ISSN 0859-600X

Volume IX No. 2 April-June 2004

AQUACULTURE ASIA

New Marine Finfish Aquaculture Magazine!

All-male Macrobrachium culture in India

Opportunities in Myanmar aquaculture

Koi herpes virus and transboundary diseases

Now available on CD-ROM!

Carp culture in Iran

HACCP in shrimp culture

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

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

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

Printed by Scand-Media Co., Ltd.

AQUACULTURE ASIA

Volume IX No. 2 **ISSN 0859-600X**
April-June 2004

From the Editor's desk

Asia-Pacific Marine Finfish Aquaculture Magazine

As of this issue the marine finfish section has been revised and expanded into a small magazine in its own right, the *Asia-Pacific Marine Finfish Aquaculture Magazine*, produced quarterly. The hard-copy version will be printed as part of Aquaculture Asia, and a stand-alone electronic version is available for download from the NACA website. This is a natural progression of the highly successful MFAN electronic newsletter, coordinated by NACA in cooperation with ACIAR, APEC, the Queensland DPI&F, and SEAFDEC Aquaculture Department. It builds on and supplements the regular Marine Finfish Aquaculture Network e-news service, which is now also circulated with greater frequency (fortnightly).

Contributions to the magazine are most welcome. If you are involved in marine finfish aquaculture and have some research findings or perhaps some hot hands-on farming tips then please write them down!

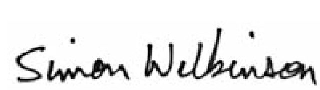
Regular visitors to the website may have noticed the 'Marine finfish photos' link in the Databases & services section, which leads to an online collection of high-quality photographs. We are always on the lookout for more, particularly for clear "specimen" shots of different species that can be used for identification purposes, and culture systems. Please help us put a good collection together - if you have any photographs you would like to share with the network please send them in. All contributions to the Marine Finfish Aquaculture Network should be sent to sim@enaca.org.

With regards to Aquaculture Asia Magazine itself, we have recently added a 'Magazine' section to the website as a further alternative means of access (this magazine is now circulated in print, on CD, and online in html and PDF formats). The Magazine section contains all of the feature articles in html format, so you can simply click and view them in your browser. Down at the bottom of each story you will also find two useful buttons: 'Printer friendly page', so you can generate your own hard copy if you wish, and 'Email to friend', which speaks for itself. The website is updated in real time with new articles added as soon as they are edited, so check it out from time to time for the latest stories.

Lastly, we are expanding both our magazine and website coverage to include ornamental fish and genetics. In order to kick off these new sections we need high-quality articles and regular contributions of news stories, market prices and industry gossip !

If you would like to contribute to either of these sections please contact me at simon.wilkinson@enaca.org. We that request prospective authors please refer to our Guidelines for Contributors before making a submission. You can email me to request a copy, or download them directly from the website at:

http://www.enaca.org/modules/mydownloads/viewcat.php?cid=83



AQUACULTURE ASIA

In this issue

Page 8

Page 12

Page 15

Page 27

Page 37

I.R. Iran and NACA

Pedro Bueno is the Director-General of NACA. He is the former Editor of Aquaculture Asia

We would like to announce the membership of and warmly welcome the Islamic Republic of Iran to the NACA Organization. The Governing Council unanimously accepted I.R. Iran's application – made through the Office of the FAO Director General in accordance with the provisions of the NACA Agreement - during its 15th Meeting, held in Colombo and Kandy, Sri Lanka in on 21-25 April 2004.

Iran first had official contacts with NACA in 1992: Attendance in the First Technical Advisory Committee Meeting in Hat Yai, Thailand and the 4th Governing Council Meeting held in Hong Kong. The delegation was led by then Vice Minister for Jehad-e-Sezandegui, the Hon. Lahijanian, who told the Council of the desire of Iran to join NACA as a member. An immediate offshoot of this was the visit, on the invitation and hosting of Iran, of a NACA Team consisting of then NACA Coordinator Dr Banchong Tiensongrusmee, India's Governing Council Member Dr P.V. Dehadrai, and the NACA Information Specialist to identify areas for cooperation.

Following these initial official contacts, Iran requested NACA to organize several training and study tour programmes for their professional and technical personnel in a number of areas including shrimp hatchery and pond culture management (in Thailand and the Philippines) and Indian major carp breeding and culture (in India), as well as continuing participation in the integrated farming course in Wuxi, China. (I was at the opening ceremony with other NACA and FAO and IDRC representatives, and represented the NACA Coordinator as the closing speaker for the 1988 IFF course in which 18 Iranians were among 39 graduates). A number of the participants have gone on to pursue graduate studies, and many have subsequently taken up managerial posts in various field offices of SHILAT (Iranian Fisheries Company). NACA also arranged visits of experts on shrimp and freshwater prawn to Iran. There have also been instances when NACA identified for the private aquaculture sector of Iran suitable consultants for their projects.

It had taken time to complete the accession but the Government, following the initial contacts, continued to actively and responsibly take part in a number of regional projects under NACA as well as participate in all but one Governing Council Meeting since 1992 and all seven the Technical Advisory Committee Meetings so far.

Indonesia confirms

At the same meeting, the Government of Indonesia through its Foreign Ministry, confirmed the Government's decision to accede to the NACA Agreement. The announcement was made at the Governing Council Meeting by an official of the Embassy of the S.R. of Sri Lanka in Jakarta. Since the NACA project years from 1980 to 1989, Indonesia had been an active participant in all the core activities and projects. It hosted the 7th Technical Advisory Committee Meeting, held in Bali in July 2003. A regular course on grouper culture, as a component of the Asia-Pacific Marine Fish R and D Program - has been instituted at the Gondol Research Institute for Mariculture in Bali. During the period when NACA was funded by UNDP and operated by FAO, Indonesia voluntarily contributed a yearly sum to NACA; after autonomy, it continued with this yearly contribution.

Also taking part for the first time as observer at GC 15 was the Sultanate of Oman represented by its Fisheries Director General Dr. Younis Khalfan Al-Akhzami. Dr Younis mentioned possible areas of cooperation and said that Oman will study the possibility of their participating in NACA.

Way to go for Sri Lankan aquaculture

Preceding the 15th Governing Council Meeting was the Third AquaBusiness Seminar with the theme "Aquaculture for Rural Development: Way to Go for Sri Lanka". It was organized by NAQDA and the Fisheries Ministry with the cooperation of the private sector, and the assistance of NACA. More than 150 people participated including the Council Meeting delegates. The two-day seminar discussed technical, environmental and social issues related to aquaculture and aquatic resources management. The resource persons were from NAQDA, NARA, Fisheries Ministry, the universities, and were complemented by experts from the Governing Council, the NACA Secretariat, STREAM Initiative, the NACA Regional Lead Centres, and others who have been "sourced" out by NACA, particularly the expert on ornamental fish from Prague (Dr.Petr Pozel), who stayed on to provide advice to farmers and to NAQDA. A presentation on the principles and prospects for certification of harvested as well as bred marine ornamental animals was also contributed by Paul Holthuis of the Hawaii-based Marine Aquarium Council.

Topical issues in genetic diversity and breeding

Genes and Fish

Genetic impacts of translocations on biodiversity of aquatic species with particular reference to Asian countries

Thuy T. T. Nguyen[1] and Uthairat Na-Nakorn[2]

1. Network of Aquaculture in Asia-Pacific, Bangkok, Thailand
2. Department of Aquaculture, Faculty of Fisheries, Kasetsart University, Thailand

Thuy Nguyen graduated from Nhatrang Fisheries University, Vietnam, in 1995 in aquaculture and proceeded to complete her Diploma and Masters in Aquaculture (1999) at Deakin University, Australia. Thuy obtained her PhD from Deakin in molecular genetics in 2003. Her particular interest is using molecular genetics markers to addressing questions relating to phylogenetics, phylogeography and population genetics. Currently she holds the position of Research Associate in NACA and is responsible for developing programs on application of genetics in biodiversity issues related to inland fisheries management and aquaculture in the region.

Long term damage could result to aquaculture and to fisheries when translocations (or transfers or introductions) of aquatic species are haphazard. This article by Dr Nguyen T. T. Thuy and Professor Uthairat Na-Nakorn, explores some past and potential influences on the genetic diversity of aquatic fauna from translocations, focusing on genetic interactions that could be brought about. Some 30 years ago, Dr T.V.R. Pillay suggested that the era of haphazard translocations was over and that any future translocations will be better planned and evaluated. This has not yet happened; many nations and countries, signatories to international conventions included, continue to indulge in translocation of aquatic species for aquaculture and the pet trade, often based on the narrow objective of increasing production.

Fish species translocations, inadvertently or otherwise, have been taking place ever since humans started large-scale migrations. Most major human migrations were associated with movement of plants and animals that were familiar to the migrating communities. In the modern era, translocations of fish and other aquatic animals (as well as plants) has become more deliberate, carried out mainly for purposes of food production, as pets or for ornamental value, and even for control of noxious weeds and the like (Welcomme 1988). In addition to apparently purposeful translocations, unintentional and accidental translocations occurred and continue to be so even today. A major problem facing most maritime countries is translocations or accidental introductions associated with the discharge of ballast water, which is a subject on its own right (Crossman and Cudmore 2000)

Translocation is defined as the transfer of an organism, by human agency, from one place to another (Hodder and Bullock 1997). A number of synonyms are also commonly used, these being “introduction” or “transfer”. Translocation therefore includes the introduction of species into areas where they did not previously exist, and the movement of individuals or populations from one locality to another within the natural distributional range of the species (Doupé and Lymbery, 2000). The introduced species/populations are then referred to as exotic or alien species/populations. The use of the term “alien” came into prominence since its adoption by the Convention on Biological Diversity (CBD) (Convention on Biological Diversity, 1994), and is the preferred term of some international and national agencies.

The bulk of translocations of aquatic species have been primarily associated with fish food production. The overall success of such translocations as well as the impacts of translocations on native fauna have been reviewed by Welcomme (1988) and De Silva (1989). In general, most of these translocations have been a post World War I phenomenon and have been associated with aquaculture development in the world and the commercial pet trade. In 1977, Pillay suggested that the era of haphazard translocations was over and that any future translocations will be better planned and evaluated. This is still a long way from being realised; many nations, even though they are signatories to international conventions, continue to indulge in translocation of aquatic species for aquaculture and the pet trade often based on the narrow objective of increasing production.

