ISSN 0859-600X

Volume XII No. 2 April-June 2007

AQUACULTURE ASIA

Towards sustainable monodon culture in Sri Lanka

Development of green mussel cultivation in Thailand

Aquaculture of sea-pineapple in Japan

Optimal nutrition for marine fish

Producing high-quality fish seed

Selective breeding of river catfish

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

Editor
Simon Wilkinson
simon@enaca.org

Editorial Consultant
Pedro Bueno

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

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

Printed by

Scand-Media Co., Ltd.

AQUACULTURE ASIA

Volume XII No. 2
April-June 2007

ISSN 0859-600X

Capacity needed in broodstock management

There are indications that the seed quality of some important cultured freshwater fish species in Asia have declined. The cause of the decline in seed quality is unknown, but there is a perception amongst government technical agencies that poor broodstock management practices (genetic and husbandry) are a contributing factor. Few public or private sector hatcheries in the region have effective broodstock management plans in place. Seed production is often based on a handful of fish that may have been imported in some cases decades ago, creating considerable potential for genetic deterioration if broodstock have not been carefully managed.

When problems with seed quality are observed such as reduced growth rate the most common coping strategy is to try and introduce 'fresh' broodstock from an outside supplier, which may be no better managed, and frequently by requesting assistance from another country. A 'quick fix' perhaps, assuming that the source stock are actually in better condition (they may not be), but not really a sustainable solution as it does not address the underlying problem of the need for better broodstock management practices.

The translocation of broodstock within the region also has its own risks. Firstly, there is a substantial risk of homogenizing genetically distinct fish populations. Accidental escapes from aquaculture facilities happen with monotonous regularity, and the deliberate restocking of public waters is frequently undertaken without reference to the genetic diversity of receiving populations. It also creates the risk of introducing serious exotic pathogens into key seed supplies, an event that has frequently occurred throughout the aquaculture sector leading in some cases to massive and ongoing economic losses throughout the region.

There is a real need to identify issues and strategies for building capacity in broodstock management that will assist countries in the region to sustain quality seed production. This is not only a prerequisite for reducing reliance on imported broodstock and seed, it will also underpin the possibility of selecting representative broodstock for restocking public waters and developing or maintaining genetically improved strains for farming purposes. Look to this to become increasingly a burning issue in future.

Starting this issue you'll find a new section on the last page, the 'NACA Bookshelf'. The purpose of this section is to highlight key publications of interest to readers who may not have regular internet access, and who may not be able to visit www.enaca.org often. We hope that this section will help raise awareness of some of the fantastic publications that are available for free download on the NACA website, and maybe encourage the occasional visit to an internet cafe to obtain them, and some of the other 780 or so publications that are available there. In this first printing of the 'bookshelf', we have focussed on some of NACA's flagship and most popular publications from the last couple of years, which should be on the 'bookshelf' of every serious aquaculturist. Future issues will emphasise new publications as they are published on the web.

Simon Wilkinson

AQUACULTURE ASIA

In this issue

Sustainable aquaculture

People in aquaculture

Research and farming techniques

Genetics and biodiversity

Asia-Pacific Marine Finfish Aquaculture Network Magazine

NACA Newsletter 42

Opposite.

Page 8.

Page 18.

Page 21.

Page 24.

Page 33.

Towards sustainability of black tiger shrimp (*Penaeus monodon*) farming in Sri Lanka

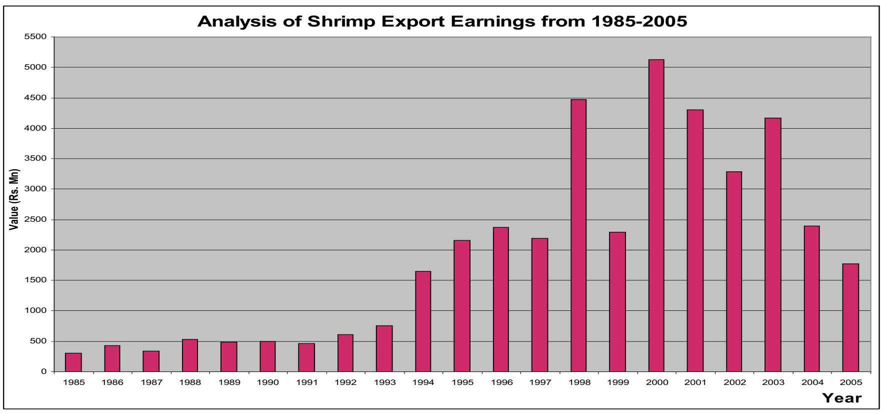
D.E.M. Weerakoon PhD

Director General, National Aquaculture Development Authority of Sri Lanka

In the early 1980s, a number of local entrepreneurs and a few multinational companies embarked on culture of *Penaeus monodon* (black tiger shrimp) in ponds along the North Western coastal belt from Madampe to Puttalam, responding to initiatives by the government to develop shrimp farming for the export trade. The shrimp aquaculture industry in Sri Lanka originally commenced in Batticaloa in the eastern coast in the late 1970's and finally concentrated in the northwestern coastal belt covering with 1,344 farms covering an area of more than 4,500 ha, around 3,000 ha of which comprised actual grow out ponds. This industry also triggered the development of about 120 hatcheries catering to the post larval needs of the farmers. In Batticaloa District, where shrimp farming first began and was later abandoned due to civil unrest, farming activities have recommenced in recent years. Over 60 small scale farms with an average farm extent of 1-2 ha were in operation by the end of 2002, with a total pond area of 155 ha. However, during the recent tsunami that swept the North, North-Eastern and Southern coasts of Sri Lanka, most if not all shrimp farms on the eastern coast were affected or destroyed.

The Dutch Canal, an important shared water source for the shrimp farming industry.

Shrimp farming has been the most lucrative commercial aquaculture activity in Sri Lanka since it commenced in mid eighties. The industry recorded its peak economic performance in the year 2000, earning Rs. 5,041 million in foreign exchange. However, the quantity of processed (headless) shrimp exported in the year 2004 was 2,462 MT earning a total export value of Rs. 2359 million (Ministry of Fisheries and Aquatic Resources, 2005). This fall has been as a result of the advent of 'white spot' viral disease which sprang up intermittently from 1996 onwards.



Shrimp farmers originally practiced the 'open system' aquaculture technique in earthen ponds, until the white spot virus and yellow head viral diseases devastated the industry, firstly in 1996 and subsequently in 2003. This caused serious economic losses to the industry and its stakeholders. After these disease outbreaks, the farmers adopted reduced water exchange systems, namely, closed systems, semi-closed systems and re-circulation systems for culture. However, up to the year 2003, as there was inadequate monitoring and regulation of the industry, uncontrolled farming practices utilizing substandard culture techniques and post larvae, especially by small scale unauthorized shrimp farmers, brought about an unprecedented escalation of the white spot disease resulting in a near total collapse of the industry in 2004.

In 2003, the National Aquaculture Development Authority (NAQDA) along with the Fisheries Ministry of the Wayamba Provincial Council, spearheaded a comprehensive program for control of the disease spread and rehabilitation of the shrimp farming industry in the NWP. The initial steps taken by NAQDA were so firm and decisive that it led to a series of events, amidst stiff opposition from some stakeholders with vested interests effectively counteracted by NAQDA, culminating in the formulation of 'Crop Calendars' resulting in effective control of the spread of disease amongst shrimp farms. The Sri Lanka Aquaculture Development Alliance (SLADA), which was established in mid 2004, subsequently extended their assistance in implementing this control mechanism initiated and implemented by NAQDA. At present, the spread of the white spot disease is effectively controlled. This article describes the activities undertaken by NAQDA which led to control of the disease spread.

Certification of shrimp hatcheries

During the hey days of shrimp farming in Sri Lanka, the lending institutions made the initial mistake of dishing out loans to shrimp farmers without evaluating the pros and cons of this industry vis a vis: a) the carrying capacity of the Dutch Canal for example determining the number of shrimp farms that the water in the Dutch Canal can sustain without bringing about changes in the ecosystem, b) the quantity of post larvae needed to stock all the shrimp farms and c) the number of hatcheries available to cater to the needed requirement. As the total number of shrimp farms, both authorized and unauthorized began to grow (unauthorized shrimp farms mushroomed during the mid 90's with the change in government), the number of shrimp hatcheries also grew rapidly to cater to the much needed post larvae of shrimp. These backyard hatcheries which lacked basic standard requirements were set up by villagers who did not have the basic technical know how and standards required for operating shrimp hatcheries. Due to the lucrative returns from operating a shrimp hatchery - the price of a post larva at the time ranged between Rs. 0.60 to Rs. 1.25 - some villagers borrowed from banks while others sold their personal assets in order to set up shrimp hatcheries on the advice provided by the so called consultants who were aplenty at the time. The author is personally aware of some boat owners of the fishing industry, who sold their assets (boats) to set up shrimp hatcheries.

Up to the year 2004, there were 130 shrimp hatcheries operating in the Puttalam district. A majority of these lacked the basic requirements, with the owners adopting substandard methods to produce post larvae to supply the shrimp farmers. After the disease outbreak, the demand for shrimp post larvae gradually dropped and some hatchery owners also dropped the price to a figure as low as Rs. 0.10 to Rs. 0.20 per post larva. This resulted in the production of low quality post larvae and the escalation of the disease which culminated in the latter period of 2003. Total processed shrimp exports dropped to 2,400 MT in 2004 compared to 4,300 MT in the year 2003.

Establishment of a Shrimp Farm Monitoring & Extension Unit

The very first action initiated by NAQDA was to establish a Shrimp Farm Monitoring and Extension Unit (SFM&EU) in Chilaw with a well trained technical staff. The staff comprised of two groups; one group to monitor the activities of the shrimp hatcheries and the second group to monitor the activities of the shrimp farms.

A committee comprising various stake holders of the industry, including officials from the Fisheries Ministry of the WPC, the Wayamba Central Environmental Authority, Coast conservation Department, NARA, the District Secretariat, the Department of Fisheries & Aquatic Resources and NAQDA, was appointed to visit each and every shrimp hatchery operating in the Puttalam district with the view to inspect and examine whether the hatcheries were operating in accordance with previously established guidelines and requirement criteria. Non compliant hatcheries were given adequate time to make the necessary structural changes necessary and to obtain equipment critical for the production of quality post larvae. Hatcheries that met the prerequisites were certified and issued with Management Licenses and non-complying hatcheries were closed down. At present, only 50 of the former 130 hatcheries are operating in the Puttalam district. These are regularly monitored by the officers of the SFM&EU in Chilaw.

Testing shrimp broodstock for white spot disease

The next action initiated by NAQDA was to test the incoming brood stock and the hatched post larvae of shrimps in hatcheries for white spot viral infections. This was carried out by NAQDA using polymerase chain reaction (PCR) facilities of the Fisheries Ministry of the WPC, and is still being carried out today as a service to the industry. This, together with the actions described above, have helped NAQDA to control the outbreak of the WSDV to a significant extent.

Table 1. Details of Hatchery Regularization.

	Total
Hatcheries inspected	91
Approved hatcheries	54
Illegal hatcheries	37
No. regularized	30
No close down	43
No. licensed	49

Disinfecting shrimp ponds infected with white spot disease

Another action initiated by the SFE&MU officers was to act immediately on receiving information about disease occurrence in shrimp farms. In this instance, the officers, on arriving at the affected site, would inform the shrimp farmers to harvest non-infected shrimps from the pond using nets. The officers would assist in this process by making available the drag nets from the SFE&MU in Chilaw. Every attempt was made to prevent the farmers from discharging the contaminated waters into the environment. After the non infected shrimps were harvested, the SFE&MU officers disinfected the water in the affected ponds using a chemical, which destroyed the diseased shrimp in the pond. After 4 to 7 days the water was released to the surrounding sedimentation canals. This process is still continued by the SFE&MU officers based in Chilaw to the best of their ability. However, there are some errant farmers who discharge the contaminated waters to the Dutch Canal on the sly. Awareness programs have been conducted by the SFE&MU officers on the detrimental effects of such actions and in certain sub-zones the shrimp farmers themselves are taking action to prevent the contaminated waters being discharged in to the canal, once they detect such disease occurrences in farms in and around their own facilities. SFE&MU officers will also inform the other shrimp farmers in an affected area through mobile public address systems, about the location of the diseased farm and urging the farmers to restrain from pumping water from the Dutch Canal into their ponds until the crisis period is over. This action however, has now waned as the need for such does no longer arise due to lower incidence of disease.

Regularizing unauthorized shrimp farms

After 1995, with the then government change, a large number of shrimp farms without proper government approvals mushroomed from Thoduwawa to Puttalam in the NWP. Some of these unauthorized shrimp ponds/farms were constructed in reservations provided under the law by the authorized shrimp farms, some in wetlands and some others in the dried up areas of the Dutch Canal itself. These farms increased the pressure on the Dutch Canal and also led to floods during the rainy season, which were the main cause of the proliferation of diseases in the sector over a period of time.

Under the rehabilitation of the shrimp farming industry program, another action initiated by NAQDA is to regularize these unauthorized ponds/farms. This is done not by closing them down in their entirety, which would result in immense social problems, but by undertaking an inspection of these unauthorized shrimp ponds/farms by a committee specially appointed for the purpose. The main task of this committee is to determine the areas of the Dutch Canal and other reservations that have been encroached upon and to take action to have those ponds within the reservations demolished, after informing the illegal operators.

As a first step in implementing this activity, NAQDA has taken steps to obtain the services of the Department of Surveys to demarcate the boundaries on either side of the Dutch Canal which are predetermined reservations and to mark the boundaries using standard concrete posts used by the Department for such purposes. About two kilometers have been already surveyed and marked and the work is in progress. A 60 km stretch along the Dutch Canal is earmarked to be measured and permanently marked using concrete posts, during 2006/2007.

Replanting destroyed mangrove areas along the Dutch Canal

Along with the demarcation of the reservation along the canal, steps have also been taken to replant the boundaries along the canal and other mangrove areas which have been destroyed due to illegal constructions with mangrove plants in collaboration with the Forest Department. A 10 acre stretch has already been planted with mangroves during 2005 with the assistance of the Fisheries Ministry of the NWPC.

Implementation of ‘Crop Calendars’

The implementation of the ‘Crop Calendar’ came in to being in the year 2004. As mentioned earlier, this was necessitated by events leading to a total collapse of the shrimp farming industry in late 2003. Although there was stiff opposition to this decision by various stakeholders with vested interests, NAQDA stood firm in its decision to implement this ‘Crop Calendar’.

The principle underlining the ‘Crop Calendar’ was to divide the shrimp farm area in the Puttalam district from Thoduwawa to Kalpitiya and Puttalam in to sub-zones and next devise a calendar with the participation of the stakeholders (shrimp farmers, processors, hatchery operators and shrimp feed importers), to enable shrimp farmers in particular sub-zones to farm and crop within a particular time frame. This method prevented all shrimp farmers from engaging in farming and cropping at the same time and also prevented haphazard stocking of shrimp ponds by errant farmers. This calendar was streamlined over the next two years and at present there are three cropping periods, vis-à-vis, ‘Pera Yala’, ‘Yala’ and ‘Maha’ during which periods shrimp farmers in selected sub-zones are allowed to farm and crop. This process reduced the number of farms being stocked at any given time to a minimum, so reducing the pressure on the Dutch Canal which provided the water to the shrimp farms. This also prevented all farms from cropping two times a year as was practiced earlier resulting in the escalation of the disease among the shrimp farms. This was essential as most farms could not practice closed farming system approaches as the small scale farms did not have the capacity to re-circulate the water within the ponds without adhering to water exchange with the Dutch Canal. Some shrimp farmers who had the capacity to engage in closed farming systems were allowed to crop two times per year with the concurrence of the Shrimp Farmers’ Association, to which those particular farmers belonged, and with the approval of NAQDA.

One drawback in this practice was a reduction in the total farm production output per year which had a direct effect on export volume. In the year 2005, the quantity of processed shrimp exported was 1,800 MT down from 2,400 MT of processed shrimp exported in 2004, the year in which the industry experienced the biggest loss in production, a result of the worst disease outbreak in the latter half of the year 2003, as was mentioned earlier. However, NAQDA is confident that this drawback is only a temporary one and that the industry will pickup once NAQDA completes its most ambitious program, with regard to the rehabilitation of the Dutch Canal, ever to be undertaken up by an institution.

Rehabilitation of the Dutch Canal

One of the most ambitious projects to be undertaken by NAQDA after its establishment in 1998 by an Act of Parliament was to de-silt/dredge the Dutch Canal, based on a study carried out by a private consultancy. The major reason for white spot disease escalation from its inception in the year 1996, to its worst attack in 2003, was the pollution in the Dutch Canal brought about by years of silting which prevented the free flow of water in the canal. The discharge of used water from the shrimp ponds back to the canal took along with it unutilized shrimp feed, pond bottom wastes and a nutrient load which compounded this problem resulting in the intermittent disease outbreak and its escalation to other farms as well.

The Dutch Canal or Hamilton Canal was built during the Dutch occupation of Sri Lanka from the seventeenth to eighteenth century. This canal was built by connecting the lagoons in the North Western and Western coastal zones with the objective of developing a waterway from the Puttalam Lagoon right up to the Negombo Lagoon to facilitate the transportation of goods from Puttalam to Colombo for trading purposes. Various proposals were put forward by the Ministry of Fisheries & Aquatic Resources to dredge this canal where it was most silted, but failed due to the lack of funds needed for the purpose. However, in the Year 2004, after presenting the facts on the relationship of the silting of this canal to escalation of the white spot disease in shrimp in the NWP to Treasury officials by NAQDA and the Shrimp Farmer's Consortium, for the first time in the history of the Dutch Canal, funds were provided by the Treasury to commence de-silting the canal at designated areas.

The de-silting of the Dutch Canal is expected to improve its water flow, thus bringing about a flushing of the spent water from the shrimp farms. It is envisaged that this cleaning up operation and the increase in the flow rate would enhance the carrying capacity of the water in the canal, thus making it possible for more farms to be stocked during a particular crop cycle. With the increase in the number of farms being activated in a particular crop cycle, there will be a gradual increase in the farmed output, contributing to an overall increase in the quantum of processed shrimps exported per year. With the farmer confidence returning, as a result of less incidence of diseases afflicting shrimp production, with other factors remaining unchanged (international market price and cost of imported shrimp feed), its only a matter of time before the industry ca reach the export production levels recorded prior to the year 2004. That is, to generate an export production of 3,000mt to 4,500mt per annum from the NWP only.

Maintenance of the Dutch Canal - years of accumulated silt must be removed.

Formulation of Best Management Practices (BMPs)

NAQDA has formulated BMPs for the following activities with the concurrence of NARA, shrimp industry stakeholders, Dept. of Animal Production & Health, Central Environmental Authority of the NWPC, Faculty of Veterinary Science, SLSI, Quality Control Unit of the Dept. of Fisheries & Aquatic Resources and the University of Wayamba:

- Shrimp farm management
- Shrimp hatchery management
- Shrimp brood stock collection
- Shrimp feed imports
- Chemicals imports and their usage

Shrimp farmers/hatchery managers/ broodstock collectors/feed & chemical importers are expected under Aquaculture Regulations to adhere to the above BMPs. Failure to comply with regulations will result in prosecution and if found guilty, operators will be liable for a substantial fine and/or a term of imprisonment.

With the afore mentioned activities initiated by NAQDA to rehabilitate and sustain the shrimp farming industry in the NWP, it has been possible to effectively control the proliferation of the white spot disease and at present, there is a general awareness among the shrimp farmers who have grouped themselves together to form associations in each sub-zone about Good Management Practices (GMPs), which is the key to long term sustainability of this industry. However, over the last few years, the international market for processed shrimps has been subject to fluctuations due to various reasons, which have resulted in drastic reductions in prices paid by importers for processed shrimps in the major markets such as Japan and the USA. EU prices have always been below the Japanese and US prices for processed raw shrimp, as the market there is mainly for value added cooked products.

Pumping sediment from the Dutch canal.

Other factors affecting future production

The very first major market to drop prices was Japan way back in the late '90s, particularly around 1998. During this and subsequent years, exports of processed raw shrimps to the US market increased, although only grade 2 quality was exported to that country. The grade 1 product always went to Japan but at much reduced prices compared to prices prior to 1998. The farm gate prices which enjoyed a minimum profit of nearly Rs. 200-250 going up to Rs 350-400 per kg prior to 1998, depending on market demand, gradually dropped between 1998 and 2006. Today, with rapid fluctuations in international prices and high cost of inputs, such as imported shrimp feed which swallows up about 60% of the cost of production, and present day high cost of energy, the farmers are lucky if they can generate a profit margin of Rs. 50 to Rs. 75 per kg for their farmed product when the international prices are down. However this may rise to about Rs. 100 to Rs.150-200 when market prices increases.

From 1998, the major market Japan has been under a cloud of economic recession which has forced consumers to stop spending on luxurious items such as exotic and expensive food and to conserve their savings. At the time, the Japanese major importers and wholesalers had enough buffer stocks which were moving out slowly, while several container loads of processed and value added shrimp from various exporting countries were in the water at any given time making their way to either Tokyo or Osaka. In such a situation, the Japanese importers/wholesalers found it difficult to move their products and the end result was a reduction in wholesale prices to encourage sales. This is happening even today. To add to this, occasional political disturbances in the region such as weapons testing and similar issues have lead the Japanese consumer to adopt a more protective attitude and conserve their savings.

Similarly, the demand for luxury consumer products such as for processed shrimp among many others, started to decline in the US after the attack on the World Trade Centre in New York and continues to fluctuate in response to changes in the regional and global political environment. Prices have barely reached the earlier highs, but have varied at reasonable levels that have sustained the industry in producing countries.

