the "Aquatic Conservation Act-1961" was promulgated. However, due to insufficient enforcement, the rules and regulations set out in this act are hardly followed. Poisoning of water bodies for fishing and other destructive fishing practices are known to have increased in recent years[9,10], which have not only threatened the aquatic life but also the lives of the people associated with it.

Aquaculture and related research activities in Nepal

There are only a few institutions and limited human resources involved in fisheries and aquaculture research in Nepal. Some of these are Fisheries Research Division of Nepal Agriculture Research Council, (NARC), Tribhuvan University (TU), and RONAST (Royal Nepal Academy of Science and Technology). These institutions have contributed to an understanding of aquaculture, fishery, fish diversity and awareness about fish in Nepal. The credibility of aquaculture expansion in the last 50 years is mainly due to the Ministry of Agriculture and a few international agencies such as Food and Agriculture Organizations of United

For sale: This bighead carp was caught by net from Lake Rupa (above)

*Mahseer (*Tor putitora*) broodstock, reared in the pond environment*

Nation Development Agencies (FAO/UNDP), Asian Development Bank (ADB), Japan International Co-operative Agency (JICA), United States Assistance for International Development (USAID), International Development Research Centre (IDRC), Hill Agriculture Research Program of DFID (Department for International Development) for financial and technical support. Considering the potential of fisheries and aquaculture research and development, additional investment with a more autonomous large organization established for decision-making is needed in the country.

Aquaculture in Nepal is predominantly subsistence in type except trout farming. Carps are emphasized to grow as they can sustain on natural food. Fish are cultivated in pond, cage, pen, rice fields and raceways. Presently, the productivity in ponds ranges from 2-3 Mt/year and 3-5 Kg in cage fish farming. According to DOFD the aquaculture production in 1999/2000 reached about 14000 Mt (Fig 2). Carp farming in suitable southern warm water areas contributes the highest aquaculture production in the country, where major fish species used are big head carp (*Aristichthys nobilis*), silver carp (*Hypopthalmichtys molitrix*), grass carp (*Ctenopharyngodon idella*), common carp (*Cyprinus carpio*), rohu (*Labeo rohita*), mrigala (*Cirrihinus mrigala*), and bhakur (*Catla catla*). In the northern cold water region cultivation of rainbow trout has been initiated.

At present the main topics of fisheries and aquaculture research are: development of suitable technological package of sustainable rice-fish farming and studies on a technological package for rearing high value native species such as Himalayan Mahseer (*Tor putitora*), Katle (*Acrossochilus hexagonolepis*), Asala (*Shizothorax* spp), and Magur (*Clarius batrachus*). The major achievement in this area is successful demonstration and community mobilization for rice-fish farming in mid hill mountain[11] and captive breeding of pond reared Mahseer[14] (Fig 3). Previously, it was suggested that Mahseer do not mature in captivity but only breed in running waters[13]. At present, up to 0.2 million hatchlings of the species can be produced in the hatcheries (Fig 4). Early observation showed that Mahseer grow slowly with artificial feeds in experimental tanks[15], but recent experiments showed more encouraging results when early fry were grown in fertilized ponds (Bista et al. in prep). In the near future Mahseer will be examined for polyploidy population production. Recently, semi-natural spawning success of Magur (*Clarius batrachus*) without sacrificing the male has been demonstrated at Pokhara Fisheries Research Center, Nepal[18].

Research on technological package development for rice-fish farming practices in the hills has been recently completed[17]. The findings showed that rice-fish farming is one of the simplest and most beneficial approaches to increase the rice and fish production. The study also revealed that rice production was increased by up to 12% in rice-fish integrated plots, despite of the loss of the rice cultivation area through the rice-fish integration for trench construction as life giving system to fish during emergencies such as drought, predation and heat shock (Box-1). As a consequence of the successful research demonstration, rice-fish farming is spreading in many mid hills areas. However, mechanisms of fish seed supply in remote areas have yet to be developed to full functional efficiency. The rice-fish farming technology was known to have started 30-40 years back in Nepal, but inadequate technology such as variety of rice appropriate to use for rice-fish integration, increased use of pesticides, social and technical problems

Fig. 4. About 60 days old Mahseer (Tor putitora) fingerlings reared in pond environment

Lake Begnas, Pokhara Valley. Fish farming is just one of many activities for the people here

constrained its rapid adoption. To resolve most of the problems outlined above group or community involvement for scaling up rice-fish farming is now recommended.

Nepalese cage fish farming completely depends on natural productivity of the water bodies. In cages, silver carp (*H. molitrix*) and bighead carp (*A. nobilis*) are used as the main species for production. Sometimes, rohu (*L. rohita*) are stocked in small numbers as they help to keep the cage clean because of their browsing activities for feeding on detritus attached to the cage mesh. The dimension of the cage usually used in Nepal is 5m long, 5m wide and 2m deep. At present the productivity of cage fish culture ranges from 3.0- 5.0 kg per m^3. The cage is stocked with 10-20 g size fish at the rate of 10 individuals/m^3 for harvesting once a year. The stocked planktivorous fish reach approximately 0.5-1.0 kg each with about 80-90% survival. A collaborative research through farmer's participation for the possibility of productivity enhancement in cage fish culture is ongoing in the lakes of Pokhara and the reservoir at Kulekhani region. Under this study testing of high-density stocking and multiple harvesting in the cage are expected to improve the productivity.

"...usually, the poorest most deprived people are known to harness nearby natural resources such as water bodies or forest for their livelihood."

The cultivation of reintroduced rainbow trout, after nearly ten years of testing inside the government farms, outreach research with direct farmer's collaboration in three mid-hill districts is now smoothly going on for the possibility of large-scale adoption of trout farming. Relatively, the production cost of trout is higher than for carp even though the market demand at present is increasing day by day in the main urban areas of tourist destinations, which is highly encouraging for trout farmers.

Recently, a research project has been initiated to restore the diminishing Lake Rupa (135 ha) of the Pokhara Valley. Under this project a lake, which is turning into marsh due to silt deposition, is scheduled to be restore to its original condition through engaging the people living around it by establishing a co-operative for lake conservation and income generating fisheries activities. A cooperative comprising of 292 people has been established for the purpose, and a large share of the benefit from fish harvest from the lake will be utilized for cleaning and restoration of the lake. If this lake restoration is successful this model can be applied to other wetlands of the country for restoration, economical, environmental and social benefits.

If abundant water resources and fish diversity could be attributable to higher scope for fisheries and aquaculture development, then it can be concluded that the future potential of fisheries and aquaculture sector is high despite the

Formerly transient fisher-folk have adopted cage culture in Lake Begnas, near Pokhara, Nepal. They have established permanent settlements nearby and their childeren can now attend school on a regular basis mostly terrain features of the country from the fisheries perspective. For proper utilization of its aquatic resources investment and skilled human resources are essential. Only a few scientists are engaged in fisheries research. This clearly shows that the social and economic potential of fisheries and aquaculture research remain under a low profile and are yet to adequately recognized and prioritized in national policies.

Future areas of fisheries and aquaculture research

Mountain fisheries and aquaculture for increased production

Fishing plays an important role in providing food and income to the people in the mountain areas. Therefore, fish resources, people and their environment should be integrated for an overall ecosystem and rural development approach.

Intensive aquaculture in southern warm water region

Aquaculture at present provides subsistence employment and income to the nation despite of the higher potentiality. The existing pond aquaculture, which is mostly extensive, can be intensified by for increase productivity. Research should be focused on increasing production by strengthening existing aquaculture practices. Fish species such as prawn and Tilapia should be included for aquaculture production as these species are suitable for the warm water zone of southern terai for their growth and production.

Study on the possibilities of riverine habitat for commercial aquaculture

There are about 6,000 large and small rivers in Nepal, but the fisheries and aquaculture potential in these rivers have not yet been assessed. In many countries, rivers have been used for aquaculture production, and so efforts should be made to assess the riverine potential for aquaculture development.

Indra Gurung of Baradi, Tanahun

Mr. Gurung of Baradi, Tanahun started fish farming in ponds around 1992/93. He also used to farm fish in his rice field without any technical assistant from a research station. He didn't know about the trench and its benefits. When a HARP (Hill Agriculture Research Project) funded project on rice-fish culture was implemented in the Baradi area, he participated as one of the research farmers out of 6 in the area. He started growing fish in his rice field with a proper trench. He recalls when the technicians asked him to dig the trench in the middle of his paddy field. He was not very comfortable with the purpose at that time. But later when the function of the trench in rice – fish farming was explained to him and the importance of having the trench as the 'life saving place' for fish, he agreed to follow the instructions. After the completion of the project, he was convinced with the technology, as he was able to harvest about 12 kg of fish from his 1 Ropani (1 Ropani is 500m^2) rice field with no reduction in the rice yield. He then converted his original fishpond (about 3 Ropani) into a paddy field and integrated fish on it in 2000. In the spring of 2001, he harvested about 40 kg of fish and 10 Muri of paddy (no reduction in yield) from the one parcel (about of 2 Ropani) of his rice – fish farm. He is very pleased to have the extra income from integrating fish in his paddy fields almost same as to the total economic value of the paddy. Convinced by the result, he has now extended his rice fish farming to 7 Ropani from this year main season rice. He believes that demonstration of the successful farming is the most convincing tool for other farmers to adopt the technology.

Source: Gautam[11]

Research on community based riverine fish conservation and development

Conservation and utilization of forest resources through community mobilization is a major success story in Nepal. Research on participatory exploitation of riverine aquatic resources, emphasizing conservation and utilization needs to be carried out.

Study on the lacustrine fishery resources and their restoration

Nearly 5000 small to medium sized lakes are known to be scattered throughout the country from the southern plains to the high mountain region. Most lakes in the southern plain are known to be highly encroached and environmentally degraded negatively affecting the local biodiversity. The lakes of glacier origin in the high mountains have not yet been studied from a fisheries perspective. Therefore, a review of lacustrine resources, their potential for restoration and use for community development, and their academic values also needs to be highlighted.

Recreational and ornamental fishery resources

Sport and recreational fisheries are highly regarded in many societies. Fish species that occur in Nepal are highly renowned for sport and recreational purposes, such as Mahseer and Asala. Similarly, many species possess considerable ornamental value for garden and aquariums. Such fishes of high value should be studied for income and employment generation opportunities.

Research on socio-economics aspect of aquaculture and fisheries

Socio-economic aspects of aquaculture and fisheries are one of least developed topics in Nepal. Research on socio-economics perspective is highly desirable for identification of social values and issues of different aquaculture and fisheries related activities in relation to communities and group of people.

Community or group based rice-fish farming with carps and other species

A rice-fish farming methodological package has been developed recently. To overcome a number of technical and social constraints implementation of rice-fish farming by involving communities or groups has been recommended. Research on the difference between isolated and community or group based rice-fish farming should be performed in near future to develop a "social shield" to avoid the social problems such as poaching and poisoning[12]. In addition there would be many other advantages of rice-fish farming in-group or community in terms of management, services and marketing.

Fish biodiversity and introduction of native species in culture practices

Little attention has been paid to fish diversity in Nepal due to limited human resources. The area of fish diversity in relation to socio-economical perspective of community living near by water resources is prerequisite for the development fish diversity conservation strategies and. High valued potential fish species should be studied for inclusion for commercial cultivation because they fetch higher prices in local market and this could be a means for fish conservation.

Conclusion

The per capita consumption and contribution of aquaculture and fisheries in Agriculture Gross Domestic Production (AGDP) is low (1.8%). This is due to inadequate priority for the promotion of the fisheries and aquaculture sector in national policies and implementation, inadequate skilled human resource, awareness and effective training mechanisms. Therefore, the main focus at present should be to increase total production through effective research and extension mechanism by involving the farmer, fisher community, planners, entrepreneurs, consumers and donors. In general, extensive orthodox farming systems seem to be the main backbone of present aquaculture enterprise in Nepal. Aquaculture production is known to increase by adding inputs such as feed, manure, and fertilizers. Therefore, further research and development should be focus on intensification of aquaculture production system in addition to mountain aquaculture and the above mentioned research areas.

Acknowledgement

Thanks to Mr. J.B. Abington for correcting the English in the manuscript and Dr. William Jones for comment and suggestions. This paper is dedicated to all those fisher community who despite of their hardship still stand at the brink of poverty and below poverty line. I also sincerely thanks to Dr. A. K. Rai, Mr. S. R. Basnet, Mr. J. D. Bista for fruitful discussion on the subject.

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Handling Mahseer broodstock at the Fisheries Research Centre, Pokhara

Aquaculture calendar

International Symposium on the Management of Large Rivers for Fisheries: Sustaining Livelihoods and Biodiversity in the New Millennium, 11-14 February 2003, Phnom Penh, Cambodia

The symposium will review and synthesize the current status, management and development of large rivers systems including their ecology, fisheries, environmental impact assessments, multiple uses of resources and associated socio-economic considerations. The symposium will also raise the political, public and scientific awareness of the importance of river systems, the living aquatic resources and the people that depend upon them and contribute to better management, conservation and restoration of the living aquatic resources of large rivers. Organized by the Mekong River Commission, the Cambodian Department of Fisheries and the FAO.

Visit http://www.lars2.org for more information.

Work Boat World Asia, 18-20 February 2003

Contact Baird Publications, 135 Sturt St, Southbank, Melbourne 3006, Australia, Tel +61 (3) 964 50475, fax +61 (3) 9645 0475, or email marinfo@baird.com.au.

Aquaculture America 2003, Kentucky USA, February 18-21

The conference theme is 'new frontiers in aquaculture' and the meeting has an extensive technical program and trade show.

For more information contact Aquaculture America 2003, Conference Manager, 2423 Fallbrook Place, Escondido, CA 92027 USA, tel +1 760 432 4275, fax +1 760 432 4275, email worldaqua@aol.com or visit www.was.org.

FishEye View 2003, Kuala Lumpur, Malaysia 7-9 March

The combined event will feature three exhibitions on Aquaculture and Commercial Fisheries; Recreational Fisheries; and Tropical Ornamental Fish. There will also be three seminars on 'Recent developments and technologies in the aquarium industry', 'Investment opportunities in tropical aquaculture and fisheries', and 'Sustainable fishing and fish farming practice – developments in equipment and technology'.

For more information contact Jungle Motion, 27-2 Jalan USJ 10/1E, UEP Subang Jaya, 47620 Selangor D.E. Malaysia, tel. +603 5683 2019, fax +603, 5636 6821 or email equiries@fisheyeview.net.

Wetland and Ecosystem Restoration Short Courses 14 March-30 October, Ohio USA

A suite of five short courses will be taught as a part of the Ohio State University's Olentangy River Wetland Research Park (ORWRP) Summer Short Course Series in 2003. There are several notable features of this year's course schedule. Four of the courses will be taught in the brand-new 10,000 ft2 Wetland Research and Education Building at the Olentangy River Wetland Research Park, with a conference room that was designed specifically for these courses. And for the first time, the ORWRP is taking its show on the road with Wetland Restoration and Creation taught in southwest Florida in 2003.

Courses range from 3 to 5 days in duration and are taught by the world's experts in those fields. Continuing education credit is available for those interested. A 10% discount is available if enrolled before May 30 for the Ohio courses and March 14 for the Florida course.

Information on course content and available accommodations can be found on the ORWRP short course web site: http://swamp.ag.ohio-state.edu/ShortCourse.html

Advanced Fish Medicine course, Florida USA, 25-28 March 2003

Advanced Fish Medicine is an intensive six-day course that will provide instruction in the most recent and advanced procedures associated with clinical fish health management. The course will emphasize a "hands-on" approach to many of the latest techniques including anesthesia, hematology, nutritional therapy, imaging, histopathology and surgery. The primary goal is to encourage practitioners to increase their expertise in clinical fish medicine. The course is intended for the advanced student who has prior education in fish diagnostics and health management. Acceptance into this course is by permission of the faculty. The course will start and end in Orlando, Florida with behind-the-scenes workshops at Walt Disney World and Sea World Orlando, respectively. Lectures and laboratory exercises will be conducted at the University of Florida College of Veterinary Medicine in Gainesville, Florida.

For more information visit http://conference.ifas.ufl.edu/fishmed/ or email rff@mail.ifas.ufl.edu

3rd International Symposium on Fish Vaccinology, Bergen, Norway 9-11 April 2003

The program will include:

- Vaccination for disease control – status and future potential
- Recent progress in fish and crustacean immunology
- Update on new vaccines for fish
- New adjuvants, formulation technologies and delivery methods
- Recombinant and live vaccines for fish
- DNA vaccination of fish – successes and constraints
- Regional and international standards for approval of vaccines for fish
- Societal aspects of vaccination in aquaculture
- Vaccinology – more than disease prevention

For more information visit http://www.veso.no/courses/fishvaccinology/ or contact fishvaccinology@veso.no. A brochure is available.

5th International Abalone Symposium 20-25 April 2003

The symposium will be held at the Ocian University of Qingao, China. Presentations dealing with the biology, fisheries and aquacutlure of abalone are invited. Presentations addressing the practical implementation of scientific resouts are particularly encouraged. A carefully selected panel of world-renowned experts in abalone biology, fisheries, aquaculture and marketing will address the symposium in a series of plenary and concurrent sessions. The main topics include: International abalone marketing; Fisheries management; Aquaculture technology; Larval biology and settlement; Pathology and diseases; Nutrition and feeding; Genetics; Physiology, biochemistry and biotechnology; and harvest and processing. An exhibition will also be held and abalone related tours and field trips are available.

For more information contact: Ms Hongming Ma & Wenbing Zhang, Secretariat, AB 2003, Tel +86 532 8978075, Fax +86 532 897 8076 or email ab2003@ouqd.edu.cn

Facilitating the Agricultural Innovation Process: Workshop 21 April to 3 May 2003, Andra Pradesh, India

A 12 day workshop will be held at the International crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Andra Pradesh. The objective of the training workshop is to promote opportunities for the national, regional, sub-regional and international agricultural research/extension program leaders in Asia to improve tgheir capacity and abilities in three areas of the agricultural innovation process:

- Strengthening creativity skills to promote innovation
- Facilitating linkages between stakeholders in the innovation system
- Engendering participatory research to engage researchers, extensionists and farmers in the process of innovation.

Candidates should have some field experience in participatory agricultural research and extension. The cost of the training workshop is US$2,000, including accommodation, meals, incidentals, training materials and local transportation. The workshop will be held in English.

For more information, contact Mr Rex Navarro, Head of the Learning Systems Unit, ICRISAT, Tel +91 40 3296161, Fax +91 40 3241239, email rex.Navarro@cgiar.org.

NOTICE: Change of date for Aquamarkets 2003 meeting

Due to current developments in the Mid-East which could make it difficult for people to decide whether or not travel, NACA and its two co-organizers, the Philippine Department of Agriculture and the Philippine department of Industry, have deemed it prudent to re-schedule AquaMarkets 2003 – Regional Seminar, Consultation and Exhibition to 2-6 May 2003 at the same venue (PICC, Manila). The daily Programme remains the same.