In general, analyses and evaluations of translocation have been confined to direct, visible affects on the diversity of native flora and fauna. These include specific influences on the status of individual native species such as whether an alien species/populations has affected the vulnerability of a species or a flock of species, such as for example the effects of the introduction of Nile perch (*Lates niloticus*) on the Haplochrominid cichlid species in Lake Victoria, Africa (Leveque, 1995). In addition, disease and parasite transmission associated with translocations also have been well documented (Dobson and May, 1986) and indeed in the recent times this aspect has been given much prominence particularly in respect of disease transmission associated with the shrimp aquaculture industry (Bondad-Reantaso, 2004). On the other hand, relatively unnoticed and paid scant attention to are the effects of translocations on the genetic make up of indigenous species/populations.

This article explores and documents some past and potential influences on the genetic diversity of the aquatic fauna, with particular reference to Asian countries, as wherever appropriate, resulting from translocations. It makes no attempt to evaluate ecological impacts of introductions apart from indirect genetic impacts on the native gene pools. Although generally not evaluated, in some areas these aspects have been dealt with (eg. Beverton, 1992; De Silva et al., 2004; Guerrero, 1999; Kudhongania et al., 1992; Welcomme and Vidthayanon, 2003, amongst others). The major focus here will be on genetic interactions that could be brought about through translocations.

Potential genetic effects of translocations

Genetically, translocations can be considered in two ways: (1) the introduction of an entirely new species into a new location/habitat, and (2) the introduction of new populations/strains of species already present in that locality. The former is relatively easy to detect and the effects are generally more obvious (Beverton, 1992; Kudhongania et al., 1992; Welcomme and Vidthayanon, 2003). In contrast, the latter event is often difficult to recognise due to the lack of morphological differentiation between populations/strains within species. Also, more often than not, genetic data regarding population structure prior to translocations are not available and this makes it difficult, if not impossible, to conduct comparative studies on the changes brought about as a result of the translocation.

Introduction of exotic species/populations into a new environment can alter the genetic composition of the native fauna in many different ways. Direct effects include reduced genetic diversity and outbreeding depression by hybridisation/introgression, and indirect effects are those related to reduced population size and changes of selective pressure due to ecological interactions such as competition, predation and disease transmission (Waples, 1995). Domestication for aquaculture can alter allele frequencies and reduce genetic variation and therefore also contribute significantly to the modification of genetic composition of the native fauna if these stocks are released for stock enhancement and/or escape from aquaculture operations.

Hybridisation and introgression

Hybridisation is interbreeding of individuals from genetically distinct populations, regardless of the taxonomic status of such populations (Harrison, 1993). Introgression is gene flow between populations whose individuals hybridise, and occurs when hybrids backcross with one or both parental populations. Hybridisation, however, need not necessarily be accompanied by introgression. For example, offspring of hybrids might all be sterile. Introgression can also be unidirectional, with backcrossing with one parental population only, but hybridisation can pose a threat to small populations even if gene pools do not mix. Hybridisation and introgression can be especially problematic for rare species when they are forced to interact with more abundant and dominant ones.

An example of loss of diversity of native species due to massive introgression has been reported for a number of trout species in Western US watersheds (Allendorf and Leary, 1998; Dowling and Childs, 1992; Leary et al., 1993). For example, rainbow trout (*Oncorhynchus mykiss*) hybridise easily and extensively with threatened Apache trout (*O. apache*) and endangered Gila trout (*O. gilae*). Now it is known that 65% of Apache trout have rainbow trout alleles and one native population is completely composed of rainbow trout. Comparable molecular studies are also available from Northern Italy with regard to domestic forms of brown trout (*Salmo trutta*), as well as from Poland with regard to *Coregonus pele* that have affected the native *C. lavaretus* in about 70% of lakes.

Although Asia has experienced a large number of translocations of aquatic species since the World War I (Welcomme, 1988; De Silva, 1989; Welcomme and Vidthayanon, 2003), and it is the leading continent in aquaculture production in the world, there is very little information available on Asian fish species with regard to genetic effects arising from hybridisation and introgression. To date, there is only limited numbers of genetic studies in this regard. Based on diagnostic alleles at six allozyme loci and one microsatellite locus, the study by Senanan et al. (2004) demonstrated that introgression of African catfish (*Clarias gariepinus*) genes into native *C. macrocephalus* has occurred in four wild and two broodstock populations in central part of Thailand. Later, Na-Nakorn et al. (2004) reported such introgression in 12 natural populations of *C. macrocephalus*; nine from Chaophraya river system, one from Mekong river system, two from the south; and a hatchery population. These observations indicate that the native gene pools of *C. macrocephalus* have been diluted and are threatened if no appropriate management strategies are undertaken. Similar problems may arise in Bangladesh through the use of hybrid *C. batrachus* x *C. gariepinus* for aquaculture (Rahman et al., 1995).

Hybridisation can also have a variety of effects on fitness of the resulting mixture of gene pools. Although hybridisation is known to produce heterosis this is more likely in the case of the two parental stocks that are not too different genetically. If genetic distance between the two parental stocks increases, genetic incompatibilities become more likely and fitness (usually in either fertility or viability) of hybrids declines (Waples, 1991). The assumption is that local adaptation leads to the possession by members of a population of a particular arrangement of alleles at different loci, called co-adapted gene complexes.

Hybridisation between two populations may lead to the breakdown of these complexes, resulting in reduced fitness. This effect has been demonstrated in pink salmon *Oncorhynchus gorbuscha* by Gharret and Smoker (1991) and little is known in the Asian context.

Indirect genetic effects

Any factors such as predation, competition and disease transmission from exotic species/populations can reduce population size of native species and would eventually lead to inbreeding and as a consequence result in loss of genetic diversity. Although inbreeding can only happen when the bottleneck is severe and lasts for many generations it has important long-term effects. In the short-term a significant reduction in population size can disrupt various demographic features of a population and may lead to extinction from severe perturbation in environmental conditions (Waples, 1991). One of the classic examples in this regards probably the introduction of the Nile perch, *Lates niloticus* into Lake Victoria in the 1950s. This introduction may have contributed to the extinction of up to 260 endemic fish species (Leveque, 1995).

In Asia, one of the worst documented negative effects on fish biodiversity has resulted from within country translocations, for example in Donghu Lake, Wuhan, China when the introduction of grass carp resulted in the decimation of submerged macrophytes and the consequent ecological changes brought about an upsurge of bighead (*Aristichthys nobilis*) and silver carps (*Hypophthalmichthys molitrix*) but also the disappearance of most of the 60 fish species native to the lake (Chen, 1989). The introduction of the Nile tilapia (*Oreochromis niloticus*) was also blamed to be the cause of the disappearance of the endemic species sinarapan (*Mistichthys luzonensis*) from Lake Buhi, Philippines (Gindelberger, 1981), although a recent analysis of the available evidence does not suggest so (De Silva et al., 2004). Also, there are anecdotal and unconfirmed evidence that tilapia (*O. mossambicus*) is a nuisance species in many countries. However, more recently, De Silva et al. (2004) evaluated the current status of tilapia introductions into the Asia-Pacific region and concluded that that there is no scientific evidence to confirm that tilapias have negatively influenced fish biodiversity in the region.

The presence of exotic species may also alter the genetic composition of native ones via the change in selective pressures, for example predation on certain phenotypes or competition on a certain kind of food. These changes are difficult to demonstrate. However, the potential for deleterious effects on native stocks is real and needs to be considered in the planning stages of any translocation events.

Effects of cultured stocks on wild populations

Genetic effects of translocations involving the movements of genetically distinct conspecific individuals, including the release/escape of cultured fish into wild populations have been well documented in the last decade, particularly in respect of salmonids in North America (Hindar et al., 1991). It is noted that the genetic make up of most cultured populations has often been altered through inbreeding, selective breeding, domestication and more recently through genetic modification such as transgenic (Beaumont and Hoare, 2003; Gjedrem et al., 1988) and all of these may affect gene pools of the corresponding wild populations.

When fish are removed from the natural environment and placed in a cultured environment, random genetic drift and domestication effects (new and greatly different selective forces act upon fish in the domestic environment compared to the natural environment) alter the gene frequencies and reduce genetic variation. Domestication reduces genetic variability in fish through both selective processes and random genetic drift.

One of the primary reasons for the large increases in Asian aquaculture production over the past two decades was the ready availability of artificially propagated seed stocks of major cultured species, such as of Chinese and Indian major carps, thereby enabling culture of these species to be independent of the wild seed supplies. The technical developments in artificial propagation led to the establishment of a specialised hatchery sector in the leading aquaculture production nations, include the establishment of backyard hatcheries that use simple technology but have been very successful. However, most of these hatcheries did not practise or rarely practised a turn over of the broodstock(s) from the wild. Poor management of breeding practices potentially lead to the reduction of genetic diversity of cultured stocks.

The limited number of studies available seems to indicate that extensive inbreeding has been occurring in hatchery-produced seed of major cultured species in Asia. Frequently, broodstock are derived from a small founding number and the number of broodstock kept is relatively small. In the Philippines, the commonly cultured “Israel” strain of Nile tilapia (*Oreochromis niloticus*), which is a major contributor to the annual production of over 90,000 tonnes, is derived from a single introduction of 100-200 fry, possibly from a single family, and this situation is similar in many countries in Asia (Pullin, 1988). Eknath and Doyle (1990) based on a study of 18 hatcheries in India demonstrated that there had been rapid inbreeding of stocks of six carp species (catla, rohu, mrigal, common carp, silver carp and grass carp). They estimated that the annual rate of inbreeding was from 2 to 17% per year. In a recent study by Deepak et al. (2004) the above observations were reinforced by a detailed analysis of hatchery stocks of three Indian major carp species. In Vietnam there is also evidence of inbreeding of grass carp. In a recent allozyme study on grass carp in Vietnam, collected from four major hatcheries, only one variable allozyme locus was observed out of 25 loci screened, thereby indicating low levels of genetic variability of the hatchery stocks (pers. obs.).