The 'vannamei factor'

Penaeus vannamei, better known as white shrimp was first farmed in South America. Due to uncontrolled farming activities in those countries the entire industry was devastated with the advent of another viral disease called the Taura Syndrome. The industry has not recovered fully from the earlier onslaught in countries such as Ecuador. However, extensive research has been carried out in Hawaii and today the scientists there have developed a Specific Pathogen Free (SPF) *P. vannamei*.

With the decline in farm production of *P. monodon* (tiger Shrimp, which is farmed in Sri Lanka) the world over, countries such as the People's Republic of China, Thailand, Vietnam and Indonesia started producing *P. vannamei* and within no time the major importing countries, Japan and USA started to import *P. vannamei* due to a dearth in the production of *P. monodon*. The high production capacities in the above mentioned producing countries and the quantities exported, succeeded in offsetting the comparatively lower profit margins for *P. vannamei*. This tempted the producers in the above mentioned producing countries to increase stocking densities beyond recommended limits in order to increase production. The production of *P. vannamei* in these countries was next hit by the Taura syndrome viral disease, however, the availability of SPF *P. vannamei* by that time, enabled some farmers in these countries to resolve the disease problem to a certain extent by farming SPF *P. vannamei*.

The special characteristics of *P. vannamei* are that i) it is less expensive to culture, ii) it can be stocked at high stocking densities compared to *P. monodon* and iii) it only grows to a maximum commercial size of around 20 g. The only drawback is that the international market price for *P. vannamei* is comparatively lower and therefore larger scale production of this species is necessary in order to generate a decent profit. Countries with vast areas available for culture such as China, Vietnam, Indonesia and Thailand are at a tremendous advantage compared to a small country like Sri Lanka. Based on these two issues, vis-à-vis the possible introduction of a new disease (Taura syndrome) and lack of economies of scale, careful thought has to be given and discussions held with various stake holders before even thinking of introducing *P. vannamei* to Sri Lanka.

Prospects for the future

With the gradual increase in production of farmed shrimp as a result of the rehabilitation work carried out by NAQDA, prospects for shrimp farming are still good for Sri Lanka if we stick to *P. monodon* as a niche will develop for this product in major markets with reasonable prices. The major producing countries are now finding it difficult to revert to *P. monodon* culture due to various reasons. However, due to extensive research being done in especially Thailand, with the involvement of the universities and the Department of Fisheries in that country, they are in a position to overcome problems through technological advances and the development of improved farming practices.

NAQDA is encouraging shrimp farmers to carry out alternate cropping using fish varieties such as milk fish (*Chanos chanos*, known in Sinhala as 'wekkaya'), a brackish water fish, and tilapia, a fresh water fish that can be acclimatized to slightly brackish waters with salinity levels of 10 to 15 ppm. Milkfish is a brackish water fish which is very tasty when cooked; the only draw back is that it has a lot of small bones which is a non-starter for Sri Lankan cuisine. However, NAQDA with the assistance of the Asian Development Bank funded Aquatic Resource Development & Quality Improvement Project (ARDQIP), have demonstrated to stakeholders the method of removing bones by engaging a Philippines de-boning expert and very soon boneless whole fish fillets will appear in super market chains. Apart from the usage of milkfish as a consumer product, another market exists for milkfish juveniles as bait for the tuna long line industry. Discussions are underway with the Ceylon Fishery Harbours Corporation to introduce milkfish to long line tuna catching vessels, both local and foreign. Alternate farming and cropping of shrimp with milkfish and tilapia would result in the long term sustainability of shrimp farming in Sri Lanka. With planned shrimp farming activities yet to commence in the east, Sri Lanka could act as a role model for *P. monodon* farming in the region.

An economic analysis of stock enhancement of Persian sturgeon (*Acipenser persicus*) in Iran

Hassan Salehi

Assistant Professor and Head of Economic Group, Iranian Fisheries Research Organization, No. 279 West Fatemi Ave, Tehran, Iran. Email hsalehi_ir@yahoo.com.

It is essential to the successful development and management of a sturgeon farm to know the production costs and their evolution, showing the main items on which cost reduction is worth the effort. Production factor costs analysis of a sturgeon hatchery may also helps the manager in decision making and in adjusting to changes. Basically the production cost comprises all expenses incurred during the production process. According to Jolly and Clonts (1993), production may be defined as the process of combining resources and forces in the creation of some valuable good or services, and the purpose of production is to satisfy human wants and needs. The primary interest in most sectors is directed toward establishing viable industries for the purpose of domestic consumption, export, employment opportunities, income distribution, or a combination of these objectives (Shang, 1981). As Shang (1990) noted, elements such as biology, technology, feed and nutrition, engineering, fish pathology, and institutional factors all affect the economics of production. From a micro-economic view point the primary motivation of a fish farm may be profit making, but sometimes there can be other considerations such as stock enhancement (Salehi 2003).

Research on the economics of sturgeon culture will play an important role in its future development. It is clear now, that to overcome the problem of declining Persian sturgeon (*Acipenser persicus*) stocks the promotion of hatcheries to produce large quantities of fingerlings for stock enhancement is certainly going to be an important strategy. Stock enhancement is practiced in many countries with different methods and various objectives, not the least of which is the reconstruction of stocks of economically important species. For example, Japan has a long history in using stock enhancement to support and rehabilitate almost 80 species (Matsuda, 2000) with varying results. Iran contributes to these efforts through the reproduction and enhancement of ten main native species, releasing more than 250 million fingerlings into the Caspian Sea and the Persian Gulf annually (Bartley, 1995, Shehadeh, 1996, Bartley and Rana, 1998, Abdolhay, 1998, Tahori, 1998 and Salehi, 2002, 2005) (Figure 1).

As Fushimi (2001) noted, the main issues that should be considered in any stock enhancement plan are those dealing with fingerling quality and economic aspects. The economic advantages of stock enhancement like other aspects of population rehabilitation have been considered in recent years, as noted by (Bartley, 1995, 1999; Sreenivasan, 1998; Hansson, et al., 1997; Ahmad et al., 1998; Lorenzen et al., 1998; Gateway,1999, Salehi, 1999, 2002, 2005b; Kitada, 1999) and some researchers have emphasized the profitability of stock enhancement and stressed that in some species the rate of return of investment can be very high (Hansson, et al., 1997; Ahmad, et al., 1998; Lorenzen et al., 1998, Lorenzen et al., 2001, and Gateway, 1999).

The analysis of the economics of all aspects of stock enhancement for species such as Persian sturgeon is a very complicated undertaking while also being expensive and taking long time to gain satisfactory returns. Therefore, accurate programming, may have to play a key role on improving the productivity of stock enhancement while enhancement activity serving the conservation of the species has to be judged on other grounds rather than on economics. The natural maturation of all species of sturgeons in the Caspian Sea has faced serious problems. As noted by Vlasenkov (1995) the contribution from hatchery production in the northern Caspian Sea landings were estimated to be almost 7.5% for *Acipencer guldensteadi*, 30.1% for *A. stellatus*, and 91.5% for *Huso huso*. By considering the background data on stock enhancement of sturgeon species and the results of fishing data, it seems the increase of the contribution of Persian sturgeon in total catch in Iran was most probably affected by the stock enhancement programme. Keyvan (2002) noted the current situation of Persian sturgeon enhancement plans in Iran playing a key role in the protection of the population. Over the last decade, the quality and quantity of Persian sturgeon fingerling production has increased in Iran, and reached more than 18 million fingerlings by 2004 (Abdolhay, 1998; Tahory, 1998; Salehi, 2001, 2002 and 2005b; PDD, 2004). This study could present a developing policy for increasing the productivity and breeding procedure of hatchery production of Persian sturgeon in Southern parts of Caspian Sea in Iran, on which the Iran Fisheries Organization has made a huge investment over the last two decades, and which needs more investment for future development.

Study methods

To determine the costs of production for Persian sturgeon fingerlings in the year 2003, a questionnaire was prepared in 2004. A study of fingerling production of Persian sturgeon, input costs and the contribution of cost factors was carried out to help clarify sturgeon fingerling production costs. An expert team comprising of economists, statisticians and aquaculturists completed the questionnaire, while referring to all sturgeon centers. To improve accuracy, the experts referred to documents available in different sections of the Fisheries Organization, especially offices involved in accounting, budgeting and stock enhancement. Data were entered into a Microsoft Excel spreadsheet and methods for classification, summarizing, averaging, and for other functions were used for analysis.

Results

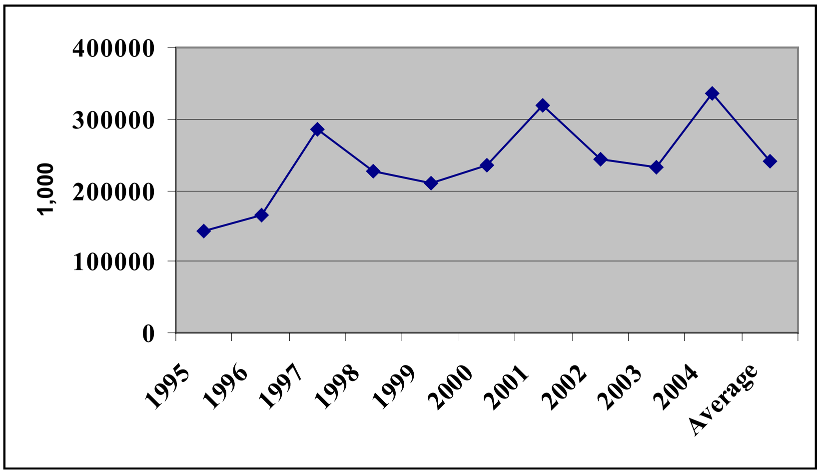
Over the 1981-2005 periods, the hatchery production of Persian sturgeon is shown in Figure 2. As Table 1 shows, in 2003, it is obvious that *A. persicus* accounted for almost 80% of total sturgeon fingerlings production while other species were of much less significance in this activity.

Among various expenditures, cost of labor and salary have the greatest share of the overall costs with 41% while costs of fertilized eggs and their incubation accounts for 29%, and depreciation for 12%, feed and fertilizer only 5% and maintenance 5% as the important factors (Table 2). Results also show that on average the costs of the production of a single fingerling of Persian sturgeon was 2,000 Rials and this takes into account the year 2003 data only. The cost of labor and salaries had a great share in total expenditures, which is mainly due to the seasonal activity of the centers with little work to do for permanent staff during almost 6 months.

Discussion

In Iran, there are many economic and environmental issues associated with any ranching and stock enhancement programme (Razavi Sayyad, 1995; Abdolhay, 1998 & 2006; Hosseini, 1998; Parafkandeh & Rezvani, 2005; Pourkazemi 2000 & 2006). Overall, the question on economic returns of hatchery release programmes have also been extensively discussed (Bartley 1995, 1999; Hansson et al., 1997; Sreenivasan, 1988; Salehi 1999, 2002 & 2005b; Ahmad et al, 1998). Despite the many advantages claimed by several authors with regard to stock enhancement programmes, one of the key factors that determine the economics of such operations is the real costs incurred in producing the juveniles. It is for this reason that this study was designed to acquire some basic insight in the cost structure of hatcheries operations as a first step in assessing the opportunities to improve efficiency for Persian sturgeon enhancement in Iran. As shown in this study, the major costs in hatchery operations are labor (temporarily hired workers) and salary (permanent staff). The average costs for both amounts to 820 Rials (almost 0.1 US$) for each fingerling produced. This is really a high cost item and in terms of large-scale production one would expect to see the prices are coming down with increasing production level. There are many reasons why these costs are so high. One is certainly the seasonality

Figure 1. Number of fingerlings of all valued species were produced in Iran over the period between 1995 and 2004 (modified PDD, 2006 and Abdolhay, 2006).



Demand for caviar has placed enormous pressure on stocks of several sturgeon species in the Caspian Sea. Above, surgical removal of eggs from captive broodstock to support restocking activities.

Figure 2: Number of Persian sturgeon fingerlings produced in hatcheries over the 1981-2004 (modified PDD, 2006, Abdolhay, 2006 and Salehi, 2005b).

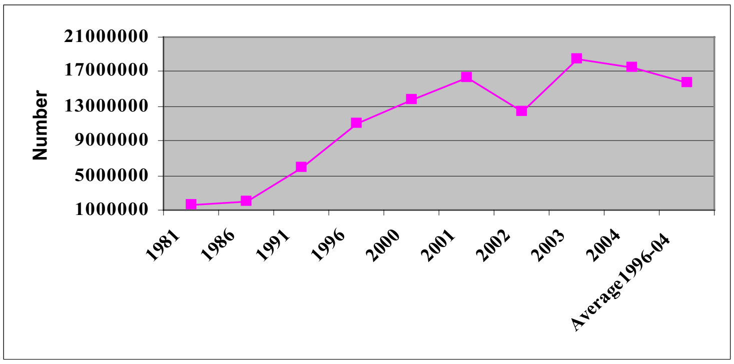


Figure 3. Average costs factors (Rials per fingerling production) of Persian sturgeon in 2003 in Iran. L&S: Labour and salary, FE: Fertilized eggs, F&F: Feed and fertilizer, M: Maintenance, W&E: Water & energy, D: Depreciation, O: Other.

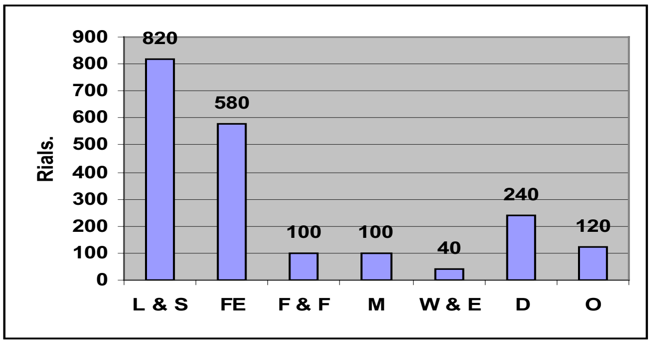


Table 1. Approximate number of sturgeon fingerlings produced in Iranian hatcheries by species in the years 2003-2004.

Species	2003	2004	% of total 2003	% of total 2004
Huso huso	42,100	1,464,832	0.2	7
A. persicus	18,420,200	17,412,529	91.8	82
A. stellatus	196,000	314,913	1	2
A. nudiventris	1,414,000	1,311,726	7	6
A. gueldenstaedtii	-	617,562	-	3
Total	20,072,300	21,121,562	100	100
Modified PDD, 2006, Abdolhay, 2006 and Salehi,2005b.				

of the operation which does not allow year-round efficient operational effectiveness of employees. One option to overcome this economic drawback would be to seek for alternative work during the off-season, including extended hatchery and enhancement programmes with other species for which the breeding season falls exactly into the non-reproductive period of sturgeons. The second most important cost items are the operational costs for obtaining fertilized eggs and to cover the incubation period, averaging 580 Rials (29% of total costs). Compared to other aquaculture activities, the share of labor and salary in hatcheries (41% of total costs) are very high, as noted by Salehi (1999, 2003, 2005a and 2005b) being 12% for carp farming, 13% for trout farming, 17% for shrimp farming, 26% for shrimp hatcheries due to use of foreign experts, and 12% for sturgeon farming in the USA (Katherine et al., 1985). When incorporating the costs for obtaining fertilized eggs and for egg incubation, the costs for labor and salary may increase to more than 50%.

Table 2. Average costs factors (Rials per fingerling production) of Persian sturgeon in 2003 in Iran.

Cost factors	Rials	%
Fertilized eggs	580	29
Feed & Fertilizer	100	5
Water and energy	40	2
Labor & salary	820	41
Maintenance	100	5
Depreciation	240	12
Miscellaneous	120	6
Total costs	2000	100

Figure 4. The cost sensitivity of fingerling production of Persian sturgeon for the year 2003 in Iran.

The cost sensitivity of hatchery production of Persian sturgeon in the year 2003 shows labor and salary are the most sensitive items, followed by fertilized eggs (Figure 4). Current production and enhancement of Persian sturgeon populations in the Caspian Sea needs many more fingerlings to be released then is presently practiced in order to be successful in conservation of sturgeon species and it is anticipated that a lot of investment will have to be made by the fisheries authorities of Iran to reach the objective. It is suggested that this sector might become increasingly important in coming years. The present study also shows that there is a high variability in cost efficiency between various hatcheries in Iran. Therefore, there is an urgent need to analyze in more detail the reasons why such differences exist and the measures that can be taken to bring fingerling production costs down. Certainly, the ability to obtain reliable brood fish from the Caspian Sea is one factor that contributes to cost variability, expanding hatchery operations to include other species is another way of reducing expenditures per fingerling produced. Overall, the sturgeon rehabilitation industry may benefit from research aimed at developing technically viable production and enhancement systems that deal with reasons to reduce early egg and larval mortality, develop adequate nutrition for juveniles, prevent infectious diseases and culture strategies that improve fitness for survival, engage in genetic improvement, and adaptive industry management. Considering a 1% fingerling return for Persian sturgeon (Pourkazemi (2003) estimated 0.86% for this return), aged 16 for Persian sturgeon, female/male 1:2.4, (Moghim, 1999) it might be expected that between 57,000 to 70,000 female Persian sturgeon will be returned from 2018-2020, and with 4.5 kg caviar for each fish (Moghim, 1999). This might result in total caviar production from enhancement of around 256-315 tonnes. This caviar would come from almost 5 tonnes of fertilized eggs, the amount that was used over the year 2003. The questions are, is the sea safe and clean for Persian sturgeon and what needs to be done to reduce the pollution load (nationally and internationally)? Who will be responsible for the common management of the sea fisheries? Are the assumptions made correct so that the estimated 265-315 tonnes yield of caviar is attainable? Interdisciplinary research is needed with new concepts and scientific working hypothesis to answer these questions.

Key opportunities for regional cooperation arise from pro-active approaches to regional comparative studies, including identification of key issues to design national and international programmes for collection and analysis of regional data.

Acknowledgment

We would like to gratefully acknowledge the assistance of the Fisheries Organisation of Iran and its affiliated departments, the Fisheries Research Institute, International Sturgeon Research Institute and especially Mr Akhonzadeh, Mr Abdoulhy, Mr Mogaddsi, Mr Amini, Mr Tahori, Mr. Soltani, Mr. Fakhreddini, Mr. Ansari, and Mr. Khosravi.

References

Abdolhay, H., 1998: Artifical hatching for stock rehabilitation , 7th National Fisheries conferences, Responsible Fisheries, Shilat, Tehran, Iran, p187-205. [In Persian].

Abdolhay H. 2006, Fingerling production and release for stock enhancement in the Southern Caspian Sea: an overview, Journal of Applied Ichthyology, Dec. 2006- Vol. 22, p 125-131.

Ahmed, I.; Bland, S.J.R.; Price, C.P.; Kershaw, R., 1998: Openwater stocking in Bangladesh, experiences from the Third fisheries Project. FAO Fish. Tech. Pap. No. 374, 351-370.

Bartley, M.D., 1995: Marine and coastal area hatchery enhancement programmes: Food security and Conservation of Biological Diversity, Paper prepared for Japanese/FAO Conference on Fisheries and Food security Kyoto, Japan, Dec. 1995, p15.

Bartley, M.D.; K. Rana, 1998: Stocking inland waters of the Islamic Republic of Iran, FAO, 5p.

Bartley, M.D., 1999: Marine ranching : current issues, constraints and opportunities. In Marine ranching; FAO Fish. Circ., No. 943, pp28-43.

Fushimi, H., 2001: Production of juvenile finfish for stock enhancement in Japan, Aquaculture 200, pp33-53.

Gateway, J., 1999: Small water body fisheries and the potential for community-led enhancement: case study from the Lao PDR, PhD Thesis, University of London, 414 p.

Hansson, S.; Arrhenius, F.; Nellbring, S., 1997: Benefits from fish stocking-experiences from stocking young-of-the year Pikeperch, to a bay in the Baltic Sea. Fish, Res. 32, 123-132.

Hosseini, M., 1998: The end of unresponsible sturgeon Fishing, 7th National Fisheries conferences, Responsible Fisheries, Shilat, Tehran, Iran, pp. 115-128. [In Persian].

Jolly C. M. and H. A.Clonts. 1993. Economics of Aquaculture. Haworth Press. Inc. Binghamton. New York. 319p.

Katherine, J.; Shigekawa, S.; Logan, S., 1985: Economic analysis of commercial hatchery production of sturgeon. Aquaculture, 51, pp299-312.

Iran is producing hatchery-bred fingerlings of several species of sturgeon, including beluga (Huso huso), Persian sturgeon (Acipenser persicus), stellate sturgeon (A. stellatus) and others.

Keyvan, A., 2002: Introduction on biotechnology of cultured sturgeon, Azad University, Lahijan, Iran, 270 p. [In Persian].

Kitada, S., 1999: Contribution of hatchery enhancement and compereheSive fishery resource management: from Japanese experience. In Marine ranching: global perspective with emphasis on the Japanese experience, FAO. Fish. Circ. 943, pp98-130.

Lorenzen, K.; Juntana, J.; Tourongruang, D., 1998: Assessing culture fisheries practices in small water bodies: a study of village fisheries in Northeast Thailand, Aquaculture Res. 29, 211-224.

Lorenzen, K.; Amarasinghe, U.S.; Bartley, D.M.; Bell, J.D.; Bilio, M.; de Silva, S.S.; Gateway, J.C.; Hartmann, W.D.; Kapetsky, J.M.; Laleye, P.; Moreau, J.; Sugunan, V.V.; Swar, D.B., 2001: Strategic review of enhancements and culture- based fisheries, Aquaculture in the third millennium, Subasinghe R., Bueno P., Phillips M., Hough C., McGladdery S. and Arthur R., NACA/ FAO, Bangkok, Thailand 2001, p. 221-237.