In view of this postponement, the deadline for the receipt of your acceptance and completed participation forms is now moved to 30 March 2003. Please send them by fax to 662 561 1727, or send the electronic forms to: aquamarkets2003@enaca.org.

For those who have confirmed their participation, please contact aquamarkets2003@enaca.org for further information or questions.

AQUAMARKETS 2003 : Accessing and Meeting Requirements of Markets for Aquaculture Products, Regional Seminar 2-6 May 2003, Manila, Philippines

We invite you to a seminar of fish farmers, fishery product traders, entrepreneurs, prospective investors, suppliers, technical service support providers, industry analysts, experts, advisers, technologists, researchers and government policy makers from more than 25 countries from Asia- Pacific, Europe and North America.

Interact with co- participants and with resource persons from various UN specialized agencies and other international organizations including ADB, ESCAP, ICLARM, INFOFISH, FAO, IBRD, ITC, OIE, UNCTAD, WHO, WTO and others. The topics: various issues and policy approaches relating to access and competitiveness in markets for aquaculture products and impacts of certain trade issues on poverty and environment.

Contact the NACA Secretariat on aquamarkets2003@enaca.org or Fax +66-2 561 1727 or visit http://www.enaca.org/RegionalSeminar.htm

World Aquaculture 2003, 19-23 May 2003, Salvador, Brazil

Contact WAS Conference Manager, 2423 Fallbrook Place, Escondido, CA 92027 USA. Tel +1 (760) 4324270, fax +1 (760) 4324275, or email worldaqua@aol.com

Mangrove 2003, Bahia Brazil, 20-24 May

The theme of the conference is Connecting research and participative management of estuaries and mangroves. The Mangrove 2003 Conference will seek to promote the necessary link between generation of knowledge and environmental management, in order to enhance local participation in solutions for socio-environmental problems.

For more information please contact: The Conference Secretary at mangrove2003@ufba.br or visit http://www.mangrove2003.ufba.br/

AQUARAMA 2003, 29 May – 1 June

The meeting is billed as the 3rd World Conference on Ornamental Fish Aquaculture. Sessions cover application of biotechnology in the ornamental fish industry; production of new ornamental species; culture of freshwater ornamentals; culture of marine ornamentals; new developments in the ornamental fish industry; and challenges and issues facing the ornamental fish industry. For more information contact julian_lim@cmpasia.com.sg or visit www.aquarama.com.sg.

Rights and Duties in the Coastal Zone: Multidisciplinary Scientific Conference on Sustainable Coastal Zone Management, 12-14 June 2003, Stockholm, Sweden

This conference will compare various property-rights regimes in the coastal zone, and their associated management systems, with a focus on the developed part of the world. It will also consider various policy instrument options and other formal or informal institutional solutions, in cases when property rights are difficult to defined or enforce.

One way to prevent or resolve conflicts is through insightful design and enforcement of property-rights regimes in the coastal zone. Whose are the property rights, i.e. who are entitled to rights and duties in the use of the coastal zone? And what rules for exercising the rights do the property-rights regimes involve? Are present property-rights regimes in the coastal zone inconsistent with the dynamics of the ecological resource they are supposed to control? For example, do they take into account migration among species and the existence of thresholds in the behavior of ecosystems? These and other issues, which are crucial for the management of the coastal environment, have been addressed by the Swedish research programme Sustainable Coastal Zone Management, a partner in the conference.

For more information visit http://www.beijer.kva.se/conference.htm

Organic Aquaculture & Sea Farming 2003, 15-17 June 2003, Ho Chi Minh City, Vietnam

The programme will include: Industry situation & outlook; production and processing case studies; markets and marketing; technological developments and issues. The annual VIETFISH international fisheries exhibition will be held in conjunction with the meeting.

Contact INFOFISH, PO Box 10899, 50728 Kuala Lumpur, Malaysia, tel (603) 26914466, fax (603) 26916804, email infish@po.jaring.my.

Sixth International Symposium on Fish Parasites 22-26 September 2003: Bloemfontein, South Africa

Contact Professor Jo Van As, Department of Zoology and Entomology,University of the Free State, PO Box 339, Bloemfontein 9300, South Africa, fax: +2751 448 8711, vanasjg@sci.uovs.ac.za

Environmental Management of Enclosed Coastal Seas, 18-21 November 2003, Thailand

The conference program will include three special session themes: i) Gulf of Thailand; ii) Asian forum for discussion of sustainable development in Asia and the preservation of coastal environments; and iii) NGO forum, to discuss the roles of NGOs in better understanding and promoting friendly coexistence between nature and people in coastal areas. The technical session themes will be related to the scientific, technical, management, educational and information aspects of coastal seas. Technical tours will be held after the conference to Kung Krabaen Bay, the King's project on Coastal Zone Management in Chantaburi Province and on Koh Chang Island in Trad Province. The deadline for submission of abstracts is 30 April 2003.

For more information visit www.emecs2003.com.

Aquaculture Australia, 3-5 December 2003

Heighway, the publisher of Fish Farming International, has launched an international trade exhibition – Aquaculture Australia – to be held at the prestigious Sydney Convention & Exhibition Centre, in the city's Darling Harbour, from December 3 to 5, 2003.

The Australian aquaculture industry is predicted to increase its current first-sale product value of around A$750m to some A$2.5 billion by the end of the decade. Spearheading this are the growth leaders tuna, pearls and edible molluscs, salmon, barramundi and tropical shrimp. Yet given the many other diverse species at advanced stages of development, this estimate is viewed as conservative.

Aquaculture Australia aims to reflect the growing commercialisation of the host nation's industry, focussing on how to make aquaculture work as a business. Such a theme will no doubt be evident among the booths at Darling Harbour in 2003, but it is intended also to address this theme by way of a major international conference running alongside the exhibition. This would feature a range of international speakers passing on their advice and experience in running successful aquaculture businesses.

At its recent launch at the AquaFest 2002 conference in Hobart, Tasmania, the Heighway team received positive backing from all of the leading figures in the industry it canvassed – including the host Tasmanian Aquaculture Council, the National Aquaculture Council, the Fisheries Research & Development Corporation (FRDC) and the federal department of Agriculture Fisheries & Forestry Australia (AFFA) – as well as many producers and industry suppliers attending the Hobart event.

In addition, the New South Wales government's business development department has signalled its interest in helping such an event through the possibility of hosting an official function during the Sydney show. Farther afield, and in keeping with Australia's strategic position for business in the region, Heighway has received a positive response for the event from the Network of Aquaculture Centres in Asia-Pacific (NACA)– an inter-governmental body of which Australia recently became a member.

Add all this to the setting in one of the world's most dynamic and enjoyable cities, and Aquaculture Australia has all the potential to become a regular leading event in the industry's calendar.

For further details please contact: Sue Hill, Exhibition Sales Manager, Heighway Events, Telephone House, 69-77 Paul Street, London, EC2A 4LQ, UK, Tel/Fax: +44 (0)20 7017 4516 / 4537 Email: sue.hill@informa.com.

Topical issues in genetic diversity and breeding

Genes and Fish

Graham Mair

Graham Mair is a research fellow at the University of Wales Swansea, on secondment since 1997 to the Aquaculture and Aquatic Resources Management Group at the Asian Institute of Technology, Bangkok. Based in Asia for the past 14 years, he has been coordinating and conducting research projects under DFID's Fish Genetics Research Program, focusing on the appropriate aplication of genetic technologies to species for low-input aquaculture systems.

Email: *gcmair@ait.ac.th*

Hybridisation – More trouble than its worth?

Hybridisation

"Hybridisation" in this article refers to the crossing between fish species - I prefer to use the alternative term "crossbreeding" to describe crosses between stocks or strains, within a species. We are lucky, or in the context of this article perhaps unlucky, that the biological species concept based on reproductive isolation or "non-crossability" of species, does not apply very well in fish. We know that it is possible to make crosses and produce viable and fertile progeny in a great many different fish stocks, which by all other definitions of the term, we would consider as different species. Even crosses between different genera are possible in a number of cases including some important aquaculture species such as the major carps and tilapias.

The rationale

If we exclude scientific curiosity, hybridization is usually attempted for two reasons. The main reason is the hope of observing heterosis or "hybrid vigour" for one or more commercially important traits. The rationale behind this hypothesis is that different species are likely to have evolved different alleles at common gene loci and thus that there will predictably be high levels of heterozygosity in the hybrid progeny. High levels of heterozygosity are often associated with greater "fitness". If hybrid vigour does result in good characteristics for aquaculture then these should be consistent for all F1 crosses of the species, providing predictable gains in the hybrids.

The other main rationale for carrying out hybridisation is to combine a set of desirable characteristics from two or more different species into a single hybrid with the combination of traits in the hybrid then having significant benefits, in the context of production or marketing, over either of the parental species.

Its popular science!

Perhaps because it's often relatively simple research to carry out there is a very large body of literature on scientific studies in which hybrids have been produced and evaluated for a range of traits. In my own library alone I have several hundred publications that make significant reference to hybrid fish and there are over a thousand and possibly several thousand publications dealing with the issue. It is my impression that in the majority of studies in which viable hybrids are produced, the hybrids have traits that essentially represent an average between the traits of the two parental species. Deviations from this norm, where clear-cut heterosis in which the hybrid out performs both parental species for commercially important traits, are rare

In the US the cross between two Ictaluriid catfish, the channel catfish (female) and the blue catfish (male) produces a fish with superiority for growth rate and several other important traits. Efforts to produce the hybrid on a commercial scale have however failed. In other hybrids, whilst they may not grow faster or have higher production than parental species, the combination of two species may result in fish with other desirable traits. Some hybrids are sterile (common in crosses between species with significantly different chromosome number), whilst others may have enhanced environmental tolerances (e.g. tilapia hybrids), attractive appearance or flesh quality (e.g. Clarias catfish hybrids) or they may be monosex (tilapia or North American bass). These traits can be advantageous under certain circumstances. For example triploid hybrids between grass carp and bighead carp might have benefit from a conservation perspective where the fish might have an application for weed control in a location to which neither species is indigenous.

A poor return

Despite the large body of research on hybridisation, the bulk of it justified in the context of potential applications in aquaculture, there are very few hybrid fish produced in commercial aquaculture worldwide. Probably the best example is the hybrid catfish cultured in South-east Asia, principally in Thailand and, to a lesser extent, Vietnam. This is a hybrid between the indigenous *Clarias macrocephalus*, a small, slow growing species particularly desired for its flesh quality, and the exotic *C. gariepinus*, the African catfish, a larger faster growing catfish but with poorer marketability. The hybrid, which has characteristics that are essentially intermediate between the two species, represents a good compromise as it is faster growing and more robust than the indigenous catfish with a much-improved marketability compared to the pure African catfish. Whilst the parental species used to be cultured as pure species in small quantities the hybrid is now cultured very widely in Thailand where it represents the second most important inland aquaculture species with a production of over 70,000 MT per annum. Another example of significant use of hybrids in aquaculture is the culture of hybrid tilapia, mainly the F1 hybrid between *O. niloticus* and *O. aureus*, which are often near monosex male. Whilst FAO published statistics do not record significant production of this hybrid it is thought that 50-75% of Chinese tilapia production is of this hybrid indicating a very significant contribution to global tilapia production. The exact reason for the preference for this hybrid in China and Taiwan is not clearly understood as it is no longer a popular tilapia for culture in the rest of the world. One of the other well-known examples of hybrids is the hybrid striped bass which is used in aquaculture in North America and Israel although levels of production are relative low. With apparently only three hybrid finfish in significant commercial production, surely it has to be considered that research on hybridisation has not lived up to its potential with regard to commercially valuable outputs. This is of course not to say that that may not be other reasons for carrying out hybridisation, for example as a prelude for inter specific backcrossing which can be used to introgress advantageous genes (e.g. for disease or environmental tolerances) from one species to another.

The downside?

There is a downside to hybridisation, particularly if it is carried out indiscriminately. The main risk lies with a permanent loss of species purity in aquaculture stocks with the prospect of this being passed on to wild stocks in locations where the species are indigenous, resulting in a break down of species barriers. As so many hybrids are fertile they can be used either deliberately or accidentally, as broodstock resulting in segregation of genotypes with some of the subsequent F2 hybrids or backcrosses being indistinguishable from either or both of the parental species. Use of hybrids as broodstock on any kind of scale would thus fairly rapidly lead to widespread introgression.

Commonly, aquaculture systems in Asia have developed to exploit the particular feeding habits or ecological niche of distinct species. This is very much so in the case of multi-species polyculture where the species used occupy complementary, non-competitive niches, enhancing the overall productivity of the systems. With the use of hybrids or with hybrid introgression the integrity of the behavioural patterns breaks down. One example where this appears to be occurring is in Bangladesh (and some other Asian countries) where the introduced Chinese carps are widely used in polyculture. A common practice in some Bangladesh hatcheries is to use the sperm of one species to cross with females of the other, typically using silver carp sperm to fertilize eggs from bighead carp when males of the latter species are in short supply at the end of the breeding season. The hybrid is difficult to distinguish from the parental species and is quite likely to enter the broodstock. As might be expected, the hybrid has traits intermediate between the two species making it fairly omnivorous given that silver carp are primarily phytoplankton feeders and with bighead mainly feeding on zooplankton. Culture of hybrids or widespread introgression of the species thus removes the advantage of complementarity of feeding behaviour in the two pure species. Based on morphological investigations, it has been suggested (Rajts, pers. comm.) that introgression has reached the point in Bangladesh that the current "silver carp" stocks are widely introgressed and as a result tend to compete with more omnivorous Catla in carp polyculture

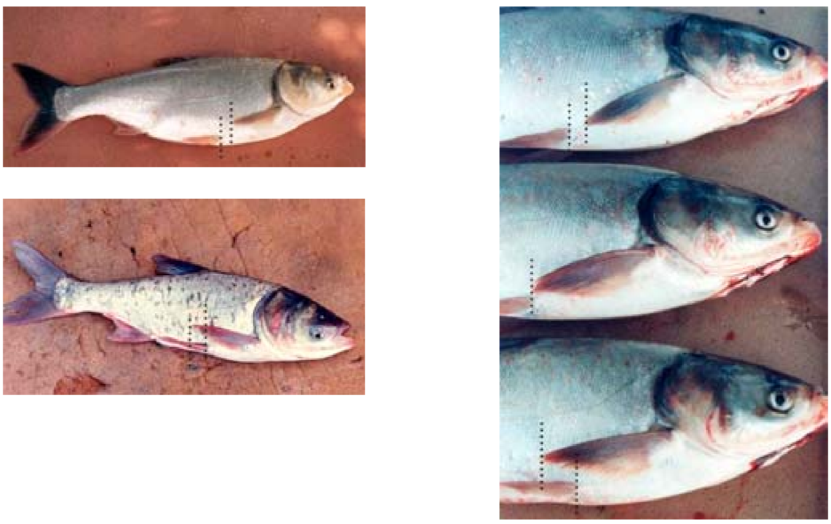


Figure 1: Illustration of differences between silver and bighead carp and the properties of their hybrids. In silver carp (top left) it is thought that the pectoral and pelvic fins do not overlap whilst in bighead carp (bottom left) an overlap is clear. A range of intermediate types can be seen among cultured stocks in Bangladesh (right) probably representing hybrid or introgressed stock. In the intermediate types the gill rakers also vary between the fine dense rakers of the bacteria and phytoplankton feeding silver carp and the coarser rakers of the zooplankton feeding bighead carp. Gut length is also intermediate between the longer gut of the silver carp and the shorter one of the bighead. (Photo and accompanying information provided by F. Rajts)

systems. However, genetic analysis using DNA markers being carried out under an on-going DFID funded project involving the University of Stirling, demonstrated that introgression is present in less than 10% of broodstock in hatcheries surveyed, indicating that the problem may not yet be very widespread.

"It is debatable whether the potential risk-benefit ratios of hybridisation warrant continued experimentation...

Introgression was also found to be widespread in Philippine tilapia stocks in the 1980s, with the majority of stocks considered at the time to be pure *O. niloticus* found to be introgressed with the previously introduced and slower growing *O. mossambicus*. This resulted in the fresh introduction of tilapia stocks from several sources and it has taken over a decade to effectively replace the introgressed stocks. Given the almost ubiquitous presence of feral tilapia through much of Asia, introgression of cultured stocks is commonplace, although it often goes undetected.

In summary

It is debatable whether the potential risk-benefit ratios of hybridisation warrant continued experimentation and certainly efforts to raise awareness of the risks of indiscriminate hybridisation should be made. Even the relative success story of the hybrid catfish in Thailand is not without its risks. Wild stocks of *C. macrocephalus* are threatened not only by collection of females for use as broodstock but also by introgression with hybrids escaping from commercial farms. The only reason that this had yet to happen on a wide scale would appear to be down to the good fortune that the hybrid has reduced reproductive capacity.

What's New on the Web

www.techsoup.org

Technology assistance for non-profit organizations

A few days ago I stumbled across the 'Techsoup' website completely by accident. Techsoup is a US-based organization that calls itself a 'comprehensive source of technology information just for nonprofit organizations', and this would seem to be a fairly accurate claim - Techsoup does a number of things. If you or your organization is involved in use of technology for development, community work or education then I recommend that you take a careful look at the resources available through this website. The site has a very impressive list of sponsors and partners including Microsoft and AOL Time Warner, BP, Adobe Systems, VodaFone, Lotus and Cisco Systems. It is also partnered with an organization called Computer Mentor and…CNET…ok guilty, so I was enviously reading reviews of a great new handheld computer that is available pretty much everywhere but Thailand (grumble…why, Dell, why ?).

Free and discounted technology for non-profit organizations

Firstly, Techsoup partners with the philanthropic groups of leading technology companies to provide centralized access to technology products that have been donated (ie. are available for free) or discounted for non-profit organizations. There is some quite good equipment available here – for example virus protection software from Symantech, Office XP from Microsoft and switches from Cisco Systems. Some things are available directly through the Techsoup website (they charge relatively small administrative fees) and for others you have to apply directly to the providing company. There are application procedures (of course) and the vendors also impose varying restrictions in line with their company policies.

Grants, funding and resource links

You'll find lists of free and discounted software distributors. There is also a comprehensive list of links to technology-related funding and grants providers – Adobe, Dell, the Gates Foundation, the Hewlett Foundation, Mitsubishi, the Packard Foundation and the list goes on. Application details are provided along with comments and ratings from people who have already applied so you can find out which grants schemes have user-friendly procedures and which would be a waste of your time.

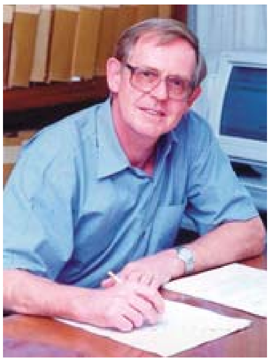
User-friendly technology guides

At last a technology organization that actually provides user-friendly information. A wide range of easy-to-understand articles are provided through the site that to help laypersons understand technology, and to use it effectively and appropriately. No computer background is assumed. Subjects covered include technology planning and hardware, using the internet and email effectively, options for online discussions and making technology accessible to people. There's a lot of other useful stuff that you might need to know if you're going to get involved in using technology for development – how to find appropriate volunteers, dealing with consultants, and What To Do When Your Techie Leaves You !