Increasing release of hatchery-bred individuals into the natural environment could bring about dilution of the native gene pools. In this regard, there appears to be emerging evidence in respect of Barbodes gonionotus in Thailand. A study of 12 natural populations and 29 hatchery stocks of *B. gonionotus* indicated that the natural variability was high (Kamonrat, 1996). Although there was high genetic variability within populations and significant genetic differentiation between populations of both wild and hatchery stocks there was evidence to indicate the possibility of loss or alteration of genetic integrity of both groups. For example, mixed stock sampling indicated that 75 to 96% of river samples were from hatchery populations, possibly resulting from consequences of restocking or stock enhancement programs. In this regard there was also evidence of reduction of genetic integrity between regions and it has been suggested that genetically based stock management policies are needed urgently.

Conclusion

It is clear that translocations have impacted on the aquatic fauna in Asia. The few studies done to date have provided significant warnings of the genetic effects of translocations of aquatic animals within the region. Any translocation event should be well planned with proper risk assessments. In the present context of development, ecology, disease aspects and management implementations that could arise from translocations need to be supplemented with genetic considerations of the particular translocation or stocking plan before embarking on a decision. In order to achieve this there is an urgent need to increase human capacity in molecular genetic techniques and their usage and application, and awareness building in the region on the issues discussed to help sustain the aquaculture industry and in aquatic resource management. Genetic information will provide an additional and a useful tool to ensure that environmental integrity and biodiversity are sustained in the long term.

Acknowledgements

TTTN would like to thank Pedro Bueno and Professor Sena De Silva for their corrections on an early draft of this manuscript. Special thanks to Dr. Devin Bartley for his advice on indirect genetic effects.

References

Allendorf, F.W., Leary, R.F., 1998. Conservation an distribution of genetic variation in a polytypic species, the cutthroat trout. Conservation Biology 2, 170-184.

Barel, C.D.N., Dorit, R., Greenwood, P.H., Fryer, G., Hughes, N., Jackson, P.B.N., Kawanabe, H., Lowe-McConnell, R.H., Nagoshi, M., Ribbink, A.J., Trewavas, E., Witte, F., Yamoka, K., 1985. Destruction of fisheries in Africa's lakes. Nature 315, 19- 20.

Beaumont, A.R., Hoare, K., 2003. Biotechnology and Genetics in Fisheries and Aquaculture. Blackwell Science, UK, 158 pp.

Beverton, R.J.H., 1992. Fish resources; threats and protection. Netherlands Journal of Zoology 42, 139-175.

Bondad-Reantaso, M. G., 2004. Trans-boundary aquatic animal diseases/pathogens. p. 9-12. In J. R. Arthur and M. G. Bondad-Reantaso (eds.). Capacity and Awareness Building on Import Risk Analysis for Aquatic Animals. Proceedings of the Workshops held 1-6 April 2002 in Bangkok, Thailand and 12-17 August 2002 in Mazatlan, Mexico. APEC FWG 01/2002, NACA, Bangkok.

Campton, D.E., Johnston, J.M., 1985. Electrophoretic evidence for a genetic admixture of native and nonnative rainbow trout in the Yakima River, Washington. Transaction of American Fisheries Society 114, 782-793.

Chen, H.D., 1989. Impact of aquaculture on the ecosystem of Donghu Lake, Wuhan.

Acta Hydribiologia Sinica 13: 359-368 (in Chinese).

Convention on Biological Diversity,1994. Text and annexes. Interim Secretariat for the Convention on Biological Diversity, Chatelaine, Switzerland. 34 pp.

Crossman, E.J., Cudmore, B.C., 2000. Summary of North American fish introductions through the ballast water vector. In: Nonindigenous Freshwater Organisms: Vectors, Biology and Impacts (eds. Claudi R, Leach JH), pp. 204-215. Lewis Publisher, United States of America.

Deepak, PK, Shrinivas, J., Sharada, MK, Indira, NK, Biradar, RS, Lakra WS. 2004 (Abstract only). Prediction of cumulative inbreeding rate in future generations of hatchery reared Indian major carps. Fourth World Fisheries Congress, Vancouver, 2nd - 6th May, 2004.

De Silva, S.S., 1989. Exotic organisms in Asia. Asian Fisheries Society, Manila, Phillipines, 154 pp.

De Silva, S.S., Subasinghe, R., Bartley, D., Lowther, A., 2004. Tilapias as exotics in the Asia-Pacific: a review. FAO Fisheries Technical Paper, 453, 000 pp.

Dobson, A.P., May, R.M., 1986. Disease and conservation. In: Soulé, M.E. (Ed.), Conservation Biology: The science of scarcity and diversity. Sinauer, Sunderland, MA, pp. 345-365.

Doupé, R.G., Lympery, A. J., 2000. Managing translocations of aquatic species. Aquaculture Research 31, 151-156

Dowling, T.E., Childs, M.R., 1992. Impact of hybridisation on a threatened trout of the Southwestern United States. Conservation Biology 6, 355-364.

Eknath, A.E., Doyle, R.W., 1990. Effective population size and rate of inbreeding in aquaculture of Indian major carps. Aquaculture 85, 293-305.

Gharret, A.J., Smoker, W.W., 1991. Two generations of hybrids between even- and odd-year pink salmon (*Oncorhynchus gorbuscha*): a test for outbreeding depression. Canadian Journal of Fisheries and Aquatic Science 48, 1744-1749.

Gindelberger, B., 1981. Why sinarapan almost disappeared from Lake Buhi. ICLARM Newsletter 4: 3-5.

Gjedrem, T., Gjerde, B., Refstie, T., 1988. A review of quatitative genetc research in salmonids at AKVAFORSK. In: Weir, B.S., Goodman, M.M., Elsen, E.J., Namkoong, G. (Eds.), Proceedings of the Second International Conference on Quantitative Genetics. Sinauer, Sunderland, MA, pp. 527-535.

Guerrero, R.D., 1999. Impacts of tilapia introductions on the endemic fishes in some Philippine lakes and reservoirs. In: van Densen, W.L.T., Morris, M.J. (Eds.), Fish and Fisheries of lakes and Reservoirs in Southeast Asia and Africa. Westbury Publishing, Otley, UK, pp. 151- 157.

Harrison, R.G., 1993. Hybrid Zones and the Evolutionary Process. Oxford University Press, New York.

Hindar, K., Ryman, N., Utter, F., 1991. Genetic effects of cultured fish on natural fish populations. Canadian Journal of Fisheries and Aquatic Science 48, 945-957.

Hodder, K.H., Bullock, J.M., 1997. Translocations of native species in the UK: Implications for biodiversity. Journal of Applied Ecology 34, 647-565.

Johnson, M.S., 2000. Measuring and interpreting genetic structure to minimise the genetic risks of translocations. Aquaculture Research 31, 133-143.

Kamonrat, W. (1996). Spatial Genetic Structure of Thai Silver Barb *Puntius gonionotus* (Bleeker) Population in Thailand. Ph.D. Thesis, Dalhousie University, Halifax, Canada.

Kudhongania, A.W., Twongo, T., Ogutu- Ohwayo, R., 1992. Impact of Nile perch on the fisheries of Lakes Victoria and Kyoga. Hydrobiologia 232, 1- 10.

Leary, R.F., Allendorf, F.W., Forbes, S.H., 1993. Conservation genetics of bull trout in the Columbia and Klamath River drainages. Conservation Biology 7, 856-865.

Leveque, C. 1995. Role and consequences of fish diversity in the functions of African freshwater system - a review. Aquatic Living Resource 8, 59-78.

Park, I.-S., Kim, J.-H., Cho, S.H., Kim, D.S., 2004. Sex differentiation and hormonal sex reversal in the bagrid catfish *Pseudobagrus fulvidraco* (Richardson). Aquaculture 232, 183-193.

Pillay, T.V.R., 1977. Planning of Aquaculture Development - An Introductory Guide. Fishing News Boks Ltd., England, 71 pp.

Pullin, R.S.V. (ed.) 1988. Tilapia Genetic Resources for Aquaculture. ICLARM Conference Proceedings 16, ICLARM, Manila, 108pp.

Rahman, M.A., Bhadra, A., Begum, N., Islam. M.S., Hussain, M.F., 1995. Production of hybrid vigor cross breeding between *Clarias batrachus* Lin. & *Clarias geriepinus* Bur. Aquaculture 138, 125-130.

Ryman, N., 1981. Conservation of genetic resources: experiences from the brown trout (*Salmo trutta*). In: Ryman, N. (Ed.), Fish gene pools. Ecological Bulletin, Stockholm, pp. 61-74.

Senanan, W., Kapuscinski, A.R., Na-Nakorn, U., Miller, L., 2004. Genetic impacts of hybrid catfish farming (*Clarias macrocephalus* x *C. gariepinus*) on native catfish populations in central Thailand. Aquaculture In press.

Waples, R.S., 1991. Genetic interactions between hatchery and wild salmonids: lessons from the Pacific Northwest. Canadian Journal of Fisheries and Aquatic Science 48, 124-133.

Welcomme, R.L., 1988. International introductions of inland aquatic species. FAO Technical Paper 213. 120 pp.

Welcomme, R.L., Vidthayanon, C., 2003. The impacts of introduction and stocking of exotic species in the Mekong basin and policies for their control. MRC Technical Paper. Mekong River Commission, Cambodia, 65 pp.

Carp culture in Iran

Hassan Salehi

Assistant Prof. of Iranian Fisheries Research Institute and the Vice President of Fisheries, Iran, No.250, West Fatemi, Tehran, Iran. Email h-salehi@iranfisheries.net

Carp culture is the most important fisheries subsector. This article provides a comprehensive overview of the industry, its structure, operations and economics

Kiosk for wholesale of fishery products and other agricultural produce, near Shilat, Tehran.

The culture of carp is an ancient activity, using a mixture of four species with different feeding habits: Plankton-consuming, herbivorous, malacivorous, and benthivorous. Carp is widely sold fresh, whole and in a range of value added forms. In Iran, warm-water fish farming is based on Chinese carps, namely common, silver, grass, and bighead carp. These carps are easy to breed in hatcheries in large numbers at little cost, and are distributed to farmers to grow out in ponds or open waters. The common carp and the three Chinese ones are often reared in polyculture. Since the 1970s carp farming has spread along the Caspian coast, with total carp production peaking at almost 54,000 tonnes in 2001. The structure of fish consumption has also changed resulting in expanded markets and growth in fish demand.