Matsuda Y., 2000: Recent development on stock enhancement in Japan, cited by Tahori, 1998, Aquaculture Department, Shilat, Tehran, Iran, No. 18. p73-109.

Moghim, M., 1999: Final report of statistics and biologic of sturgeon fish, Mazandaran Research centre. [local document; in Persian].

Parafkandeh F. & Rezvani. S., 2005, Status of sturgeon stocks in the south of caspian Sea, 5th International Symposium on sturgeon, ramsar, 9-13 May., Iran. p.302-304.

PDD, 2004: Annual report of Shilat, Shiat, Tehran, Iran, 40 pp. [In Persian].

PDD, 2006, Fishing data information, Shiat, (in Persian, unpublished),Tehran, Iran, 35p.

Pourkazemi, M., 2000: Management and enhancement of sustainable resource, Aquaculture Department, Shilat, Tehran, Iran, No. 18. p17-30. [In Persian].

Pourkazemi, M., 2003; The sturgeon resources of Caspian Sea, High commission on sturgeons, Shilat, Iran, [In Persian], 35p.

Purkazemi, M., 2006, Caspian Sea sturgeon Conservation and Fisheries: Past, Present and future, Journal of Applied Ichthyology, Dec. 2006- Vol. 22, P 12-16.

Razavi Sayyad, B., 1995: Kutum fish, IFRO. Tehran, Iran, 165 pp. [In Persian].

Salehi, H., 1999: A strategic analysis of carp culture development in Iran, PhD.Thesis, University of Stirling. Stirling, UK, 328 pp.

Salehi, H., 2001: Economics analysis of sturgeon fingerlings production in Iran, Paper presented in Second national conferences, Zibakenar, Rasht, Iran, 5 pp. [unpublished document; in Persian].

Salehi, H., 2002: Economics Analysis of Kutum (Rutilus frisii kutum) Fingerling Production and Releasing In Iran, 10 pp. (unpublished document, in Persian).

Salehi, H., 2003: The needs of research on aquaculture economics in Iran, Iranian Journal of Fisheries Sciences, IFRO., (in Persian), Tehran, Iran, p75-96.

Salehi, H., 2004: An economic analysis of carp culture production costs in Iran, Iranian Journal of Fisheries Sciences, IFRO., Tehran, Iran, pp1-24.

Salehi H. 2005a , An Economic analysis of trout farming production in Iran, World aquaculture 2005, May 2005, Bali- Indonesia, unpublished, 35p.

Salehi H. 2005b, An economic analysis of fingerling production of sturgeon in the south Caspian Sea over the years 2002-03, 5th International Symposium on sturgeon, ramsar, 9-13 May., Iran. p.319-324.Shang Y. C. 1981. Aquaculture economics: Basic concepts and methods of analysis. Croom Helm Ltd. London. 153p.

Shang Y. C. 1990. Aquaculture economics analysis: An introduction. Advances in world aquaculture. Volume 2. The world aquaculture society. USA. Louisiona state university. Baten Rouge. 211p.

Shehadeh, Z.H., 1996: Major trends in global aquaculture production and summary overview of the Gulfs (Persian Gulf and Gulf of Oman) area (1984 to 1994), TOFC Committee for development and management of the fishery resources of the Gulfs, Cairo, Egypt, 1-3 October, 8 p.

Shilat, 2004: Fisheries statistics, Shilat, Tehran, Iran, 65 pp. [In Persian].

Sreenivasan, A., 1988: Fish stock enhancement in larger Indo- Pacific inland water bodies using carps and tilapias, FAO Fish. Rep. No. 405, pp. 6-33.

Tahori, B.H., 1998: Sturgeon hatching in South Caspian Sea, 7th National Fisheries conferences, Responsible Fisheries, (in Persian), Shilat, Tehran, Iran, pp. 221-244. [In Persian].

Vlasenkov, 1995: cited in Tahori, 1998 [citation see above].

Aquaculture and environmental sustainability in Thailand: Food or financial security?

By Jamie Stewart and Ram C. Bhujel

The rise of aquaculture

Aquaculture is a worldwide tradition that is thought to trace its roots back roughly 4,000 years, when early fish husbandry techniques were developed in China. The knowledge of early, small back yard aquaculture techniques was carried and passed on to neighboring countries by emigrating Chinese, and through the age old medium of word of mouth, the practice spread into Thailand and throughout South East Asia, where aquaculture has been practiced for around 400 years.

The practice continued, with production steadily rising throughout the 1900's. Aquaculture quickly provided a cost-effective source of protein for the small-scale farmers throughout rural Thailand, with back yard pond culture requiring relatively little outlay and maintenance. As advances in knowledge and practice slowly began to gather pace, the rise in production predictably gathered pace.

According to figures provided by the Fisheries Global Information System (FIGIS), the national total for aquaculture production in Thailand was only about 24,000 tons in 1950 with a sharp increase in 1960 followed by another increase in the late 80's. Total fish production has increased 800% over the past 20 years. In 2004, the most recent year for which figures are available, aquaculture production in Thailand neared 1.2 million tons which has maintained the country's position at 7th largest aquaculture producer in the world (Table 1) and lead to Thailand becoming a hub of aquaculture development/business. By comparison, wild fish catch in Thailand has risen unpredictably since the 1950's, and has stagnated since the mid 90's. Throughout Thailand, the main species produced through aquaculture are shrimp (*Litopenaeus vannamei*), snakehead (*Channa* spp.), catfish (*Clarias* spp.), and tilapia (*Oroechromis niloticus*). Thailand is one of the world's leading shrimp producers with exports valued at about US$2 billion. Nile tilapia has become the main farmed species produced for consumption within Thailand. This is due to its ease of breeding, fast growth rate, taste and resistance to disease amongst other factors. In addition, the government, NGO's, and the private sector are playing an important role in promoting tilapia to the people as a cheap source of protein. However, this scale of mass production does not come without its cost to the natural environment. Large areas of mangrove forest have been destroyed, some of which to construct shrimp farms, in the ongoing push for increased production.

The rise in aquaculture production in Thailand, mirroring the steady rise across Asia and worldwide, results from the series of technological advances relevant to the practice, allowing for more and more intensive farming practice plus growing world wide population and the inevitable increase in the demand for food security that this growth brings. The combined population of Asia was estimated at 3.95 billion in 2006, according to UN figures. This accounts for roughly 60% of world population, with this figure expected to continue on its current growth trend. It is in the developing nations of Asia, Thailand among them, that the need for food security is paramount. Hence, the introduction of aquaculture and its rise in production and intensity as a cost effective answer to the worldwide protein shortage. Figures from the Food and Agriculture Organization (FAO) show that nine out of the top 10 aquaculture producing countries are from Asia (Table 1).

Cage culture of tilapia in Klong 13, Central Thailand.

FAO data for 2004 shows that nearly half of total fish consumed worldwide are produced by aquaculture, the fastest growing food production sector. This production is anticipated to further accelerate to meet the increasing demand for seafood, because more and more people are shifting towards seafood and small animal meat from red meat, and as the chicken industry often suffers problems such as bird flu. To further complicate the issue of food security in the future, recently researchers have predicted increasing collapses of marine fisheries by 2048, should the current trends continue. This means that if we want to have fish in our meals, we will increasingly need to grow them by ourselves!

Environmental concern

As with any practice that interacts with the surrounding eco-systems, as the practice becomes more and more widespread, and increases in intensity on an international scale, so the environmental impact increases. The types of the environmental impacts of aquaculture are well researched and documented. They range from the discharge of effluents and waste products containing high nitrogen (N), Phosphorous (P) and chemical residues into surrounding waterways leading to changes in natural ecosystems, to the effects of chemicals on the surrounding natural environment, to conflicts over water and land use. With regards to the practicalities of aquaculture systems, the effect on the surrounding environment can be minimized if the system is enclosed, and / or integrated into existing farming systems, for example, paddy field culture. Recirculatory tanks also help to minimize impacts through their efficient use of water. As production shifts towards more intensive forms of aquaculture, however, particularly in the case of cage culture, which by its nature is an open system, releasing waste products directly into surrounding waters, the environmental impact inevitably increase alongside. For aquaculture production to continue to grow over the coming years, as it must in order to keep pace with growing world wide protein demand, its growth must be controlled within an environmentally sustainable framework. If the ecosystems that are utilized to support aquaculture and the surrounding ecosystems are diminished due to an inability to contain the impacts of human activities then the potential for aquaculture to grow, or even to continue at its present rate, will be lost for generations.

Global reaction

The global reaction to the need for environmental sustainability in aquaculture has manifested itself in the development of a variety of environmental management systems. Most notably, nations have adopted various levels of Environmental Impact Assessment (EIA) for new aquaculture developments. These range in severity from EIA as a legal necessity for all coastal aquaculture (Australia, the USA, and many European countries), to no EIA requirements, as was previously the case in Thailand. Generally, countries have adopted EIA as a requirement for developments of a certain size and intensity. However, as is the case in a capitalist society in which people run after the profits, where there is a need for change and a need for development/ improvement, there is an opportunity for those who can provide the means for change, to profit through their practices. As a result, Good Aquaculture Practices (GAP) and Good Management Practices (GMP) have recently been developed in various countries including Thailand and laws/regulations related to these have been enforced, especially for shrimp culture. Not only for the culture systems, there are also mechanisms of quarantine in place in each country for the control of trans-boundary movement of fish species and disease causing organisms associated with them.

Profiteering through the development of aquaculture - whose right?

The conflicts over profiteering through aquaculture arise as a result of the original reasons for the development of aquaculture, and the distribution of skills around the world; the original intention being to provide food security to the small scale farmer, thus reducing poverty on a global scale. From a socio-cultural viewpoint, aquaculture has taken massive steps toward this goal. However, the need for progressively intensive farming methods in some areas has led to small scale farmers, providing a source of protein to the local community, seeing their source of income threatened, or being put out of business altogether. Intensive methods of farming require higher levels of technological input, and amenities beyond that which the small scale farmer can afford.

There are also cases whereby major corporations, on the hunt for the profit margins that intensive aquaculture can bring with it have placed local farmers under contract offering in return an inadequate income. For example, in central Thailand, farmers along Klong 13 (Fig. 2), one of the many canals that cut through the province, were contracted by a major corporation to purchase their fry from the company, and to sell them back to the company once they had reached marketable size, at a price set by the company, virtually turning whole farming communities into employees along with the loss of economic decision making freedom which that status brings. It is fair to say that farmers have the right of refusal before signing their economic freedom away, and that there can be benefits to such arrangements, however, it is difficult for small-scale farmers to otherwise compete with large companies unless they band together. In Pathumthani the formation of a cooperative of some 50 members enabled participating farmers to make the break to financial independence. Once a major corporation is removed from the equation, the profit margins of the corporation, with sound financial management, can be fed back into the local community, so working towards the original good intentions of aquaculture development.

It is also possible for companies or individuals to profit through the development of technologies necessary to limit the impact of aquaculture on the environment without limiting production if the research and development is carried out as part of a private enterprise. For example, in Mbour, 80km from Dakar, Senegal, a French company, ‘Institut de recherche por le Developpement’ (IRD), has designed and built a prototype of a fully enclosed, self recycling aquaculture system, breeding tilapia. The system is a commendable example to the rest of the world. Unused feed and the wastes from the fish are mineralized and used as nutrients by phytoplankton. The phytoplankton is consumed by zooplankton, these are in turn recycled to feed the juvenile tilapia. The system is entitled ‘SARI’, (Systeme Aquacole Recyclage Integral). SARI requires only a small amount of fish feed, emits no effluents, and protects the fish from the dangers of contamination in surrounding waters. SARI could prove to be a huge step in the right direction to the food security of the worlds growing population. It is reported to be cost effective, and possible to develop on a mass scale. The system is, however, protected by legalities regarding the laws of patenting. In order to seek protection from those who may wish to profit from their competitors ideas, it is standard practice for a company to protect any new invention by reporting to and filing with their countries corresponding patent office. This allows the company the opportunity to recoup any necessary financial outlay expended during the research and development stages of their product or idea, by giving them the sole rights to the market over a given period of time. It also gives them the right to charge, by licensing agreement, those who wish to develop and make use of their product or idea, thus limiting access to those who can afford to pay.

Table 1. Top ten aquaculture producers in 2004 (Source: State of World Aquaculture, 2006, FAO).

Country	Production volume	Global	Production value	Global
	Million tonnes	%	(Billion US$)	%
China	41.33	69.6	35.997	51.2
India	2.47	4.2	2.936	4.2
Philippines	1.72	2.9	0.794	1.1
Indonesia	1.47	2.5	2.163	3.1
Japan	1.26	2.1	4.242	6.0
Vietnam	1.23	2.1	2.459	3.5
Thailand	1.17	2.0	1.587	2.3
S. Korea	0.95	1.6	1.212	1.7
Bangladesh	0.91	1.5	1.363	1.9
Chile	0.69	1.2	2.815	4.0

Public versus private development

Technological developments in any field can benefit the particular industry as a whole if they are made within the public sector, as opposed to the private. By way of example, research into the technological advancement of aquaculture is continually carried out at the Asian Institute of Technology (AIT) some 40 km north of Bangkok, affiliated to government agencies, international organizations and private sector partners among others. While funds are often hard to come by in the public sector, some advancement has been made to benefit the aquaculture industry on a huge scale. Such developments include the artificial incubation of tilapia eggs and rearing of fry from the fertilization stage, which contributed to increased production of tilapia, which are otherwise unsuitable for high intensity aquaculture, to a suitable level; and the development of all male

Tilapia on sale in the market place, Thailand.

offspring through the use of methyltestosterone, a sex reversal hormone. In the case of tilapia farming, all male offspring are preferable, as tilapia reproduce from a very early stage raising competition for food and so limiting the number of stock that grow to market size. Males also grow around 25% faster than females. Though methyltestosterone has had its critics of an environmental nature, research carried out has shown the impact to be minimal in the extreme. Since such advancements were achieved in the public sector, the technology is currently widespread, throughout Thailand and beyond. As research within public institutions is funded by the public along with various donors there are no research and development costs to be refunded, as there is within the private sector. Hence the technology, though it must still be protected from those who could profit from it within the private sector when in its early stages of development can be made available to all upon its completion and recommendation.

Conclusions

Over the past two decades, global aquaculture production has risen from 13 million tons, to 60 million tons, and the practice maintains an increasingly vital role in the future of food security for an ever-expanding global population. If the growth of aquaculture in Thailand and across the world is to continue, then frameworks to support and sustain the surrounding natural environments first need to be put in place, in countries where they have not already been applied.

Environmental Impact Assessment is not a costly exercise and, provided the system by which new developments are assessed is efficient and accurate, the long term benefits could turn out to be invaluable. Aquaculture cannot continue to grow at its current rate, funded by those eager to profit from a cost effective source of protein production, completely unrestrained by environmental concerns. If it does, then we risk destroying the very capacity for growth and development of the industry altogether.

Along with these measures to protect the natural environment, aquaculture must also be managed from a socio-cultural perspective. Though it is not possible to impede upon the perfectly legal involvement of major corporations in aquaculture, it would benefit local communities, and the relations of communities with those corporations, if a greater degree of profit margin was channeled back into the communities responsible for production. For example, profits could be used to fund locally conducted research in order to maximize aquaculture production within a particular area or community, within the aforementioned environmentally sustainable framework, so benefiting the corporation in question, and the local community at present, and for future generations.

Developmental programs should also be undertaken, in communities where they have not already been instigated, to bring the practice of aquaculture to the poor, through enclosed back yard pond systems, taking aquaculture back to its original roots, and allowing the rural poor a self replenishing source of protein. Such programs have been undertaken throughout Bangladesh, and in other developing countries across Asia and Africa by non-profit organizations such as the Food and Agriculture Organization (FAO), with a great degree of success.

Finally, technological advances in aquaculture, that benefit the growing need for food security of an ever expanding population but do not adversely affect the natural environment, should be made available on an international scale. Though it pays to bear in mind, that if private sector companies were not permitted to profit from their enterprise via legal frameworks such as the patent system then much research and development would never be undertaken in the first place. Research and development within the private sector is beneficial, if less so than public sector research, and should continue, as must the financial incentives that encourage such research. Therefore, more funding should be provided for research and development within the public sector, through affiliated governments or private sector companies who themselves may stand to profit from public advancements in aquaculture technology. Such profits could then be channeled back into public research and development, and / or local aquaculture community development. When combined, these systems benefit all environments within which we operate including natural, socio-cultural, and socio-economic.

Mr. Jamie Stewart, a trainee journalist, was in Thailand as a short-term intern working with Ram C. Bhujel, PhD, Senior Research Scientist and Affiliated Faculty at Aquaculture and Aquatic Resources Management (AARM), Asian Institute of Technology (AIT), Klong Luang, Pathumthani 12120, Thailand. For more information email to: Bhujel@ait.ac.th).

Cage fish culture - a successful income generation in manmade reservoir Kulekhani, Markhu, Nepal

Ash Kumar Rai*, Suresh Kumar Wagle**

**Resources Himalaya Foundation, Kumaripati, Lalitpur, Nepal, email akrai@akrai.wlink.com.np; **Fisheries Research centre, Pokhara*

Nepal is very rich in its water, possessing about 2.27% of the world water resources (CBS 2005). Out of total 818,500 ha of total water surface area, fish ponds cover about 6,500 ha producing about 20,000 metric tonnes annually (DoFD 2061/'62). Aquaculture development has concentrated on pond fish culture particularly in the southern region. Of the lakes and reservoirs, most fishery developments have occurred in the Pokhara valley lakes and the Kulekhani reservoir in the central of the mid-hill region.

Reservoir coverage in Nepal is about 1,500 hectares. Kulekhani reservoir (a 126 km^2 catchment) was impounded in 1982 by damming main Kulekhani river and its tributaries at an elevation of 1,430 meters above sea level. It is located about 83 km south-west of Kathmandu city in Markhu, Makwanpur district. This was the first large-sized reservoir constructed in the hilly region of Nepal, and was established for electricity generation. The reservoir is characterized by a draw down of about 54 m resulting in a surface area ranging between 75 to 220 h, a range of 220 ha to 75 ha.

Kulekhani reservoir is the first man made reservoir in Nepal in which aquaculture development has been explored as a means of providing livelihoods to displaced people living in the vicinity. This development program was initiated by the government with technical assistance from the International Development Research Centre (IDRC), Canada, in 1984. The project was visualized to assess the feasibility for a fisheries development program by gathering in-depth information on the limnological/biological parameters and also to help layout the foundation for the future reservoir fisheries development programs in the country.

Water quality parameters

The annual water temperature in the reservoir ranges from 12.0ºC during January/February to 25.5ºC during July/August. Dissolved oxygen does not fluctuate significantly and distribution ranges from above 7.0 to 8.7 mg/L in surface waters to below 60 m depth during January/February; however, the fluctuation is very high, ranging from 0 to 11.2 mg/l, during May, June, July, and August. Transparency ranges from 1.2-3.4 m in June to January/February. Alkalinity ranged from above 28.6 to 80.0 mg/l between the surface and the bottom. The annual pH remained in the range 7.5-9.8. Total hardness ranges from 30-66 mg/l. Carbon production ranged from 350 mg/m^2/day during October to 3,000 mg/m^2/day in April (Rai 1989).

Eleven zooplankton species have been identified the most dominant being *Keratella* (about 51%) followed by *Cyclops* spp. (14%) abundant in July to September and least abundant during December and March (Pradhan 1986/87). Total zooplankton density was about 682 individuals/liter and was highest during October and lowest about 131/liter during December. Cyclops density was highest (35/liter) during October followed by nauplius (244/liter). Eighteen phytoplankton species have been identified the most prominent being *Peridinium*, *Anabaena*, *Melosira*, *Synedra* and *Staurastrum* (Pradhan 1986/87). Phytoplankton was most abundant during May, June, July, October and September and least during January, and February.

Fish catch composition

The three main fish species available in Kulekhani reservoir are Katle *Neolissocheilus hexagonolepis* ranging from 41-89% of total catch followed by Karange *Puntius chilinoides* (11-69.9% of total catch) and Asla *Schizothorax* spp. (0.5-7%). Sahar *Tor putitora* was very rare. The total fish catch from the reservoir is about 3-4 tonnes during June/July and was mostly Katle (Rai 1989). Katle catch was higher during September, January, and June and lower during July, April and December. Katle can be up to 2.9 kg in weight, with males smaller than females and maturing during June to August at about 700 g size. Karange catch was higher during July, April, and May. Karange sizes range from 13-900 g. Karange spawns during January to March and spawns in flowing water exposing half the body out of the water. Asla catch was highest in May but has decreased year by year. The size of asla ranged from 15-200 g; this species matures twice per year in December/January and April/may and spawns in flowing clear water. The exotic fish silver carp and bighead carp favour the conditions in the reservoir and grow well. These grow up to about 9 kg within 3 years. The indigenous carp rohu (*Labeo rohita*) and bhakur (*Catla catla*) also showed better growth but less than silver and bighead carps. Rohu attained 1.6 kg in 4 years and bhakur 1.5 kg within 3 years.

The local fish species katle, karange and asla were affected greatly after damming of the Kulekhani river. Before damming Kulekhani was famous for asla, an algal feeder, but after damming population has decreased due to environmental changes and disturbances to the breeding grounds. Katle and karange are omnivorous and are suitable for developing a fishery supported by a well planned stock enhancement strategy. Asla on the other hand, do not perform well in the reservoir due to lack of running fresh water and preferred habitats with stones covered with algal mats.