...continued on page 53

Peter Edwards writes on

Rural Aquaculture



Peter Edwards is Professor of Aquaculture at the AIT in Bangkok where he founded the aquaculture program. He has 25 years of experience in education and research relating to small-scale, inland aquaculture based on extensive travel throughout the region. Email: pedwards@ait.ac.th

A knowledge-base for rural aquaculture

In my column in the July-September 2001 issue (Volume VI:3), I wrote about the need to develop a knowledge base for rural aquaculture which I divided into a series of subject matter fields. These were subsequently used to produce an open-ended questionnaire to solicit the views of individuals with experience in field-based R & D who have been involved in project activities at grass roots level in developing countries. The questionnaire solicited views on:

- What knowledge exists and in what form and language?
- Is more knowledge required in a particular area, and if so, how should it be produced, and in what form and language should it be produced?
- How should the new knowledge be disseminated?

Some of the major finding and quotations are used for this issue's column to provide a "flavor" of what is to come in a paper being produced on the survey.

Most respondents stated a need for rural aquaculture, particularly where wild fisheries are in decline, but even in areas with abundant wild fish in the rainy season, poor people may not be able to catch sufficient wild fish in the dry season. However, it is simplistic to believe that aquaculture can replace capture fisheries and there is a need for knowledge of the complex interrelationships between aquaculture and wild fisheries.

The degree of involvement of small-scale farmers in aquaculture varies widely from, for example, almost none in Africa and in Sri Lanka in Asia, to very few in Cambodia and Laos compared to Bangladesh and Vietnam where there are significant numbers. Small-scale farmers who now farm fish could benefit even more from aquaculture if constraints to gaps between current and potential yields were addressed in both Africa and Asia. There is huge potential for more small-scale farmers to farm fish if various limiting factors, depending on context, were addressed.

The intricate relationship between aquaculture and other farming systems is not understood by professionals in aquaculture and other development sectors and "a fundamental change in the education system is necessary to develop appropriate knowledge and skills of students and staff in the fisheries sector". There was consensus regarding the question of how rural aquaculture technology should be developed or improved for farmers:

Participatory on-farm research - weighing nursed fingerlings in Northeast Thailand

- Rural aquaculture should be demand driven
- A participatory approach used for both development or improvement of technology rather than technology transfer.
- It should be more focused on resource-poor farmers.
- There is a need to better understand farmer decision-making processes.
- There is a need to strengthen participation of government at all levels down to local level
- Involve NGOs.

Concerning the attention aquaculture receives in national policy compared to other development sectors, policies in Africa were reported to be weak, incomplete or lacking and even where they exist, strategies to implement policy are lacking. Policies for aquaculture in Asia are improving although allocation of resources may not correspond to recognition. Some countries are increasing government investment in rural aquaculture e.g., Vietnam's program "Sustainable Aquaculture for Poverty Alleviation or SAPA.

Turning now to a series of technical issues, the limited availability of quality seed is regarded as a constraint in Africa and many areas of Asia, especially the timely availability of large fingerlings. In response to a question on which groups of species are now farmed and which have the greatest potential, the answers are aptly summarized by a respondent who wrote "more confusion than clarity exists in regard to the issue of native and exotic species", suggesting the need for knowledge on their relative merits, both positive and negative.

The question concerning the adequate of existing breeds of indigenous and exotic fish provoked a varied response. A majority view was that "existing species" are sufficient" and that "technical preoccupation on new introductions should not be a high priority at the current stage of development". One respondent wrote that awareness of new breeds has prompted many to misdirect attention of poor growth of adequate fish from poor management. However, several respondents mentioned the issue of seed quality as nicely summarized by a respondent from Bangladesh: "I doubt if many hatchery workers understand the basis of broodstock management and simple genetics to obtain decent fingerlings".

Exploring the possible role of aquaculture for a poor Cambodian family

There was general consensus that the principles and practice of effective pond fertilization are poorly understood. Sub-optimal fertilization is probably one of the major management weaknesses in Africa and the same applies to most of Asia. Respondents from Bangladesh called for more knowledge on "green water" culture techniques. There is inadequate knowledge of use of ingredients for feeds and feeding in Africa and Asia but as one respondent pointed out, this level of intensification may be largely outside the scope of poor farmers. One commented that much of the knowledge generated by the Western mode of nutrition research has little relevance for small-scale farmers in developing countries.

Disease was reported not to be a major issue in Africa at the current level of aquaculture development and generally ranks below seed and feed as issues in rural aquaculture in Asia. Disease was stated by one respondent to not be a major problem in Bangladesh although poor production due to poor management is often attributed to "disease".

There appears to be poor knowledge in both Africa and Asia regarding stock management.

With regard to culture systems, respondents pointed out that technology and literature are readily available for rice / fish culture but there has usually been a low adoption rate and, as a consequence, hardly any information on its sustainability as a profitable enterprise or on "scaling-up". Pond culture is the most common culture system in most areas although many ponds receive little management once they have been stocked with seed. Most respondents considered ponds to have huge potential although one respondent considered them to have low priority for poverty alleviation. Fish are usually cultured in cages by better-off farmers but some respondents felt that they have potential for small-scale farmers. Wastewater-fed aquaculture is practiced in peri-urban areas in some countries in Asia but more knowledge is required on

The professor receiving a lesson from the farmer in Vietnam

Asking a farmer in Northeast Thailand for his opinion on integrating aquaculture into his resource-poor farm

its economics and safety for possible wider dissemination. There is an erroneous view that coastal aquaculture farmers are mostly the better-off; it has considerable potential for poverty alleviation if small-scale farmers are targeted.

As most respondents had field level experience, the inadequacy of commonly used “top-down” or “trickle-down” systems of R and D (extension) were severely criticized. Rural aquaculture requires technology either created or upgraded by the farmer. Traditional development programmes do not reach the poorest of the poor, only the richest part of society. There is a need for alternative extension methodologies as current services are also understaffed and underfunded. There is a need to avoid “model farmer” approaches. Extension services should be trained to be people centered and participatory. They should include also farmer extension with an experiential learning approach and the creation of “farmer to farmer” learning opportunities.

The need for participatory farming systems R & D approaches is increasingly understood but there is a huge need for capacity building and scaling up. One respondent from Bangladesh wrote that “most NGOs speak well on such approaches but do not do it in reality”. In Sri Lanka there is use of rhetoric (participatory, market-oriented, community management and co-management) but it is a façade for continuing high-tech, production-oriented, top-down approaches. One respondent, recognizing that participatory approaches appear to be an effective way to reach out to the small-scale farmer, asked do we have documented “models”? Other respondents provided answers:

- In Africa “there are certainly sites which could serve as case studies of successful small-scale aquaculture”
- “most aquaculture systems in Asia are poorly documented and rarely brought out as educational materials to help teaching and plan research activities”.
- “surprisingly limited and inaccessible – a priority”
- “there are lots but few have been documented and disseminated”.

In conclusion in the words of respondents concerning knowledge:

- “sharing knowledge is the biggest issue in all fields of knowledge”.
- “knowledge exists in limited networks, in limited media and few languages”.
- “the components are probably available but need to be integrated, evaluated and distilled in a regional context”.

And regarding the level of knowledge of teachers, trainers and researchers in participatory, farming systems approaches:

- “very limited, huge capacity building drive essential. We are supposed to halve world poverty by 2015. It will not happen unless we fund this”
- “large investment in this area to build the capacity of staff involved in teaching, research and development would result in multiple benefits”.
- “huge field of educational work itself to develop the capacity of teachers, trainers and researchers in applying approaches”.

Field-testing extension materials in Northeast Thailand prior to wider dissemination.

Farmers as Scientists

This is a series anchored by M.C. Nandeesha. It describes farmer-driven innovations and experiences.

Commercialization of Giant Freshwater Prawn culture in India by Farmers

Dr. M.C.Nandeesha has taken up a new position as Professor and Head of the Department of Aquaculture, College of Fisheries, Central Agricultural University, PO Box No. 120, Agartala-799001, Tripura, India. This is a four-year old institution established to cater to the manpower and research requirements of the Northeastern part of the country in the fisheries sector. He has nearly two decades of experience in teaching, research and development and has worked with Universities, NGOs and multilateral organizations within and outside the country. Email address: mcnraju@yahoo.com.

Research on freshwater prawn breeding and culture has been going on for almost two decades with varying degree of success in different research centers of India. The Central institute for Freshwater Aquaculture (CIFA), the Central Institute of Fisheries Education, some of the Fisheries Colleges under the State Agricultural Universities in the states of Kerala, Andhra Pradesh and Karnataka have long been involved in giant freshwater prawn (Macrobrachium rosenbergii) research and have developed technologies appropriate to local conditions. There are also a number of other organizations like MPEDA (Marine Products Export Development Authority), State Fisheries Departments and private consulting firms, which all have contributed significantly to the promotion of freshwater prawn culture. However, much of the research and developmental efforts of these Institutions remained largely as small-scale demonstrations in different states until recently. With the involvement of farmers from Andhra Pradesh in Nellore district on a large scale, the activity has been expanded widely and the maximum water area is under fresh water prawn culture in this state. The farmers of Andhra Pradesh are known for innovations and entrepreneurial skills and they have successfully demonstrated these qualities in establishing carp culture and shrimp culture. Declining profitability from carp farming and disease problems in shrimp culture encouraged farmers to look for new candidate species for aquaculture. As a result, farmers of this state have explored opportunities in freshwater prawn farming with the support provided by various agencies and individuals. In this article another successful adaptation of freshwater prawn farming by the farmers of Andhra Pradesh and the constraints faced by them at the present are presented.

National Fish Farmers' Day

The Government of India has declared 10th July to be celebrated as the Fish Farmers Day to commemorate the success achieved in induced breeding of carps by Dr. Hiralal Chaudhary on this day in 1957. Fishing Chimes, a widely read and well respected Indian Fisheries Magazine has instituted a Gold Medal in the name of Dr. Hiralal Chaudhury through the "Jayashree Trust" to be given to a progressive farmer who

Mr. Ch. Srikanth receiving Dr. Hiralal Chaudhary Gold Medal and citation from the then Honorable Minister for Agriculture Mr. Nitish Kumar.

makes a significant contributions for the development of aquaculture in India, on an annual basis. This prestigious award for the year 2001 was presented to Mr. Ch. Srikanth for his significant contributions for the promotion of freshwater prawn culture through the active partnerships of farmers in India. His accomplishments are worthy for others to emulate in how commerce, service and science can be coupled together to have the best possible effect. In 1980s, while looking for self-employment opportunities in the field of agriculture, Mr. Srikanth started experimenting with various activities like poultry, agriculture and aquaculture. Among various occupations, he recognized aquaculture as an activity through which maximum profitability can be obtained with less risk based on his maiden experience in carp farming and carp seed production. From carp, he moved into prawn farming and seed production in 1990s. As a producer of prawn seed, to popularize prawn farming, he worked closely with farmers to demonstrate the culture potential of freshwater prawn through innumerable number of demonstrations and various other strategies. Today he owns a group of Maharaja hatcheries known for quality seed production of giant freshwater prawn. Besides Andhra Pradesh, he is now moving the prawn farming activity to several Northern States of India.

Composite culture of carps and prawn

Composite culture of carps with prawns has been proved to be successful in many of the experimental demonstrations in the past. However, the technique has not become popular owing to seed availability and also marketing problems of prawns when such culture is undertaken only by a small number of farmers. Mr. Srikanth banked on these proven results to encourage farmers in Nellore region initially to experiment culture of carps with prawns. Carps are generally stocked at about 5,000 fish / ha and grown for a period of about 8-12 months. Along with carps, farmers were encouraged to stock up to 10,000 juveniles / ha of prawn. While carps were grown through periodic fertilization and regular feeding with de-oiled rice bran, no feed was given to prawns. Farmers were able to obtain 5,000-6,000 kg of fish at the end of culture period and obtain even more than 50% survival of the prawns depending on the size of the stocked seed and other pond water quality conditions. Often the revenue realized from prawn, which would have attained a weight of up even up to 100 g at the end of the year was as good as revenue from carps. The repeated confirmation of results by several farmers on the possibility of growing carps and prawns together and the high income realized from prawn farming stimulated some of the farmers to explore the possibility of monoculture of prawn. The success in the monoculture of prawn has led to the replacement of carp culture almost entirely with prawns. In addition, low saline areas in the coastal belt are also used for prawn culture.

Mr. Srikanth seen with his family and a galaxy of key Indian Fisheries Scientists.

Monoculture of prawns

The technology developed by farmers for monoculture of prawn involves greening of ponds by application of lime (500 kg/ha), organic manure (2,000-3,000 kg cow dung) and inorganic fertilizers like super phosphate (50kg /ha) and urea (20kg/ha) at a low dosage. While some farmers buy the post larvae and nurse them to juvenile stage over a period of 1-2 months, others directly stock post larvae for commercial culture operations. Nursing of post larvae is undertaken by stocking at 100,000 to 200,000 /ha. The larvae are fed daily several times with the supplementary feed at 15% of body weight at the beginning and gradually reduced to 5%. The larval feed containing more than 30% protein is fed to larvae during the nursing period. Coconut fronds are provided as shelter for the larvae to take protection while molting. The larvae would attain a weight of 4-5 g depending on stocking density and other management practices.

The post larvae / juveniles are stocked at the rate of 25,000 to 40,000 / ha in ponds that are greened by following the procedure of application of lime, organic manure and inorganic fertilizers. To regulate plankton bloom, surface feeding fish like catla (*Catla catla*) are stocked at about 500/ha. Unlike carp ponds wherein manure loading is high, prawn ponds are maintained to have only adequate levels of green condition through water exchange. After the initial fertilization, the green condition of water is generally maintained by the unused feed and fecal matter contribution of prawn and other organisms. Prawns are fed at 5% of the body weight in the beginning by splitting the quantity in to 3-4 meals by broadcasting feed in to the pond. With the increase in size, feeding rate is gradually reduced to 1-1.5%. While feeds supplied by major feed manufacturing companies have major share in the market, several of the farmers produce their owns feed by procuring various ingredients, processing and preparing feed pellets using the industries set up to provide such services at cost. The cost of such prepared feeds is much less than the

Water evaporation and seepage loss is maintained by pumping ground water in many cases.

company feeds with experimentation and experience of farmers is helping them to become independent on this feed component, which is the largest cost in cultivation. The food conversion ratio of feeds vary widely from 1.5 to 5 depending on the management strategies adopted by farmers, although with experience, most farmers are able to get a conversion of 1.5 to 2.5. The protein level of feed is maintained around 25-30% for growing market size prawns.

Harvesting begins after 3-4 months of stocking and bigger individuals are culled and marketed. Several farmers adopt the strategy of harvesting bigger size prawns at fortnightly / monthly intervals until the end of culture period, which can extend up to 8-12 months period. Harvested prawns are kept in fresh condition using ice at 1:1 ratio until it is reached to the processing units. Partial processing is also carried out in farm by removing head and legs. The recovery rate of prawns varies depending on the size of larvae stocked and other management practices adopted and can be as high as 90%. There would also be a small percentage (5-10%) of stunted prawns, which are called "runners" which are grown by stocking them separately. These runners compensate growth in about 1-2 months and grow up to be sold as "winners". Evaporation seepage loss and partial replenishment of water are other important criteria that determine the growth and productivity. Several farmers have been using ground water for replenishment and partial exchange of water. Shelters for prawns are not generally provided in culture ponds, particularly when they resort to continuous harvesting strategy since such placement of shelters create problems for regular harvesting. Production of prawn varies depending on the management strategies adopted from 600 to 3,000 kg/ha/year, though on an average most farmers obtain about 1,000 kg/ha/year.

Small farmers derive benefits: Some examples

A number of small farmers have gotten involved in prawn farming activity through seeing the successful demonstrations of large farmers. These small farmers are deriving the benefit of prawn farming and have been able to improve their livelihood through aquaculture. Mr. Ismail Sheik is one such small farmer who hired a pond of 1.5 acres on a lease basis for Rs.15,000/-year. He prepared the pond by applying 200 kg lime and filled the pond with canal water. The pond was stocked directly with the 25,000 post larvae and they were fed with the commercial feed at 5% body weight by splitting the quantity of food to be given 3-4 times a day. After four months of culture, harvesting resulted in 1,150 larger-sized prawns and thereafter throughout the culture period of one year, larger prawns were harvested at monthly / fortnightly intervals. Lime was applied at the rate 50 kg/acre after every harvest as a sanitation measure to maintain good water quality. For the whole culture period about 1600 kg feed was used. Altogether 16,000 prawns with an average count of 40 prawns /kg were harvested. The farmer spent Rs. 22,000 for seed and Rs.40,000/- for feed and incurred another Rs. 6,000 towards the cost of lime, geolite and harvesting expenses. Selling of prawns yielded

Pellets are broadcast in to ponds

Rs.170,000 and after deducting the expenses a net profit of Rs.87,000/- was made. Most of the activities were managed with the family labor, excepting harvesting by hired labor. For a small farmer like Mr. Sheik, this has been very risky business involving huge expenditure. However, in the end the risk has been worth since profit realized was more than 100% on the investment, though the production obtained was not impressive. With the encouragement derived from this beginning, he has converted his own paddy land into fish pond and is continuing prawn culture in both the leased pond as well as his own pond.

Mr. Venku Reddy is another farmer involved in prawn farming, but his scale of operation is slightly larger. He has taken on lease four ponds totaling about 3.75 ha. Mr. Reddy purchased about 140,000 post larvae and nursed them for about 2 months in a 0.8 ha pond. The pond was prepared by applying lime at 500 kg and about two tones of cow dung followed by the application of super phosphate and urea to give an adequate green color of water. Larvae were fed at 15% body weight in the beginning and the rate was reduced to 5% with the increasing larval size. During two months rearing, the seed attained a weight of about 4g. These juveniles were grown to marketable size by stocking them at about 30,000 /ha in grow out ponds. Prior to stocking rearing ponds were also prepared in the same fashion by applying lime, followed by cow dung and inorganic fertilizers.

In larger ponds, simple floating devices are used for movement and broadcasting feed. Rope tied from one end to another will serve as support structure for movement and broad casting of feed all over the pond.

Ponds were also stocked with surface feeding fish like catla at 300 fish /ha. Partial harvesting commenced after 120 days: Larger prawns were harvested and sold at fortnightly intervals. The quantity of feed given to prawns was adjusted based on the number of prawns harvested and the probable number remaining in pond. The farmer was able to harvest more than 90% of the stocked prawns and on an average obtained a production of more than 1,400 kg/ha yield in ten-month culture operation. After all the expenses, he was still able to earn good net profit.