Iran is large and rapidly developing and its pattern of supply and demand may be expected to change markedly over coming years. The carp culture industry is currently the most important sub-sector of fisheries in Iran and its rapid development has attracted considerable attention in recent years. Iran covers an area of about 1.6 million square kilometres[1] and had a population of more than 66 million in 2003[2]. Since the end of the Iran-Iraq war in 1988, Iran has undergone a process of economic transition, changing from a government controlled military economy towards a more liberal and market oriented economic structure. Key factors contributing to the government's decision making have been the large population growth, unemployment rate, as well as the attempt to optimise management of the economy by privatisation. Other key social developments have been rapid urbanisation leading to more job opportunities, better living standards, higher literacy levels, growth of student numbers in universities, growth in the role of women in society (eg. the female literacy rate, 35% in 1979, has risen to 75% in 1995, and the number of female students in universities had increased to more than 55% by 2002) and better facilities in urban areas However, all of these key factors have also improved more recently in rural areas.

The characteristics of the carp farming industry in the four main fish farming provinces, Gilan, Mazandran, Golestan and Khuzestan are different. For almost 20 years, carp has been considered a subsistence food, particularly in Gilan, but also in Mazandran and Golestan, and is a preferred food item by a majority of people in these provinces. Carp culture initially developed in the Caspian area, with more than 95 % of farms, in Gilan 67% of farms are less than 1 ha and 95% are less than 5 ha, while in Mazandran and Golestan 59% of farms are less than 1 ha and 86% of farms less than 5 ha, and only 1% of farms in the Caspian Sea littoral are larger than 20 ha. In Khuzestan, more than 90% of farms are larger than 5 ha and 33% larger than 20 ha

Table1: Percentage share of number of farms in provinces and categories.

Province	**<1 ha**		**1 to 5 ha**		**5 to 20 ha**		**20< ha**		**Total**
	% p	**% c**	% p	**% c**	% p	**% c**	% p	**% c**	
Gilan	80	**67**	77	**28**	41	**4**	24	**1**	75
Mazandran and Golestan	20	**59**	22	**27**	32	**11**	26	**3**	22
Khuzestan	0	**0**	1	**9**	27	**58**	50	**33**	more than 3
Total	63		27		7		almost 3		100

% p: as % in province, % c: as % in categories, Sources: Salehi[3,8].

Table 2: Carp farming production in Iran, 1991-2000 (tonnes)

Year	1991	1993	1995	1997	1999	2000	% growth 1990-2000
CC	5502	4206	6561	5435	4600	7000	27
BhC	983	1052	1269	1360	1150	1500	53
SC	10019	12619	15228	16310	13800	17000	70
GC	3143	3155	3942	4078	3450	2000	-36
Total	19647	21032	27000	27183	23000	27500	40

CC: Common carp, BhC: Bighead carp, SC: Silver carp, GC: Grass carp

Source: FAO[9].

According to stocking density, carp systems can be distinguished, as:

- Extensive fish farming, where stocking density is generally low; with no supplementary feeding,
- Semi-intensive fish farming, where stocking density is higher, with better management and supplements of daily feed.

Carp culture

In 1970, Shilat (the fisheries organization of Iran) established a carp culture research station in Gilan province, while the first commercial facility for carp culture was established in 1969, supported by Romanian experts[3]. Since 1985 aquaculture has been developed mostly by private entrepreneurs and co-operatives. Small-scale trials are also being conducted by Shilat in cages and pens in the Anzali lagoon[4] and Dez reservoir. Iran has recently directed considerable effort to developing freshwater aquaculture and enhancing fish stocks in inland water-bodies[5]. In 2001, there were some 3,065 registered carp culture farms, with a total pond area of almost 9,493 ha. Warm-water fish production now includes several cyprinid species, raised either in monoculture or polyculture in earthen ponds or in open water bodies. Annual production figures for carp show large changes from year to year, although the trend over the last decade has been positive.

Hatchery production

Hatchery production is the main source of seed for both carp farming and culture-based fisheries. Production of carp fingerlings increased to 90 million pieces by 2001, of which only 15% is produced by Shilat. Hatchery production of carp species was started by Shilat, but Government policy encouraged the role of the private sector and in 2001, some 20 private hatcheries produced more than 85% of the carp seed. It is expected that eventually all hatchery production of carp fingerling will come from co-operatives and private farms.

Production systems and practices

Traditional fish farming in Iran was based on the European system and this was expanded in 1970 with the introduction of the Chinese carps, namely the grass, silver and bighead carp. The common carp and the Chinese carps are often reared in polyculture, although some farmers prefer to keep common carp in monoculture. After hatching, larvae are transferred to tanks and fed with diets of powdered yolk and powdered milk. When the larvae are about 8 days of age they are transferred from the hatchery to nursery ponds where they feed on natural food. Fry of 10 g size are usually transported for release into water-bodies, or grown to market size on fish farms. Recently, both public and private hatchery operators have been testing the traditional Chinese technique. This avoids all handling of the spawning adults until the eggs are ready for transfer to the hatchery or, in some cases, the eggs hatch and the larvae remain in the tanks until transfer to nursery ponds[3].

Table 3: Production in open water-bodies (culture-based fisheries) in key provinces, 1991-2001 (tonnes)

Year	1991	1993	1995	1997	1999	2001	% share in 1995	% share in 2001
Khuzestan	9119	6019	2830	12000	4309	200	11	0.8
Gilan	6689	2164	1445	1360	1029	1270	6	4.8
Mazandran and Golestan	1958	3813	8975	10060	9518	15700	36	60.9
Sistan-B.	4353	3000	4600	4200	11307	0	19	0
Fars	216	2657	1320	1450	743	400	5	1.5
W.Azarbiajan	875	1065	1633	1800	1905	2350	7	9
Others	1693	3539	4036	3915	5007	5865	16	23
Total	24903	22257	24836	34785	33818	25785	100	100

Sources: Salehi[3] and Aquaculture Department[10].

FAO[4] and Salehi[3] concluded that carp farming in Iran was economically attractive. In Khuzestan, carp farming was profitable but farmers claimed that the cost of construction of ponds had drastically increased, possibly making carp farming a risky investment. In Gilan, Mazandran and Golestan, where carp farming is mainly an artisanal activity carried out by small farmers as a sole or a part-time activity, carp farming is another income-generating venture. There are about 15,800 non-governmental persons active in carp farming[6]. The majority of these people will also have another employment, either seasonal or non-seasonal activity.

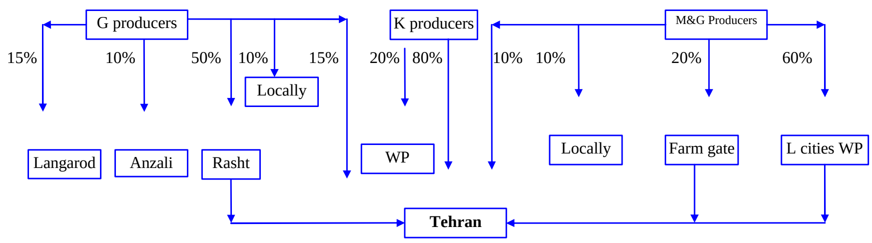
Production systems and practices in the culture-based fisheries

There are about 1,900 natural, semi-natural and artificial water-bodies and 150 earth dams, 235 barrage dams and 1,500 irrigation reservoirs[3] in Iran. The total water surface is estimated at 558,000 ha. These are distributed through all the provinces and can be used for fresh fish culture. The composition of carp species used to stock these water-bodies depends on the availability of fingerlings from the Shilat or other hatcheries, but is usually (28-32%) common carp, (40-50%) silver carp, and (5-10%) bighead carp, the rest being grass carp. Carp production in open water-bodies in the key provinces is shown in Table 3.

Harvests of carp and other warm-water species from the water-bodies, whether natural, semi-natural or artificial, are difficult to measure. Incomplete production data prepared by the aquaculture department indicate average yields of 43 kg ha^{-1} in 1993, and 40 kg ha^{-1} in 1994, increasing to 49 kg ha^{-1} in 1995.

The agriculture sector contributes 21% to the GDP so that there is considerable emphasis on water conservation and management. As part of this national effort, there are thousands of small artificial reservoirs, earthen ponds, and tanks constructed as integral parts of irrigation schemes for valuable agriculture land. These small units, many of which are seasonal, are used as focal points for village fish farms, in which villagers, working as a co-operative, take up fish

Figure 1: Carp marketing outlets in main provinces.



WP: Within province, L cities WP: Large cities within province, G: Gilan province, M&G: Mazandran and Golestan provinces, and K: Khuzestan province, Sources: Completed from FAO, 1992, op.cit *and Salehi, 1999 & 2003$_b$* op.cit.

farming as a part-time activity. In the first year, the units are stocked with fingerlings while certain operational needs are provided by Shilat free of charge, after which the co-operative has to provide fingerlings and other required facilities. Typically, fingerlings are 30 g in weight, and are stocked at a density of 2,500 ha^{-1}. With growth possible only during the warm months of the year, this type of extensive production differs by region. With suitable farming practices but without mechanical aeration and possibly without additional water, the yields range from 300-500 kg ha^{-1}, though yields have improved over recent years. In Mazandran province it had reached 1,300 kg ha^{-1} by 1997 and 1,540 kg ha^{-1} by 2001 with some 13,400 t total production[3,7].

Carp harvesting and marketing

Carp farmers use different marketing channels depending on the quantity of fish they have for sale, the distance to their intended market, the availability of transport and the credit they may receive for production. In general, small carp producers sell to local markets, dealers or wholesalers within the same province, whereas large producers would ship directly to the capital or other large provincial fish markets, or auction at the farm gate.

The marketing channels for carp differ between provinces. In Gilan, Mazandran and Golestan harvest starts in September, but in Khuzestan it may be two or three months later. The standard market size for carp is about 1 kg. Some farmers may delay their harvesting up to November, or even December to obtain larger fish and potentially better prices. However, this delay is constrained by additional cost, and most farmers, except a few with large farms and high capital investments, are unable to do so. Harvesting is by draining water from the pond or by using a net, and usually carried out by the farmers. Buyers are usually responsible for transporting the fish to the market. The majority of farmers harvest a pond only once a year, or even once per farm, but very large ponds or farms may require more than one harvest.