Cage fish culture

Cage fish culture started using silver and bighead carps during late 1980s on an experimental scale. The cage culture technology has been developed in the lakes of Pokhara valley in Nepal and the technology was applied successfully by the farmers in the valley. This technology was applied in Kulekhani reservoir. Cage culture production was high at about 5 kg/m^3 with silver and bighead carps together cultured singly (4 kg/m^3) (Rai 1989), indicating better utilization of available natural food items. The average growth rate was 2.8 g/day with highest growth rate about 8.4 g/day during April to May but some loss in weight during January/February when water temperature falls below 14ºC (Rai 1989/90).

Cage culture gradually became successful in the reservoir providing job opportunities to the local people and uplifting incomes and supporting their livelihoods. Now there are 212 farmers (100 females and 112 males) involved in cage fish culture using 32,024 m^3 for production and 7,104 m^3 for nursery and grow-out (Fig. 2). About 166 members are involved in 10 fishermen associations. In addition, about 2,024 m^3 production cages and 1,021 nursery and rearing cages are used by the public sector, as demonstration and fry to fingerling rearing for distribution to prospective farmers. Accordingly, a total cage volume of 34,048 m^3 in the reservoir produces more than 136 tonnes of fish annually which is equivalent to NRs 10,880,000.00 (@ NRs 80/kg) = US$ 155,429.00).

Kulekhani reservoir is eutrophic. Organic fertilizers, primarily from domestic animals, enters via run off during the rainy season from the surrounding villages and makes the reservoir fertile. The resulting phyto- and zooplankton provide a rich food source for the cultured fish species like silver and bighead carps. The growth of caged fish depends entirely on the natural food developed within the reservoir. Fish growth is better above 20ºC when plankton population also is high. Growth of silver and bighead carps shows a direct relationship to the water temperature and the plankton density. Indigenous carps rohu and bhakur also show favorable growth in the reservoir although they perform better in open water than in cages. About 49% of people living around the reservoir have benefited directly from cage culture in the reservoir, which provides their livelihoods and better incomes than they had previously.

Socio-economics

The average family size living around the reservoir is 6.5 people. The average size of a family land holding was 0.77 ha, with an average of 3 large and 6 small livestock but with only 0.12 ha of per capita available cultivated land (Adhikari 1988). The cost and return evaluated from the crop and vegetable shows that the average net return varied from NRs 7,167/ha m^2 for cereal crops, NRs 5,611/ha m^2 for oilseeds and NRs 19,784/ha m^2 for potato, respectively while in cage fish culture, the net return was NRs 2,644/18m^3 (NRs 147 per cubic meter of cage volume) (Adhikari 1995). However, the available land area is decreasing due to increasing human population in the area. Cage fish culture activities will be the best alternative source for supporting livelihoods of the people living around the reservoir.

References

Adhikari, N. 1995. Impact of Inland Fisheries Project on Farmers Living around Indrasarobar Reservoir, Kulekhani, Makawanpur District, Nepal. Submitted to International SDevelopment Research Centre, Canada. 121 pp.

Adhikari, N. 1988.A study on the socio-economics of farmers living around Indrasarobar Reservoir, Makwanpur, district, Nepal.

CBS, 2005. Statistical Year Book of Nepal. Cetral Bureau of Statistics. HMG/N, NPC., Secretariate, Ramshah Path, Thapathali, Kathmandu, Nepal. 460 pp.

DoFD, 2061/'62. Annual Progress Report HMG, MoAC, DoA, Fisheries Development Directorate, Balaju. 96 pp.

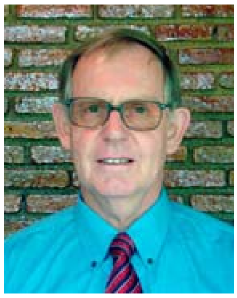
Pradhan, B.R. 1986/'87. Annual Progress Report (1986/'87). Inland Fisheries Project, Indfrasarobar Kulekhani, Fisheries Development Division, HMG, Nepal. 42 pp.

Rai, A.K. 1989/90. Annual Progress report (16 July 1989 – 15 July 1990). Inland Fisheries Project, Indrasarobar, Kulekhani, Fisheries Development Divison, Dept.Agri. MoA, HMG, Nepal. 25 pp.

Rai, A.K. 1989. Final Progress Report (16 July 1984- 31 December 1989). Inland Fisheries Project, Fisheries Development Division, National Agricultural Research and Service Centre, MoA, HMG, Nepal. 73 pp.

Peter Edwards writes on

Rural Aquaculture



Dr Edwards is a consultant and Emeritus Professor at the Asian Institute of Technology in Thailand where he founded the aquaculture program. He has over 30 years experience in aquaculture education, research and development in the Asian region. Email: pedwards@inet.co.th.

Diversification of rice farming alleviates poverty in a Bangladesh village

Pond/dike preparation.

Bangladesh is among the poorest countries in the world with about 50% of the population below the national poverty line with insufficient food to eat. Although the contribution of agriculture to GDP is only about 20% and declining, it employs over 60% of the labor force. Most of the poor live in rural areas and depend directly or indirectly on agriculture for their livelihoods, mainly rice farming. Bangladesh is also one of the most densely populated countries in the world with over 1,000 persons/km^2. Increasing agricultural productivity or intensification is therefore essential for reducing poverty as well as ensuring national food security.

Rice is the most strategic commodity in the Bangladesh economy as it is the main national food staple as well as the largest overall contributor to farm income. Although the production of rice continues to increase, its price remains low making it difficult for most small-scale farming households to escape from poverty. However, there is an increasing consumer demand in the country as the economy grows for higher value food items such as animal products (fish and livestock, and fruits and vegetables) which farmers can produce to raise their standard of living. Agricultural diversification as well as intensification is required to help to lift farmers out of poverty and to satisfy increasing consumer demand for fish and vegetables.

A visit to Damgao village

During a recent trip to Bangladesh, I visited Damgao village in Gouripur sub-district, 22 km from Mymensingh district city. The village provides a good example of the kind of changes that are required to lift villagers out of poverty. Some of the village rice fields are being converted into fish ponds, which is increasingly taking place in Bangladesh today, but in addition crops are grown on fish pond dikes in a few villages in the area, which is uncommon in the country. These relatively new farming practices have lifted the villagers out of poverty; they generate income as well as providing the villagers with an improved diet.

Damgao was one of the villages studied by Dr. Manjurul Karim of the WorldFish Center, Bangladesh in his doctoral thesis, 'The livelihood impacts of fishponds integrated within farming systems in Mymensingh District, Bangladesh'. His study was part of the PondLive project funded by the EC to the University of Stirling and Wageningen University with Bangladesh Agricultural University as a local partner. Dr Karim kindly guided me to the village so I could witness the villagers' experience in agricultural diversification and intensification.

I interviewed a group of four to five villagers who recalled how diversification of their rice farms, first through introduction of fish culture and later vegetables, had considerable improved their welfare In the words of the villagers 'they were really poor in the past' and were not even able to eat three meals a day. In those days when the village was a subsistence economy, households consumed all the rice they grew although it was still insufficient to satisfy their consumption needs and in addition caught small wild fish and bought vegetables at the market.

Some of the fish and vegetables raised on the farm are consumed by households but mostly they are sold to generate income. All the rice produced is still consumed by the village households but today about 75% of the household need for rice is purchased from earnings from more profitable fish and vegetable production.

The farmers interviewed reported that they produce about Tk. 25-26,000 (US$1 = Tk. 69) worth of fish, 85-90% of which is sold, and Tk. 15-18,000 worth of vegetables, almost all of which is sold, a total value of Tk. 40-44,000 (US$580-638). The farmers produce about 500-520 kg of fish from their approximately 1,000 m^2 fish ponds. This extrapolates to an impressive 4.6-4.8 tonnes/ha, even higher than the 3.1 tonnes/ha achieved by small-scale farming households in nearby Kishoreganj district (see my column on 'Small-scale pond culture in Bangladesh', Aquaculture Asia Vol. X, No.4, p.5-7, 2005). Through producing their own fish and vegetables and being able to buy sufficient rice, the farming households are now above the national poverty line which is defined by the total consumption or income at which households satisfy their nutritional requirement of 2,122 calories/person/day.

Knowledge of fish culture came from the villagers' neighbors in other villages who themselves learned from the owner of Jhalak fish hatchery in the sub-district who attended a training course in

Diversification and intensification

The village comprises about 200 households which all integrate pond fish culture with vegetable cultivation on the pond dikes. Rice fields are ploughed by tractor but 50% of households have a couple of dairy cows and sell milk. All households have 6-7 scavenging poultry and 20% have 1-2 goats. The average land holding in Damgao village is 50 decimals (1decimal = 40 m^2) or 2,000 m^2 although 60-65 households have less than 20 decimals (800 m^2) of land. One absentee landlord holds 10 ha. More than 50 households have to lease land or ponds. In an average land holding of 50 decimals, 10 is taken up by the household, 13 is for the rice field and the largest area (27 or 1,080 m^2) is for the fish pond.

Some of the fish ponds in the village are very old as they were originally dug as borrow pits to provide soil to raise the level of the houses and surrounding area above the flood plain to minimize flooding. This is the origin of older fish ponds in many areas in the low lying country. Stocking fish in the ponds in the village began 17-19 years ago. Many of the ponds were 'derelict' (shallow with the pond surface covered by water hyacinth) but they have been deepened by the villagers and cleared of floating weeds as they are aware that they consume nutrients. Water hyacinth now occurs mainly in the large beel (perennial water body) adjacent to the village.

As the villagers increasingly appreciated the benefits of fish culture, some of the rice fields began to be converted into fish ponds starting about a decade ago as the older fish ponds were insufficient to meet the villagers growing involvement in fish culture. Wild fish have declined markedly in amount over time as farmers now use pesticides, have raised the dikes around the rice fields and have reduced the area of rice fields through conversion into fish ponds. Rather than wild fish, flood waters now are more likely to bring cultured fish into the fields.

Mixed cropping on pond dykes.

Thailand 10-12 years ago. The idea to grow crops on the pond dikes came shortly after the introduction of fish culture, about 16 years ago, also from a neighboring village. The introduction of both improved fish culture and vegetable farming into the village indicates the importance of farmer-to-farmer dissemination of technology, once farmers are convinced that it is relevant for them.

Villagers stock a polyculture of up to seven species of fish: indigenous catla (*Catla catla*), mrigal (*Cirrhinus mrigala*) and rohu (*Labeo rohita*); and exotic common carp (*Cyprinus carpio*), Chinese silver carp (*Hypophthalmichthys nobilis*), Thai puti or silver barb (*Barbichthys gonionotus*) and Nile tilapia (*Oreochromis niloticus*). Ponds are fertilized with cow manure compost and chemical fertilizers (urea and TSP) to produce natural food and fish are also fed with rice bran and mustard oil cake. Only cow manure and 30% of the rice bran are sourced from the farm with other inputs being purchased.

Farmers first grew cucumber when it was introduced into the village on level land. The current practice of cultivating vegetables on fish pond dikes was initiated by one farmer who observed a significant increase in production of cucumber planted on a dike repaired with pond bottom mud. A range of dike crops is grown: beans, brinjal or egg plant, chili, cucumber, lady's fingers or okra, and bottle gourd. Cucumber is the main crop with a peak from July- September but during my visit in November gourds were in season. Pond water is used to irrigate the vegetables and pond mud is removed annually as a fertilizer. Most vegetables are now grown on pond dikes in spite of the considerable amount of labor required to remove pond sediments. However, it remains to be seen if this practice, rare elsewhere in Bangladesh and in other countries, continues and spreads.

Villagers still grow two crops of rice each year, the boro or winter-dry season crop from December–January to March–April which is irrigated by surface water and tube wells; and the amon or monsoon season rice crop from July-November. A third crop called aus is not cultivated in the village due to lack of water following the boro crop. Boro is a high yielding crop at 6 maunds/10 decimals (1 maund = about 37 kg) or about 5.6 tonnes/ha while amon yields only half this amount at 3-4 maunds/10 decimals. Boro is a HYV (high yielding variety) that responds well to irrigation and fertilizers in the sunny winter-dry season.

The future?

I asked the villagers to imagine their situation 10 years into the future? They expect their production of fish and vegetables to be even higher than today from the introduction of new technology but they expressed concerns about increasing costs as well as increasing population. They also believe that they could increase their fish pond area further from conversion of rice fields. To help to maintain their rice production, they added that they could grow rice in the fish pond during the 3-4 month boro rice season, followed by 2 months with the pond empty due to insufficient water, and then a 6 month period of growing fish in the pond following the start of the monsoon with plenty of water for fish culture.

Continued on page 27.

Aquaculture of sea-pineapple, *Halocynthia roretzi* in Japan

T.T.T. Nguyen[1], N. Taniguchi[2], M. Nakajima[2], U. Na-Nakorn[3], N. Sukumasavin[4], K. Yamamoto[1]

1. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand; 2. GradutateSchool of Agriculture Science, Tohoku Univeristy, Japan; 3. Department of Aquaculture, Faculty of Fisheries, Kasetsart Univeristy, Thailand; 4. Department of Fisheries, Ministry of Agriculture, Thailand.

Sea pineapple attached to rope, cultured in Shizugama Bay, Japan.

More often than not in aquaculture we tend to pay more attention on species that are produced in high volume such as finfish species, molluscs, crustaceans among others. Added to all these are certain species that are produced in relatively small quantities but which are of high value and relished by certain communities. Generally, the culture of such species is often confined to localized areas. One of such group are the Ascidians, commonly known as sea squirts.

Sea quirts are sac-like marine filter-feeding animals of the class Ascidiacea (phylum Chordata). During metamorphosis, the planktonic larval phase of sea squirts attaches to the substrata and adopt a sedentary habit. At this point the tail, along with the notochord and neural tube, is reabsorbed, however this transient feature is one reason why Ascidiaceans fall under the sub-phylum Urochordata, commonly known as "urochordates" (uro = tail): they are thought to exhibit characteristics of the evolutionary ancestors of chordates and vertebrates. Sea squirts are hermaphroditic and live in shallow coastal waters. They typically feed on plankton and detritus that they filter from the seawater. They are characterized by a tough outer "tunic" made of the polysaccharide tunicin. More than 3,000 species of Ascidiacea are known worldwide, around 100 of which are distributed around the Japanese coastline, principally occurring from the rocky subtidal areas to the deep sea bottom.

The culture of sea squirts is localized and consumption is also restricted to a few countries, principally Japan and Korea, where they are considered a delicacy. Although small, world sea squirt aquaculture production has been increasing steadily (Figure 1), Total world sea squirt production has increased from about 14,000 tonnes in 2000 to around 21,500 tonnes worth around US$18 million (FAO, 2006). Aquaculture currently accounts for

Oyster and sea pineapple culture in the Shizugama Bay, Japan.

approximately 90% of total world sea squirt production. In Japan in 2006 a total of 16,000 tonnes of cultured sea pineapple was produced worth around US$ 9 million, with 12,163 tonnes from Miyagi Prefecture, 3,037 tonnes from Iwate Prefecture, 536 tonnes from Aomori Prefecture and 264 tonnes from elsewhere in Japan. Production is on the increase due to increasing demand from Korea.

In Japan the popularly cultured species is *Halocinthya roretzi*, commonly referred to as 'sea pineapple', or 'hoya' or 'maboya' in Japanese. Sea pineapple spawn in the winter from late November to early March when the water temperature is 10-11ºC. Eggs hatch after two days with larvae entering a free-swimming larval phase lasting a few days before settling.

Mariculture of the sea pineapple began in 1908 in Japan. The culture method developed from the observation of sea squirts attached to wild grape vines that fishermen in Miyagi prefecture were using as anchor ropes on their ships.

Wild grape vines were initially used as a settlement substrate for the larvae in the initial culture practice. Since culture takes three to four years, it is important to use a substrate that will not rot easily.

Modern seed collection is achieved using dark colored ropes with oyster shells installed at 0.5 meter intervals to facilitate settlement of the metamorphosed larvae, in a manner similar to that commonly used to collect the seed of oysters, mussels and other bivalve molluscs. The settlement ropes are set in rocky coastal areas at a depth of 6 to 10 metres. The length of a typical horizontal rope is about 90 meters with vertical ropes at 30 to 80 cm intervals. Each vertical rope is 4 to 6 meters in length and has 60 to 70 areas of settlement substrate. The intervals between settlement substrates on the vertical ropes can be changed according to the growth of the attached seed. It is important to set the ropes at the right time and water temperature otherwise the ropes will be settled by another (non-edible) sea squirt *Ciona savignyi*.

Settled sea pineapple are visible as white dots on the ropes around April and begin to acquire a red color around May to June, reaching 5-10 mm during the first year. On completion of the settlement the ropes are cleaned of

View of a whole sea squirt.

Above and below: Sea squirt ready for consumption - it is prepared in many different ways.

other sessile organisms and of excessive numbers of juvenile sea pineapple seed. The ropes are cut and attached to grow out ropes around September to the middle of October, which are then maintained for a further three to four years when the animals are ready for harvesting, having grown into ball-shaped masses with individual animals having reached approximately 15 cm in length and 10 cm in diameter and a meat weight of 200-300 g. Three-year old animals are mainly used for processed foods, while four-year old animals area mainly eaten raw as sashimi.

The culture of sea pineapple is an environmentally friendly culture activity; it does not involve any feeding. In general, and in Japan, sea pineapple culture sites are often mixed with those for oysters and fin fish cage culture in semi-enclosed bays.

Historical literature indicates the consumption of sea pineapple started at least since 800 AD. It is considered highly nutritious seafood. Consumption just after harvest is favoured for the best flavour as a metallic taste may become evident as the product becomes less fresh.

Sea pineapple is a food that evokes strong reactions because of its unusual flavour, which is caused by one of its minor constituents called cynthiaol, an unsaturated alcohol present at low levels. The peculiar flavour of sea pineapple is very attractive to those who are accustomed to it, especially those who like to drink Japanese sake, which is a traditional Japanese alcoholic drink. The most general method to eat sea pineapple is raw as sashimi. The animal is cut vertically and removed from the shell and the internal organs removed. Pieces are cut to a suitable size and served with vinegar soy sauce. Other methods of preparation include salted (Bakurai in Japanese), smoked, grilled, deep fried or dried. All of these methods are good when served with sake. If you have a chance to visit the northern part of Japan, please order maboya in the Japanese tavern style and enjoy this special taste of Japan.

Development of green mussel cultivation in Thailand: Sriracha Bay, Chonburi Province

Suriyan Tunkijjanukij[1,2] and Alongot Intarachart[1]

1. Sriracha Fisheries Research Station, Faculty of Fisheries, Kasetsart University, Chonburi Province 20110, Thailand; E-mail: ffissrt@ku.ac.th; 2. Department of Marine Science, Faculty of Fisheries, Kasetsart University, Bangkok 10900, Thailand.

Mussel rafts viewed over the bay.

Chonburi is a coastal province situated in the eastern region of Thailand, about 100 km from Bangkok. Its 157 km coastline is well known for a vibrant tourism industry, port development, fisheries and mariculture. Within Chonburi, Sriracha Bay is a famous area for aquaculture of the green mussel, *Perna viridis*, which is produced using a raft culture method. Mussel culture in Thailand relies entirely on the collection of natural spat using ropes and bamboo poles as settlement substrates. The raft culture method has been studied and developed since 1994 by the Sriracha Fisheries Research Station of Kasetsart University through funding from the Kasetsart University Initiatives Project (KIP). Three different kinds of mussel culture methods have been examined through this research and raft culture has been found to be both the most profitable method and the easiest. Thai national production of green mussels stands at around 297,000 tonnes per year.

Mussel raft culture

In the past the predominant method of mussel culture in Sriracha Bay was bamboo culture. However, this method had many problems, for example, it could not be conducted on hard substrates, the bamboo was vulnerable to damage by wave and wind action, which could lead to production loss, and theft. This lead the Sriracha Fisheries Research Station (SFRS) to support development of a new raft culture method for green mussel production using recycled materials. The end result of long years of work are a more convenient and comfortable to harvest system that is resistant to wind and wave action and provides some of the benefits of artificial reefs.

Raft culture of mussels is now well adopted in areas where bamboo pole culture is not possible, ie. places with hard substrates or that are exposed to the open sea. The raft culture system is predominantly made from polypropylene and/or polyethylene components, mostly obtained second-hand from industry and old trawl nets respectively. These have the advantage of lasting much longer for bamboo, enduring for several years, making mussel raft culture more profitable and viable than the bamboo pole culture method. For example, to

Mussel raft constructed from recycled materials.

make 1,600 m^2 of mussel raft, 50 m lengths of 16 mm polypropylene rope are tied together to create a grid 40 meters in length and width with ropes spaced at 1 meter intervals. The outside perimeter of the raft is tied with 20 mm polypropylene rope. Sealed plastic containers (20-30 liter) are tightly tied to each knot in the grid with 6-8 mm polypropylene rope, to provide flotation for the raft.

In Sriracha Bay area, during July-September 2005 there was a total of 235 mussel rafts under culture, representing 140 Rai (approx. 25 hectares) (Seekao, 2006).

Harvesting and marketing of green mussels

Mussel raft culture can harvest using small boats, allowing selection of mussels of suitable size to be sold. After eight months of culture the average of shell length of mussels is around 6.55 cm, shell width is 3.18 cm, total weight 20.57 g, shell weight 7.06 g, fresh meat weight 5.89 g and dry meat weight 0.89 g. The density of green mussels was around 240 pieces per meter with a survival rate of around 19.46%. The average increase in shell length was 0.74 cm/month. The total production of raft culture method was 57,800 kg which converted to 346,800 baht per rai (Alongot and Poramet, 2002). Mussel raft culture is currently expanding due to a favorable ex-farm price of around 10-12 baht/kilogram, with current yields standing at around 30,000 kg/rai and rafts having a useful lifespan of 6-8 years.