Harvesting of market size prawns is undertaken on fortnight / monthly basis

Conclusion

The area under freshwater prawn cultivation has been expanding rapidly with the simultaneous growth of support industries. It is estimated that at present about 22,000 ha of ponds are under prawn culture in Nellore district of Andhra Pradesh alone To cater for the various inputs to this large area, a network of other industries like hatcheries, feed processing units, feed supply companies, chemical stores and prawn processing factories have been established. In addition there are supply channels that organize various inputs and collect harvested prawns to processing units.

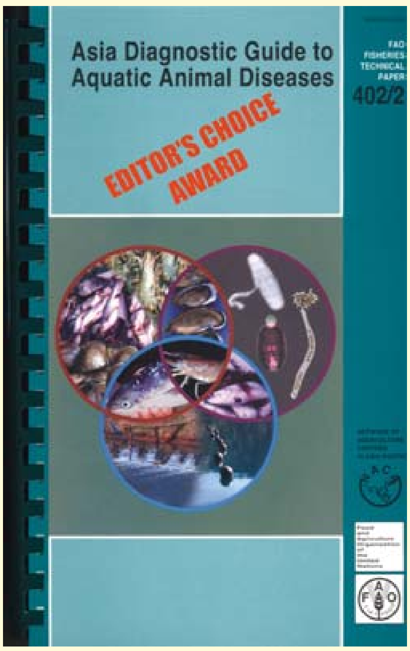
There are a good number of private hatcheries that have been established to cater for the seed requirements of farmers. However, there are major problems confronted by farmers in regard to seed quality. Many of the quality problems in regard to growth and disease problems have been attributed to importation of poor quality seeds. Some of hatcheries like that of Srikanth's are now sourcing natural wild breeders to overcome certain of these problems and establish quality broodstock banks.

Only bigger size prawns, known as "winners" are harvested "runners" are released back for further growth.

Beheading and removal of legs s undertaken immediately after harvest. Ice is commonly used at !:1 ratio to preserve the quality of prawn

Diseases have become a major problem both in the hatchery and grow out system. Similar to the problem of white spot in shrimp, another virus disease is reported to be becoming a major threat to fresh water prawn industry.

The drought and disease problems are reported to have already affected the industry and a number of farmers have given up the activity since the input costs are too heavy and they will not be able to bear the heavy losses. Freshwater prawn farming is gradually picking up even in other parts of the country based on the proven experience of farmers and technology promotion efforts made by fisheries development agencies. While farmers have been able to demonstrate that it is possible to commercially produce prawn, active research support is needed at this stage in terms of improving genetic quality of stock, disease prevention strategies and treatment of various diseases. While addressing the existing technical problems, there is also a necessity to promote environmentally-friendly aquaculture and avoid high intensification activities. Commercial culture potential of *Macrobrachium malcolmsonii*, which also grows well and has good market value need to be explored. It is reported that China is making good progress with this species. Timely intervention is required by the scientific community to help farmers to sustain this activity by reducing risk factors.



Asia Diagnostic Guide to Aquatic Animal Diseases

The Asia Diagnostic Guide is a comprehensive, up-datable diagnostic guide for the pathogens and diseases listed in the NACA/FAO and OIE Quarterly Aquatic Animal Disease (QAAD) Reporting System including a number of other diseases which are significant in the Asia region. It jointly published by FAO and NACA under the Asia-Pacific Regional Programme on Aquatic Health Management.

This 240 page volume contains a general introduction on health and aquatic animals and the roles and levels of diagnostics. Section 2 to 4 cover Finfish Diseases, Molluscan Diseases and Crustacean Diseases. Each host section commences with a chapter on "General techniques" which covers essential starting points that will enable prompt and effective response(s) to disease situations in aquatic animal production. These chapters are not disease specific and emphasize the importance of gross observations and how and when they should be made, including information on environmental parameters worth recording, general procedures for sampling and fixation and the importance of record-keeping. The guide is illustrated with more than 160 colour photos. Limited hard copies and a CD version are available for cost of postage. A free electronic (PDF) version is available from the NACA website (http://www.enaca.org/Publications.htm).

What's New in Aquaculture

14th Governing Council to be held in Myanmar

The 14th NACA Governing Council will be held in Yangon, Myanmar from 28-31 March 2003. A joint meeting with local industry will also take place. More information on the meeting will be posted in due course.

Outcomes of advisory group on health

The first meeting of the Asia Regional Advisory Group on Aquatic Animal Health (AGM-1) was held at the NACA Headquarters, Bangkok, Thailand on 6th-8th November 2002. This high level advisory group, comprised of health experts from governments and the private sector, was constituted by NACA to advise Asian governments on aquatic animal health matters in Asia, and more specifically the implementation of the Asia Regional Technical Guidelines on Health Management and the Responsible Movement of Live Aquatic Animals. The first meeting was very productive, and provided a number of important recommendations on aquatic animal disease control in Asia. A summary of the recommendations follows. The full report will be available within the next few weeks.

1. The recent suspected outbreak of koi herpes virus (KHV) that has spread rapidly through Koi and common carp in Indonesia has re-emphasize the need for effective surveillance programmes of serious aquatic animal disease, and also the need for implementation of the 'Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals'.

2. The continued occurrence of VNN in marine groupers and red spot disease in grass carp was also highlighted during discussions and is a serious concern for the region.

3. Within the region, mollusc diseases are under estimated and too little attention is given to these species and associated diseases. However, cases such as controversial cause of mass mortality outbreaks of pearl oysters, *Pinctada fucata*, underline the importance of addressing mollusc diseases issues in the region.

4. Recent reports record Taura Syndrome Virus (TSV) spreading in the region, related to the continuous introduction of *P. vannamei*, and highlight concern over possible new pathogens that may be passed on to *P. monodon* and other Asian shrimp species. This is a major development of serious concern. The advisory group recommended a study on TSV and P. vannamei introduction to Asia and it is expected this study will be implemented next year, with possible technical support from FAO. The occurrence of TSV, while generally accepted as being increasingly widespread, is not being officially reported. There is therefore clearly a need to strengthen surveillance and reporting. The group urged any new outbreaks to be rapidly reported to OIE and NACA.

5. Given these elements and in the light of recent changes to the OIE list of aquatic animal diseases notifiable and other significant diseases, the current Quarterly Aquatic Animal Disease (QAAD) list will be revised for reporting during 2003.

6. Viral haemorrhagic septicaemia and MSX disease (*Haplosporidium nelsoni*) have both been reported in the region and need to be moved to the QAAD section "Diseases prevalent in some parts of the region".

7. Although there is as yet no definitive aetiological diagnosis, "Koi mass mortality" and "Akoya oyster disease" will be listed to assist in the collation of data. A short summary of the key epidemiological features of the incident, containing background for concern, case definitions, outbreak investigation, and diagnostic test options, will be prepared and circulated.

8. Epitheliocystis, the mollusc pathogen *Marteilioides chungmuensis* and Grouper iridoviral diseases are of concern in the region and proposed for listing to assist in the collection of occurrence data.

9. The new QAAD form for 2003 will be provided with AG meeting report that will be circulated soon.

10. The group agreed that although there have been considerable improvements in the quality of disease reporting in Asia, the quality of the QAAD should be further improved and suggested approaches to assist in achieving this goal.

11. A future get-together of all NCs, to undertake a 3-year review of the reporting system is proposed. If this is not feasible as a meeting of NCs of all participating countries, then NCs' participation in sub-regional meetings should be facilitated.

12. Improving communication between NCs and the Chief Veterinary Officers/OIE national delegates, improving NC access to national experts, and generally promoting in-country networking on disease status.

13. The OIE representation in Tokyo informed that it was important to continue and further develop cooperation in collecting of information. When possible, OIE would like to collaborate in other areas.

14. The need to build cooperation between veterinary and fisheries authorities was emphasized strongly. The OIE Regional Commission meeting in New Caledonia in November 2003 may provide one opportunity, but other opportunities will be sought to promote cooperation.

Building the leading source of global information on Aquaculture

CAB International has announced the development of a new Aquaculture Compendium. The Compendium is a versatile reference and problem-solving resource that brings together a wide range of encyclopedic and multimedia tools to present a continually updated scientific overview. The compendium will take two years to develop and will involve the contribution of the worlds' experts in Aquaculture and Aquatic Resource Management. It will be available on CD-ROM or via the Internet.

The Compendium is intended to help users understand aquaculture in its broader context. Addressing issues of livelihoods, natural resources and environment, biodiversity, trade, food production and safety and poverty alleviation. It will also help people:

- Find information about finfish, crustaceans, molluscs and other commonly cultured aquatic species;
- Determine solutions for identifying, solving and preventing health problems in different production systems, including detailed coverage of pests and diseases;
- Identify trends in aquaculture worldwide;
- Recognize good practice through examination of detailed case studies from around the world; and
- Promote the sustainable development of aquatic resources.

The compendium will be developed and funded through a consortium of donor agencies, technical bodies and private sector corporations including the University of Stirling and the Asian Institute of Technology. It will be the fourth produced by CABI in its award-winning series, which has covered Crop Protection, Forestry, and Animal Health and Production.

Negotiations are underway to build partnerships with FishBase, the FAO and others. If you would like more information on the Aquaculture Compendium, would like to contribute material or can assist in funding – simply email m.parr@cabi.org

For further information visit: www.cabicompendium.org

Survey toolbox for aquatic animal diseases: A practical manual and software package

As a result of demand from aquatic animal scientists, ACIAR (the Australian Centre for International Agricultural Research) commissioned Dr Angus Cameron to produce a version of his Survey Toolbox, target specifically at aquatic animal diseases. The new book deals with the particular problems of undertaking rapid, cost-effective, and reliable surveys of aquatic animals. Aimed primarily at those working in developing countries, and using English as a second language, the book will also have considerable appeal to many developed country scientists. Its predecessor, the Survey Toolbox for Livestock Diseases has been translated into four languages. All of these documents have been kindly made available for free download from http://www.ausvet.com.au/content.php?page=res_manuals. A printed version is also available from ACIAR (visit www.aciar.gov.au).

FAO holds Expert Consultation on Surveillance and Zoning for Responsible Movement of Live Aquatic Animals

FAO held an Expert Consultation in Rome, Italy, 14-18 October 2002. The objective of the consultation was to develop a framework for reducing the risk of trans-boundary spread of aquatic animal diseases, thereby underpinning sustainable trade and production. Background documents are available. *For more information, please contact rohana.subasinghe@fao.org*

African Chapter of Aquatic Animal Pathogen & Quarantine Information System

ICLARM & FAO are working together to make the AAPQIS-Africa chapter the major networking venue for Aquatic Animal Health information exchange in Africa.

At this point we are looking for a) names and contact information of scientists/others interested in aquatic animal health in Africa and b) names and contact information of laboratories, research centers, university research departments, national institutions, regional bodies and networks, etc., working on aquatic animal health in Africa.

Let's work together to advance the aquatic animal health information exchange and to further the networking capabilities in Africa.

Please send the information to:
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GAA raises funds for shrimp antidumping paper

The Global Aquaculture Alliance has joined with the American Seafood Distributors Association to generate an authoritative white paper on issues related to a potential antidumping case involving shrimp imports to the United States. The organizations' position is that viable alternatives to legal action can be enacted to help the U.S. Gulf fishery coexist with farmed shrimp.

Titled "Cooperation or Protectionism: A Review of Shrimp Antidumping Considerations," the paper will be completed in November and made available through various forms of print and electronic media as a reference for cooperative efforts.

Representatives of GAA approached the international shrimp industry for support to underwrite the creation of the paper. Exporters from India, China, Venezuela, and Guatemala donated U.S. $15,000. Additional funding commitments have been received from firms in Indonesia, Colombia, Brazil, Vietnam, and Ecuador.

For additional information, contact Jeanne McKnight (425-451-2828, jeanne@mcknightpr.com) or Michael Kaye (202-887-4115, mkaye@akingump.com). Source: GAA update 18 October 2002.

India to Promote Ornamental Industry

The tiny ornamental fish industry in India is being investigated by the central government with a view to expansion and tapping into the lucrative expanding trade in ornamentals. Countries such as China, Singapore and Malaysia represent potential nearby markets. The Indian varieties of fish for ornamental purposes would be selected and reared in Kerala and northeast states. Licences would be issued to selected farmers to rear ornamental fish so that the specific Indian varieties could be marketed in foreign countries. India's ornamental trade is currently worth only US$ 206,000 and aquaculture concentrates on food fish. The plan will assist the government to achieve growth in inland fish production from 2.5 to 6-8 percent. *Source: Asia Pulse, August 26, 2002.*

Breeding and culture of the sea cucumber Holothuria scabra in Vietnam

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The sea cucumber *Holothuria scabra* (sandfish) has been commercially exploited over a wide tropical and subtropical range for centuries. It can produce a high-value grade of beche-de-mer if processing is carried out well. In many cases sandfish have made up the most valuable fraction of the total sea cucumber trade from particular producing countries, both in terms of price per kilogram and of total value. However processing weight losses can be as high as 95%, and wet-weight prices to fishermen are typically in the range $US1-3/kg. Higher prices are generally paid for larger specimens.

Two subspecies are reported from the South Pacific (Conand 1990), with *H. scabra var. versicolor* generally breeding at and reaching a larger size, living in deeper water and having a wider colour range. Sandfish found in Vietnam (at least in Khanh Hoa Province) appear to be closer to *H. scabra* in terms of their small size and size at first maturity. However the colours range from black through dark brown to light beige, often with transverse stripes. They also appear less deeply ridged than many pictured from Oceania.

Sandfish are found in sandy estuarine or lagoon conditions at depths of 2-25m or more, often in patches of high concentration. They are easily overexploited. Fishermen/divers who collect shellfish and sea cucumbers along the Khanh Hoa coast (free-diving or using hookah diving gear) commonly say they that there are now few sandfish to be found where they were once plentiful. However stocks remain in Cam Ranh Bay (about 60km south of Nha Trang) and Van Ninh (a similar distance north), which are still fished.

The species may have potential for commercial aquaculture and for restocking or stock enhancement. Sandfish have been bred on an experimental scale in India, Indonesia, Solomon Islands, Vietnam and the Maldives. There are also accounts of commercial culture based on cage or pond storage and growth of wild-collected animals. Some people in the Cam Ranh and Van Ninh areas ongrow some collected sandfish in shrimp-style ponds or in pens, to benefit from the higher prices paid for larger animals. However it is not known on what scale or how successful these activities are, or whether culture together with shrimp is anywhere practiced successfully.

In Solomon Islands a release of small numbers of hatchery-produced sandfish juveniles of a few grams weight suggested that they are quickly attacked by a range of coral reef fish, but survive better in a mangrove-seagrass environment (Dance et al. in press). Seagrass beds may be the natural habitat of newly settled sandish juveniles (Mercier et al 2000). Seabed culture and releases of sandfish in Vietnam may benefit from the severe depletion of fish stocks.

Sandfish are broadcast spawners with roughly equal numbers of males and females. In some regions of their wide geographical range, sandfish with ripe gonads can be found in most months of the year. This is the case for example in Solomon Islands, at about 9°S. In other regions there seems to be a single spawning season of only a few months duration. This may be more common in higher latitudes (Morgan 2000) with bigger seasonal temperature ranges. Freshly collected sandfish, or animals that have been cultured for many months at low density in ponds, pens or tanks have all been spawned by different workers. Temperature shocks, drying, water jetting, high concentrations of dry algae and UV irradiation of water are commonly-used induction techniques, with 1-3 million eggs per spawning per female.

Animals bought in Cam Ranh (at about 12°N) were small, typically averaging not more than 150-200g. In the first year after work started they could only be spawned once, in February (after some months of ongrowing) when they averaged 260g. In the second year, after further ongrowing in ponds or seabed pens, broodstock groups of 200 – 600g individual weight have been spawned once or twice every month, from September to July, so far.

Hatchery rearing of eggs and larvae, at densities up to 1/ml, through hatching, auricularia, doliolaria, pentacularia and early juvenile stages, has generally been quite easy, using indoor fibreglass or concrete tanks of 1.7-6.2m. Only partial water changes were made, about 20-30% per day. Incoming seawater was sand filtered, stored briefly in a reservoir tank then and then passed through 1µ filter bags or cartridges. 5ppm EDTA was routinely added after water changes in hatchery tanks. Larvae were fed algae from open outdoor batch cultures: *Chaetocerus muelleri* and calcitrans, *Nanochloropsis occulata*, *Platymonas* sp., *Isochrisis galbena*, *Rhodamonas salina* etc., at gradually increasing concentrations. Feeding rate was generally judged by colour since it was difficult to count or otherwise estimate residual algal cell densities.

When auricularia numbers dropped with the start of metamorphosis pre-conditioned stacks of plastic plates (pvc, polythene or polypropylene) were added to the tanks. Conditioning systems included painting plates with a slurry of dry algae and allowing them to air-dry, immersing in benthic diatom cultures (*Navicula* etc) or *Platymonas* cultures for a few days, or immersing in running unfiltered seawater for a few days, with or without fertilization. All the materials and conditioning systems seemed to work reasonably well. Live algae were supplemented after the start of settlement with dry algal preparations, mainly commercially produced *Spirulina* plus some *Schizochytrium* (Algamac 2000). Most competent larvae have metamorphosed and settled within 10-20 days of spawning, depending on temperature and feeding.

Despite careful filtration copepods were able to enter and breed in the hatchery tanks. Heavy infestations destroyed good batches of settled juveniles within a few days, perhaps because repeated collisions caused skin damage. Treatment with the organophosphate insecticide Dipterex (trichlorofon) at 1-2ppm for 1-2 hours (followed by rapid dilution to about half or one-third) was usually effective in killing swimming stages, but not eggs.

After settlement pentacularia were usually left indoors for 2-6 weeks, depending on the availability of outdoor tanks for first nursery. Many had by then become juveniles of 1-2mm in length, although much larger and smaller animals could usually be found because growth rate is very variable. Juveniles were transferred outdoors either by moving the plate stacks on which they had settled, by siphoning the floor onto a seive or by draining and hosing down the tank walls and floor. Stocking rates outdoors for the first nursery stage were generally 500-2000/m^2.

A wide range of first nursery conditions were assessed, usually in bare tanks from 0.6-16m^2 surface area, of 0.5-1m. in depth and made from fibreglass, flexible pvc-cloth liner or concrete. Different tank preconditioning methods, additional substrate, shade levels, flow rates, water treatments and feeding systems were all looked at, some in controlled trials.

Results have not yet been fully analyzed but they have broadly agreed with the findings of Battaglene et al (1999). It appeared that water should be at least 60 cm deep. Shading seemed to be helpful, at least in the first weeks of first nursery. Unfiltered seawater gave better results than filtered, and high flow rates better than low. There was no clear advantage in putting in additional surfaces such as sea grass (*Enhalus* sp.), additional plate stacks or roofing tiles, although small juveniles appeared to avoid the brighter and more open parts of tanks.