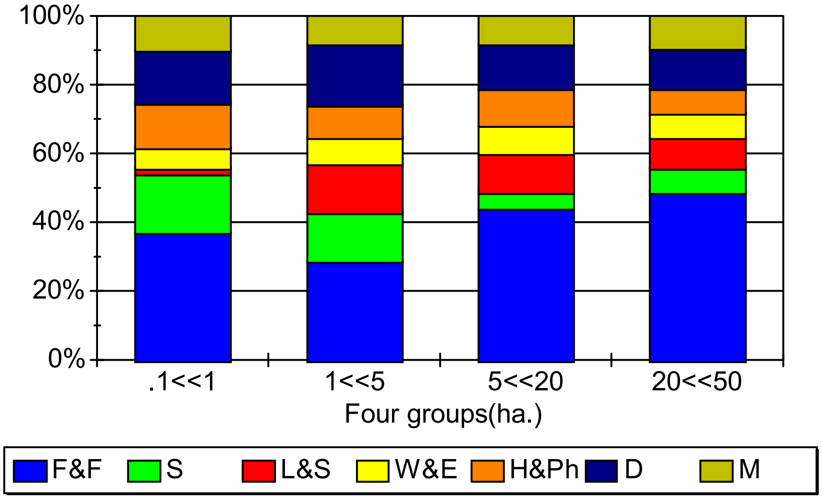
A variety of market outlet ranges from local fish markets, wholesalers within each province, and the co-operatives or wholesalers at Tehran. Wholesalers in Gilan, Mazandran and Golestan, often provide credit to the farmers[3]. As Figure 1 shows, in Gilan province, 50% of carp production is sold to wholesalers in Rasht city, the centre of Gilan province, 15% to the Langarod fish market, 10% to the Anzali fish market and the balance is sold to local market, co-operatives or shipped to Tehran. The wholesalers at Rasht transport and sell some 50% of their carp to wholesalers in Tehran.

In Mazandran and Golestan, more than 60% of cultured carp is sold to wholesalers in the large cities of the province, though small farmers may sell their fish in the local market, and 20% of cultured carp is auctioned at the farm gate. A small amount of the fish sold by auction to wholesalers or at the farm gate is transported to Tehran. In Khuzestan province more than 80% of carp production is sold to wholesalers from Tehran, less than 20% sold at Ahvaz city, the centre of the province, and the balance is sold in local markets.

Carp prices

In Iran, the prices of carp are low relative to prices of red meat and chicken, and these have fallen in real

Figure 2: Contribution of costs per ha of carp farms production in four categories[3].



F&F: Feed and fertiliser, S: Seed, H&Ph: Harvesting and post harvest, W&E: Water and energy, L&S: Labour and Salaries, D: Depreciation, and M: Miscellaneous.

terms. Grass carp usually has the highest price followed by silver carp, while common carp is the cheapest. The price of bighead is between silver and common carp. In 2003, wholesale prices of grass, silver and common carps were US$ 1.60, 1.15 and 1.12 respectively in Tehran.

Cost structure and profitability of carp farming

The various producer locations, categories and cultured systems have different cost structures and consequently different profitability, depending on availability and quality of inputs, farm management, climate, area of farms, location of production, selling price and other factors. On average, farmers in all locations and categories made a profit (gross revenue minus total costs). However, this aggregate picture includes notable variations as profits of farms of less than 5 ha, and farms in Gilan, Mazandran and Golestan. Special case farms such as those obtaining additional income from seed sales were more profitable than other systems.

Considering only farms in Khuzestan, on the basis of costs per kg of production, total cost declined as farm size increased, though economies of scale for this province may be relevant. In the Caspian region it may also be relevant to conduct comparisons between farms of 1-5 ha with farms of 5-20 ha as economies of scale may also be relevant.

In the Caspian littoral the history of cultured carp is longer and farms of less than 1 ha water surface are only found in this area. Smallholder carp culture, in some cases integrated with agricultural activity, is seen as a simple and low cost source of income in this area. Carp farming does not appear to be a particularly attractive investment in West-Azarbiajan, but in Kerman it may be. Factors such as feed and fertilizer, seed, water and energy, labor and salary costs all influence yield and profitability, but farm management, location, production system and size of farms also influence this. In the Caspian region, a wide range of plant materials, and other organic by-products are used to improve pond productivity and carp growth, either directly as feed or indirectly as fertilizer. This practice reduces total operating costs and consequently increases profitability. Some farmers in Gilan, based on the price of fish and the price of rice have reported shifting from aquaculture to rice farming. However, in the present situation, carp farming would bring considerably higher operating returns than the principal crop (rice).

In many cases, especially in Gilan, Mazandran and Golestan, family labor may be used during the off-agricultural season, in which case there would be minimal costs for pond preparation. It appears that farmers in Gilan and especially small farmers were more profitable because they can take advantage of management with reduced cost of inputs especially feed and fertilizer. The break-even production point averaged 2.3 t ha^{-1}, ranging from 1.5 t ha-1 in Mazandran and Golestan to 3.2 t ha^{-1} in Khuzestan. On average, the benefit-cost ratio and the rate of farm income were closely related to location. This suggests that Gilan farmers practice more efficiently and have better conditions, resulting in higher farm income per ha followed by Mazandran.

Future development

Applied research, market-oriented strategy, extension services and the training of core personnel for development may need to be given particular attention, considering existing technology, the transfer, adaptation and development of new technology for hatching, farming, harvesting, handling, processing and marketing. Considering the lack of information services for producers, distributors and marketing agencies, as well as development institutions, the establishment of an information network needs to be given attention. This would draw support from organisations like NACA and INFOFISH. The absence of a legal basis for the sector as a whole and affiliated sub-sector is also a critical need to be addressed. The Shilat law provides a framework for this sector, but additional and specific legislation for aquaculture is required.

References

1. **SCI (1998)** Iran Statistical yearbook 1998 (in Persian), Statistical centre of Iran, Tehran, Iran, 958 p.
2. **Salehi H.** (2003$_b$) Market perspective on cultured carp products in Iran, presented in Asia-Pacific aquaculture 2003, Bangkok, unpublished, 13p.
3. **Salehi H.** (1999) A strategic analysis of carp culture development in Iran, PhD Theses, University of Stirling, Stirling, 328p.
4. **FAO** (1992) Aquaculture sector fact-finding mission, Technical co-operation programme, FI: TCP/IRA/ 2251 (F), FAO Rome, Italy 65p.
5. **Shehadeh Z. H.** (1996) Major trends in global aquaculture production and summary overview of the Gulfs (Persian Gulf and Gulf of Oman) area TOFC Committee, Cairo, Egypt, 1-3 Oct. 8p.
6. **Abzigostar** (1996) Iran Fisheries sector study, Shilat, Tehran, Iran, 190p.
7. **Salehi H.** (2003$_a$) Carp culture sector in Iran: An economic analysis of farmed production, presented in World Aquaculture 2003, Brazil, unpublished, 17p.
8. **Salehi H.** (1997) Analysis of the key factors on producing and improving of carp farming in Iran (in Persian), unpublished, Tehran, Iran, 92 p.
9. **FAO** (2002) The World Fisheries and Aquaculture production, FAO, Italy, Rome, p.
10. **Aquaculture Department** (2003) Annual report of aquaculture production in Iran, (in Persian), Shilat, Tehran, Iran, 40p.

Opportunities and challenges in Myanmar aquaculture

U Hla Win

The coastline of Myanmar faces the Indian Ocean in Rakhine State, the Bay of Bengal in Ayeyarwady Division, and the Andaman Sea in Tanintharyi Division. These long stretches of coast provide 213,720 km^2 of continental shelf with water rich in nutrients and marine life. Myanmar is also endowed with large rivers and huge networks of their tributaries that are rich in freshwater fisheries resources.

Myanmar's inland water bodies consist of 8.2 million hectares of lakes, rivers and reservoirs, producing more than 53 million tons of fish and prawns in 2002-3 including catch from 3,742 lease fisheries. During the monsoon season from May to September, inundated flooded plain are breeding and nursery grounds for freshwater fishes. At this time of year, DOF is stocking fish seed and broodstock in natural and man-made water bodies to enhance and sustain commercially important species.

Fisheries have a major role in social and economic development; the people of Myanmar are largely rice and fish eaters. Annual per capita fish consumption was 26.18 kg in 2002, and fisheries are the country's third largest sector in export earnings, after agriculture and forestry.

Aquaculture has been the fastest growing sector for over a decade, registering a growth rate of over 40 percent per year since 1988, compared with 5 percent for capture fisheries. By 1988 there were only 6,300 acres (2,550 hectares) of fishponds. As fish is the staple diet for the people and one of the potential growth industries in the national economy of Myanmar, the State Peace and Development Council promulgated Aquaculture Law No. 24/89, which lead to a substantial increase in the number of fishponds in the country.

Sub-leased lake-based fishing, such as the unique 'saung' trap (opposite) used by Intha fishers on Inle Lake in Shan State provides a livelihood for canoe owners for an annual fee of K1000. Fishers can fish every day and sell their catch at K600.

Large-scale fisheries of 10s to 100s of acres are leased, via auction, to those with means to operate and sustain them. Lease holders are required to manage these as culture-based fisheries.

The Department of Fisheries plays a vital role in National Aquaculture development. There are 14 fisheries stations for fish seed production, located in Mandalay Division in the upper Myanmar region, Bago Division, Ayeyarwady Division, and Yangon Division in the lower part of the country. In line with the three-year fish culture development special project, 19 new stations are being established throughout the country. These stations will:

- produce quality seeds;
- provide fish seed to fish farmers and stock replenishing activities and culture-based fisheries;
- impart technical knowledge on aquaculture and expertise to fish farmers through extension services;
- conduct aquaculture research and training.

Status and targets

Freshwater fish culture has been practiced since the early 1950s and currently almost 50,000 hectares of freshwater fishponds are under operation. However, marine finfish culture has only recently begun to take hold as a commercial venture by private companies and is only present in a few places at present. Local communities have not previously been interested in farming seabass *(Lates calcarifer)* and groupers (*Epinephelus* spp.) as they are abundant and easy to catch. Recently, due to high foreign market demand, groupers and seabass have become more popular for fisheries trade, which has encouraged farmers to begin trials on their aquaculture.