Benefit of mussel raft culture to local fishermen

In addition to its direct economic benefit, mussel rafts provide additional benefits to the fishers of Sriracha Bay, in that they provide an area of artificial habitat that provides food and shelter to other marine animals of economic importance, as well as protection from trawling operations. Areas surrounding mussel rafts have become favored by fishers for operation of crab traps and gill nets.

Harvested mussels are cleaned and sorted on shore.

Conclusion

The potential for successful mussel raft culture in Sriracha Bay, Chonburi Province has been demonstrated through expansion of this culture method in both Sriracha and other coastal areas in Thailand. However, some minor adjustment to the system may be required in areas that have higher seas.

Acknowledgement

We are grateful to all farmers and staff that are associated with and that have been instrumental in making mussel raft culture in Sriracha Bay a success. Thanks are also due to Kasetsart University Research and Development Institute (KURDI) for providing funds for fisheries research and to the Faculty of Fisheries, Kasetsart University and Sriracha Municipality for their kind support.

References

Poosiripinyo, R. 1984. The green mussel (Perna viridis) marketing system of provinces in the inner part of the Gulf of Thailand, 1982. Master degree's thesis, Kasetsart University, Bangkok, Thailand.

Seekao, C. 2006. Application of Geographic Information System and remote sensing for green mussel culture zoning in Sriracha Bay, Chonburi Province. Master degree's thesis, Kasetsart University, Bangkok, Thailand.

Sriracha Fisheries Research Station. 2003. Intensive culture of the green mussel. pp.43-53. In Project on Potential Development in Aquaculture and Economic Fish Processing in Complete Cycle. Sriracha Fisheries Research Station, Faculty of Fisheries, Kasetsart University, Chonburi Province Thailand.

Selective breeding for growth and fillet yield of river catfish (*Pangasianodon hypophthalmus*) in the Mekong Delta, Vietnam

Nguyen Van Sang, Nguyen Van Hao, Dinh Hung, Pham Dinh Khoi, Bui Thi Lien Ha, Vu Hai Dinh, Nguyen Dien

Research Institute for Aquaculture No.2 (RIA2), Nguyen Dinh Chieu Street, District 1, Ho Chi Minh City, Vietnam. Email: nguyenvansang1973@yahoo.com

Aquaculture production

River catfish is distributed in the Mekong River system through Laos, Cambodia, Thailand and Vietnam. In Vietnam, induced breeding of the river catfish was attempted in 1978 but successful completion of the life cycle was achieved only in 1997. River catfish is the most important species in freshwater aquaculture in South Vietnam. Catfish are farmed in ponds, cages and river-net pens. Production of this species was about 90,000 tonnes in 2000, and thereafter increased somewhat dramatically to 300,000 tonnes and 400,000 tonnes in 2004 and 2005, respectively. The great bulk of farmed catfish is exported, currently to about 50 countries, primarily the EU and the US.

Harvesting eggs for hatchery production of river catfish.

Research requirements

The absolute fecundity of this species is very high at around 300,000 eggs per kg body weight and normally the fry from a few pairs of brooders can provide sufficient seed for rearing and grow-out. If the hatchery managers choose fish from farms as broodstock, the chances of increasing inbreeding is significantly high. A breeding program based on an optimum design utilizing a maximum number of families for different populations can reduce the rate of inbreeding. Although the fillet yield of catfish is relatively low (33 %) the main export product is fillets. Accordingly, a fillet yield together with a high growth rate will be most desirable traits for maximizing the cost benefits in catfish farming. Thus, estimates of the magnitude of genetic variation for fillet weight and fillet yield, and their genetic correlation with growth rate are crucial for determining the objectives and planning of an efficient breeding program.

The selective breeding program for improving some economically important traits commenced in Vietnam under the auspices of the program "Support for Freshwater Aquaculture" (SUFA) by DANIDA (2001-2005), and was carried out by the Research Institute for Aquaculture No.2. Breeding programs to select for growth in two year-class populations 2001 and 2002 was commenced using individual selection, and for fillet yield and body weight in year-class population 2003 using combined individual and family selection. Like in other species, the breeding program first started with growth rate, the trait preferred by producer, and fillet yield was included later. This program is now being continued through funding from the Vietnamese Ministry of Fisheries (2006-2008).

Experimental design

Base populations for each experiment were selected from three different stocks from three different freshwater fish hatcheries in Mekong Delta in Vietnam. Each stock was collected from different periods over 1999-2001 from the farms in An Giang, Vinh Long, Dong Thap, Tien Giang, Long An provinces in Mekong Delta (Southwest of Vietnam) and Binh Duong province in Southeast of Vietnam. The fry for fingerling rearing were collected at different times of the year in Mekong River in Vietnam. Thus, the base population for each year class is considered to have a high genetic variability.

The first generation (F1) of family selected 2001 year class fish were produced in 2005 from 462 fish in the selected line and 120 randomly selected fish in the control line. The partial factorial mating design, 2n males mating with 2n females was used. A total of 95 males mated with 97 females to establish 162 full-sib families within one month. Fertilized eggs were incubated in separate net-jars in the same cement tank. Fry of each family was reared separately in fiberglass tanks and in hapas in ponds until tagging.

On average, 75 individuals from each full-sib family were randomly selected and marked with passive integrated transponder tags (PIT) that were implanted into the back of the fish of 10 g weight in December 2005 (about 170 days). Tagged fish were communally stocked in ponds of 2000 m^2 at the Southern National Breeding Center for Freshwater Aquaculture – Research Institute for Aquaculture No.2 (RIA2). Fish were fed in excess a commercial pelleted feed of 22% protein. In August 2006 some 2,767 surviving fish of 279 days age were sampled, with an average weight of around 1 kg. Body weight, fillet weight and fillet yield were recorded. The number of fish each full-sib family was drawn until it reached an average of 17.5.

Statistical analyses

The linear mixed animal model and restricted maximum likelihood method were used to estimate the variance and co-variance of recorded traits in order to acquire heritability and genetic correlation. A multi-trait analysis and ASReml package were used for analysing the data. The expected genetic response for growth and fillet yield, and realized genetic response for growth were calculated.

Phenotypic and genetic parameters

Very high coefficients of variation (CV) were observed for harvest weight and fillet weight, 40.02% and 35.54%, respectively. The estimated heritabilities were quite high for body weight and fillet weight, 0.39 and 0.40, respectively and low for fillet yield, 0.08. The genetic correlation between body weight and fillet weight was very high (0.98) while that between body weight and fillet yield was nearly zero. With the heritability and genetic correlation shown above it is difficult to select for body weight alone in order to acquire a correlated response for fillet yield. Thus, the selection index of these two traits will be applied to improve for both traits. The predicted response for body weight and fillet yield are about 25% and 2.5%, respectively if each trait is selected separately. The realized genetic response for body weight per generation is 13%. This means that the selected fish grow 13% faster than non-selected fish (the control) after one generation of selection.

Dissemination of improved seed

Primary dissemination shows that selected fry has higher survival and faster growth and selected fingerling have performed better than the non-selected fish at farms. This is an excellent initial result for our improved lines. We have been establishing multiplier and dissemination networks to assist in rapid dissemination of our product. To speed up the dissemination program, we provide all life stages including mature broodstock, reserved broodstock, fingerling and fry to hatcheries, rearing and grow-out farms in the Mekong Delta, Vietnam.

Conclusion

The selective breeding program will acquire a medium to high response for growth and a rather low genetic response for fillet yield, respectively. In conclusion, we strongly recommend that selective breeding programs for this commercially important species be implemented with the expansion in multipliers and dissemination networks to satisfy farmers demand for better quality seed.

Acknowledgements

The research was supported by SUFA (Support for Freshwater Aquaculture), DANIDA and managed by the Vietnamese Ministry of Fisheries, 2001-2005. It is currently funded by the Vietnamese Ministry of Fisheries, 2006-2008.

References

Gjedrem, T., 2000. Genetic improvement of cold-water species. Aquaculture research, 31: 25-33.

Gjerde, B., Gjøen, H.M., Villanueva, B. (1996). Optimum designs for fish breeding programs with constraint inbreeding: mass selection for normally distributed trait. Livestock production Science, 47: 59-72.

Kause, A., Ritola, O., Paananen, T., Mäntysaari, E. & Eskelinen, U., 2002. Coupling body weight and its composition: a quantitative genetic analysis in rainbow trout. Aquaculture, 211: 65-79.

Neira, R., Lhorente, J.P., Araneda, C., Díaz, N., Bustos, E. & Alert, A., 2004. Studies on carcass quality traits in two populations of Coho salmon (Oncorhynchus kisutch): phenotypic and genetic parameters. Aquaculture, 241, 1-4: 117-131.

Rutten, M.J.M., Bovenhuis, H., Komen, H., 2005. Modeling fillet traits based on body measurements in three Nile tilapia strains (Oreochromis niloticus L.) Aquaculture, 231, 1-4: 113-122 .

Sang, N. V., 2004. Genetic parameters and genotype by environment interaction of carcass quality traits in rainbow trout in Norway. MSc Thesis.

Peter Edwards writes on rural aquaculture

Continued from page 20.

The Bangladesh government is concerned that conversion of rice fields to fish ponds might threaten national food security. The current population of 148 million is predicted to increase by about 70% to a maximum of 250 million towards the end of this century before it begins to decline. However, conversion of some rice fields to fish ponds and the promotion of intensified aquaculture and cultivation of vegetables on pond dikes holds great promise to provide more nutritional food for a population of increasing socio-economic status, as well as to provide a better diet and higher income for farming households who comprise the bulk of the population as well as the poor. Bangladesh has reached self sufficiency in rice with production increasing at an average annual rate of 3.6% over the last 25 years, higher than the annual population growth rate which has declined from about 3% in the 60s to 2% in the 90s to today's 1.6%. The challenge is clearly to increase the productivity and profitability of farming to feed an expanding population, to provide it with a more diversified diet and to give farmers a more profitable livelihood than rice farming alone.

Fish for life: Producing high quality fish seed in rural areas of Asia

David C. Little[1], Benoy K. Barman[2] and Corinne Critchlow-Watton[1]

1: Institute of Aquaculture, University of Stirling, Stirling FK9 4LA; 2: WorldFish Center, Bangladesh and South Asia Office, House 22B, Road 7, Block F, Banani, Dhaka 1213, Bangladesh.

Setting the scene

Aquaculture has expanded rapidly in many areas of Asia and this can be related to rapidly changing conditions in both rural and urbanising parts of the region. As human population growth has ensured that demand for aquatic products has increased, wild stocks of fish and other aquatic products have typically declined. The rural poor have been badly affected by this trend in wild stocks but cultured fish are becoming an affordable substitute. In addition to providing an alternative fish supply, aquaculture also creates many employment opportunities. Importantly, even poor people derive benefits as they are often important actors in the supply networks of fish seed that connect seed producers to rural fish farmers. Ready availability of juvenile fish or 'seed' has been a key factor in aquaculture becoming successfully established. Maintaining or improving the quality of seed reaching farmers is now believed to be critical for both aquaculture development and rural livelihoods.

Most fish species produced and stocked in Asia are riverine carps. Traditionally, hatcheries have been located close to natural sources of hatchlings and now often occur as clusters around these resources or where the promoters of aquaculture focused their initial efforts. Hatcheries typically specialise in the production of eggs from ripe breeding fish held in concrete tanks. Fry, or larger juvenile fish (fingerlings), tend to be produced by different people who purchase hatchlings and then nurse them to a larger size in earthen ponds. These producers sell the nursed seed through networks of traders to food-fish farmers who are typically widely dispersed. This situation has resulted in more competition between producers and over time, has reduced profitability. Both hatcheries and nurseries have become more efficient producing increased numbers of smaller seed to enhance cash flows and profitability. These efficiencies have however, often been achieved at the expense of seed quality.

The size of juvenile fish that can be supplied to a food fish farmer is the single most important indicator of

Private sector seed networks often locate around Government investment such as here in Cai Be, Mekong Delta, Viet Nam where an entrepreneur is selling fingerlings in front of major new Government financed National Broodstock Centre.

quality. A larger seed will survive better and grow to marketable size faster than a smaller fish produced under the same conditions. However, under current conditions it is difficult for hatcheries to produce large seed economically; as a result they are expensive for rural farmers or simply unavailable. Fish seed are fragile and often damaged during long distance transportation. Smaller-sized seed can be moved more efficiently but typically survival after stocking in farmers' ponds is poor. Small seed are also more susceptible to predation after stocking.

Alternative approaches to seed supply

Local production and use of seed can benefit food-fish farmers and their neighbours directly; additionally intermediaries and consumers may also gain. Improved availability of larger fingerlings when and where required means that quality seed is more accessible to rural farmers. Production and distribution of seed closer to food-fish farmers should also reduce risks, and increase opportunities for poorer people in the marketing network.

This view on how to improve seed quality is contrary to accepted wisdom. Currently the main strategy for enhancing seed quality is through the production and maintenance of genetically 'improved' seed in centralised facilities. This approach allows the introduction and application of technology at key locations, but requires considerable initial and long term investment. This "techno-centric" approach follows a well established trend for plant and livestock breeding which has had mixed success in Asia. Major problems include inequitable access to improved seed and its associated benefits and negative impacts on biodiversity. Maintaining or enhancing links between the users and producers of improved species and strains of fish is likely to be critical to their sustained success.

Here we outline some alternative approaches to seed supply. We contrast 'centralised' with two different approaches to 'decentralised' production:

1. The local nursing of seed originally obtained from centralised hatcheries; and

Private sector investment in seed production can be rapid if the climate is right such as here in Dong Thap, Mekong Delta, Viet Nam, where Pangasius hatcheries developed rapidly over thre last few years and supported major aqaculture development.

2. The production of juveniles, relatively independent of external support, close to the area in which they will be sold/used.

Centralised hatching and nursing

Conventionally centralised fish seed production has been associated with public sector investment. In reality due to the rapid growth of the private sector, the volume of seed produced by most governments in Asia now represents only a small fraction of the total produced. Some governments and donors have attempted to promote a less centralised approach with mixed success.

In the private sector, the production of fish seed in clusters of hatcheries and nurseries is a common phenomenon. This has many advantages. Concentrations of seed producers usually have good access to specialised equipment and consumables which may be difficult to obtain elsewhere. It is easier for specialised knowledge to spread, especially among people who are relatives or neighbours. This know-how, such as the

Private sector seed producers in the region tend to family based enterprises that involve family labour such as this Pangasius hatchery in Dong Thap, Mekong Delta, Viet Nam.

methods used to prepare and manage earthen ponds for nursing riverine hatchlings, has sometimes developed over time. Government extension staff may have acted as catalysts in this process by introducing key information such as how to use hormones to induce mature fish to spawn.

In common with marketing other perishable products, the close proximity of numerous, competing producers is complementary for traders. A 'cluster' of enterprises provides traders with greater choice and availability. In turn, large numbers of hatcheries and nurseries located close together strengthens the role of 'distributors'. Such middlemen trade seed from hatchery to nursery and between nurseries to food-fish farmers that may be located over large areas.

Concentrations of seed producers should allow close contact and strong linkages between government and non-government service providers. In practice these linkages may have never existed or have weakened as private and government sectors have grown apart. In theory the dissemination of improved strains and new species should be easier and less costly if the producers are located in clusters, but in practice the benefits are not often realised for a variety of reasons.

Decentralised nursing

Decentralised nursing is integrated with and reliant on the centralised hatcheries described above. Under a decentralised nursing system fry are transported from a hatchery to dispersed nurseries in order to produce larger juveniles close to the areas of high demand (i.e. the production areas). Local 'advanced' nursing can provide larger high quality juveniles to farmers in isolated areas where choice of fish seed is limited. The production of large fingerlings during periods of cooler weather (overwintered seed) and between food-fish culture cycles appears to have great potential. Overwintered seed available locally at the beginning of the season enhances productivity and profitability of food-fish culture. Commercial level nursing may encourage farms to buy directly from hatcheries but the livelihoods of poorer traders may be enhanced by servicing a larger and more dispersed network of smaller producers.

There are two 'types' of decentralised nursing: i) conventional earthen pond nursing; and ii) alternative methods based on nursing in hapas or in rice fields.

Pond-based nursing has been heavily promoted by grass-roots organisations with mixed success. Young fry are stocked at high densities in carefully prepared shallow earthen ponds. This system tends to produce large numbers of seed in each production cycle and requires specialised technical and market knowledge. Such nursing is resource intense and technically complex. It is also risky, especially as local demand may be unpredictable. Despite these constraints, nursing in ponds has developed without formal institutional support in some areas, particularly as aquaculture becomes well established. Farmers who have adopted pond nursing tend to be more experienced and nursing often becomes a major source of revenue. They are also aware of the potential benefits of improving the quality of their seed.

Making the benefits of decentralised nursing available to a larger and more diverse group of people is a challenge. Less risky, smaller-scale systems based on fewer seed is one alternative. Promising approaches include stocking small fry in irrigated rice fields or fine mesh cages (hapas). Both methods can be adopted by landless and resource-poor people as initial investment costs are low, culture cycles are short and cash-flow tends to be high. Although the production achieved per household may be low, the total numbers of large seed from many small producers can be very high. While the contribution to household income may not be economically attractive for better-off people, producing large seed in rice fields or hapas can be very worthwhile for poorer households.

Nile tilapia seed produced in irrigated ricefields is a decentralised approach to seed supply that can benefit even poorer housholds directly as producers. These practices are spreading among farmers in rural areas of NW Bangladesh after their introduction several years ago and having numerous benefits to the seed producers, their customers and various poor intermediaries.

Stocking fry in irrigated rice fields has spread rapidly with little external promotion in several parts of Asia. A strong local demand for large fingerlings is a key factor for success. Using rice fields as fish nurseries improves their overall productivity with little additional investment. Such integration has also led to a reduction in the use of chemical pesticides.

Advanced nursing of juveniles in hapas suspended in water bodies has been promoted in several places in Asia. This is a simple method as it does not require expensive and complicated preparation of ponds. Additionally, hapas can be suspended in community water bodies or placed in ponds. Therefore only access to these resources is required rather than ownership. In recent years the improved availability of suitable synthetic mesh material has made nursing in hapas possible in many places.

Decentralised spawning, hatching and nursing locally

Some species of fish such as Nile tilapia and common carp can reproduce without specialised facilities and may

be suitable for local spawning. These species are produced in specialised clusters of hatcheries in some places, but where riverine carps dominate culture such as in Northern Vietnam and Bangladesh such systems are undeveloped. Nile tilapia and common carp seed are more difficult to mass produce than riverine carp and seed production costs are higher. Paradoxically both species are easy to produce in relatively small numbers as they breed naturally in ponds, hapas or even in shallow ricefields. Resource poor people may have a relative advantage in producing seed of these species on a small-holder basis provided quality is maintained.

Demand for fish seed peaks with the onset of monsoon in much of Asia. An important advantage of local production of common carp and Nile tilapia seed is that both the quality and timing of seed availability will correspond to local demand. Large seed can be produced in irrigated rice fields and hapas ahead of the main season of demand; they are then available locally as the rains fill seasonal water bodies. In comparison, seed from centralised systems reaching rural communities at this time is often smaller and long distance transportation results in poorer survival after stocking.

Benefits of locally produced seed, fry and juveniles

Fish seed produced in decentralised systems is unlikely to replace seed produced in centralised, specialised hatcheries. The two systems are complementary. For example in Bangladesh, farmers producing their own Nile tilapia and common carp seed in ricefields, also tend to begin stocking and nursing riverine carps. This is related to farmers' preference for polyculture and therefore a variety of fish species.

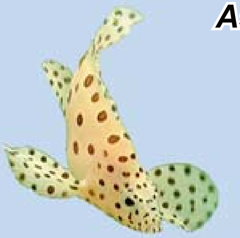
The ready availability of seed from ricefields stimulates the production of food-fish in nearby seasonal or perennial water bodies. This has resulted in higher levels of local fish consumption. Seed producing households can increase their food security by directly consuming larger fingerlings or restocking for later consumption. Local sales of tilapia and common carp seed enhance the productivity of local riverine carp polyculture, benefiting both producers and consumers.

Local availability of large seed enhances employment opportunities for the poor. Traders suffer less risk if supplies of high quality seed are locally available. Experience has shown that traders, most of whom are particularly poor, can become involved in aspects of seed production as well. Furthermore their role as informal promoters of seed production is critical to the practice spreading.

Issues for promoting decentralised seed production

- Successful extension of decentralised seed production requires that grass-roots promoters understand the value of larger seed available locally. Organisations that promote decentralised seed supply also need to have the capacity to support farmers in a practical way.
- After introduction into communities, decentralised production of Nile tilapia and common carp seed can spread rapidly from farmer to farmer. Promoting fish seed production as part of integrated pest management of rice through farmer field schools has proved effective.
- Maintaining positive linkages between rural seed producers and centralised promoters is a challenge. Creating some type of local producer 'clubs' as a focus for interaction is one approach.
- Ensuring that the origin of fish is considered and adequate numbers of fish are supplied during initial transfers to communities. This is critical to ensure adequate diversity of stock initially and to avoid rapid deterioration in quality of fish.
- Profiling of target communities is important to ensure that resources and a need for decentralised seed production exist.
- Seed production for cash generation as opposed to meeting subsistence needs alone, appears to be an important driver for adoption amongst the poor with access to land.
- Selection of fish species is also important. The promotion of Nile tilapia in addition to common carp stimulated the rapid spread of decentralised seed production from farmer to farmer in Northwest Bangladesh.