All tank materials were satisfactory on at least some occasions but very small tanks (about 300l) did not give good results. Most consistent were square fibreglass tanks of about 1.8m^2 surface area and 60cm depth, perhaps because it was easy provide one or more water changes per day. However they are too small for large-scale production. Good first nursery rearing runs were sometimes achieved in bigger tanks; PVC-lined pools of 10m^2 area and 70cm depth or concrete tanks of 6 or 16m^2 and 1m depth. Tanks were generally pre-conditioned for a few days using flowing unfiltered water. Dry algae were usually fed to tanks at a rate of about 1g/m^3 twice a day. This was sometimes supplemented by live phytoplankton when available.

There is still a high degree of hit-or-miss uncertainty about the success of transfer outdoors and first nursery rearing, with some tanks and batches performing well and others poorly. Disappearance of nearly all transferred juveniles within a few days of transfer was not uncommon. Yields from first nursery tanks, after 1-2 months, were typically about 200-300 juveniles/m^2, of a wide size range, from very small (less than 0.1g) up to 2g or more. On occasion as many as 500 juveniles/m^2 were obtained, with survival up to 50%.

The juveniles were then usually sorted by size and stocked in tanks with fine sand on the floor, for a further period of nursery. Dry algae feeding was then usually partly replaced by shrimp postlarva starter food, which is cheaper. At this stage culture with shrimp postlarvae (at about 80/m^3) often showed improved growth for the sandfish without appearing to harm the shrimp. However, with shrimp of about the same size as or bigger than the sandfish in the same tank there were some mass losses of the sandfish.

Sandfish juveniles of various sizes have been transferred for further further nursery and/or ongrowing, into earth ponds, seabed pens or seabed cages. Again the results have been mixed. In examples of successful tranfers to ponds, juveniles of 1.6g average took 1½ or 2 months (in different ponds) to reach 60g average, 5.5g juveniles took 2½ months to reach 130g, 28g animals took 1½months to average 96g and animals of 30g (at low stocking density) took only 3 months to reach 300g. In all cases growth slowed down or stopped when sandfish density reached about 200-250g/m^2. Closed seabed cages used for farming babylon snails (*Babylonia areolata*) are being tried as nursery facilities for sandfish (with or without the snails), and open seabed pens are also being used for nursery and growout trials.

A single attempt at transferring 1-2mm juveniles to a pond failed completely; none were ever found again. Juveniles of a few grams also disappeared from ponds shortly after stocking on some occasions. Currently attempts are made to exclude fish and crabs where juveniles are stocked, at least while the sandfish are small. In some ponds many sandfish became sick, with white lesions on the dorsal surface. *Vibrio* bacteria (tentatively identified as *V. salmonicida*) were isolated from these lesions but it is not known what was the primary cause of the lesions. Sometimes these animals recovered spontaneously in ponds or after being moved to a tank with clean seawater.

Survival rates to 1-2mm were usually only a few percent, but as eggs were plentiful this was not the main bottleneck to production. Hundreds of thousands of settled 1-2mm juveniles were produced (and tens of thousands have been reared to larger sizes). Hatchery survival might be improved with more reliable algae culture systems. Rhodamonas salina, perhaps the best species for larval culture (Battaglene 1999) was rarely available at the right time and *Chaetocerus* was often in short supply. Sometimes the 'weed' species *Nanochloropsis* and/or *Platymonas* formed the main food source.

Production has been limited mainly by the lack of nursery and ongrowing space. The 35m^3 hatchery could supply several times more 1-2mm juveniles than the total of 200m^2 of nursery tanks available could absorb. The nursery facilities in turn could feed tens of hectares of nursery and grow-out ponds or pens.

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The potential use of palm kernel meal in aquaculture feeds

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Aquaculture is currently the fastest growing animal production sector in the world. The rapid expansion of the aquaculture industry is most pronounced in Asia, which contributes about 90% of the total global aquaculture production (by weight). This increase in aquaculture production must be supported by a corresponding increase in the production of formulated diets for the cultured aquatic animals. For most aquaculture systems, the cost of feed constitutes 30 to 60% of the operational costs of the farm, with protein being the most expensive dietary component. Even though fishmeal continues to be used as a major source of dietary protein in commercial aquafeeds, its escalating cost has stimulated much research into the use of alternative plant protein sources. Among the plant proteins tested, soybean meal has enjoyed the most commercial success. Nevertheless, soybeans are not grown in tropical countries and soybean meal has to be imported.

In recent years, the cost of imported feed ingredients used in commercial aquafeeds in many developing countries in Asia has continued to rise due to increased global demand and because of foreign currency exchange fluctuations. The rising costs of imported ingredients such as fish meal, soybean meal, corn flour and wheat flour greatly cuts into the profit margins of local fish farmers to such an extent that many local aquaculture enterprises are no longer profitable. This is especially true for the culture of lower-value fish species such as catfish, tilapia and carps. There is currently great interest within the animal feed industry to reduce costs by using locally available feed ingredients.

Palm kernel meal

Palm kernel meal (PKM) is a by-product of palm kernel oil extraction from the nut of the palm tree, Elaeis guineensis. The global production of PKM is ever increasing due to the tremendous growth of the oil palm industry in many parts of Asia and Africa. In Malaysia alone, about 3 million tons of palm kernels were harvested in 2001 producing about 1.4 million tons of palm kernel oil together with 1.6 million tons of PKM as its by-product. Currently, most of the PKM produced in Malaysia is exported at a low price to Europe for use as cattle feed concentrates in dairy cows to increase milk fat. PKM is an established feed ingredient for ruminants, supplying valuable dietary sources of protein, energy and fiber. PKM has also been successfully tested in poultry and swine feeds at low levels of incorporation. The low cost and availability of PKM in many tropical countries where aquaculture is practiced have recently generated much interest in its potential use in fish diets.

Challenges in the use of PKM in fish diets

As with most plant-based and oilseed meal ingredients, several factors can limit the incorporation of PKM into fish diets. These include (1) relatively low protein content, (2) possible amino acid deficiencies, and (3) presence of antinutritional factors. The Fish Nutrition Laboratory at Universiti Sains Malaysia has initiated a series of experiments to attempt to enhance the nutritive value of PKM by dealing with each of these three major challenges so that higher levels of PKM can be incorporated into fish feeds.

Increasing protein content of PKM

One way to increase the protein content of PKM is by the process of solid state fermentation with fungus. We have screened about one hundred isolates of microorganisms obtained from soil samples for the optimal formation of fungal biomass and protein content when cultured using PKM as the substrate. A fungus, which was later identified to be *Trichoderma koningii*, was selected as a potential

Center: Palm kernels before oil extraction which gives palm kernel meal as a by-product. Photo courtesy of S.L. Lim.

Figure 1 and 2 (above/below). Palm oil fruit bunches are harvested from oil palm trees, Elaeis guineensis. *Photo courtesy of MPOB.*

microorganism. This process almost doubled the protein content of raw PKM, from about 17% to 32% crude protein. Since *T. koningii* is a cellulolytic fungus, the reducing sugar content of the fermented PKM was also higher compared to raw PKM. However, when the fermented biomass was incorporated into tilapia diets, a marked reduction in fish growth was observed. We believe that despite the higher protein and digestibility of the fermented PKM, mycotoxins might have been released during the fermentation process. Further studies are being planned to use mycotoxin adsorbers to alleviate these problems in the use of fermented PKM.

Another way to increase the protein content of PKM is to extract the protein using chemical and physical processes. Isolating proteins from PKM will essentially eliminate the problems of low nutrient digestibilities. Despite the high costs of such processes, we are currently conducting some initial studies to see if the protein isolate is of high enough nutritive value for high value marine fish.

Amino acid supplementation

Some studies have reported that amino acid supplementation can improve the growth of fish fed plant-based diets. PKM is low in sulfur amino acids and probably lysine, which are essential amino acids necessary for optimal fish growth. A feeding trial conducted with hybrid catfish showed that up to 20% raw PKM could be incorporated into

catfish diets without any negative effects on growth performance. However, at 40% PKM, growth was significantly depressed and this was not alleviated with the addition of 1.2% dietary L-methionine. One possible reason could be that methionine may not be the first limiting essential amino acid in the PKM-based diets. Further studies involving the use of other essential amino acid and combinations thereof are currently being planned.

Utilization of feed enzymes

The low digestibility of PKM is commonly attributed to the high levels of non-starch polysaccharides (NSP) found in the cell wall materials. These anti-nutritional factors impair the digestibility and utilization of nutrients present in PKM either by direct encapsulation of the nutrients or by increasing the viscosity of the intestinal content thereby reducing the rate of hydrolysis and absorption of nutrients in the diet. The use of proteolytic, fibrolytic or carbohydrate-degrading enzymes to PKM-based diets have great potential in releasing unavailable nutrients and energy.

Studies have shown that tilapia fed PKM pretreated with commercial feed enzymes consistently show better growth and feed utilization efficiency compared to fish fed similar levels of raw

"Initial studies on the use of PKM in tilapia and catfish diets have generated encouraging results..."

PKM. Up to 30% enzyme-treated PKM could be incorporated into red tilapia diets without significantly depressing growth (Ng et al., unpublished data). However, direct inclusion of exogenous enzymes in diets for tilapia have so far not been successful. Research is currently being carried out in our laboratory to further optimize the use of feed enzymes in PKM-based diets, varying parameters such as the type, levels and application method (direct, pretreatment, post-extrusion coating).

Conclusion

Initial studies on the use of PKM in tilapia and catfish diets have generated encouraging results with fish growing well on dietary levels as high as 20%. Studies with grass carp were even more encouraging in terms of higher levels of raw PKM being used in their diets (Ng and Teoh, unpublished data). It is anticipated that with further research on enhancing the nutritive value of PKM, this low cost locally available oilseed meal can be used as a viable partial substitute for many of the imported feed ingredients resulting in savings in feed costs for the local fish farmers.

Culture of sandfish

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Without these facilities many animals were kept in tanks at high density (where they grew only slowly), long past the time when they were ready for transfer.

The area of bare tanks for first nursery needs to be about 15-30 times the area of the hatchery. The area for nursery in tanks with sand and ponds has to be 10-20 times bigger again, depending on the size of juveniles required. A basic hatchery and fairly simple culturing methods should be able to produce enough seed for at least pilot-scale commercial aquaculture and/ or restocking trials as long as there is sufficient tank and pond space for the nursery stages.

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Using a Simple GIS Model to Assess Development Patterns of Small-scale Rural Aquaculture in the Wider Environment

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A Geographical Information System (GIS) is a tool for collection, storage, analysis and presentation of spatial data, essentially computer based mapping. There is currently much excitement over GIS as a solution to many different social, environmental and operational problems. This popularity can take away from the very functional role that a GIS, as a tool for spatial analysis, can provide.

This article discusses the role that a simple GIS can play in assessing the development patterns of fish ponds and as a low cost tool for broader social environmental analysis in an information poor country. Preliminary findings are presented as examples for analysis. These examples use fish ponds, a one-dimensional resource, as a means of representing the wider multi-dimensional environment.

The development and use of a GIS in Savannakhet province in the Lao PDR provides an example of a simple analysis of aquaculture pond development across three districts. This has been facilitated through a postgraduate research project in joint collaboration with the Regional Development Committee (RDC), Provincial Livestock and Fisheries Office and District Agriculture and Forestry Offices.

Information collected and processed through the project has been designed as a capacity building exercise in developing a system of data collection on aquaculture ponds that can be understood and developed by these local organisations. In an information poor environment such as the Lao PDR low cost, easily collected information is an aim in itself.

Background of aquaculture in Laos

Aquaculture as a means for rural development in Laos has had a relatively recent history beginning in the 1950s through USAID and Japanese foreign aid development of government hatcheries across the country[1,2]. Later intervention in the country included three phases of a UNDP/FAO project that ran from 1980 to 2000. All three phases, although fundamentally different in terms of their immediate short-term goals, aimed to develop technical expertise at the household level[3,4].

The UNDP/FAO and other projects have tended to focus on the poorer northern provinces and not on the relatively fish abundant southern provinces of the country. However, there has been increasing attention on the southern provinces over the last decade through the Asian Institute of Technology's Aqua Outreach Programme (AOP) and, feeding into this work, the Provincial Aquaculture Development project (the third and final phase of UNDP/FAO involvement).

It is estimated that around 5 million fry are traded from Thailand every year to feed the local demand in the southern provinces of the Lao PDR; Khamouanne, Savannakhet, Sekong, Salavane, Attapeu and Champassak[5]. In response to such figures AOP developed two creative ways of fish culture extension. The first was the development of a fish nursing network and the second was development of a fish-spawning network.

Such locally based systems are extremely pragmatic in a country where local capacity is low and access to many communities is difficult due to poor infrastructure. As such, low cost, small scale, planning of aquaculture is high on the agenda of the government and non-government agencies alike. It is through such development that the Department of Livestock and Fisheries hopes to achieve its aims of food security for the country by promoting the provision of fish, the main focus of which is aquaculture[6].

Although information is becoming increasing available in specific localities[7,8] there remains no collective understanding of the role of aquatic resources, either wild or cultured, throughout the country.

Localised studies are essential. However, there is also a need for understanding general patterns of aquatic resource development and use on a broader scale.

Using GIS to Collect and Present Information

A major benefit of a GIS is that it can collect, store and present information at different spatial scales. This means that information can be either detailed and locally specific or general and wide scale. A GIS has the capacity to analyse and present information in either way.

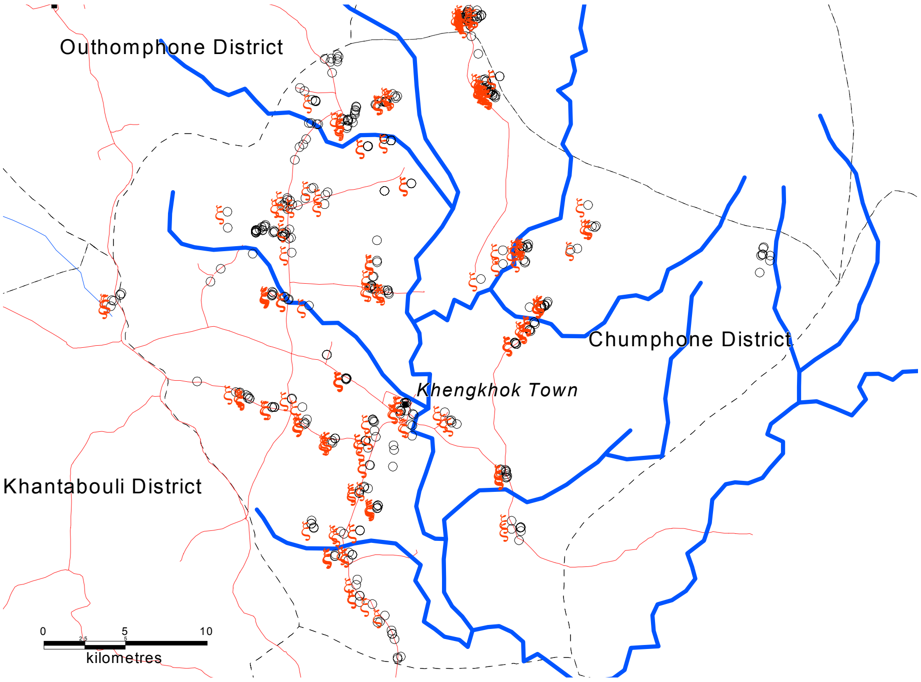
Geographical Positioning System (GPS) units were used to record the latitude and longitude of each fish pond, to be loaded into a GIS program. Staff from three district Agriculture and Forestry Offices were given a half day training in the use of GPS units and then given two weeks to collect the position of every pond in their respective districts. Basic information on the fish ponds was also collected such as:

- Species stocked
- Number of fish stocked
- Area of ponds
- Types of food used
- Age of ponds
- Main uses of harvested fish

More detailed environmental information was also collected such as:

- Species of wild capture fish present
- Sources of water
- Incidence of flooding

This information was put into Microsoft Access database before being imported to the GIS where each pond is linked with the above characteristics.



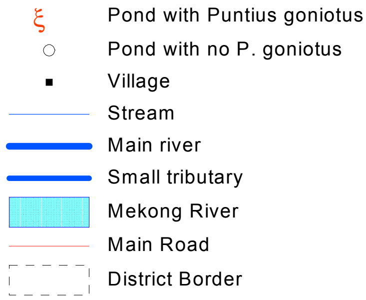
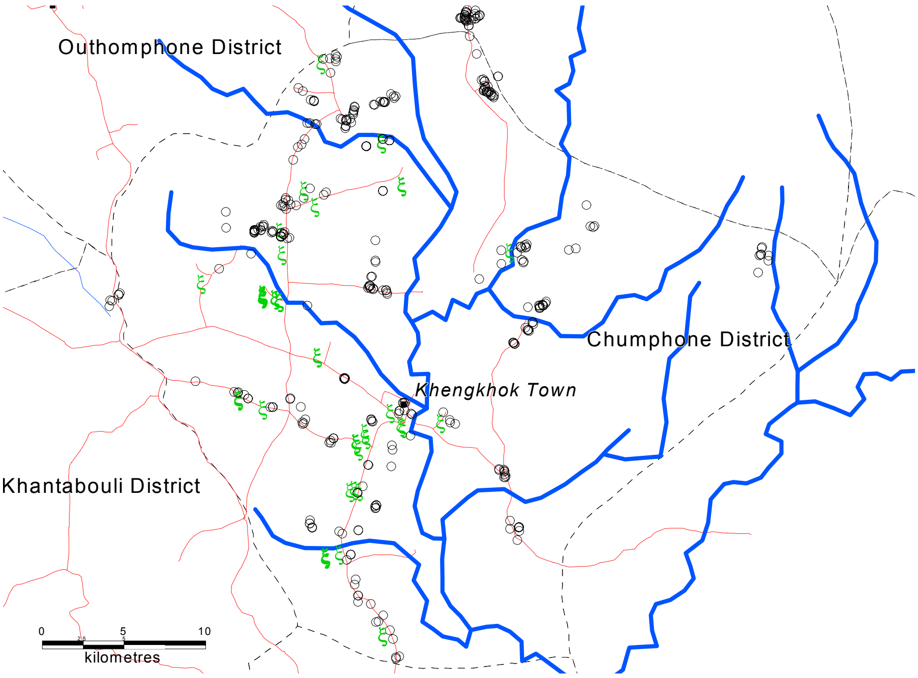


Figure 1: Distribution of Silver barb culture in Chumphon district



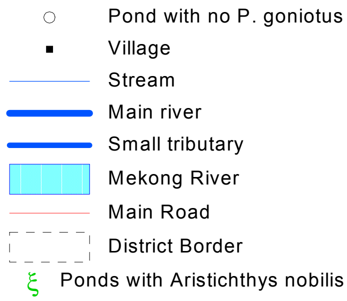


Figure 2: Distribution of Bighead carp culture in Chumphon district

Simple Visual Analysis

Once stored in a GIS, information can be presented in a number ways. Firstly the general development patterns of pond construction across a landscape can be presented in a single layer or map. To analyse this distribution relative to other objects in a landscape, such as roads, streams and rivers, layers or maps of these features can be overlayed. This means that the position of fish ponds can be compared to features in a landscape that may or may not influence their construction.