A three-year fish culture expanded plan (2000-2003) has been prepared to accelerate the development of the aquaculture sector. The plan's targets include: Development of 26,315 hectares of fishpond and establishment of 19 new fishery stations, including three stations for mariculture. The DOF mariculture fishery station is under construction at Chaungtha in Ayeyarwady Division. Two others are to be constructed at Taungok

This canoe owner at Inle Lake claims hook and line gear provides a better return for the same K1,000 annual fee. This man will leave his 200 m line (with hooks at meter intervals baited with shrimp) overnight every day of the year. Best catches are in April.

Township in Rakhine State and Kyun Su Township (Myeik area) in Taninthayi Division respectively.

The area of aquaculture in 2002-2003 was 127,204 hectares including 80,000 hectares of freshwater prawn (*M. rosenbergii*) and marine shrimp (*P. monodon*) ponds.

Mariculture

Commercial scale net cage culture of groupers is found in Kyun Su Township (Myeik area) in Taninthayi Division. It is a pioneering farm run by private sector, which has some 300-350 net cages of 3 x 3 x 3 meters in size. It on-grows *Epinephelus coioides* and *E. tauvina*. Grouper juveniles are collected from the wild during May through November. Different sizes of juveniles of 10 cm to 25 cm are stocked. According to initial stocking size, culture period varies from three to twelve months to reach marketable size. Generally stocking rate is 800-2,500 fishes per cages depending on the fish size and the survival rate is about 30% at harvest.

Similarly grouper juveniles are collected at Thandwe and Gwa Township, in Rakhine State for holding in net cages before marketing. Fish are fed with small trash fishes for some period until they attain size and strength for transport to grow-out farm and restaurants, as well as for export. The most common species in that area is *E. coioides* but commercial-scale culture is not yet practiced in that area.

Regarding sea bass farming, hatchery management techniques are urgently needed for its development into commercial culture. Inadequate seed supply due to lack of skills in hatchery technology is now the major constraint for the development of marine finfish aquaculture.

Freshwater culture

Freshwater pond fish culture is a major source of aquaculture production. The dominant species is Rohu (*Labeo rohita*). Most farmers practice polyculture, using major carps, and common carps. Farmers in upper Myanmar prefer to stock fingerling 2 to 5 cm but those in lower Myanmar especially in Yangon and Ayeyarwady Division, prefer stocking yearling of 12 to 15 cm so that the fish can reach marketable size in a short time.

A common practice is to put 3,000 yearlings into an acre of pond. Culture period is 10-12 months and the average yield 5 tons per acre (or 12 tons per hectare).

The most successful culture industry is found in Twantee Township, near Yangon where 50% of the total fishpond area is situated. The sizes of the ponds vary from four to eight hectares with an average water depth of 1.5 meters.

Tilapia cage culture has been demonstrated successfully by DOF in the Ayeyarwady River in Magwe Division, situated in the dry zone where there is not only poor soil condition but also scarce water resources for fish culture. Altogether over 300 cages of 5 x 5 x 3 metre size are stocked with 2,000 fish seed per cage. One company, the Yuzana Company has cage culture operations in Ayeyarwady River in the delta region. *Pangasius* species are grown in cages of 2 x 8 x 8m at a rate of 110,000 fish 10 cm size per cage.

Culture species

Twelve freshwater fish species are being cultivated, Rohu *(Labeo rohita)*, Catla *(Catla catla)*, Mrigal *(Cirrhinus*

Grouper cage culture near Myeik

mrigala), Common Carp *(Cyprinus carpio)*, Grass carp *(Ctenopharyngodon idella)*, Big head carp *(Aristichthys nobilis)*, Silver carp *(Hypophthalmichthys molitrix)*, Red tilapia *(Tilapia mossambica, T. nilotica)*, Hybrid catfish *(Clarias gariepinus x Clarias macrocephalus)*, Rohtee *(Rohtee cortio)*, Striped catfish *(Pangasius hypopthalmus)*. DOF has recently succeeded in breeding three new species, freshwater pomfret *(Pitratus brachypomum)*, feather back *(Notopterus chitala)*, and silver barb *(Puntius gonionotus)*.

The stations under the Department are producing quality fish seeds by applying various breeding techniques. Fish seed production in 2000-2001 was over 300 million out of which 85 million fish seed were stocked into natural water such as lakes reservoirs and big rivers. To expand the industry a good number of seeds are distributed freely to potential fish farms and institutions as an incentive.

Experiences and culture techniques of some species such as eel *(Anguilla* spp; *Synbramchus* spp.), Soft shell turtle (*Tryonix* spp and *Lyssemes* spp.) are also to be introduced. Therefore training course on culture and propagation techniques of commercially importance species is needed.

Feeds

Most of the aquaculture feeds are made up of locally available agricultural by-products such as rice bran, boiled broken rice, and oil cakes of groundnut, sesame, and coconut and cotton seed. Rice bran and groundnut cake are a major source of fish fed and pellet feed are commonly used in catfish farms. To attain one kilogram of fish about 4-5 kilograms of bran are feed. So food conversion ratio is 4-5, depending on quality and type of rice bran FCR is significantly improved when it is mixed with other ingredients, vitamin and minerals.

Several feed factories have been established recently. They are producing thirty to fifty tons of formulated fish or shrimp feed per day in pellet form. Apart from these bigger ones, medium size feed mills with daily production capacity of five to ten tons of aqua-feed either in mixed powder or pellet from are also supporting the fast growing industry.

Challenges

The aquaculture sector faces a number of constraints despite its seemingly bright prospects and high potential for expansion and continued growth. There is also an urgent need to consider the practical foundation on which to establish a sustainable aquaculture sector to ensure sustainable development. Awareness of environmental responsibilities in the aquaculture industry is growing and farmers and investors are increasingly practicing improved management practices.

The following issues face Myanmar's fast growing aquaculture sector:

- Technologies and farming systems
- Environmentally friendly technologies, which have benign impact on the community. Due consideration should be given in selection of farming system applied, i.e. traditional, extensive, semi-intensive, intensive, super intensive.
- Improved management practices and codes of good practice for aquaculture sector.
- Minimize the harmful effects of farm-bred species to the ecosystem.
- Improved culture-based fisheries.

Species

Selection and improvement of species feeding low on the food chain.

- Appropriate use of genetic resources and biotechnology.
- Careful introduction of exotic species.
- Diversification of animal and plant species for aquaculture.

Socio-economics

Better awareness of responsible aquaculture concepts and practices.

- Mitigating the impact of industrial aquaculture in rural areas.
- Improving the contribution of small-scale aquaculture to rural livelihoods.
- Defining property rights and access to resources.
- Mitigate conflicts among common resource users.

Fish seeds

- A consistent supply of high quality and healthy seeds.
- Deterioration of quality seed due to inbreeding, limited number of captive and wild breeders, lack of techniques in broodstock manipulation and poor hatchery technologies.

Feeds

- Improving the efficiency of food through good aquaculture feed manufacturing practice and feeding techniques.
- Cost effective feed.
- Research on the dietary nutrient requirement and feeding habits of cultured species.
- Culture of species that can utilize good farm made feed rather than require high quality protein rich feed.

Conclusion

There are considerable opportunities for further development in aquaculture, especially mariculture in Myanmar. Joint efforts of the government and the private sector would realize for the nation and people the huge aquaculture potential. To do so without the adverse side effects and impacts on the environment and social harmony, the government is taking measures to encourage, with appropriate incentives and assistance, the investors, farmers and other stakeholders to practice responsible production practices. It has, for instance, tasked the Department of Fisheries with the responsibility of promoting the conservation of biodiversity and habitats and providing assistance to all forms of aquaculture.

U Hla Win is the Deputy Director General for Fisheries. He had been national coordinator for the Regional Seafarming Development Project of UNDP/FAO managed from NACA, coordinator for NACA in Myanmar, and chairman of the Governing Council.

Impacts of mono-sex *Macrobrachium* culture on the future of seed availability in India

Paramaraj Balamurugan*, Pitchaimuthu Mariappan and Chellam Balasundaram

Crustacean Aquaculture and Behaviour Unit, Department of Animal Science, Bharathidasan University, Tiruchirapalli 620024, India.
**e-mail: parama999@rediffmail.com*

India has about 2.36 million hectares of ponds and tanks of which hill states cover 0.4 million ha. Out of the 1.9 million hectares remaining at least 300,000 could be utilized for monoculture and polyculture of freshwater prawn[1].

Macrobrachium culture is gaining momentum since it is less likely to have a detrimental impact because these prawns cannot be reared at densities as high as the marine shrimp. Indeed while its productivity is generally lower, management is less labour intensive and the potential pollution of water sources is minimal. Among the 200 species reported under the genus *Macrobrachium*, *M. rosenbergii* is by far the most commercially important species, with its life cycle closed over three decades ago in Malaysia[4]. Other species such as *M. malcolmsonii*, *M. nipponense*, *M. carcinus*, *M. amazonicum*, *M. vollenhovenii* and *M. acanthurus* are under trial as new candidate species and have the potential to enter the commercial aquaculture[6]. Almost all the river systems and even some of the independently flowing small streams of peninsular India are richly endowed with giant freshwater prawn[7].

In India freshwater prawn farming has been practiced by adopting traditional methods, where the young ones collected from the wild are reared in semi intensive farms[8]. The first artificial seed production technique was attempted during the year 1963-65 at the Central Inland Fisheries Research Institute, Barrackpore; afterwards systematic research on freshwater prawn culture began in the pond culture division of the Central Inland Fisheries Research Institute at Cuttack[9]. The successful rearing of larval stages of *M. rosenbergii* was achieved in 1975 at prawn breeding centre, Kakinada[10].

Freshwater prawn culture has attracted more attention in the recent years due to its export potential and increasing demand as luxury protein. India is the second largest contributor of freshwater prawn to the world market with production of 30,450 MT in 2002-2003 (Table 1). The farmed area utilized for scampi production increased from 12,022 ha to 34,630 ha marking a four-fold spurt and a three-fold increase in cultivation[11]. The main constraint in the culture potential is currently a lack of quality seeds. At present 56 freshwater prawn hatcheries are in operation with a production capacity of nearly 1.3 billion seeds.