This article was based on field and policy development work conducted by the authors with funding from the UK Government Department for International Development's (DFID) Aquaculture and Fish Genetics Research Programme (AFGRP). The conclusions of this policy brief reflect longstanding collaboration of the authors with field-based colleagues. In particular those at the Asian Institute of Technology Aquaculture Outreach, DFID Bangladesh Fisheries programme and the MOFI/DANIDA SUFA Project in Vietnam are acknowledged.



Asia-Pacific Marine Finfish Aquaculture Network

Magazine

SKRETTING

Utilisation of local feed ingredients in tiger grouper grow out moist diets

Usman[1], Rachmansyah[1], Neltje N. Palinggi[1] and Taufik Ahmad[2]

1. Research Institute for Coastal Aquaculture, Jl. Makmur Dg. Sitakka, No. 129, Maros, Sulawesi Selatan, 90512, Indonesia, E-mail: rsyah@indosat.net.id; 2. Research Institute for Freshwater Aquaculture, Bogor, Jawa Barat, Indonesia.

The development of tiger grouper (*Epinephelus fuscoguttatus*) culture faces several problems, among which is the reliance on trash fish availability. Compared to artificial diets, the availability of trash fish is seasonal, it quickly decomposes, and can be the source of serious pathogens. Ideally, commercial grouper culture should not rely only on trash fish but instead have a continuous supply of good quality feed throughout the year. In practical terms, a continuous supply of good quality feed can only be assured by using pelleted feed that is well accepted by the fish and that provides all of the nutrients necessary for rapid growth and development at least cost.

Commercially-manufactured dry pellets for groupers are available but they may not always be the best alternative to feeding trash fish. Because of their cost, including both manufacture and freight, farmers may find the commercial dry pellets to be too expensive to use. Morever, wild-caught and less well-adapted hatchery-bred tiger grouper fry may not readily accept dry pellets. Fortunately, tiger grouper will readily accept and grow well on appropriately formulated moist pellets where most of the ingredients can be sourced locally. Being a carnivorous fish, tiger grouper requires a diet with a high protein content of 45-50% on a dry matter basis. While imported fish meal is an excellent source of protein, it is expensive and its sometimes limited availability mean that locally available protein alternatives should be considered as they may provide a more assured source of supply.

Digestibility of selected feed ingredients for tiger grouper, *Epinephelus fuscoguttatus*

Apart from considerations of palatability and anti-nutritional factors, the apparent digestibility of an ingredient determines how much of the nutrients it contains can be utilized by the animal. The higher the digestibility of the ingredient, the more of its nutrient content will be available to support growth and other metabolic functions. Consequently, the digestibility of an ingredient is an important measure of its nutritional quality.

The most commonly available alternative sources of protein in Indonesia are poultry offal, golden snail, green mussel and mysid meal. Yellow and white corn meal, rice bran and sorghum meal are carbohydrate sources that are in plentiful supply in Indonesia. Therefore, an experiment was carried out to determine the apparent digestibility of these feed ingredients because of their potential as ingredients in cost-effective dry or moist feeds for tiger grouper. The findings from the work are summarized in Table 1.

Tiger grouper digested the animal feed ingredients more efficiently than plant feed ingredients with DM, CP, TL and energy ADCs generally being significantly higher. Of the animal meals, golden snail meal was the least digestible while the fiber-rich rice bran had the lowest DM, CP and energy digestibility of the plant meals. However, the lipid digestibility of the rice bran was comparatively high, much higher than all other plant meals and equivalent to that of golden snail meal. The low ADCs of these plant ingredients were probably due to their high content of nitrogen free extract (NFE), particularly the complex carbohydrate components of seeds, which are poorly digested by piscivorous fish.

The study has shown that tiger grouper efficiently digest animal feed ingredients, indicating that the ingredients have potential to be used as dietary replacements for fish meal. Some caution is advised for golden snail meal since its overall digestibility was inexplicably poor, perhaps indicating that unknown factors may be affecting its nutritional value. While the plant meals were not easily digested, nevertheless, they are an integral part of compounded diets and data on their digestibility are important when formulating diets to satisfy

Australian Government
Australian Centre for International Agricultural Research

APEC

Tiger grouper fed moist pellet in floating net cage.

the animals requirements for digestible nutrients. However, steam conditioning of these meals prior to pelleting or using hot extrusion manufacturing procedures may increase their digestibility for tiger grouper. The high digestibility of green mussel suggests its polyculture with fish may provide an additional local source of protein for the fish while helping to alleviate nutrient output from farms. Until more eco-friendly pelleted feeds become commercially available, such integrated systems may be an effective way of reducing the environmental impacts of cage aquaculture.

Substitution of fish meal with golden snail meal (*Pomacea* sp.) in tiger grouper grow-out diets

Golden snail, considered a pest in paddy fields, is a potential fishmeal replacement; it contains 50-54 % protein on a dry matter basis with essential amino acid index (EAAI) about 0.84. (Table 2). Golden snails are plentiful and meals made from them are a potential fish meal substitute in fish diets. Collecting golden snails in paddy fields also provides additional social and economic benefits through provision of additional job opportunities. Because of these potential advantages, the use of golden snail meal as a source of protein for fish diets was assessed.

Snails were collected from a rice field in Maros Regency, boiled at 100ºC for about 15 minutes, sun dried until they contained less than 10 % water and then pulverized to produce the golden snail meal. The proximate composition (% DM) of golden snail meal was: crude protein 56.9%; lipid 5.2%; ash 11.2%; and crude fiber 2.8%. Test diets were prepared containing five different levels of golden snail meal (0%, 10%, 20%, 30% and 40%) substituting for a similar amount of fish meal protein. The test diets were made as moist pellets (42% water content) and all had the same protein (45% DM) and energy (19.8 MJ/kg) content. Trash fish was used at a constant inclusion rate in all diets. Increasing the amount of golden snail meal in the diet resulted in a slight curvilinear deterioration in growth rate, FCR and nitrogen retention with the adverse effects most noticeable at inclusion rates greater then 20% (Fig. 1). Survival rates were high (> 94%) on all treatments. There were no differences between treatments in the chemical composition of the fish at the end of the experiment. Golden snail meal contains less methionine than tiger grouper carcass (Table 2) and this may be why high inclusion rates of the meal resulted in reduced growth of the fish. However, other unknown anti-nutritional factors in golden snail meal may have contributed to the poorer performance of the fish fed the high golden snail meal diets. This experiment has shown that golden snail meal can be used at inclusion rates of up to 20% of the DM content of the diet to replace fish meal protein without adversely affecting the performance of tiger grouper.

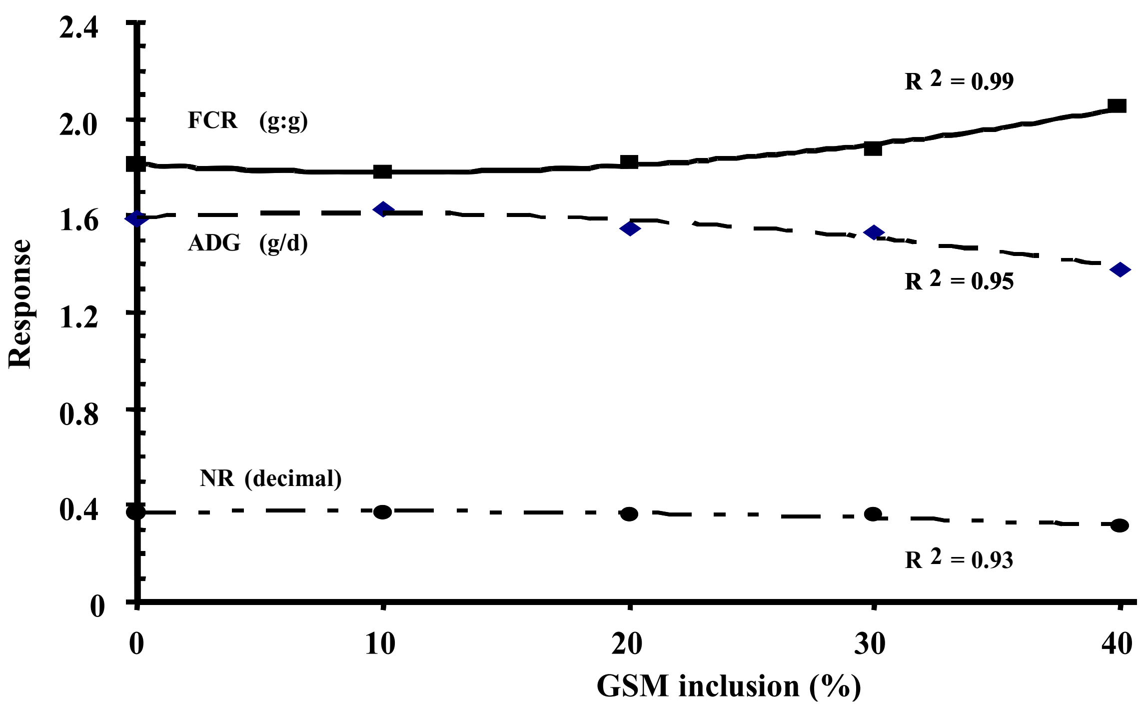
Farm-made moist pellet.

Golden apple snail and other alternative feed ingredients.

Utilization of poultry offal silage meal (POSM) in tiger grouper

Being a piscivorous fish, tiger grouper have a relatively short digestive tract and low digestive enzyme capacity for carbohydrate-rich food. Thus, they grow best when fed on formulated diets that contain high amounts of protein >45% but only moderate amounts of lipid (<15%). To meet this high protein specification, diets typically contain 50% fish meal. At an FCR of about 2.5:1 and a 4:1 conversion of low-value fish into fish meal, some 6 kg of low-value fish is required for every 1 kg weight gain of the cultured fish. Clearly, this is not a very efficient or appropriate use of a limited resource. Replacement of fish meal with more sustainable terrestrial feed ingredients is a high priority for all aqua feeds. An alternative ingredient, which has potential to replace fish meal in grouper feeds, is poultry by-product meal (PBM), also known as poultry offal meal (POM). In South Sulawesi, raw poultry waste product is available but there is no commercial manufacture of this material into POM. At a farm scale, poultry waste product can be ensiled with organic acids to produce a poultry offal silage meal (POSM). POSM is produced by acidifying (3% formic acid and a similar amount of propionic acid) chicken viscera and other abattoir waste to activate the endogenous proteolytic enzymes in the material. In turn, this results in a partially digested product that is rich in protein, polypeptides and free amino acids. The acidity of the product aids in retarding microbial growth. The product can be incorporated as wet product for moist diets or conventionally dried for dry pellet formulation. Typical analysis (% dry matter) of the POSM is: crude protein 65.6%; total lipid 18.1%; crude fibre 0.2%; ash 4.7%, nitrogen free extract 11.4%; and gross energy 24.57 MJ/kg. To assess the extent to which POSM could replace fish meal in diets for groupers, five diets with the same crude protein (45%, dry matter) and energy (20 MJ/kg, dry matter) content were formulated in which POSM was included at 0%, 5%, 10%, 15 or 20% of the diet as isonitrogenous substitutes of fish meal. All dry ingredients were mixed

Figure 1. Effect of dietary inclusion level of golden snail meal (GSM) on tiger grouper average daily gain (ADG), feed conversion ratio (FCR) and N retention coefficient (NR).



together after which the minced raw trash fish and oil were added to produce a dough of approximately 40% moisture.

Survival rate during the 20-week experiment was high for all treatments, averaging 97%. Fish grew well on all diets with biomass gains averaging 303% of initial weight. There were no significant differences between treatments for any of the measured biological traits (Table 3). Thus, the addition of POSM at dietary inclusion rates of up to 20% and equivalent to a 37% replacement of fish meal protein was well accepted by the fish without any adverse effects on fish productivity. Compared to fish meal, POM contains lower amounts of the essential amino acids methionine, histidine and lysine.

A digestibility experiment (Table 4) showed only a slight decrease in dry matter, protein and lipid apparent digestibility as the amount of POSM increased. The progressive decrease in dietary digestibility with increasing POSM inclusion is most likely due to the higher content of poorly digested poultry feather fibre.

Locally available sources of protein such as GSM and POSM can be cost-effective substitutes for fish meal in tiger grouper diets. However, careful handling of the raw ingredients during collection, storage and processing is critical to ensure that only the best quality product is used in grouper feeds. Further, it is not profitable to produce moist pellets on a large scale because they have to be used on the same day of manufacture unless cold storage is available to extend their shelf life. Developing on farm-moist feed pellet production is a real need for the grouper farmers to help develop a sustainable tiger grouper farm. The use of small scale feed production machinery would help tiger grouper farmers to become more self sufficient in on-farm moist feed production.

Table 1. The dry matter (DM), crude protein (CP), total lipid (TL) and gross energy (GE) apparent digestibility of the test feed ingredients.

Essential amino acids	Fish meal (CP: 61.7%)	Golden snail meal (CP: 56.9%)	Whole body of tiger grouper (CP: 62.2%)
Arginine	3.96	3.67	3.63
Histidine	1.77	1.05	1.02
Isoleucine	2.86	2.60	2.42
Leucine	5.00	4.31	3.99
Lysine	5.03	3.14	3.77
Methionine + cysteine	1.36	0.32	0.47
Phenylalanine	2.71	2.19	2.04
Threonine	2.97	2.35	2.47
Valine	3.20	2.61	2.64
Tryptophan	na	na	na
Note: na=non-analysed			

Table 2. Essential amino acid composition of fish meal, golden snail meal and whole body of tiger grouper (% dry matter).

Essential amino acids	Fish meal (CP: 61.7%)	Golden snail meal (CP: 56.9%)	Whole body of tiger grouper (CP: 62.2%)
Arginine	3.96	3.67	3.63
Histidine	1.77	1.05	1.02
Isoleucine	2.86	2.60	2.42
Leucine	5.00	4.31	3.99
Lysine	5.03	3.14	3.77
Methionine + cysteine	1.36	0.32	0.47
Phenylalanine	2.71	2.19	2.04
Threonine	2.97	2.35	2.47
Valine	3.20	2.61	2.64
Tryptophan	na	na	na
Note: na=non-analysed			

Table 3. Biological responses of tiger grouper fed different levels of poultry offal silage meal (POSM) in diets.

Response trait	Poultry offal silage meal levels (%)				
	0	5	10	15	20
Initial weight (g/fish)	63.8	63.6	64.2	65.1	64.3
Final weight (g/fish)	262.3	253.9	261.0	256.0	261.6
Weight gain (%)	311.3	299.2	306.5	293.2	306.8
Survival rate (%)	97.9	95.8	97.9	95.8	97.9
Daily growth rate (%/d)	1.02	1.00	1.02	0.99	1.02
Daily feed consumption (%/d)	3.75	3.88	3.89	3.85	3.82
Feed conversion ratio	3.4	3.6	3.6	3.6	3.5
Protein efficiency ratio	1.1	1.0	1.0	1.0	1.0
Protein retention (%)	20.13	18.9	19.2	18.4	19.7
Differences between treatments were not significant (P > 0.05) for all traits.					

Table 4. Apparent digestibility coefficient (ADC) of diets containing different levels of POSM when fed to tiger grouper.

ADC	Poultry offal silage meal levels (%)				
	0	5	10	15	20
Dry matter (%)	79.0	77.9	74.2	66.5	62. 5
Crude protein (%)	92.3	92.0	92.2	91.5	89.4
Total lipid (%)	95.9	95.4	94.5	92.6	91.2

Optimal nutrition for marine fish

Dr. Arjen Roem, Skretting Asia

Traditionally marine fish farmers have used locally caught trash fish as a feed for their fish, often ground into a moist pellet. The advantages have been the (daily) availability of trash fish, good palatability and the low price per kg. Current trash fish prices can range from 0.2-0.4 USD per kg depending on the region. On the other hand there are also a number of disadvantages to using trash fish:

- The price of a kg feed or trash fish is not a good parameter for fish farming. Instead one should calculate what is the production cost per kg farmed fish or even better what is the total profitability. Feed conversion ratios (kg feed/kg weight gain) are typically 8-10 for trash fish feeding which is very high.
- Feeding trash fish or moist pellets leads often to lower water quality (dirty water). Moist feeds do not bind so well, integrate easily and give a high organic load in and around the farm. That increases the risks for oxygen depletion and/or outbreak of diseases when water currents are low.
- Fisheries for trash fish are seldom well regulated and may not be sustainable in the future. There are great worries about global overfishing and catching large volumes of often small juvenile fish for use as feed, and this practice may be banned in the coming years in some parts of the world.

However, the most important reason to consider dry extruded feeds for marine fish has to do with providing optimal nutrition. Fish have a high requirement for protein and at the same time for energy. Trash fish is normally low in energy content. A high protein-to-energy ratio can only be provided by modern dry feeds made with extrusion technology. The extrusion process is optimal for fish nutrition. The combination of high temperature, high pressure and high shear forces gelatinise the carbohydrates (starch) in the formulation. Thereby, a very stable pellet is formed which minimises the risk for feeding losses and water pollution. Moreover, the gelatinised starch is more digestible and available to the fish, so more energy is accessible for growth.

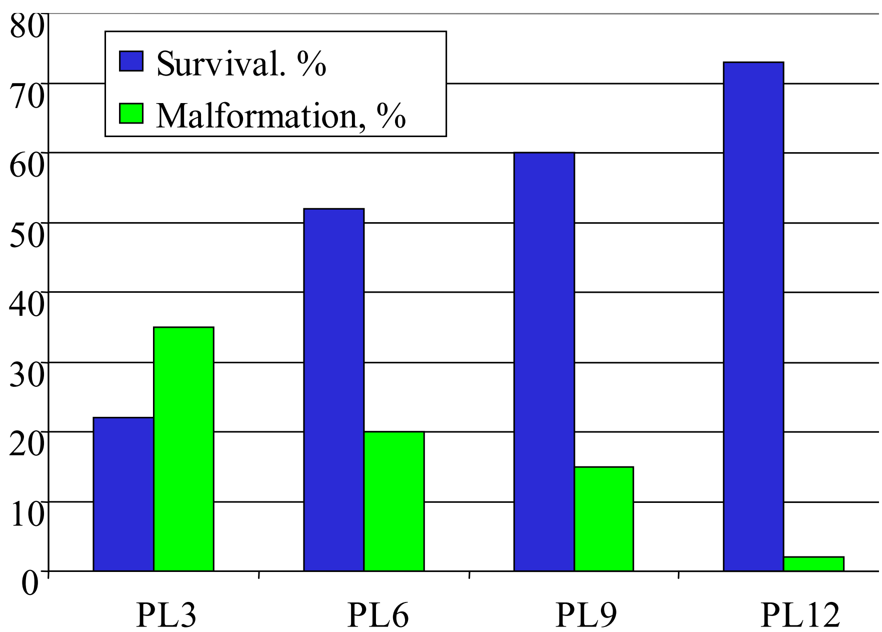
The open porous structure of the pellet, which is a protein-starch matrix, allows for the pellets to be coated with oils. Both fish/animal oil and vegetable oils can be used for this coating. Oil is the best energy source for marine fish and has the highest energy concentration (calories/gram). The end-result is an extruded pellet with the optimal protein-to-energy ratio for fish. Research has shown that this optimal protein/energy ratio leads to better growth rates, lower feed conversions and contributes to farm economy.

Skretting has invested a lot in R&D to define the optimal protein-to-energy ratios for marine fish species for different sizes and under different environmental conditions like salinity and temperature. Moreover, crude protein is not always digestible protein. The REAL dietary requirement of fish is for amino acids which are the building blocks of protein (rather than for protein per se). This has led to new insights in replacing fish meal with alternative protein feedstuffs like soya, glutens and animal proteins. Skretting called this the AminoBalance™ concept. It means that all diets have been formulated to meet the digestible amino acid requirements of a particular fish species and particular size class and temperature for maximum growth and feed efficiency, topped with the right energy level. Recently, Skretting have launched a complete feed range for marine fish in Asia.

Starter diets

Perla is a starter diet for juvenile marine fish. It comes in eight sizes: first four extruded crumbles for weaning them from live feeds like rotifers, copepods and Artemia. Perla contains high protein levels are especially suited for this lifestage. Phospholipids have been included to improve larval development, quality and survival. Thereafter, four minipellets are available for pre-growing. The minipellets come with Aquasoft™ technology. Aquasoft stands for a new form of extrusion that allows for fast water absorption. In 10-15 minutes these minipellets will absorb up to 100% or more water. The pellets become more soft and spongy which improves the weaning process. Another advantage of Aquasoft is that it is possible for the farmer to add special ingredients on-site. Farmers can simply add them to the water that is mixed and absorbed by the feed. Aquasoft is proven technology from Japan. All Perla

Higher inclusions of phospholipids in starterfeeds improve larval survival and reduce the rate of deformities (Ifremer, 2000).



sizes contain special immunostimulants to support health status and produce robust fingerlings for on-growing.

Grower diets

After Perla farmers have a choice in grower diets depending on the fish species and other demands:

1. Marine is a grower feed designed for species like pompano, croaker and some grouper species. Like all grower diets the protein-to-energy ratio is adapted according to fish size (pellet size) to reflect that larger fish have a lower requirement for most nutrients compared to smaller fish.
2. Marine Red is a grower feed designed for red snapper, red seabream and some grouper species like the coral trout. All those species are valued for their (red) skin condition. Marine Red contains a special blend of pigments for enhanced coloration.
3. Excel is a high energy feed designed for species like seabass and cobia. These species are fast-growing, especially cobia which can grow up to several kg per year, and this requires an even higher protein-to-energy ratio compared to other species. Excel is a floating feed for easy feeding and feed management. Use of this feed requires a floating collar on the surface to prevent feed from dispersing/floating out of the cages.
4. Active is a grower diet for turbot, flounder and other flatfishes. Most flatfishes are very sensitive to sensoric qualities of the feed. This means that fish meal freshness and raw material quality require special attention from a feed supplier. Palatability agents can improve feed intake and the performance of flatfish significantly.