Not all information is available to researchers or extension workers, as is the case in an information poor environment such as the Lao PDR. However basic information on a resource such as fish ponds can provide a basis for understanding not only aquaculture development patterns but also of wider social and environmental patterns. The use of such indicators is seen as a way of understanding complex landscapes with limited reliable information[9].

Visual analysis is one of the simplest and potentially most powerful methods of analysing spatially presented information[10]. This can pick up various spatial patterns that may not be obvious or possible with more sophisticated techniques. It is also an extremely easy form of analysis for staff with little experience in GIS or more technical statistics. This makes a GIS a useful tool for many organisations.

GIS can also reduce highly complex social and environmental information into defined parcels of information in the form of maps, as seen in the results presented from the fishpond survey in Savannakhet province. In the absence of information on environmental or even basic agricultural statistics, concentrating on a single resource such as fishponds can give a general understanding of the wider environment.

Aquaculture development in the Lao PDR and specifically in Savannakhet province has been subject to extension projects dealing with small scale, low intensity aquaculture production that can be sustained and extended by farmers.

The pattern of pond development in Chumphone district is one example of how this development has progressed. The following maps were chosen as preliminary examples able to be analysed visually by provincial and district officials.

Figures 1 and 2 are maps of Chumphone district showing a comparison between two aquaculture species, *Puntius goniotus* (Silver Barb) and *Aristichthys nobilis* (Big Head Carp). Each of the maps highlights the

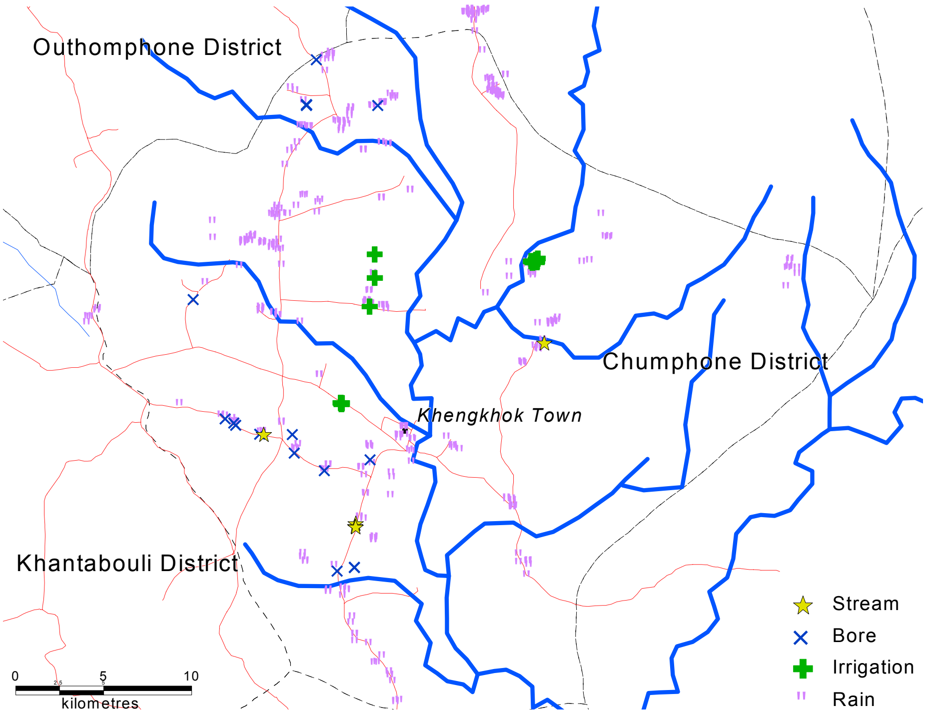


Figure 3: Distribution of water sources for filling ponds

distribution of fish culture along main roads throughout the district. The maps also highlight the very different occurrence of the two species. Whereas *P. goniotus* is found throughout the district *A. nobilis* is concentrated closer to the main roads extending from the district centre Kheng Khok to Savannakhet town and Outhomphone district to the north.

Spatially presented information can also show patterns of environmental constraints faced by some farmers in the district. Figure 3 shows the distribution of various sources of water for the ponds. Most of the ponds are rain fed and despite the large amount of irrigation development in the district there are only a few ponds with access.

Socio-economic patterns can also be revealed, for example, the general pattern of consumption and marketing. Fish grown near the major roads in the district are mostly sold whereas ponds from which the fish are mostly eaten by farmers are more widely dispersed.

"Spatially presented information can also show patterns of environmental constraints..."

Conclusions

The above analysis is by no means extensive but rather aims to provide a few simple examples of the type of spatial analysis a GIS can provide. By using fishponds as a reference point general social and environmental patterns can be seen and as such provide an opportunity to develop management plans and public policy.

For example, the three maps above provide the basis for not only general conclusions as to the development pattern of ponds. They build on current systems of analysis in the form of tables and description by showing the absolute distribution of not only ponds but also the various fish species grown in them. Such analysis allows provincial and district staff with little such technical experience to be able to immediately develop further (non GIS related) research questions such as:

- What areas in the district have potential for further activities by the government or development agencies?
- How and why are fingerlings of different species traded throughout the district?
- What influence does the availability of water resources have on farmer's adoption of aquaculture?
- What are the marketing constraints and potentials for farmers in different parts of the district?

By asking such questions wider spatial socio-environmental patterns are taken into consideration and can lead to more directed, locally appropriate extension and development of aquaculture.

However, using a GIS in isolation is not a solution in itself. GIS is a tool just as Participatory Rural Appraisal and more traditional survey techniques are. Without such complimentary research or other GIS data such as land use, forest cover, flooding extent or socio-economic information its real potential remains limited. As such a GIS is only ever one part of any management or research strategy. In the case of Savannakhet province it has provided a low cost way of obtaining valuable information on aquaculture ponds and with further development has the potential to provide a system of data sharing, planning and evaluation for the Department.

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Aquaculture in reservoir fed canal based irrigation systems of India – a boon for fish production.

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The dependence of Indian agriculture on the southwest monsoon and its consequent vulnerability have necessitated maximum utilization of country's surface and ground water resources. Consequently, a large number of tanks and small reservoirs have been created to raise the gross irrigated area. Experience has shown that these water bodies offer great potential for fish culture through extensive aquaculture techniques. Raichur farmers have developed the technique of constructing storage tanks for the dual purpose of agriculture and aquaculture. In this way the canal water of Tungabhadra reservoir captured during the wet season is used to sustain aquaculture and agriculture activities for the entire year.

Raichur is one of the districts of Karnataka situated along the southwest part of India (Fig. 1). It is endowed with two major perennial rivers, the Krishna and Tungabhadra, which cover a total length of about 300 km. The water area of Tungabhadra reservoir is about 15,600 ha. There are 120 major and 218 minor tanks with water area of 4,299 and 728 ha, respectively. In this article, we will be discussing the system wherein these tanks, constructed mainly to store water to raise nursery and to save paddy crops during canal breaches, are successfully used for fish rearing.

Construction of water storage tanks

Paddy cultivation is the main agricultural activity in Raichur district followed by cotton, sunflower and groundnut. Since this region receives a very low amount of rainfall (average 687mm per year), which is confined to certain periods of the year, the major agricultural activities depend on the water supplied through the network of irrigation canals of Tungabhadra reservoir. Due to the length and complexity of the canal network, canals often breach leading to irrigation failure. This situation occasionally causes panic among rice cultivators, especially those at the tail end of the canals. To overcome this problem, the farmers started looking for ways to save their standing crop. As a result, the idea of having farm ponds has taken the shape of water storage tanks. A farmer having 4 ha of paddy land will have a storage tank of 0.4 ha size. Similarly, farmers having 16-20 ha land will have a storage tank as big as 1.5-2 ha. The depth of these ponds ranges from a minimum of 2.5 meters to a maximum of 4-5 meters. In exceptional cases, the depth may be as high as 7 meters. Similarly, the bund height above the ground level may range from 1.25-2.5 meters up to 3.25-4 meters depending on the size of the tank. All these water storage tanks are constructed using own or hired tractors. The bunds are compacted so strong that there is no leakage. In most cases grasses are grown on the bunds to prevent soil erosion. It adds to the natural beauty of the pond. Depending on the width of the bunds, horticultural crops like mango, coconut, banana, flowers and vegetables are grown. These water storage tanks are filled with water, using either irrigation canal facilities or rainwater. Pumps are used to store water above the ground level or to lift water from below the ground level.

"...a cautious approach needs to be adopted in expanding the area under fish culture..."

Feeding from a coracle

Aquaculture activity

The water storage tanks are also used for raising fishes. This activity starts during the months of July – August. Prior to stocking of fish seeds, pre-stocking management practices are followed. The water level in the pond is usually very low, as the water is utilized for irrigating paddy crops during April – May. If necessary, water is pumped out of the tanks using electrical, diesel or tractor pumps. Mahua oil cake is applied (250 kg/ha) to eradicate weed and carnivorous fishes. Lime is applied at the rate of 100 – 250 kg/ha. The ponds are also fertilized, usually with cow dung, which is locally abundant at the rate of 2,000 – 3,000 kg/ha depending upon the age of the tank. Some farmers use poultry droppings as an alternative. Inorganic fertilizers like super phosphate and urea are sometimes used as well.

The tanks are stocked either with fingerlings or stunted yearlings of Indian major carps with the stocking density varying from around 2,000 – 2,500 / ha to 10,000 as the case may be. In most cases, only Indian major carps such as catla, rohu and mrigal are cultured. Feeding is usually done with de-oiled rice bran and groundnut oil cake at the ratio of 3:1 or 4:1. In bigger tanks, the rice bran filled in gunny bags with holes and is tied to the bamboo poles. The bags are hung in different locations so that only half of the bag is immersed in the water. The tanks are regularly manured with cowdung at 15 or 30 day intervals. Inorganic fertilizers are also used when necessary. Normally these supplementary fertilizer rates are restricted to 10 to 20 percent of the initial dosage.

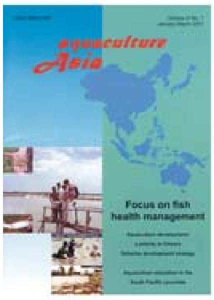
The water in the irrigation canal is available once in 15 days for a period of four to five months in a year. Most farmers pump nutrient rich water from the tanks to irrigate paddy fields and again store fresh canal water in the tanks. After 10 to 12 months of rearing, the fishes are harvested using drag or cast nets. The average fish production is around 5 to 6 tons/ha/crop with a survival rate of around 50 to 60 percent. The individual average weight of fish at final harvest ranges from 750 g to 1,500 g. When stunted yearlings are stocked the survival rate increases to about 75 to 90 percent with individual average weight 1.5 to 2.0 kg. Most of the farmers sell their fish to merchants from neighboring districts. A few selected farmers even sell fishes to government organizations like the Karnataka Co-operative Fish Federation. Those farmers with small fishponds often sell fishes directly from the pond to consumers following multiple harvesting. The average price obtained by these farmers varies from Rs. 25 – 30 / kg. According to the reports available from Fish Farmers Development Agency (FFDA), Raichur, the net incremental income out of fish harvest is around Rs. 48,000 to 50,000 /ha.

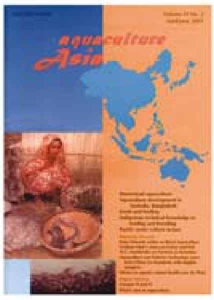
It is estimated that more than 1,000 such tanks are already been constructed for dual agriculture/aquaculture use with two crops of paddy and one crop of fish generally harvested each year.

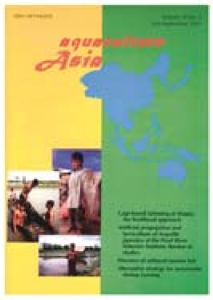
There is urgent need to educate the farmers on advantages of de-silting of tanks. It has also been reported by FFDA that the fish production has temporally been affected because the farmers have brought diseased fish seeds from Andhra Pradesh. Therefore, it is felt that enactment of an Act is very necessary on purchase of seeds to avoid spread of diseases.

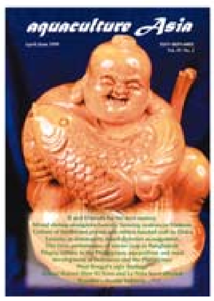
"...nutrient rich water from these tanks may even support sustainable agriculture of paddy mainly by reducing the use of inorganic fertilizers."

Although, these water storage tanks have thrown open vast potential for development of inland fisheries, a cautious approach needs to be adopted in expanding the area under fish culture to avoid conversion of large scale paddy fields into fisheries tanks adversely affecting the food grain production and rendering the surrounding areas saline. If the existing 22,000 ha of inundated area is utilized for construction of water storage tanks and consequently used for fish culture, it is expected that, with a moderate fish production of just over 4 tons /ha/crop, the fish production in this district can reach 100,000 tons /year from the present production of less than 4,000 tons per year. Further, the nutrient rich water from these tanks may even support sustainable agriculture of paddy mainly by reducing the use of inorganic fertilizers.









Marine finfish section

The Grouper Section has taken on a new and broader name: It has become the Marine finfish Section to take account of other species. This Section is almost wholly based on the Grouper Electronic Network which is prepared by Sih Yang Sim (Editor), Michael Phillips (NACA Environment Specialist) and Mike Rimmer (Principal Fisheries Biologist of the Queensland Department of Primary Industries). Visit www.enaca.org/grouper for more information on the network.

Status of Marine Finfish Aquaculture in Myanmar

U Khin Ko Lay

Director (Aquaculture Division)
Department of Fisheries

Epinephelus areolatus

Myanmar has a long coastal line of 2,832 km stretching from the Nerf River in the North to Victoria point in the South. The coast faces the Indian Ocean in Rakhine State, the Bay of Bengal in Ayeyawady Division, and the Andaman Sea in Taninthayi Division respectively. Such a long stretching coastal areas forms 213,720 square kilometers of continental shelf where the water is fertile and enriched with nutrients and plankton. As the primary production is high, the fisheries resources are turn highly abundant and recognized as one of the richest in the region with great potential to support mariculture.

Current status and species cultured

Fish culture has been practiced since 1950s and nowadays around 45,400 hectares of freshwater fishponds are recorded. However, brackish and marine finfish species are not yet in production on a significant commercial scale. Among marine fin fishes, the indigenous species of sea bass (*Lates calcarifer*) and groupers (*Epinephelus* spp.) are well known and abundant in Myanmar waters along the coast. Since the wild fishes are so abundant there has been little interest in farming until recently. However, recently groupers and seabass become more popular in the fisheries trade due to increasing export demand and people have begun exploring the feasibility of growing these species in suitable areas.

The development of aquaculture is strongly encouraged by the State and a three year plan for the development of finfish culture has been set up since 2000. According to this plan, 26,300 hectares of fishponds will be developed along with nineteen new fisheries stations, including three stations for marine fishes.

The locations of marine fish stations have been designated according to the degree of fish seed demand. At present the station at Chaungtha in Ayeyawady Division is under construction as a prototype. Two other stations are to be constructed at Taungok Township in Rakhine State and at Myeik Township in Taninthayi Division respectively.

Among several indigenous marine species, sea bass, groupers, snapper, and milkfish are potential species for mariculture. Seabass farming in brackish water ponds with juveniles collected from wild has been practiced for years; however, it hasn't reached commercial levels due to imperfect technologies and feeding regimes. Initial experiments have been carried out to produce sea bass seed but the results are not yet significant.

Commercial scale grow out farming of grouper in net cages are being practiced at Kyun Su Township (Myeik area) in

Coral trout - Plectropomus leopardus - photographed at the annual Myanmar Fisheries and Livestock Fair held in February

Tanintharyi Division. At present the pioneer farm manage up to 300-350 net cages of 3x3x3 meter size. The most common species are *Epinephalus coioides* and *E. tauvina*. Juveniles are collected from the wild from May through November during lunar periods with a peak catch around full moon. The fishes collected from sites with similar water quality and environment (salinity, water depth, etc) are most preferable for cage culture for good growth and health. Different sized juveniles from 10 cm to 25 cm in are generally stocked. Normally, two types of sizes are differentiated for market; over one kilo size and between 300 gm to one-kilo size. The culture period is 3-12 months to reach marketable size depending on the initial size at stocking. The stocking rate is 800-2,500 fish per cage depending on size and the survival rate is about 30% at harvest.

At Thandwe and Gwa Township, in Rakhine State net cages are constructed for holding groupers of various sizes, which are collected from nearby waters. Fish are fed with small trash fishes for some period until they are strong enough to transport (export) to grow-out farm and restaurants. The most common species in that area is *E. coioides* and commercial levels grow out culture is not practiced yet.

Status of larviculture

Hatchery produced species

A hatchery in Chaungtha at Ayeyawady Division is under construction and it is expected to be operational in 2003. Experiments of induced sea bass breeding were carried out last year with wild caught brood fishes. However, the results were not significant due to imperfect maturity of brood fish and also due to lack of experience.

Wild caught species

Juveniles of sea bass (*Lates calcarifer*) and groupers *Epinephelus* spp. are naturally abundant in coastal area. In the beginning, seabass seed were collected and experimentally raised in earthen ponds. Grouper juveniles mostly *Epinephelus* spp. are collected for marine net cages culture.

Imported species

Recently, seeds of sea bass were initially permitted to be imported so as to encourage and to promote sea bass farming and demonstration purposes.

Prices of various marine finfish fingerling

Grouper fingerlings collected from the wild purposes prevailing price in Myeik area are:

Size	Approximate price
10-12.5 cm (60 gm)	50 Kyats
13-13.5cm (120 gm)	90 Kyats
16-18.5 cm (150gm)	100 kyats
19-21.5 cm (200 gm)	150 Kyats
22-24.5 cm (250 gm)	200 Kyats
25-27.5 cm (300 gm)	300 Kyats

Status of nursery

Regarding the sea bass experimental hatchery program, the nursery phase is critical as the fry are highly carnivorous. High mortality was encountered due to the lack of experience in hatchery and nursery management. Almost 60 % of fry mortality was observed in first 7 days of nursery period whereas mortality during transport was found about 10%. So hatchery, and nursery management techniques are urgently needed for the development of marine finfish culture in the country.

Current grow-out systems and future direction

Cage (various types)

In general, floating net cages are used for groupers culture in Myeik. The sizes of the cage is 3 x 3 x 3 meters and a cluster of cages usually set and stationed by anchored in appropriate site where there is low water current, less wave action and away from the affect of wind direction.

Pond

Small earthen ponds of 0.4 hectare are used for small-scale sea bass farming in Palaw Township, Thanintharyi Division.

Recirculation system

This type of system is not yet used.

Feed used and feeding practices

Locally available trash fish are used as feed. Ground trash fish are fed daily in the morning and evening. In Rakhine State fishes are fed with either trash fish (whole or chopped). Normally, almost 5% of the total fish weight holding in the cages is given as daily ration.