The present commercial requirement for quality seeds cannot be fully met by collection from the wild, which has resulted in over exploitation of wild brooders, which sell for Rs 100/ each (US$ 2). Due to the shortage of brooder availability in the wild, hatcheries have resorted to procuring brooders from commercial farms. Such pond-reared brooders have advantages such as year round availability for seed production coupled with the possibility of genetic improvement. However there are some demerits like inbreeding depression, insufficient feeding and increased density in grow out ponds that affect the brooder quality. Moreover the pond-reared populations are characterized by lower reproductive performance and precocious maturation even at a 7-10g weight, which yield poor quality eggs when compared to that of wild brooders[12]. The main reason may be that these animals cannot grow large enough and cannot compete for resources in their environment and hence tend to mature precociously.

The natural stocks have the superior quality over pond populations. In the

Table1. Showing State-wise details of farmed freshwater prawn (Scampi) production in India in 2002-2003 (Source: MPEDA, 2003).

States	Area (ha)	% total area	Production (Tonnes)	% total production	Production/ha (kg)
West Bengal	4,100	11.8	2,140	7.0	521
Orissa	2,995	8.6	410	1.4	137
Andhrapradesh	21,580	62.3	27,020	88.6	1,252
Tamilnadu	180	0.5	130	0.4	722
Kerala	830	2.5	200	0.7	241
Karnataka	165	0.5	180	0.6	1,090
Goa	0	0	0	0	0
Maharashtra	4,420	12.7	290	1.0	204
Gujarat	360	1.1	80	0.3	22
Total	34,630	100.0	30,450	100.0	879

wild the females attain first maturity at 30 ±10g; eggs produced by these females are of good quality with a higher larval survival[13]. More importantly the brooders collected from wild populations have more chances to cross with individuals of different parentage with the unique advantage of natural selection. The feeding habitat and spatial distribution are more favorable for the quality brooders from wild population. The major problem is over exploitation of wild brooders, which is a limiting factor to meet the ever-increasing needs of the aquaculture industry[13].

Monosex culture (all male)

Differential growth and dominance of larger individuals characterize *Macrobrachium* populations. Males grow faster than the females aggravating the differential growth pattern within and between sexes. Monosex culture of this species aims to avoid sex based size hierarchy[14]. Further, when reared with the males the precocious maturation of the females that enter into reproductive phase stunts somatic growth, which ultimately affects the total yield of the population and production cost since the females by virtue of their smaller size are not marketed. This has paved the way for the monosex culture of all male populations. All male culture is the new trend adopted in commercial farming of freshwater prawn, in order to ensure maximum yield and unit weight/ prawn. Extensive research has been initiated to determine the factors, organs, hormones and gene sequence for regulatory mechanisms of sex differentiation[15]. In India, some farmers claim to have acquired expertise in the culture field to segregate males and females by various morphological characters. The PL 10 are collected from hatchery and stocked at nursery for a period of two months, after which experienced farmers can segregate males and females with an accuracy of around 95%. At this time an average female weigh 6.5±1.5g. Any females that finds its way into the farm are picked out and sold to the hatchery at the cost of Rs.15/individual. Through constant observation and training over a period, these local fishermen claim that they can segregate males and females even at 5g size. This has led to the wide spread practice of all male culture.

Currently the hatchery operators neither maintain specific broodstock nor maintain the brooders over a long time. They collect brooders (the 5% females that get mixed during segregation in all male culture) as and when they need them from local commercial farms. The brooders collected from these populations will be of poor quality, characterized by poor fecundity, larval survival and growth. Due to dearth of wild females the hatcheries have to depend on farms for brooder supply, despite the fact that in the long run larval quality and survival ranges from 25 to 35%, where as local hatcheries report that larvae obtained from wild stock have around 70% survival.

The recently held “International symposium on Freshwater prawns 2003” at Cochin, Kerala, India, strongly emphasized the vital need to augment quality seed production to improve and sustain freshwater prawn culture in the coming years. For instance the freshwater prawn production potential of India is 150,000 tonnes worth Rs 3000 crores @ Rs.200/kg (US$ 65 million) among the nine coastal states of India except Goa where freshwater prawn culture is yet to take off. Andhra Pradesh contributes the lion share of 88.6% in all India production of freshwater prawns (Table 1). In this state the current production is about 27,020 tonnes, is expected to increase three fold to reach 75,000 tonnes accounting to 50% of the total Indian production within the next 5 years. To achieve this target India needs to produce 12,000 million seeds with a survival rate of 50% to get 6,000 million seeds per annum[16]. In order to fulfill the seed demand the country requires 200 hatcheries located in different areas. With a viable-quality average of 30,000 eggs/ female for seed production around 2,000 broodstock are required per hatchery per year. Hence, for year round seed production the 200 hatcheries would need 400,000 brooders to supply six billion seeds.

Such a huge requirement of brooders may adversely affect the already over exploited wild stock. The situation will worsen since the emerging all male culture also can not satisfy the need for brooders. The only solution for this impasse is for hatcheries to begin maintaining their own broodstock.

References

Gopakumar, K., S. Ayyappan, J.K. Jena, S.K. Sahoo, S.K. Sarkar, B.B. Satapathy and P.K. Nayak. 1999. National Freshwater Aquaculture Development Plan. Central Institute of Freshwater Aquaculture, Bhubaneswar, India. 75 Pp.

MPEDA/NACA (2003). Shrimp health management Extension Manual. Prepared by the Network of Aquaculture Centres in the Asia-Pacific, in cooperation with the Aquatic Animal Health Research Institute, Bangkok, Thailand, Siam National Resources, Bangkok, Thailand and AusVet Animal Health Services, Australia. Published by the Marine Products Development Authority, Kochi, India. 31p.

Chanrachakool, P. 2003. Farm level management options for minimizing shrimp disease risk. MPEDA/NACA National Workshop on shrimp disease control and coastal management, Chennai, March 5-6, 2003. Papers for Technical Sessions.pp1-6.

Ling, S.W. (1969). The general biology and development of *Macrobrachium rosenbergii* (De Man). FAO World Conference on the Biology and Culture of Shrimps and Prawns. Fisheries Report 57: 607-619.

New, M.B. 2003. The role of freshwater prawns in sustainable aquaculture. Freshwater prawns 2003. International symposium Souvenir, Kerala Agriculture University, Kochi, India.pp10-13.

Kutty, M.N., F. Herman and H. Le Menn. 2000. Culture of other prawn species. Chapter 21, pp.393-410. In: M.B.New and W. Velenti (eds), Freshwater Prawn Culture: The Farming of *Macrobrachium rosenbergii*, Blackwell Science, Oxford. 467p.

Tripathi, S.D. 2000. Need to conserve and revive the depleting stock(s) of the giant freshwater prawn in Nature. National workshop on Aquaculture of Freshwater prawns.Souvenir, Central Institute of Fisheries Education, Mumbai, India.pp 9-12.

Mariappan, P., Balamurugan, P and C. Balasundaram. 2002. Diversity and utilization of freshwater prawns (Macrobrachium) in river Cauvery in Tamilnadu. Zoo’s Print Journal 17(10): 919-920.

Ayyappan, S. and J.K. Jena. 2001. Sustainable freshwater aquaculture in India. Sustainable Indian Fisheries. National Academy of Agricultural Sciences.New Delhi.pp 88-133.

Tripathi, S.D. 1992. Status of freshwater prawn fishery and farming in India. In Silas, E.G. (ed), Freshwater prawns, Kerala Agricultural University. Thrissur, India. 42-49.

Kutty, M.N.2003. Sustainable Aquaculture - A comparative view of freshwater prawn and marine shrimp. Freshwater prawns 2003. International symposium Souvenir, Kerala Agriculture University, Kochi, India.pp14-20.

Palacios, E., Racatta, I.S. APSA, 1999b. Spawning frequency analysis of wild and pond-reared of White Pacific shrimp Penaeus vannamei broodstock under large-scale hatchery conditions. J. World Aquaculture.Soc. 30: 180-191.

Hien, T.T.T., Minh, T.H., N.T. Phuong and M.N. Wilder. 1998. Current status of freshwater prawn culture in the Mekong River Delta of Vietnam. JIRCAS Journal 6:89-100.

Sindhukumari, S and T.J. Pandian. 1987. Effects of unilateral eyestalk ablation on moulting, growth, reproduction and energy budget of *Macrobrachium nobilii*. Asian Fish. Sci., 1: 1-17.

Sagi, A., Snir, E and I. Khalaila. 1997. Sexual differentiation in decapod crustaceans: role of the androgenic gland. Invertebrate Reproduction and Development, 31: (1-3) 55-61.

Sakthivel, M. 2003. Utilization of untapped water resources for scampi culture for a rapid jump in production and export in India. Freshwater prawns 2003. International symposium Souvenir, Kerala Agriculture University, Kochi, India.pp21-24.

Use of new technology and skill enhancement to obtain eco-friendly production of Tiger shrimp (*Penaeus monodon*)

Asbjørn Drengstig[1*], Asbjørn Bergheim[2] & Bjørn Braaten[3]

1. Managing Director, HOBAS Tropical Aquaculture Water Engineering LTD, email asbjorn.drengstig@hobas.no;
2. Senior Researcher, Rogaland Research;
3. Researcher, Norwegian Institute for Water Research

About the HOBAS technology

The HOBAS aeration technology consists of a motor, an impeller (pump), an air hose with a regulating valve, a manometer and a floating raft. The impeller, which is mounted inside the pump at the lower end of the motor, turns rapidly creating a partial vacuum inside the pump. The partial vacuum causes air above the waterline to be pulled into the air intake port where air is dispersed into the water. The air intake port (submerged in the water at the lower part of the pump) is connected to air above the waterline through a hose going onshore. Onshore a valve and a manometer are used to regulate the amount of air being introduced into the impeller. Due to the partial vacuum, the water leaving the pump is slightly over-saturated with oxygen.