Together these diets provide a complete range of modern dry extruded feeds for marine fish species commonly farmed in Asia. These modern diets are better for the fish, better for the environment, better for the farm economy and better for farmers.

For more information on fish nutrition or one of Skretting diets you can contact the author at arjen.roem@skretting.com or our sales managers Hiro in South East Asia hiroyoshi.matsumoto@skretting.com (+60 88 251302) and Tie in North East Asia tie.tecklok@skretting.com (+81 90 31874239).

SEAFDEC tests its feed formulations for marine fishes

Feeds and feed management are important issues that these can spell the success or failure of an aquaculture venture, typically accounting for 60-70% of the recurring cost of a fish farm. Good feed formulation and feed management can also be seen as an opportunity, providing a window to reduce this recurring cost significantly.

Researchers working on nutrition and feed development must first find a balance between cost reduction and a formulation designed to comply with the nutritional requirement of the cultured stock. Then, they must lay out a feed management scheme that has minimal environmental impacts. The experiences of the tiger shrimp industry has taught farmers prudence and responsibility, lessons that the marine fish industry must take into consideration. Accordingly, the Aquaculture Department (AQD) of the Southeast Asian Fisheries Development Center (SEAFDEC) located in Iloilo, west central Philippines ensures that its feed development program incorporates environmental considerations.

What feeds, and what is unique about these?

In developing feeds for marine fishes, SEAFDEC/AQD has evaluated the nutrient requirements of seabass (*Lates calcarifer*), grouper (*Epinephelus coioides*), snapper (*Lutjanus argentimaculatus*), and milkfish (*Chanos chanos*) (Tables 1a and 1b). On the basis of these requirements, diets for carnivorous species (grouper, snapper, seabass) were formulated (Table 2a). In addition, feed requirements of the rabbitfish *Siganus guttatus* have also been studied, and formulated feeds for different life stages of the brackishwater milkfish have been made available (Table 2b).

The following formulated feeds are now being verified by SEAFDEC/AQD:

- Seabass, grouper, and red snapper diets for pond grow-out at AQD's brackishwater station in Dumangas, Iloilo;

Pellet production.

- Seabass, grouper, red snapper, and milkfish diets for larviculture in the AQD hatcheries in Tigbauan, Iloilo;
- Grouper diet for grow-out at AQD's marine station in Igang, Guimaras island;
- Milkfish diet in marine grow-out cages in Bolinao, Pangasinan, in cooperation with the private sector; and
- Mud crab diet for pond grow-out at Dumangas.

What is unique in these feeds? The feed profiles have been developed to match the nutritional requirements of each species, increasing the possibility of the feed ingredients being effectively utilized by the stock. Also, locally available ingredients were selected, where possible, to make it easy for farmers who may opt to make their own feeds on farm.

Fish do not feed when the temperature and dissolved oxygen are too low, or when temperature is too high. Stock should not be fed during transportation. As unconsumed fish feed can cause eutrophication, which leads to the rapid increase of plankton populations followed by die-offs and oxygen depletion as they decompose, wastage of feed should be avoided in order to reduce the risk of stress, disease and mortality of the stock.

Table 1a. Summary of known nutrient requirements of seabass *Lates calcarifer*. From Feed Development Section. 1994. Feeds and Feeding of Milkfish, Nile Tilapia, Asian Sea Bass, and Tiger Shrimp. Aquaculture Extension Manual No. 21, SEAFDEC Aquaculture Department, Iloilo, Philippines. 97 pp.

Nutrient	Requirement by dry weight?	Reference
Protein[1]	43% for juvenile	VR Alava, personal communication
	50% protein : energy	MR Catacutan, unpublished
Essential amino acids[2]		RM Coloso et al., unpublished
Arginine	3.6%	
Lysine	4.5	
Methionine	2.35 (cystine, 0.7)	
Tryptophan	0.5	
Lipid[1]	10%	MR Catacutan, unpublished
Essential fatty acids[1]	0.5% n-3 PUFA	Borlongan & Parazo (1991) Israeli Journal of Aquaculture (Bamidgeh) 43 (p 95-102)
	0.5% n-6 PUFA	
Carbohydrate[1]	20-25%	MR Catacutan, unpublished
1. Requirement as percent of dry weight; 2. Requirement as percent of protein		

Table 1b. Summary of known nutrient requirements of grouper *Epinephelus coioides*, red snapper *Lutjanus argentimaculatus*, and milkfish *Chanos chanos*.

Species	Nutrient requirement	Reference
Grouper	40-50% protein 1 n-3 HUFA	Teng et al. 1978 Aquaculture 15 (p 257-271); Millamena & Golez 1999 Aquaculture Asia 4 (1) p 47
Red snapper	44% protein	Catacutan et al. 2001 Aquaculture Research 32 (p 811-818)
Milkfish	30-40% protein; 24% protein for milkfish raised in ponds 7-10% lipid 25% carbohydrates 2,500-3,500 kcal/kg of digestible energy 1-1.5 n-3 PUFA	Lim et al. 1979 Aquaculture 17 (p 195-201); Pascual 1989 Proceedings of an IFS Seminar on Aquaculture (p 228-236)

Igang Mariculture Park.

Generally speaking, the larger the fish the lower is their protein requirement. For this reason, fish in the fry and fingerling stages are in the most need of "quality" protein sources, while fish in the grow-out stage can make do with feedstuffs that contain a lower protein content.

And then there's the question of delivery: to float or not to float? Generally speaking, sinking feeds are appropriate for crustaceans and bottom feeders, while floating feeds are more suitable for fish; however, floating feeds are not usually used for marine species. Furthermore, the same species raised in different environments, e.g., marine cages and ponds, must also have different feed types in their diets. The feeding habit (surface, pelagic or bottom) and digestive physiology of fishes also influence the most appropriate diet type.

Feed ingredients have to meet certain criteria, which include their nutritional content, digestibility, absence of anti-nutritional factors, cost and availability. With these in mind, SEAFDEC/AQD researchers have formulated feeds that are composed mostly of fish meal, squid meal, and soybean meal as protein sources. Other ingredients include rice bran, cod liver oil, soybean oil, and wheat flour, bread flour, cellulose and/or κ-carageenan as binders. AQD researchers never stop looking for alternatives, substituting leaf meals such as cassava, swamp cabbage, sweet potato for fish meal, or cowpea meal and feed pea for the more-expensive soybean meal.

Bloodmeal, poultry by-products, and snail meat have the potential to partially replace fish meal as a protein source. One ingredient that did not make the list was the formerly popular meat and bone meal, now shunned due to the scare of mad cow disease.

Table 2a. Formulated diets (g/kg dry diet) for grouper (*Epinephelus coioides*), red snapper (*Lutjanus argentimaculatus*), rabbitfish (*Siganus guttatus*), and seabass (*Lates calcarifer*). From OM Millamena et al. (eds). 2002. Nutrition in Tropical Aquaculture. SEAFDEC Aquaculture Department, Iloilo, Philippines. 221 pp.

Ingredients	Grouper		Snapper	Rabbitfish		Seabass
	Grow-out (offshore cages)	Grow-out (cages in ponds)	Grow-out	Broodstock	Nursery	Grow-out
Fish meal	-	-	-	100	145	420
Chilean fish meal	80	200	-	-	-	-
Peruvian fish meal	-	-	430	-	-	-
Meat and bone meal, local		200	-	-	-	-
Meat and bone meal, imported	320	-	-	-	-	-
Shrimp meal (*Acetes* sp.)	-	-	54	-	145	100
Squid meal	10	10	80	100	134	50
Shrimp meal	100	100	-	100	-	-
Soybean meal	60	60	-	80	-	90
Defatted soybean meal	-	-	80	-	-	-
Blood meal	80	80	-	-	-	-
Corn gluten meal	-	-	-	80	-	-
Wheat germ	-	-	-	80	-	-
Wheat flour	150	150	-	-	-	-
Brewer's yeast	-	-	-	60	-	-
Cellulose	-	-	-	187.3	28.5	-
Bread flour	-	-	200	22.5	376	77.5
Rice bran	70	70	58	-	-	-
k-carrageenan	-	-	-	-	50	-
Cod liver oil	60	60	38	100	71	-
Soybean oil	-	-	-	15	-	-
Cod liver oil / soybean oil (1:1)	-	-	-		-	57.5
Soybean lecithin	-	-	5	45	-	-
Vitamin mix	40	40	-	20	30	40
Mineral mix	30	30	-	10	20	20
Vitamin and mineral mix	-	-	50	-	-	-
Butylated hydroxytoluene	-	-	-	0.2	0.5	-
DHA-Selco	-	-	-	-	-	-
Dicalphos	-	-	5	-	-	-
Ascorbyl monophosphate	-	-	0.2	-	-	-
Cellufil	-	-	-	-	-	145
Proximate composition (% dry matter):						
Crude protein	44	44	44	38.4	39.2	43.2
Crude fat	11.5	11.5	10	17.4	9.9	9.3
Crude fiber	1.8	1.8	-	13.1	5.5	-
Nitrogen-free extract	25.8	25.8	-	23.6	37.8	-
Ash	16.9	16.9	-	7.5	7.6	-
Carbohydrate	-	-	26.5	-	-	-
Energy (MK/kg diet)	-	-	18.9	-	-	-

Table 2b. Formulated diet (g/kg dry diet) for milkfish (*Chanos chanos*) at various stages of culture. From Millamena OM et al. (eds). 2002. Nutrition in Tropical Aquaculture. SEAFDEC Aquaculture Department, Iloilo, Philippines. 221 pp.

Ingredients	Broodstock	Larval	Fry (freshwater)	Fry (seawater)	Growout
Fish meal	200	330	566	300	110
Soybean meal	430	180	114	200	308
Squid meal	-	100		-	-
Shrimp meal (*Acetes* sp.)	-	120	90	-	-
Shrimp head meal	-	-	-	160	-
Soybean meal	-	-	-	-	-
Corn gluten meal	-	-	-	-	-
Copra meal	-	-	-	-	-
Ipil-ipil meal	-	-	-	-	-
Rice bran	255		87	115	492
Bread flour	40	66.9		150	50
Cassava flour	-	-	-	-	-
Sago palm starch	-	-	50	-	-
Starch	-	-	-	-	-
k-carrageenan		50		-	-
Cod liver oil	20	80	25	30	20
Soybean oil			25	-	20
Vegetable oil	-	-	-	-	-
Lecithin	-	10	-	-	-
Vitamin mix	15	30	6.9	10	-
b-carotene	-	2.5		-	-
DL-a-tocopherol acetate	-	0.1		-	-
Mineral mix	-	30	36	35	-
Vitamin-mineral mix	-	-	-	-	-
Dicalcium phosphate	40	-	-	-	-
Butylated hydroxytoluene	-	0.5	0.4	-	-
Proximate composition (% dry matter)					
Crude protein	37.6	46.3	43.9	37.6	26.7
Crude fat	8.7	11.4	10.3	8.7	10.9
Crude fiber	3.9	5.6	3.6	3.9	8.4
Nitrogen-free extract	36.4	27.3	16.8	36.4	45.1
Ash	13.4	9.4	16.2	13.4	8.9

Whatever the main ingredient, all fish should be provided with protein, lipids, carbohydrates, vitamins and minerals, which are essential to promote growth, and according to their particular requirements.

SEAFDEC/AQD assists fish farmers to formulate feeds based on ingredients readily available to them. All they need to do is send in samples of their raw ingredients to have their proximate composition analyzed; and from there, the formulation can be done. Feed milling may also be requested at AQD which operates a feed mill located in Tigbauan, Iloilo, of 1 ton capacity per day.

Live feed substitutes in the hatchery

Of course, in a culture environment, fish do not live on formulated diets alone. This is particularly true among fish in the early stages of development, and over-reliance on live feed results in increased costs, especially due to the maintenance cost of more facilities in the hatchery.

SEAFDEC/AQD conducted studies to find substitutes, or at least shorten the need for brine shrimp *Artemia* and the rotifer *Brachionus*, two expensive live feed types given to marine fish larvae. The freshwater cladoceran *Moina macrocopa* is an acceptable live food that can replace *Artemia* in the larval rearing of seabass. It is used as feed immediately after weaning from Artemia and prior to feeding minced fish or formulated diets.

Another species found to be viable for this purpose is the brackishwater cladoceran *Diaphanosoma celebensis*, noted for its high population growth rate, and high crude protein and crude fat contents. Both *Moina* and *Diaphanosoma* are viable options to partially or completely replace *Artemia* as feed for seabass larvae. These species are collected and cultured like *Brachionus*, but at a lower cost.

Further, SEAFDEC/AQD is doing mass culture of copepods and mysids in earthen ponds as alternative live food for seabass, grouper, and snapper fry.

Finally, another alternative to reduce the dependence on live food in the hatchery is the development of artificial larval diet(s). Microbound larval diets are flaked in a drum dryer, ground and passed through a graded series of sieves to obtain particles sizes, and then fed to larvae at increasing sizes as the fish grow.

Collaboration

Continuing research and application, and collaboration of stakeholders hold the key for a more productive aquaculture sector. SEAFDEC/AQD wishes to put out a call to partners who can help commercialize its feed formulations under mutually acceptable terms.

For more information about SEAFDEC/AQD's feed development R&D for marine fishes visit the SEAFDEC/AQD website at www.seafdec.org.ph, or contact:

- Dr. Neila Sumagaysay-Chavoso (nschavoso@aqd.seafdec.org.ph), Head of Technology Generation Division; or
- Dr. Joebert Toledo (jdtoledo@aqd.seafdec.org.ph), Chief of SEAFDEC Aquaculture Department.

NACA Newsletter

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

ISSN 0115-8503

Volume XXII, No. 2
April-June 2007

Expert Workshop on Guidelines for Aquaculture Certification

An expert workshop convened in Bangkok from 27-30 March to start a process for the development of guidelines on aquaculture certification. The guidelines were requested by member governments at the COFI Sub-Committee on Aquaculture (SCA), at its third session in New Delhi, September 2006.

The need for the guidelines stems from the fact that aquaculture is currently the fastest growing agricultural sector in the world, currently contributing around 45% of the global supply of fisheries products. Driven by concerns over food safety and the environmental and social sustainability of rapidly expanding aquaculture production, there have been many attempts to introduce certification schemes for various aspects of aquaculture. More than 30 schemes in place today.

While certification schemes are generally intended to improve some aspect of the performance of aquaculture, concerns have been expressed about their potential negative impacts. Many certification schemes have resulted in higher costs for producers without delivering significant price benefits, most severely affecting small-scale farmers, who are already among the most disadvantaged. The proliferation of a wide range of certification schemes and accreditation bodies has the potential to create confusion amongst producers and consumers alike. There are also serious concerns about the potential for certification schemes to be misused as a new form of trade barrier.

SCA stated that there is a need for more globally accepted norms for aquaculture production that can serve as a basis for improved harmonization of certification, thereby facilitating mutual recognition and equivalence of aquaculture certification schemes.

The objective of the workshop, which was requested by SCA, was not to develop an aquaculture certification scheme per se. Rather it was to begin scoping out general guidelines around which aquaculture certification schemes can be built, whether they be for systems, practices or products. The workshop was a first step in bringing together stakeholders to examine the key issues concerning aquaculture certification, to build consensus on the scope of certification guidelines and to lay the groundwork for their development. The workshop also discussed certification issues that are specific to the Asian region, the outcomes of which will complement a regional analysis for Latin America that will be conducted in a workshop in Brazil, in July 2007.

The workshop, hosted by the Department of Fisheries of Thailand, and co-organized by FAO and NACA brought together 72 participants, including experts from certification bodies, aquaculture farmer associations, governments, major buyers and other stakeholders from 20 countries across the worlds largest aquaculture producing and importing regions.

This wide range of stakeholders from producing and importing countries addressed many of the key issues around the growing interest in certification of aquaculture products. The status and trends in aquaculture, experiences in certification of aquaculture products, certification standards, harmonization and equivalence among certification schemes, stakeholder involvement and ownership, costs and benefits, and the participation of small-scale farmers were among the wide ranging issues discussed during the workshop.

The outcomes from the Expert Workshop included consensus on many key points to be addressed in the preparation of global guidelines on aquaculture certification to be considered for international agreement; such as the need for core standards, procedures for certification, an approach to harmonization among different schemes, stakeholder participation, and others. The aquaculture certification guidelines were also recommended to give special attention to the needs of small-scale farmers in developing countries.

The participants agreed to continue to cooperate to share information and experiences to develop the aquaculture certification guidelines. The next formal workshops to continue the work of guideline development will be held in Brazil and India in July and November 2007. The draft guidelines are expected to be ready for international consensus by the end of 2008. Additional consultations and feedback sessions are also expected during the next year.

The Expert Workshop report will be available soon. Existing workshop documents and presentations, including an MP3 recording of the opening address and comments on certification by NACA's Director General, are available for download from:

http://www.enaca.org/modules/tinyd11/index.php?id=16.

780 aquaculture publications...

...free download

• www.enaca.org •

Responsible movement of live food finfish within ASEAN: Cebu Workshop finalizes the standard operating procedures

The Second Policy Workshop under the AADCP-RPS 370-018 project "Operationalise Guidelines on Responsible Movement of Live Food Finfish within ASEAN" was held at the Costabella Tropical Beach Hotel, Cebu City, Philippines from 12-13 February 2007. AusVet, NACA, and ASEC organized the workshop in collaboration with BFAR, Philippines. The objective of the workshop was to develop the final draft of the Standard Operating Procedures (SOPs) for Health Certification and Quarantine Measures for the Responsible Movement of Live Food Finfish within ASEAN. The workshop was attended by 21 government nominated representatives from all the 10 ASEAN countries and 5 Resource experts from partner organizations (ASEC, AusVet, FAO and NACA).

International trade in live aquatic animals and their products is growing at a phenomenal rate. This is in fact very essential to support the development of sustainable and profitable aquaculture. However, with trade comes the risk of introduction and spread of pathogens. Various global and regional instruments and standards provide guidance to trading partners to minimize the risk of introduction and spread of dangerous aquatic animal pathogens. Developing operational strategies to effectively implement the guidelines is very important. In this direction, ASEAN has taken a small step forward. In order to enhance the bio-security of food finfish industries, ASEAN Member Countries have come together under an AusAid supported project to develop standard operating procedures (SOPs) for health certification and quarantine measures for responsible movement of live food finfish (LFF) within ASEAN. These SOPs have been developed under the AADCP:RPS project 370-018, Operationalise Guidelines on Responsible Movement of Live Food Finfish. This project is coordinated by ASEC, NACA and AusVet for Cardno ACIL who manage the AADCP:RPS program for ASEC and AusAID.

A goal of the Vientiane Action Program (VAP) is to develop, harmonise and adopt quality standards and regulations for food, agriculture and forestry products. The workplan for this goal further specifies the need to collect and compile national fisheries SPS measures and regulations; harmonisation of national sanitary measures into an ASEAN sanitary measure and publication of the harmonised ASEAN sanitary fisheries measures. The ASEAN Sectoral Working Group on Fisheries (ASWGFi) and the Senior

Participants in the workshop.

Official Meeting for ASEAN Ministers on Agriculture and Forestry (SOM-AMAF) are responsible for this initiative.

A Regional Seminar on Harmonisation of Quarantine Procedures for Live Fish among ASEAN Member Countries in February 2003 in Penang, Malaysia resulted in draft guidelines for the international movement of live fish. The draft guidelines was presented and agreed at the 11th Meeting of ASWGFi in May 2003 in Vientiane, Lao PDR. The Meeting agreed that the scope and title of the guidelines be changed to General Guidelines on Responsible Movement of Live Food Fin Fish and that comprehensive procedures for implementation of the Guidelines at the operational level should be developed. The SOPs have built on the recommendations of the Guidelines.

They also are consistent with the Asia regional technical guidelines on health management for the responsible movement of live aquatic animals and the Beijing consensus and implementation strategy, 2000 (TG) and the Manual of procedures for the implementation of the TG (2001). The OIE Aquatic Animal Health Code (Ninth Edition, 2006) and Manual of Diagnostic Tests for Aquatic Animals (Fifth Edition, 2006) have been used in the development of the SOPs. The SOPs complement national responsibilities under existing international standards for management of food safety and residues (for instance, Codex Alimentarius) and other environmental considerations (for instance, CITES).

The first step in developing the SOPs was to develop an inventory of countries' current practices in early 2006 and to hold a First Policy Workshop in Bangkok, Thailand in April 2006 at which all 10 ASEAN countries were represented. The workshop developed a draft Table of Contents for the SOPs and allocated tasks and selected the leaders and members of four working groups. ASEC and NACA briefed ASWGFi on progress at its meeting in Manila, the Philippines in June 2006. The leaders communicated with their group members to prepare for a leaders' workshop in Johor Bahru in September 2006 at which the first draft of the SOPs were developed. This draft was circulated to members of the work groups for consideration and comment and members of ASWGFi for information before a second policy workshop which was held in Cebu City in Philippines in February 2007 and agreed on the Final Draft SOPs. It is expected that the ASEC will place it before the ASWGFi for formal review and endorsement.