Myanmar's farmers are gaining interest in cage culture systems

Keeping an eye on the stock

Socio-economics, environmental and marketing issues

Fish is one of the major sources of protein for Myanmar people. It is consumed both fresh and processed as dried fish, fish paste, and fish juice. The geographic, environmental, and climatic conditions of the country are favorable to practice aquaculture and capture fisheries. The capture fisheries sector is well developed since the marine and inland fisheries resources are so abundant, the capture fisheries are well developed. Together with freshwater aquaculture the fisheries sector stands in third position in national foreign exchange earnings after the agriculture and forestry sectors. Due to the decline in captures fisheries, a shift to aquaculture is seen as the most effective alternative for sustainable fish production. So aquaculture has become a promising industry and has an important role to elevate the social economy by enhancing job opportunities.

Future development

Species targeted

Among the several marine species, sea bass, grouper, snapper, and milkfish, are potential species for future development.

Other issues

Lack of sufficient seed supply due to lack of technologies and hatchery capacity is the main constraint for the development of marine finfish aquaculture. So, the artificial propagation of marine finfish species and nursery technologies, and facilities as well as capital inputs are urgently required in order to increase the momentum of industry expansion.

Recommendation on future development of marine finfish aquaculture and potential for collaboration

Myanmar is active member of Network of Aquaculture Center for Asia-Pacific (NACA), the Southeast Asia Fishery Development Center (SEAFDEC) and the Association of Southeast Asian Nation (ASEAN). FAO is collaborating with these organizations in the area of regional fisheries development activities and related fields. We acknowledge all of these organizations for their contribution of appropriate assistance and sharing of invaluable experience, which are essential for sustainable mariculture development. In collaboration with regional organizations Myanmar will work to disseminate sustainable aquaculture technologies are to be disseminated among farmers. A core of appropriately trained extensions personnel is required to assist with this work.

Conclusion

There is huge potential for further development in marine finfish culture, which is just initiated in Myanmar. It is envisaged that with a concerted effort by both State and private sectors, mariculture will boom in the very near future. The Department of Fisheries is pursuing mariculture development by providing assistance and dissemination of technology to all fish farmers.

A fish market at Myeik

Mariculture can provide an important alternative or supplemental income for coastal people

Regional Training Course on Grouper Hatchery Production

Bali, Indonesia, 1st–21st May 2003

The second Regional Grouper Hatchery Production Training Course is being organized in Bali, Indonesia, for hatchery operators, technicians and researchers involved in grouper aquaculture hatchery production, research, development and extension.

The training course is organized and supported by the Ministry of Marine Affairs and Fisheries, Indonesia, the Network of Aquaculture Centres in Asia-Pacific (NACA), in cooperation with the Australian Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC), and the Japan International Cooperation Agency (JICA). It is one of the activities of the Asia-Pacific Marine Finfish Aquaculture Network.

Objective

The objectives of this regional training course are to provide practical hands-on training on the following topics:

- Grouper broodstock management techniques, including handling, feeding, broodstock nutrition, control of the reproductive cycle, spawning techniques and egg collection and incubation.
- Larval rearing, including feeding and hatchery practices.
- Grouper diseases and health management, including viruses (VNN), and common diseases of marine fish.
- Mass production of live food (phyto and zoo-plankton)

The target grouper species for this training course will be mainly on Cromileptes altivelis (mouse grouper), but participants will gain experience with handling Epinephelus fuscoguttatus (tiger grouper) and other marine finfish species.

The training course will provide participants with a unique opportunity to visit private sector hatcheries and nurseries in the Gondol area, and an insight into the diverse mariculture development in Indonesia.

Date and duration

The training course will be held at the RIM-Gondol, Bali, Indonesia, from 1st May to 21st May 2003.

Course Schedule

Participants are expected to arrive in Denpasar, Bali, Indonesia on 30th April 2003. Participants will be picked up in Denpasar airport and transported to RIM Gondol on 30th April 2003, which is a three-hour journey. Participants will return to Denpasar on 22nd May 2003, and should arrange to depart on or after 21st May 2003.

Venue

The training workshop will be conducted at the RIM Gondol in northern Bali, Indonesia, which is equipped with good facilities for training and research activities. RIM has extensive experience in short and long term training for Indonesian farmers and technical staff, in cooperation with JICA. Such activities have contributed to the development of grouper hatchery in Indonesia.

Participants

The training course involves mainly practical hands-on teaching supported by short lectures and workshop discussion sessions. The course is intended for technicians and scientists from the private sector, NGO and government who are actively involved in grouper aquaculture development, research and extension. The participants should have good English proficiency. The training workshop will be conducted in English.

Language

The course will be conducted in English. The local language is Bahasa Indonesia – translations will be provided during visits to private farms.

Resources Speakers and Trainers

Most of the topics will be delivered by the grouper breeding resource persons from RIM-Gondol, supplemented by specialists inputs from elsewhere in Indonesia and JICA expert.

Subjects to be covered

The training course will be involve: 40% lectures and small workshops, 50% practical work in the laboratory and on-station hatcheries and outdoor activities and 10% field trip.

The topics include:

- Management of broodstock
- Management of larval rearing
- Feed and feeding technique for broodstock, larvae and juveniles
- Fish diseases, prevention and control
- Mass production of live food for larvae
- Transportation of seed and broodstock
- Grow-out at floating net cages (brief introduction)

Brief overview of mariculture development in Indonesia

The fieldwork will be conducted around the island of Bali, at small-scale backyard hatcheries and private grouper hatcheries, nurseries, grow-out at northern Bali, and trading facilities at Denpasar.

Certificate of Accomplishment

All participants will be awarded a certificate of completion to certify that each participant has met minimum performance requirements as evaluated by the Resource Persons, the Course Coordinator and the Board of Directors at RIM Gondol. The trainee's performance will be based on his/her participation in class discussions and activities in the laboratory and outdoors.

Application

All participants are required to complete the attached application form and send to the NACA Secretariat, at the address on the form. NACA will then submit the applications to the Director, RIM Gondol for formal acceptance. Selected participants are required to have a valid passport and an entry visa for Indonesia at least for the duration of the training course. Travel documents including passport, visa, fiscal and exit fee are to be arranged by the applicants at their own cost. NACA will assist with visas, if required, in collaboration with RIM Gondol and Indonesian authorities. Application for registration in the training workshop should be sent to the NACA Secretariat by 21st March 2003.

Registration Fee

Qualified participants will be required to pay a course fee of US$1,500. This fee will cover the cost of training materials and supplies, administrative cost and local travel associated with the training.

The costs of accommodation and food will be the responsibility of the participant. At present, only one local hotel is available (see below), but participants will be advised of alternative options that may become available. Booking should be done through the NACA Secretariat.

Accommodation

Accommodation will be at the Celuk Agung Hotel. This pleasant resort hotel is one hour drive from the RIM Gondol. Room rates for an air-conditioned room with hot water are around US$20 including breakfast.

Payment

Registered participants are required to pay the full training course fee US$1,500 by 21st March 2003. After payment if you decided to withdraw for unforeseen reason, we will return 90% of your payment if notice is given prior to 15th April 2003. Bank fees will be born by the withdrawn participant. Payment can be made by either credit card or bank draft (details of payment are shown in the Registration Form).

NACA and the Ministry of Marine Affairs and Fisheries reserve the right to cancel the training course in the event that inadequate numbers of participants enroll, or other reasons beyond the control of the organizers.

Further information, contact:

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Aquaculture Fundamentals:

Getting the most out of your feed

Simon Wilkinson, NACA

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Feed generally represents the largest fixed cost in aquaculture systems with its importance increasing in relation to the intensity of production[1,2,3]. Feed also directly influences the capacity of the stock to realise their full growth potential. Improving the efficiency of feed utilisation in terms of reducing costs and increasing performance therefore represents a significant opportunity to increase the profit margin of the farm.

From a nutritional perspective the major elements of the culture system that influence productivity are the quality of the feed, the feeding strategies that are employed and the culture environment itself. These elements are considered below in the context of evaluating on-farm management practices to increase profit.

Records and sampling

Accurate records assist farmers to adjust feeding rates and to evaluate the results of different diets or feeding regimes[4]. Records also enable farmers to improve performance and the reliability, quality and predictability of yields. A systematic approach to the collection and analysis of feeding records is very important to maximising efficiency. Evaluation of the feeding and management practices on the farm should begin with an assessment of the monitoring and record keeping systems to determine if they are adequate to effectively manage the facility.

Evaluating the performance of feed

The efficiency of the feed should be evaluated in terms of its biological performance in promoting growth (or other culture objectives), and its economic performance in terms of feed cost per unit production.

Evaluating biological performance

The quality of feed is a function of how well it meets the nutritional requirements of the cultured animal[3]. This is in turn a function of the nutritional profile of the food and the bioavailability of the nutrients in the feed components[4]. Measurements of digestibility such as the digestible energy content or retained energy in carcass can be determined through laboratory studies[3]. However, practical on-farm assessments of diet quality are frequently made on the basis of the observed growth rates or on the observed conversion ratios of nutrients to end products. The main parameters assessed on-farm are included in Table 1.

FCR is a widely used parameter as it provides a convenient rule of thumb guide for general management purposes[6]. Indices of protein utilisation (PER and NPU) are also employed as the protein component is of greatest interest to the farmer in most instances. These parameters allow the performance of the feed to be assessed by comparing current production records with historical values for the farm, published data and with the results of other farms in the area.

However, conversion ratios are not precise measures of feed efficiency as they are affected by feeding practices and environmental factors and the availability of natural feeds[6]. With the exception of NPU they also do not give any indication of the relative conversion of energy, protein, fat and other nutrients. The interpretation of conversion ratios can be greatly assisted by simultaneous evaluation of carcass composition and quality[7].

Nutritional requirements also vary with the aims of culture. As a result, an evaluation of feed performance may need to take into account objectives other than growth such as increased larval suvivorship for larval feeds or increased fecundity in broodstock diets[8]. Manipulation of feed composition offers the potential to enhance the quality and market value of the end

Table 1: Main feed parameters assessed on-farm[5]

Parameter	Calculation
Growth	= Gain in body mass/unit time
Food conversion ratio (FCR)	= $\frac{\text{Mass of food consumed (dry)}}{\text{Increase in mass of animal produced (wet)}}$
Protein efficiency ratio (PER)	= $\frac{\text{Increase in the mass of animal produced (wet weight)}}{\text{Mass of protein in feed (dry weight)}}$
Net protein utilisation % (NPU)	= $\frac{\text{Protein gain in fish (g)}}{\text{Protein intake in food (g)}} \times 100$

product by enhancing desirable characteristics[9]. For example, the Southern blue-fin tuna industry in Australia feeds wild-caught fish with pilchards specifically to increase the oil content and value of fish destined for the premium Japanese sashimi market[9]. In this case fat content may be a more appropriate measure of performance than growth.

Evaluating economic performance of feed

To be profitable, feed must give good biological performance at a reasonable price. The cost of feed per unit production will have a large impact on the profit margin and this is a variable that should be frequently assessed since it should be a consideration in management decisions. Cost per unit production can be evaluated by comparing records of feed applied to ponds with observed growth rates. Cost per unit production can be calculated simply as per Table 2.
An estimate of cost per unit production can be generated during the course of the production cycle using observed feed conversion ratios and estimates of biomass or population. Growth rate should be monitored through regular sampling of the population. However, estimating population size can be difficult and 'rule of thumb' estimates of survival are often used based on experience.

Evaluating the cost of feed production

Manufacturing feed on-farm

On-farm manufacture of feed offers the potential to reduce the costs associated with purchasing feed from a commercial supplier. The economic viability of this option will depend on an assessment of the amount of feed consumed and of the cost of local ingredients, labour, necessary equipment and capital infrastructure for feed manufacture[10]. Successful feed manufacture also requires knowledge of the nutrient requirements and feeding habits of the culture species, nutrient composition and bioavailability of ingredients, and of the type of processing required[2,5,11].

A further advantage of on-farm feed manufacture is that it also allows greater control over the nutrient profile and hence performance of the feed. Possible mechanisms for reducing feed costs are discussed below. These mechanisms should be exploited as far as possible during the formulation of on-farm feeds.

Economically optimum protein level

Protein is the most expensive component of feeds[12] and reductions in protein content can lead to savings. De Silva et al.[13] reported that the growth rate in juvenile Tilapia increased as dietary protein content was raised up to an optimum content of around 30-34%. Higher levels of dietary protein lead to a decrease in growth rate showing that excessive levels of dietary protein can be wasteful and have a negative effect on production. The increase in growth rate was also observed to slow approaching the optimum such that there was little increase in growth across a relatively wide range of protein levels in the feed. This suggests that the protein content of feed could therefore be significantly reduced from the biological optimum with only a small trade-off in growth, leading to more economical production. They termed this the 'economically optimum dietary protein level'.

Protein sparing

Unless there is a non-protein source of energy in the diet, some of the protein intake will have to be degraded in order to support the energy demands for tissue synthesis and metabolism[13,14,15]. This will reduce the quantity of protein that is available for growth. Carbohydrates and lipids serve as alternative energy sources, thereby reducing the proportion of dietary protein that must be catabolized in order to meet energy demand[3]. Lipids have greater energy content than carbohydrates and exert a greater protein sparing effect[16]. Carbohydrates are often of limited digestibility to fish but are relatively cheap[3]. Feed formulations should therefore seek to optimise the use of fat and carbohydrate energy sources in order to reduce feed costs.

The effectiveness of the protein sparing effect of carbohydrates and lipid is related to the ratio of protein to energy in the diet. The optimum ratio is species specific and varies with protein source[5]. Variation away from the optimum ratio will result in either the catabolism of protein for energy, or the production of fatty animals[3]. However, both scenarios result in suboptimal feed efficiency[17].

Use of alternative feed ingredients

Fish meal and other animal by-products are the most important and often most expensive components of aquaculture feeds[3]. The use of lower-cost plant and other non-animal proteins in feeds is therefore an attractive approach to reducing production costs[2,18,19]. With improved processing techniques many are now routinely used ingredients in aquaculture feeds. However, there are several factors that limit the incorporation of non-conventional proteins in feeds for aquaculture. These are[19]:

a) low protein content;
b) amino acid imbalance or deficiency; and
c) presence of anti-nutritional factors.

Additionally, most animal and plant meals of terrestrial origin do not satisfy the requirements of fish for (n-3) polyunsaturated fatty acids5. Some alternative protein sources may be unpalatable to the target species[20,21,22].

Fertilisation, manuring and supplementary feeds

Fertilisation with manure or chemical fertilisers offers a relatively cheap method of enhancing production without the use of feeds. The objective of fertilisation in this context is to enhance the productivity of ponds by increasing the production of phytoplankton and other food organisms for fish[23]. This can significantly improve yields over unfertilised systems and improve apparent feed conversion ratios in semi-intensive systems[24]. Fertilisation can also have beneficial effects in some intensive systems, most notably in prawn culture. Management practices should be evaluated to determine if the farm is fully exploiting natural productivity. Fertilisation regimes should be related to the availability of nitrogen and phosphorus since algal productivity is limited by shortfalls in either of these nutrients[23].

Supplementary feeding of single ingredients to fish and shrimp is often practised in semi-intensive systems but it is often inefficient since a single ingredient is unlikely to supply a balanced intake of nutrients[10]. As a result the feeding of single feedstuffs often results in poor apparent feed conversion ratios[10]. However, even a simple compounded supplementary feed of two or more ingredients can significantly improve nutritional value[25]. The decision to apply fertilisation, supplementary feeds or to move to supplementary feeding or complete dependence on an artificial diet will depend on an assessment of the value of the cultured species, the desired level of production, the cost of supplementation and on the potential economic return.

Evaluating the efficiency of the feeding regime

Feeding practices involve[5]:

- Determining how much should be fed
- Determining how frequently cultured organisms should be fed and what time of day;
- Actual delivery of feed to the cultured organisms.

Efficiency requires that consideration be given to minimising wastage during each of these processes. Monitoring growth, feeding rates and frequencies, temperature and other management practices can help to identify optimum feeding practices. Careful evaluation of this data will allow the feeding regime to be refined over time[3].

Optimum ration size

Growth increases with ration size[26,27]. However, the rate of increase diminishes towards the maximum ration the fish is capable of consuming[3].

The utilisation efficiency and feed conversion ratio also improve up to an optimum point and then decrease towards the maximum ration due to a reduction in absorption efficiency[3,28]. Therefore it is economically beneficial to identify and feed fish at the optimum ration rather than the maximum ration[3].

Ration size is variable and is affected by scaling effects with the growth of the organism and environmental factors, particularly temperature which affects feeding and digestion rates[3]. Ration size also needs to be adjusted to account for mortalities and is dependent on accurate estimate of the size of fish and biomass within the system[5]. This requires that the average mass must be estimated through regular sampling and feeding rates adjusted accordingly.

Feeding frequency

More frequent feeding can enhance the growth rate of fish although the effect varies between species[3]. The growth of tilapia is reported to be enhanced in fish fed six times daily compared to those fed twice daily[29]. However, growth and food utilisation in the grouper Epinephelus tauvina is reported to be best in fish fed once every two days[30]. More frequent feeding in grouper lead to decreased food conversion ratios and decreased survival.

Identifying the optimum feeding frequency may therefore provide considerable economic benefit in terms of increasing growth and the utilisation efficiency of feed. Where appropriate, reducing the frequency of feeding also has the advantage of reducing labour costs[31].

Feeding time

The time of day that feed is delivered can also affect performance since feeding behaviour may be associated with environmental cues such as light levels, tidal amplitude and the movement patterns of prey[5]. Understanding the feeding behaviour of the cultured species can assist in the development of feeds and regimes that reduce the metabolic energy costs in feeding and encourage consumption, which reduces wastage and leaching of nutrients from uneaten feed[22]. For example, superior growth has been reported in the European seabass *Dicentrachus labrax* when feed was delivered during the natural feeding periods of wild fish, compared to feeding by demand or automatically at other periods of the day[32].

Feed distribution

The physical form of the feed material can also affect the efficiency of its consumption. Significant feed loss occurs from small particles and dust in the feed, which are generally not consumed by fish[3]. Feed needs to be presented in a form that is suitable for the feeding habits of the fish. In addition, the water stability of the feed will affect the rate of leaching of essential nutrients[10,11].

Feed can be distributed by hand or by a variety of automatic and demand feeders. Mechanical feed distribution devices offer the opportunity to reduce labour costs associated with hand feeding and to increase the efficiency of feed distribution, depending on the type of system employed[5]. Hand feeding can be labour intensive but it has the advantage of allowing direct observation of feeding rates among surface feeding fish[1]. Use of a floating collar to contain feed can also assist with observation and reduce wastage[10].

Automatic feeders may not account for daily variation in temperature and other factors that may affect consumption. One disadvantage of demand feeders is that dominant individuals may learn to activate the trigger and continue to trigger it even when they are satiated which may increase size variation in the crop[3].

The appropriateness of any particular feed delivery system must be evaluated according to the relative costs of labour versus technology and on the design of the culture system[3].

Enhancing productivity through manipulation of the culture environment

It is highly desirable to provide cultured fish with conditions that are within their favoured range for optimum growth and production. Failure to provide optimal environmental conditions can result in stress, which ultimately results in an increased basal metabolic rate and poor growth rates[5]. Providing a favourable environment therefore promotes efficient utilisation of feed.