These SOPs are a set of documents for health certification and quarantine measures to be used by CA for the responsible movement of LFF by land, sea and air among ASEAN Member Countries. The SOPs recognise the existing variation in capacity among ASEAN Member Countries but the SOPs have been designed so that they can be adopted and implemented within the specific policy and legal framework of each country. These SOPs have been written to help manage the movement of LFF for immediate consumption as human food.

Information and capacity requirements for maintaining aquatic animal biosecurity identified

FAO and NACA in collaboration with BFAR, Philippines organized a three day workshop on Information Requirements for Maintaining Aquatic Animal Biosecurity from 15-17 February 2007, in Park Lane Hotel, Cebu City, Philippines. The objective of the workshop was to increase awareness and build capacity on general principles of biosecurity and to deliberate on key information required for maintaining aquatic animal biosecurity focusing on aspects of risk analysis; diagnostics, health certification and quarantine; and epidemiological surveillance and reporting. The workshop was attended by fourteen delegates from seven ASEAN countries, four delegates from SAARC, one from China and twelve delegates from local host institution BFAR. Resource persons from FAO, AusVet, NACA and SEAFDEC participated in the workshop.

In brief, the workshop involved presentation of resource papers (a) General principles of Biosecurity (b) General principles of diagnostics, health certification and quarantine (c) general principles of risk analysis and (4) Principles of epidemiological surveillance and reporting by resource experts. Following resource paper presentations and general discussions, the participants worked in three working groups on the following themes:

- Risk analysis.
- Diagnosis, health certification and quarantine.
- Surveillance and reporting.

Guidelines for the working group were provided and resource experts facilitated the working group discussions and assisted the groups to come up with a list of key information and capacity building requirements for practical implementation of the three identified themes. The working group findings were presented at the plenary session, reviewed, and discussed by participants and resource persons.

Participating countries were pleased with the outcomes and were of the opinion that the information and capacity building requirements identified in the workshop would enable them to initiate specific actions to implement programs in some of the identified thematic areas. A final workshop report is being prepared by FAO and NACA and will include recommendations for implementation of workshop findings.

China-ASEAN efforts to minimize risk of spread of aquatic pathogens

The General Administration of Quality Supervision, Inspection and Quarantine of the P.R. China (AQSIQ) organized the "China-ASEAN Symposium on import and export aquatic animal safety" from 1-2 March 2007 at Grand Hotel, Kylin Villa, Shenzen. The Shenzen Entry-Exit Inspection and Quarantine Bureau of the PR China (SZCIQ) co-sponsored the event. The objective of the symposium was to strengthen China-ASEAN cooperation in aquatic animal inspection and quarantine, and facilitate aquatic animal trade between China-ASEAN. The symposium was attended by government nominated representatives from nine ASEAN countries, representatives from Macao; Hong Kong; representatives from key provinces in China (Yunnan CIQ; Hainan CIQ; Guangxi CIQ; Hubei CIQ; Zhejiang CIQ; Jiangsu CIQ; Beijing CIQ; Shanghai CIQ; Xiamen CIQ; Fujian CIQ; Liaoning CIQ; Jinan CIQ; Shenzen CIQ; Zhuhai CIQ; Tianjin CIQ; Guangdong CIQ), and representatives from key national institutions (Department of Animal and Plant Supervision and Quarantine,-AQSIQ; Department of International Cooperation-AQSIQ; The National Fishery Technical Extension Center-MOA; Division of Aquaculture, Bureau of Fisheries-MOA; Zhejiang Freshwater Aquaculture Institute).

The Symposium was formally opened by Dr You Zhongming, Director from the Department of Animal and Plant Quarantine Supervision, AQSIQ. In his opening remarks he highlighted the increasing trade in live aquatic animals and their products between China and ASEAN and stressed the need for better health management to minimize the risk of spread of trans-boundary pathogens. The need for developing and adopting harmonized approaches in inspection, certification and quarantine, amongst trading partners was recognized as important to promote trade. Welcome speech was given by Mr Qu Haifeng, Deputy Director General from Shenzen CIQ.

Dr You Zhongming, Director Biosecurity Chaired the technical sessions. The key note presentation titled "Trade in aquatic animals: tools to minimize aquatic animal health risks" was delivered by CV Mohan of NACA. The presentation dealt in detail various guidance (international agreements and standards; regional agreements, technical guidelines and SOPs; national strategies; farm level strategies) and implementation tools (diagnostics; risk analysis; health certification; quarantine; surveillance and reporting; contingency planning; farm level disease control strategies) available to minimize the aquatic animal health risks, which are an inherent part of aquaculture and trade.

Three important presentations from China (a) Control of aquatic animal diseases in China by Prof Jiang Yulin from the Key lab of Aquatic animal diseases, Shenzen CIQ, (b) Aquatic animal epidemic prevention in China by Dr Chen Jiayong, Bureau of Fisheries, MOA and (c) Introduction on inspection and quarantine of import and export of aquatic animal in China by Dr You Zhongming, AQSIQ, provided very useful information to workshop participants. The General Administration of Quality Supervision, Inspection and Quarantine of the P.R. China (AQSIQ) is a ministerial administrative organ directly under the state Council of the PR China in charge of national quality, entry-exit commodity inspection, entry-exit health quarantine, entry-exit animal and plant quarantine, import-export food safety, certification and accreditation, standardization as well as administrative law enforcement. AQSIQ has set up 35 entry-exit inspection and quarantine bureaus (CIQ) in China's 31 provinces, near 300 branches, and more than 200 local offices across the country with employees over 30,000 at sea ports, land ports and airports.

Representatives from six ASEAN countries (Singapore, Thailand, Vietnam, Philippines, Indonesia, Malaysia) provided overviews of Quarantine and disease control systems for import and export of aquatic animals and their products in their respective countries. The symposium provided an excellent opportunity for delegates from China and ASEAN to exchange information, understand each others inspection and quarantine system, discuss issues that affect trade and identify areas that need future collaboration and cooperation.

As a symposium outcome, the delegates produced a resolution calling for further strengthening the cooperation between China and ASEAN and identified some key areas. The workshop agreed that the resolution would be submitted to MOA, PR China and ASEAN Secretariat for initiating some follow up actions.

INDAQUA 2007 in Chennai, India

NACA was well represented at the INDAQUA 2007 meeting held in Chennai, India from 11-13 January. More than 600 participants attended, comprising planners, developers, private sector representatives and most of all farmers. The primary focus of the meeting was on shrimp culture. In particular, the meeting showcased the improvements that have been brought about through the adoption of Better Management Practices (BMPs), especially to small-scale farmers, with the Marine Products Export Development Authority (MPEDA) and NACA jointly organizing a special session to present the latest results from the MPEDA village demonstration programme, information on the newly established NACSA (National Centre for Sustainable Aquaculture), and experiences in BMP implementation from Indonesia and Thailand.

In addition to shrimp farming, Indaqua 2007 also dealt with common issues such as species selection, risk assessment related to species introduction and market development. The increasing importance of organic aquaculture was exemplified by MPEDA entering an agreement with a Swiss food importer.

The presentations from the session are available in PDF format from the publication section of the NACA website:

http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=71&lid=788.

National Centre for Sustainable Aquaculture inaugurated

The National Centre for Sustainable Aquaculture (NaCSA), the first of its kind in India, was inaugurated in Kakinada on the 3rd March 2007 with an impressive line up of senior Indian government officials. The Union Minister of State for Commerce Jairam Ramesh inaugurated the centre, saying it would pave the way for empowerment of farmers by extending necessary extension services and keeping them abreast with latest advancements in the field. The Union Minister of State for Defence Pallamraju, who presided over the programme, stressed the need for adopting scientific farming techniques so as to achieve better production and earn good profits.

The new centre, an outcome of the recent MPEDA/NACA cooperative project on shrimp disease control and promotion of better management practices, is registered as a Society under the Society Registration Act of Andhra Pradesh. NaCSA's Headquarters are at Kakinada, with Regional Units planned in various coastal States.

The long term objective of NaCSA as stated in the newly released NaCSA brochure for sustainable aquaculture is "to enable aquaculture farmers to adopt sustainable and environmentally friendly farming practices to produce quality and safe aquatic products such as shrimps, scampi and fish for export and domestic markets". NaCSA is intended to facilitate links between aquaculture stakeholders and strengthen aquaculture farmers to organize into self-help groups, or farmer societies. The approach, a pioneering one in the region, is intended to strengthen farmers problem solving, planning and management abilities and the capacity of farmers to adopt and develop new and appropriate technologies/innovations. NaCSA's main objectives are:

i. Promoting better management practices to improve aquaculture productivity and profits.
ii. Capacity-building and empowerment of primary producers and improving services.
iii. Facilitating improved service provision.
iv. Connecting farmers to markets to receive a better price for quality product.
v. Technology transfer and diversification to other commercially important species.
vi. Supporting improved food security and sustainable livelihoods in aquaculture communities.

The MPEDA/NACA project team outside the new Centre in Kakinada.

The inauguration also included a distribution of Registration certificates to six MPEDA registered societies and release of the NaCSA brochure for Sustainable Aquaculture.

The MPEDA Chairman G. Mohan Kumar, Collector M. Subrahmanyam, Commissioner of Fisheries N. Narasimha Rao, Dr Michael Phillips of NACA Deputy Director-General, ICAR, S. Ayyappan, former ADG, World Fish Centre, M. Vijaya Guptha, MLAs - M Gopalakrishna and A. Bulleabbai Reddy also participated in the ceremony. Also present were a number of pioneering farmer societies, formed under the MPEDA/NACA project, members of the Andhra Pradesh Shrimp Farmers Association, Seafood Exporters Association of India and All India Shrimp Hatchery Association representative.

NACA Better Management Practices program expands in Indonesia

In cooperation with WWF, a new partnership was established on 17 March with aquaculture farmers in Mesjid Utue village, Pidie district of Aceh, Indonesia. The partnership will assist 70 villagers to implement a set of "better management practices" developed for the shrimp and milkfish farming systems in this tsunami affected village of Aceh. NACA and WWF, supported by a grant from the David and Lucile Packard Foundation, will provide technical assistance to the villagers to adopt a set of better management practices designed to enhance farm sustainability, reduce shrimp disease risk and improve shrimp quality and profits. Some support for provision of key quality pond inputs is also provided. The BMPs were developed through a participatory process involving village farmers, NACA and WWF and their implementation will be supported by two locally recruited and trained Acehnese aquaculture and community mobilization specialists, linked to the small but growing NACA network of BMP specialists and farmers across Asia.

Market studies supported through the David and Lucile Packard Foundation grant, showed considerable buyer interest in the high quality "udang windu" or Penaeus monodon, of Aceh and further efforts will be made during 2007 to "connect" farmers with markets for high quality Acehnese shrimp. Whilst the extended and fragmented market chains, and lack of many essential services, are significant challenges, successful "connection" could bring substantial benefits to Acehnese aquafarmers, providing both incentives for better management of aquaculture and improved farmer incomes from sale of quality product to premium markets.

NACA is contracted by the Asian Development Bank to support implementation of the "Earthquake and Tsunami Emergency Assistance Project", for rehabilitation and reconstruction of aquaculture and fisheries sector in Aceh and Nias. NACA also works with a number of national and international partners, including ACIAR, ADB, BRR, FAO, GTZ, IFC, MMAF and WWF, to support responsible rehabilitation and better management of aquaculture in Aceh and Nias.

Manual on Application of Molecular Tools in Aquaculture and Inland Fisheries Management

NACA is pleased to announce the release of a new manual on the application of molecular tools in aquaculture and inland fisheries management. The aim of the manual is to provide a comprehensive, practical tool for the generation and analysis of genetic data for subsequent application in aquatic resources management, in relation to genetic stock identification in inland fisheries and aquaculture. The material provides a general background on genetics in relation to aquaculture and fisheries resource management, the techniques and relevant methods of data analysis that are commonly used to address questions relating to genetic resource characterisation and population genetic analyses. The manual is available for free download from the links below.

The manual includes two 'standalone' parts: Part 1 - Conceptual Basis of Population Genetic Approaches provides a basic foundation on genetics in general and concepts of population genetics. Issues on the choice of molecular markers and project design are also discussed. Part 2 - Laboratory Protocols, Data Management and Analysis provides step-by-step protocols of the most commonly used molecular genetic techniques utilised in population genetics and systematic studies. In addition, a brief discussion and explanation of how these data are managed is also included.

This manual is expected to enable NACA member country personnel to be trained to undertake molecular genetic studies in their own institutions, and as such is aimed at middle and higher level technical grades. The manual can also provide useful teaching material for specialised advanced level university courses in the region and postgraduate students. The manual has gone through two development/improvement stages. The initial material was tested at a regional workshop and at the second stage feedback from participants was used to imprve the contents.

The manual was co-written by NACA's Dr Thuy Nguyen; Dr David Hurwood and Associate Prof. Peter Mather from the Queensland University of Technology, Australia; Prof. Uthairat Na-Nakorn from Kasetsart University, Thailand; Dr Wongpathom Kamonrat, Department of Fisheries, Thailand and Dr Devin Bartley, FAO. Financial support for publication of the manual was provided by FAO and the Mekong River Commission.

Part 1 available from:

- http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=63&lid=799.

Part 2 available from:

- http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=63&lid=800.

For more information about the manual please contact thuy.nguyen@enaca.org.

Please see the NACA website for these and many more great aquaculture publications, **www.enaca.org**.

Research Needs to Sustain Asia-Pacific Aquaculture to 2025 and Beyond

Arrangements have been finalized by NACA to hold a workshop on the "Research Needs to Sustain Asia-Pacific Aquaculture to Year 2025 and Beyond", at Rayong, Thailand, 4-7 June 2007, with funding support from the International Development Research center, Canada (IDRC). The workshop is essentially a brainstorming session that will bring together 25 to 30 leading aquaculturists from the region. Some of the issues that will be addressed are:

- Background material on predicted population and relevant demographic changes and consumer demand for aquatic foods.
- Investment in fishery/aquaculture research; potential changes in trade; impacts on these on socio-economic aspects and livelihoods and required policy changes.
- Effect of climate change including monsoonal rain patterns on aquaculture, breeding and reproduction.
- Aquaculture resource demands including water, space, and biological resources such as fish meal/ fish oil.
- Events such as "bird flu'/new diseases and other potential non-fish pathogens on aquaculture.
- Poverty and employment changes in relation to aquaculture; rural, urban, large scale.
- Role of GMOs on aquaculture usage and ethical issues in the region.
- Application of gene technology in aquaculture.
- Aquaculture impacts on biodiversity; alien species; what are the strategies Changes in polyculture technology?
- Tilapia culture; lessons learnt from the Philippines in relation to rural development.
- GIFT: lessons learnt.
- Giant freshwater prawn - successes in Thailand.

For further details contact: sena.desilva@enaca.org.

Network of Aquaculture Centres in Asia-Pacific

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

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

NACA is a network composed of 17 member governments in the Asia-Pacific Region.

SOME RIGHTS RESERVED

Copyright NACA 2007.
Published under a Creative Commons Attribution license. You may copy and distribute this publication with attribution of NACA as the original source.

Endemic freshwater finfish of Asia: Distribution and conservation status

This article has been published in Diversity and Distributions (2007) 13, 172–184.

Sena S. De Silva, Nigel W. Abery and Thuy T. T. Nguyen

Keywords: Asia, native species richness, endemic species, river basins, conservation status, habitat.

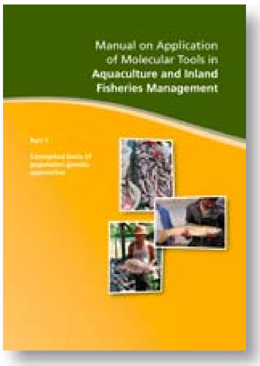
Abstract: Freshwater finfish species richness and level of endemism in East, and South and South-East Asia that included 17 nations were studied using available databases, and included nation-wise distribution, habitat types, and conservation status. The number of endemic finfish species in the region was 559, belonging to 47 families. Families Cyprinidae and Balitoridae accounted for 43.5% and 16.2% of the total number of endemic species in the region, respectively, followed by Sisoridae (25), Gobiidae (20), Melanotaeniidae (19), and Bagridae (16), and the other 41 families had at least one endemic species. Nation-wise the most number of endemic freshwater finfish species occur in India (191), followed by China (88), Indonesia (84), and Myanmar (60). In India, the endemic species accounted for 26.4% of the native freshwater fish fauna, followed by South Korea (16.9%), the Philippines, (16.3%) and Myanmar (15.7%).

Statistically significant relationships discerned between the number of indigenous and endemic species richness to land area (Xla in 103 km^2) of the nations in the region were, Yin = 218.961 Ln(Xla) – 843.1 (R2 = 0.735; P < 0.001) and Ye = 28.445 Ln Xla - 134.47 (R2 = 0.534; P < 0.01), respectively, and between indigenous and endemic species richness was Ye = 0.079Xn - 1.558 (R2 = 0.235; P < 0.05).

The overall conservation status of endemic finfish in Asia was satisfactory in that only 92 species were in some state of vulnerability, of which 37 species (6.6%) are endangered or critically endangered. However, the bulk of these species (83.7%) were cave- and or lake-dwelling fish. However, nation-wise, the endemic freshwater finfish fauna of the Philippines and Sri Lanka, based on the imperilment index, were found to be in a highly vulnerable state. Among river basins, the Mekong Basin had the highest number of endemic species (31.3%). The discrepancies between databases are highlighted and the need to consolidate information among databases is discussed. It is suggested that the Mekong Basin be considered as a biodiversity hotspot, and appropriate management strategies be introduced in this regard.

For full content of the article, email: thuy.nguyen@enaca.org.

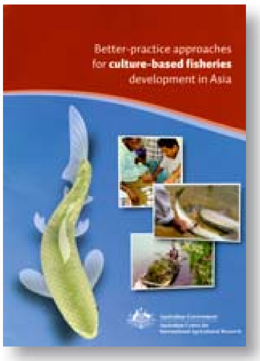
NACA Bookshelf: Highlighted publications



Manual on the Application of Molecular Tools in Aquaculture and Inland Fisheries Management

The aim of this manual is to provide a comprehensive practical tool for the generation and analysis of genetic data for subsequent application in aquatic resources management in relation to genetic stock identification in inland fisheries and aquaculture. It provides general background on genetics in relation to aquaculture and fisheries resource management, the techniques and relevant methods of data analysis that are commonly used to address questions relating to genetic resource characterisation and population genetic analyses. Published in two parts, the first dealing with concepts, and the second lab protocols:

- **Download Part 1**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=63&lid=799
- **Download Part 2**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=63&lid=800



Better-practice approaches for culture based fisheries development in Asia

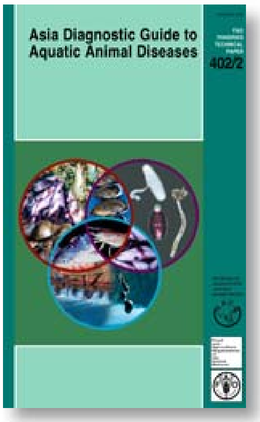
The primary objective of this manual is to provide guidelines for attaining better practices in culture-based fisheries, an emerging practice in rural areas in the Asian region. It deals will the principles of culture-based fishery practices, primarily based on relatively long-term experiences in Sri Lanka and Vietnam. It is not only targeted at researchers per se, but also at stakeholders at the grass root levels, as well as planners and policy developers, particularly those of Asian nations embarking on culture-based fisheries as a strategy to enhance fish food production in rural areas. The manual is divided into two parts: Part 1 provides general information on what is called 'better-practice approaches' to culture-based fisheries; and Part 2 provides experiences from Sri Lanka and Vietnam and includes a marketing study.

- **Download**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=3&lid=709

A guide to small-scale marine finfish hatchery technology

Recent improvements in hatchery production technology for high-value marine finfish species such as groupers have led to an increased interest in setting up hatcheries to produce fingerlings for aquaculture. Small-scale hatcheries make this technology available to poor people in developing countries. Capital costs for small-scale hatcheries are relatively low, and the profitability of these ventures ensures rapid payback of capital investment. This guide provides an outline of the requirements to establish a small-scale marine finfish hatchery, particularly the economic aspects. It is intended to provide sufficient information for potential investors to decide whether investment in such ventures is appropriate for them.

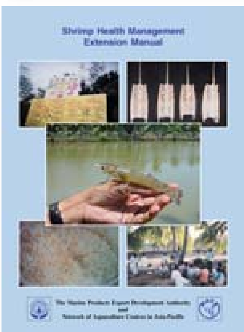
- **Download**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=75&lid=582



Asia Diagnostic Guide to Aquatic Animal Diseases

Simply the most comprehensive aquatic disease guide ever published in the region, and the single most popular NACA publication ever! With contributions from recognised experts in the field from all over the world, the guide covers economically significant diseases of molluscs, fish and crustaceans. Contains information on laboratory and diagnostic techniques, causative agents and distribution, host range, clinical aspects, screening methods, diagnostic procedures, modes of transmission, control measures. The guide includes contact details for technical support services throughout the region and national health coordinators. It is an important supporting document for the Technical Guidelines on the Responsible Movement of Live Aquatic Animals. 237 pages.

- **Download**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=10&lid=7



Shrimp health management extension manual

This extension manual summarizes farm level risk factors and practical management practices that can be used to reduce risks of shrimp disease outbreaks and improve farm production. The recommendations are based on a study conducted in Andhra Pradesh, India. The publication is therefore of particular relevance to Andhra Pradesh, but many recommendations are still of use to farmers from other areas. The study was conducted by NACA, MPEDA, the Aquatic Animal Health Research Institute (Thailand), Siam Natural Resources and AusVet Animal Health Services and ACIAR. (1MB, 46 pages)

- **Download**: http://www.enaca.org/modules/wfdownloads/singlefile.php?cid=10&lid=55