The major stress factors that occur under culture conditions are caused by: changes in pH[33]; chronic exposure to low oxygen concentrations[34,35] and temperature, ammonia, aggressive intra-specific behaviour and handling[36]. Accordingly, the entire production system should be systematically examined to identify and alleviate stressful factors, with reference to the specific requirements of the cultured species[6].

Conclusion

From a nutritional perspective the essential elements of the culture system are the performance of the feed, of the feeding strategies that are employed and of the culture environment. Feed performance should be considered in terms of biological and economic efficiency. The performance of feeds and management practices can be estimated on-farm through use of feed conversion efficiency ratios. Systematic sampling and maintenance of accurate records are essential to farm management and allow the effects of variations in feeding techniques to be evaluated. Manufacture of feeds on farm offers greater control over diet and the potential for cost savings through manipulating nutritional profile and through the use of cheaper alternative ingredients. Maintenance of an optimal culture environment can also enhance productivity.

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What's new on the web

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Getting help

The Techsoup website also supports a number of web boards and discussion groups where you can ask questions or contact people about problems or issues. A free email newsletter is also available to help you keep up to date with new resources as they become available.

While the applications procedure does look a bit US-centric I have contacted Techsoup and they have confirmed that they accept applications from organizations operating in other parts of the world. So once again, if you're involved in a non-profit organization and could use some help with your IT, you might like to have a look at the resources available through this site.

Advice on Aquatic Animal Health Care

Problems in *Penaeus monodon* culture in low salinity areas

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Tiger shrimp (*P. monodon*) is able to survive and grow in wide range of salinity from 2 to 45 ppt. Therefore shrimp farmers can expand their farms extensively in different area/environment. However, extremely high or low salinity always causes more problems than the suitable salinities which range from 15 to 25 ppt. Culture in extremely high salinities over 30 ppt may cause disease problems, particularly white spot or yellow head virus and luminescent bacteria. Therefore, more shrimp farmers keep moving toward brackishwater or freshwater areas. In 1995, the author summarized the problems and solutions for *P. monodon* culture in freshwater area which some of you may have seen. Due to the increases and changes in knowledge and problems on shrimp culture in low salinity, the author has therefore compiled this information and re-summarized for consideration so that the farmers can find the suitable culture method for each environment and farming system. The major problems on *P. monodon* culture in low salinity areas include:

Salinity

The suitable salinity for seed stocking should not be lower than 7-8 ppt during the first month in order to reduce problems in acclimatization of postlarvae (PL) transported from hatchery. Then salinity can be gradually reduced but should not be lower than 2 ppt during the growth up to 10-12 gm. If salinity is lower than this, stunting or mortality may occur. If stunting or soft shell occur, it is necessary to add more saline water to increase pond salinity.

Water management

Farmers should have reservoir/treatment ponds or canals surrounding the growout pond for sedimentation of organic loads at least 2-3 days before recycling. Water recycling should start when pond water becomes a dark color and turbid and feed amount does not increase. Pond water should be drained for recycling in order to reduce accumulated pond waste when water filling alone is not sufficient for improving water quality. Surrounding canals or treatment ponds can also serve for sludge sedimentation of pond effluent during harvest. This 1.5 m depth canal should be wider than 5.0 m or large enough for stocking/recycling of water drained from 2 grow-out ponds.

pH control

Due to its minimal water exchange system, over-blooming of phytoplankton always occurs during the culture period, which will increase water pH and also cause pH fluctuation between day and night. Therefore phytoplankton growth should be controlled by occasional water exchange from reservoir/treatment ponds. The suitable pH should be 7.8-8.0 in the morning and not exceed 8.3 in the afternoon. If water exchange does not make any difference, formalin treatment at the rate of 6.25-31.25 l/ha/day for 3-5 days will help to reduce water pH. If water pH in the morning is higher than 8.0, application of any type of lime is prohibited.

Alkalinity

Alkalinity should generally be 50 ppm in bicarbonate form, which can keep water pH stable. Lime in the forms of calcium carbonate or dolomite should be applied before seed stocking. Application of sodium bicarbonate at the rate of 62.5-125 kg/ha also increases pond alkalinity. Then fertilization should follow because plankton growth can increase water alkalinity.

Rough shell

If pond alkalinity and pH exceed 150 ppm and 8.3 respectively, calcium will deposit on the shrimp shell, which consequently stunts shrimp growth. In order to solve this problem, water pH should be kept less than 8.3 and be followed by water exchange or formalin treatment.

Shrimp mortality and cannibalism

After 70-80 days in ponds where salinity is too low shrimp cannot molt properly and may have a soft shell which allows them to be eaten by stronger shrimp. If soft shell occurs, saline water or table salt should be added to keep water salinity over 3.0 ppt. Application of table salt is generally 625-1,250 kg/ha/time depending on pond salinity.

Toxic gases

Due to high stocking density (500,000 PL/ha) and closed system, ammonia levels in ponds can be very high. In conjunction, the increase of water pH also causes severe toxicity of ammonia. Therefore, farmers should reserve water in reservoirs or in recycling ponds for exchange and pH control.

Turbid water

For newly constructed or renovated ponds water stays turbid for 40-50 days after seed stocking or water exchange. Shrimp may be then dark or red color in the morning. Farmers should solve this problem before shrimp stops feeding and while there are still some plankton in the pond water. In order to reduce turbid water, aerators should be switched off as long as possible during the daytime. This will let solid particles settle and also allow plankton to float to the surface. Bottom water should be then drained to eliminate the accumulated sediment. If turbid water still occurs, flocculating agents may be required and plankton stock from outside should be added. After the bloom of this newly introduced plankton, turbidity will disappear.

Slow growth or stunting

After 90 days culture period, farmers may observe stunting and reduced feeding of shrimp. Too low salinity or too much pond waste may cause this. These can be solved by drainage of bottom water and filling with saline water. In case of high stocking density, some shrimp should be transferred to other ponds.

The above problems are generally found in all shrimp farming areas. Farmers should carefully observe shrimp health and closely monitor water quality. For good production, proper treatment should be done urgently to prevent any loss.

ปัญหาการเลี้ยงกุ้งกุลาดำ ในพื้นที่ความเค็มต่ำ

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จากการที่กุ้งกุลาดำสามารถปรับตัว และเจริญเติบโตได้ในน้ำที่มีความเค็มต่ำตั้งแต่ 2 - 3 ส่วนในพันส่วน จนความเค็มสูงมากถึง 45 ส่วน ในพันส่วน ทำให้เกษตรกรสามารถขยายการเลี้ยงกุ้งออกไปได้อย่างกว้างขวางในหลายพื้นที่ อย่างไรก็ตามความเค็มที่สูงหรือต่ำเกินไป ก็ก่อให้เกิดปัญหาในระหว่างการเลี้ยงกุ้งได้ง่ายกว่าความเค็มที่เหมาะสมซึ่งควรมีค่าระหว่าง 15-25 ส่วน ในพันส่วน นอกจากนี้ยังพบว่าการเลี้ยงกุ้งในพื้นที่ที่ความเค็มสูงมากกว่า 30 ส่วนในพันส่วน จะประสพกับปัญหาโรคระบาดรุนแรงกว่า ไม่ว่าจะเป็นโรคดวงขาว โรคหัวเหลือง หรือโรคเรืองแสง ดังนั้นเกษตรกรส่วนใหญ่จึงนิยมหันมาเลี้ยงกุ้ง ในเขตที่มีความเค็มต่ำหรือน้ำกร่อยกันมากขึ้น ผู้เขียนเคยสรุปถึงปัญหาและแนวทางการเลี้ยงกุ้งกุลาดำในพื้นที่น้ำจืดมาแล้วครั้งหนึ่ง ในช่วงปลาย ปี 2538 ซึ่ง หลายท่านคงจะเคยผ่านสายตามาบ้างแล้ว แต่เนื่องจากข้อมูลและปัญหาต่าง ๆ ที่เกิดขึ้น ในระบบของการเลี้ยงกุ้งในน้ำที่มีความเค็มต่ำได้ เพิ่มมากขึ้นและเปลี่ยนแปลงไปพอสมควร ดังนั้นผู้เขียนจึงขอสรุปและรวบรวมข้อมูลดังกล่าว เพื่อนำเสนอ อีกครั้งหนึ่ง ทั้งนี้เกษตรกรรายใหม่ซึ่งอาจจะยังไม่มีข้อมูลเหล่านี้จะได้นำไปประกอบการพิจารณาหาแนวทางการเลี้ยงเพื่อให้สอดคล้องกับสภาพภูมิประเทศ และระบบฟาร์มของเกษตรกรแต่ละรายต่อไป ปัญหาสำคัญและพบได้บ่อยๆ ในระบบการเลี้ยงกุ้งกุลาดำในน้ำที่มี ความเค็มต่ำ ได้แก่

1. ปัญหาเรื่องความเค็ม

ความเค็มที่เหมาะสมในการเริ่มปล่อยลูกกุ้งหรือในช่วงเดือนแรกควรจะ มีค่าไม่ต่ำกว่า 7-8 ppt. ทั้งนี้เพื่อลดปัญหาในการปรับสภาพลูกกุ้งจากโรงเพาะฟัก หลังจากนั้นความเค็มอาจจะลดลงมาได้ แต่ไม่ควรจะให้ต่ำ กว่า 2 ppt. ในขณะที่กุ้งมีขนาดเล็กกว่า 10-12 กรัม เพราะจะทำให้กุ้งโตช้าหรืออาจจะทยอยตาย ดังนั้นเมื่อความเค็มมีค่าประมาณ 3 ppt. หรือเมื่อพบว่ากุ้งโตช้า ไม่กินอาหารหรือเปลือกอ่อน จำเป็นจะต้องเติมน้ำทะเลเพื่อให้ความเค็มเพิ่มสูงขึ้นกว่า 3 ppt. จึงจะสามารถเลี้ยงกุ้งต่อไปให้ได้ขนาดใหญ่ขึ้น

2. ปัญหาเรื่องการเติมน้ำหรือเปลี่ยนถ่ายน้ำ

เกษตรกรจะต้องมีบ่อพักน้ำและคลองรอบบ่อหรือฟาร์มเพื่อใช้สำหรับตกตะกอนหลังจากปล่อยน้ำออกจากบ่อเลี้ยง น้ำดังกล่าวสามารถสูบกลับมาใช้ในบ่อเลี้ยงหรือ บ่อพักได้ หลังจากทิ้งไว้ในบ่อตกตะกอน 2 - 3 วัน ซึ่งจะเป็นการประหยัดน้ำเค็ม เกษตรกรควรจะเริ่มเติมน้ำจากบ่อพักน้ำ เมื่อพบว่าสีน้ำในบ่อเลี้ยงเข้มจัด เกิดตะกอน กุ้งตัวสกปรก หรือกินอาหารไม่เพิ่ม และอาจจะต้องมีการถ่ายน้ำ เพื่อระบายของเสียออกนอกบ่อเลี้ยง เมื่อพบว่าการเติมน้ำอย่างเดียวไม่สามารถแก้ปัญหาได้ ทั้งนี้เนื่องจากมีของเสียสะสมในบ่อมากเกินไป นอกจากนี้คลองรอบบ่อยังสามารถใช้พักน้ำ เพื่อให้ตกตะกอนก่อนปล่อยทิ้งในช่วงจับกุ้งได้ คลองรอบบ่อควรมีขนาดกว้างไม่น้อยกว่า 5 เมตร ลึกประมาณ 1.5 เมตร หรือเพียงพอต่อการเก็บ กักน้ำจากบ่อเลี้ยงได้อย่างน้อย 2 บ่อ เพื่อที่จะเก็บน้ำ และนำกลับมาใช้ใหม่ได้

3. ปัญหาเรื่องการควบคุม pH

เนื่องจากเกษตรกรส่วนใหญ่จะถ่ายน้ำน้อยมากในขณะเลี้ยง ซึ่งจะทำให้แพลงค์ตอนเจริญหนาแน่นเกินไป ส่งผลให้ค่า pH ของน้ำสูงและแตกต่างกันมากในรอบวัน ดังนั้นจึงควรจะควบคุมปริมาณแพลงค์ตอนไม่ให้หนาแน่นเกินไป โดยการเติมน้ำหรือระบายน้ำเป็นครั้งคราว ค่า pH ที่เหมาะสมในตอน เช้าควรมีค่า 7.8-8.0 และไม่ควรเกิน 8.3 ในช่วงบ่าย ในกรณีที่การถ่ายน้ำยังไม่สามารถแก้ปัญหาได้ การใช้ฟอร์มาลินในอัตรา 1-5 ลิตร/ไร่/วัน ติดต่อกัน 3-5 วัน ก็จะช่วยลด pH ลงมา ได้ระดับหนึ่ง ในกรณีที่น้ำมีค่า pH ตอนเช้าสูงมาก กว่า 8.0 ควรงดการให้ปูนทุกชนิด

4. ปัญหาเรื่องค่าความเป็นด่าง หรืออัลคาไลนิตี้

โดยทั่วไปค่าความเป็นด่าง ควรสูงกว่า 50 ส่วนในล้านส่วน (ppm.) ในรูปของไบคาร์บอเนต ซึ่งจะทำให้ pH ของน้ำคงที่ ดังนั้นจึงควรเติมปูนเพื่อเพิ่มความเป็นด่างก่อนที่จะปล่อยกุ้ง ปูนที่ใช้อาจเป็นในรูปของแคลเซียมคาร์บอเนตหรือโดโลไมท์ นอกจากนี้การใช้โซเดียมไบคาร์บอเนต

ในอัตรา 10-20 กิโลกรัม/ไร่ ก็จะเพิ่มค่าความเป็นด่างได้ หลังจากนั้นจะต้องเริ่มทำให้น้ำเขียว ซึ่งเมื่อน้ำเริ่มมีแพลงค์ตอนมากขึ้น ค่าความเป็นด่างจะค่อยๆ เพิ่มขึ้นเอง

5. ปัญหาเรื่องกุ้งเปลือกสาก

เนื่องจากในบ่อ ที่มีค่าความเป็นด่างสูง (150 ppm) และมีค่า pH สูงกว่า 8.3 มักจะพบหินปูนเกาะตามเปลือกกุ้ง ทำให้กุ้งโตช้ามาก ดังนั้นจำเป็นจะต้องควบคุม pH ให้มี ค่าต่ำกว่า 8.3 อยู่ตลอดเวลาก็จะแก้ปัญหาได้ ซึ่งอาจใช้วิธีการถ่ายน้ำหรือใช้ฟอร์มาลินช่วย

6. ปัญหาเรื่องกุ้งตายและกินกันเอง

หลังจากเลี้ยงกุ้งประมาณ 70 - 80 วัน ถ้าน้ำมีความเค็มต่ำเกินไป กุ้งจะลอกคราบได้ไม่สมบูรณ์ การสร้างเปลือกใหม่ช้าทำให้เกิดการกินกันเอง ดังนั้นเมื่อพบว่ากุ้งเริ่มเปลือกอ่อนหรือน้ำมีความเค็มต่ำกว่า 3 ppt. ควรเติมน้ำเค็มหรืออาจใช้เกลือเม็ดหว่านให้ทั่วบ่อ สำหรับอัตราการใช้เกลือก็จะขึ้นอยู่กับความเค็มในบ่อแต่โดยทั่วไปจะใช้ในอัตรา 100-200 กิโลกรัม/ไร่/ครั้ง

7. ปัญหาเรื่องแก๊สพิษต่างๆ

เนื่องจาก เกษตรกรมักปล่อยกุ้งในอัตราความหนาแน่นสูงมาก (> 80,000 ตัว/ไร่) และถ้าไม่มีการถ่ายน้ำเพื่อระบายของเสีย จะทำให้เกิดแอมโมเนียในบ่อสูง ซึ่งเป็นช่วงที่ pH ของน้ำสูงจะทำให้แอมโมเนีย เป็นพิษมากขึ้นหลายเท่าตัว เกษตรกรจึงควรเตรียมน้ำไว้ในฟาร์มเพื่อทำการเปลี่ยนถ่ายและควบคุม pH ของน้ำอย่างระมัดระวัง

8. ปัญหาน้ำขุ่นเป็นตะกอน

ในบ่อที่ขุดใหม่หรือปรับพื้นใหม่ มักจะพบว่าน้ำขุ่นเป็นตะกอน หลังปล่อยกุ้งประมาณ 40-50 วัน หรือหลังจากมีการเติมหรือเปลี่ยนน้ำ เกษตรกรจำเป็นจะต้องรีบแก้ปัญหา ก่อนที่กุ้งจะไม่กินอาหาร มักจะพบว่าหลังน้ำขุ่นเป็นตะกอนจะพบกุ้งมีสีเข้มหรือแดงในตอนเช้า เกษตรกรจะต้องรีบแก้ไขขณะที่ยังมีแพลงค์ตอนบางส่วนอยู่ในน้ำ โดยการปิดเครื่องตีน้ำให้นานขึ้นในเวลากลางวัน ตะกอนจะตกลงและแพลงค์ตอนจะลอยขึ้นมาอยู่ผิวน้ำ จากนั้นระบายน้ำก้นบ่อทิ้งไป ในกรณีที่ตะกอนยังมากอยู่อาจจำเป็นต้องใช้สารจับตะกอนช่วย และพยายามเลี้ยงแพลงค์ตอนซึ่งอาจจะต้องสูบน้ำจากบ่อที่มีน้ำเขียวมาช่วย หลังจากแพลงค์ตอนเจริญขึ้นตะกอนจะหายไป

9. ปัญหากุ้งโตช้า หรือหยุดการเจริญเติบโต

หลังจากเลี้ยงกุ้งได้ประมาณ 90 วัน เกษตรกรมักจะพบว่ากุ้งกินอาหารน้อยลงและโตช้ามาก ทั้งนี้เนื่องมาจากสาเหตุหลัก คือ ประการแรก น้ำมีความเค็มต่ำเกินไป ประการที่สองคือมีของเสียในบ่อมากเกินไป วิธีการแก้ไขคือระบายน้ำก้นบ่อออกหลังจากนั้นเติมน้ำเค็ม กุ้งก็จะเริ่มกินอาหารอีกครั้งหนึ่ง นอกจากนั้นปัญหาอีกประการหนึ่งคือ อาจปล่อยกุ้งมากเกินไป ถ้าเป็นในกรณีนี้ ควรย้ายกุ้งบางส่วนออกจากบ่อเดิมเพื่อลดความหนาแน่นลง

ที่กล่าวมาเป็นปัญหาสำคัญ ๆ และเกิดขึ้นบ่อยมากในทุกพื้นที่ เกษตรกรควรหมั่นตรวจสอบ ดูแลสุขภาพกุ้งและคุณภาพน้ำ อย่างใกล้ชิด รีบแก้ไขปัญหาอย่างรวดเร็วและถูกต้อง เพื่อกันความเสียหายที่อาจเกิดขึ้นการเลี้ยงจึงได้ผลดี

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