Most aerators employed in aquaculture today mix water with air either after the pump (e.g. ejector based aeration) or with a propeller in open water (e.g. Aire-O_2, paddle-wheels). The HOBAS aerator is designed to introduce air directly in the pump housing and mechanically crush the air with water under vacuum without reducing the effect. Suction of false air usually makes pumps less efficient. Moreover, compared to other aeration technology, the HOBAS technology also introduces several other advantages in practical farm management:

- Farmers can freely regulate the depth and position of the inlet and outlet of the pump
- Farmers can freely regulate the angle of the outlet from the pump and thus avoid agitation of the pond bottom independent of pond water depth in addition to controling the direction of the physical water current according to the pond shape (individually adjustable)
- Farmers can control and regulate the amount of aeration according to the DO level in culture water (e.g. no aeration during the day – full aeration during the night, or somewhere in-between these categories)
- The pump prevents any kind of stratification and creates uniform conditions in the water column
- The HOBAS technology is easy to use, has low maintenance, runs more smoothly and makes less noise than competitive technology

Introduction

The Norwegian R&D company HOBAS Tropical Aquaculture LTD, has been working in Sri Lanka since 1999. At that time, the shrimp farming industry was severely struck by disease outbreaks and bankruptcies. Although Sri Lanka does not have a tradition of aquaculture practices, the island experienced an enormous expansion within the shrimp farming sector in the beginning of the 1990s. This rapid development was mainly possible due to a high economic return on investments and free access to unpolluted water from local lagoons. During this period (1990 – 1995), neither the environment nor the welfare of the shrimps was considered, and as a result, the industry collapsed in 1997/1998. As recently as December 2003, the industry along the western coast of Sri Lanka was again struck by a severe disease outbreak. Thus, it is now evident that measures need to be initiated in order to improve farm management and reduce the negative environmental impact from shrimp farming. The industry today realises the importance of unpolluted brackish water and suitable land sites for pond construction, and the present focus is on sustainable production yields, preserving coastal environments and achieving an eco-friendly production.

Material and methods

The present study was conducted in cooperation with Rogaland Research in Stavanger, Norway. The overall aim of the project was to evaluate the possible effects on water quality in earthen shrimp ponds when production was intensified by means of new technology. Four small-scale commercial ponds stocked with three different densities (12, 25 and 31 PLs m^{-2}) and applied three different aeration technologies were used. These were the HOBAS technology, ordinary paddle-wheels and Aire-O_2 diffuser system. The ponds were approximately 40 x 40 meters with a water depth of 3 feet (pond volume: 1920 m^3). Continuous monitoring of dissolved oxygen (DO), pH, temperature, salinity, carbon dioxide (CO_2) and ammonia (NH_3) were performed during the entire production cycle. DO, pH, salinity and temperature were measured by a hand-held YSI-556 MPS (Multi-Probe-System) instrument. Analysis of CO_2 and TAN were done at Rogaland Research's certified QA-lab in Stavanger.

In addition, water current velocities were measured along a transect (10 meters from shore) in all four ponds to compare the different aerator's ability to maintain the horizontal water circulation. The water current velocities were monitored by an Aquadop Current Meter measuring velocity (cm/s, accuracy: 0.5 cm/s or 1%) and direction (accuracy: 0.1?).

Results

The results are indicating, first and foremost, that the HOBAS technology is able to keep key water quality parameters (O_2, CO_2, TAN, (salinity), pH and temperature) un-stratified, stable and within acceptable levels in semi-intensive and intensive shrimp culture. Most efficiently, the HOBAS aerator totally removed the potentially toxic gases (CO_2, NH_3) in a highly intensive pond (stocked with 31 PLs m^{-2}). Neither paddlewheels nor aeration using diffusers proved a similar effect (Figure 1).

Moreover, the three ponds installed with standard aeration equipment (e.g. paddlewheels) did allow the accumulation of CO_2 and TAN during the last month of the production cycle. The HOBAS technology employed in this trial was superior to the others flushing capacity wise. These results clearly demonstrate that the existing technology commonly employed in shrimp farming today is not adequate to keep CO_2 and TAN at acceptable levels; at least not during the last period of the production cycle of intensive culture.

The HOBAS aerator also displayed a better utilisation of nutrients. Contrary to the other three ponds, a very healthy phytoplankton growth was observed where no algae mats (lap-laps) were produced. This simply implies that nutrients (nitrates and phosphates) were suspended in the water column for a longer time, and a larger concentration was therefore used to stimulate the bloom before sedimentation or being discharged. Moreover, the HOBAS technology maintained an optimum horizontal water current velocity (3.4 - 7.3 cm s^{-1}) in the pond which corresponds to the acceptable range suggested by Peterson et al. (2001). According to the numbers employed, paddlewheels either created too high velocities (14.9 – 20.9 cm s^{-1}) or insufficient velocities (1.5 – 5.1 cm s^{-1}).

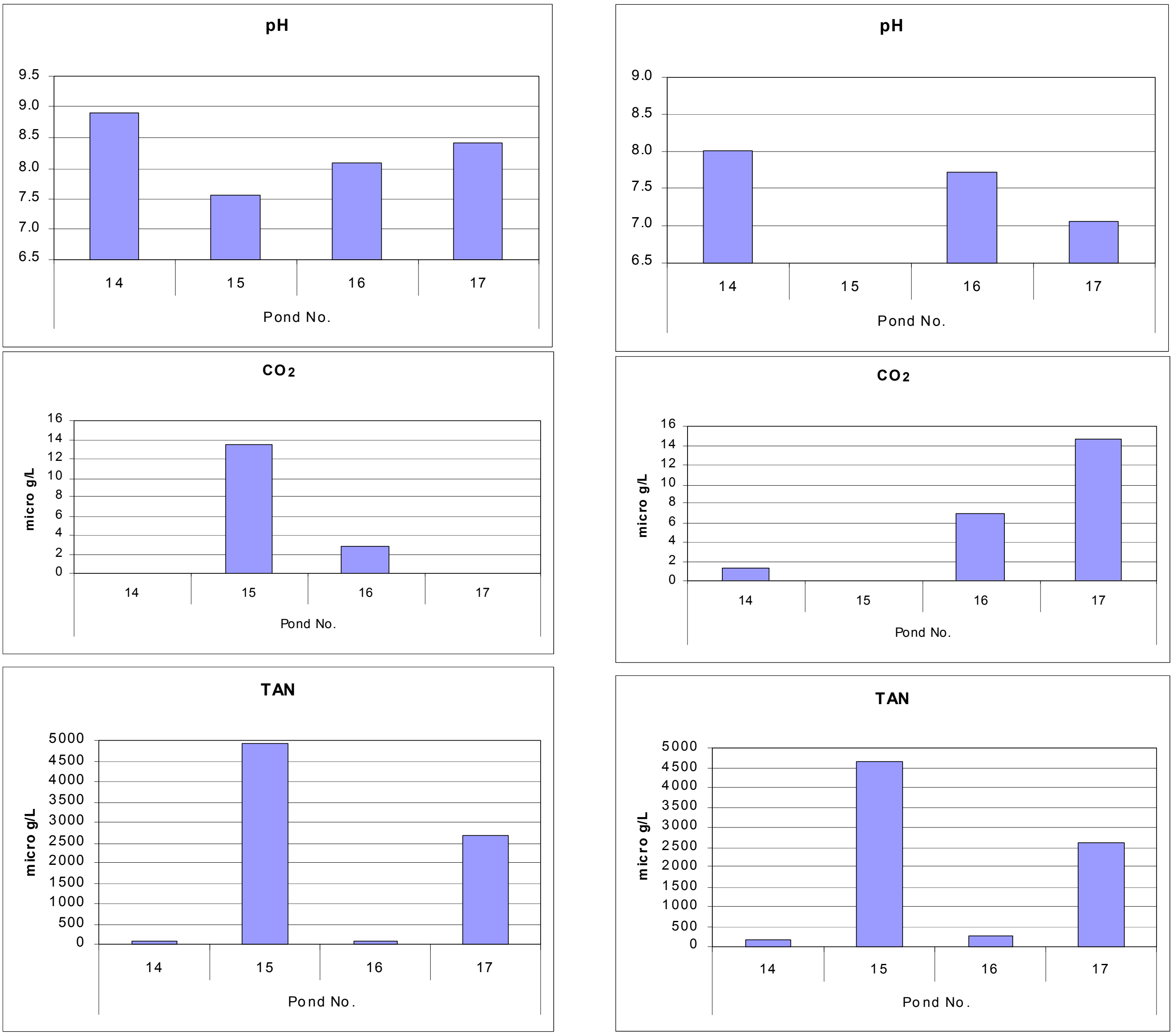
Discussion

During the last decades, there has been a development towards more efficient and intensive production units in several shrimp producing countries. In light of the worldwide debate on environmental and socio-economic issues, the industry clearly needs to produce shrimp more efficiently. However, important prerequisites for the long-term sustainability of shrimp farming have often been neglected in the past. In order to achieve an eco-friendly production, farmers must understand the complex mechanisms controlling the water quality and use technology suited for intensive production.

Poor water quality conditions in ponds stress the shrimps, which subsequently makes them more susceptible to disease. The biggest stressors are mainly toxic levels of carbon dioxide (CO_2) or ammonia (NH_3) which are much more likely to occur in intensive systems. Traditionally, CO_2 and TAN levels are seldom measured in commercial shrimp farming. According to EIFAC (1986), the daily cycle of metabolite levels in culture water should be determined at least once during the production cycle in order to locate the periods of maximum and minimum levels of the relevant water management components (DO, pH, TAN, CO_2). Therefore, in intensively run farms (20 PLs/ m^{-2} and upwards), it is of vital importance to know the exact concentration of these potentially stressful and toxic components. The results from the present study confirm the importance of monitoring water quality throughout the production cycle in intensive systems.

Furthermore, the organic content in effluent causing unwanted eutrophication in lagoons tends to be much higher in semi-intensive and

Figure 1. Sampling of pH, carbon dioxide (CO_2) and total ammonia (TAN) in four ponds in July (left) and August 2002 (right) (no pH and CO_2 measured in Pond 15 in August) Pond 14: HOBAS aerator/31 PL m^2; Pond 15: Paddlewheels/31 PL m^2; Pond 16: Paddlewheels/12 PL m^2 (control); Pond 17: Paddlewheels & diffuser/25 PL m^2



intensive farming areas than in extensive systems. In fact, extensive shrimp culture is not expected to represent any significant load of nutrients to the surrounding waters at all (Phillips et al. 1993). Recent studies of shrimp culture in Bangladesh, where mainly extensive systems are employed, support this view (Bergheim & Braaten 2002). Bangladeshi ghers actually function as biofilters and sedimentation ponds (silting) discharging rather unpolluted effluents. However, in more intensive systems, where artificial feeds are the main nutritional source, water being discharged strongly contributes to pollution of adjacent environments. Thus, more efficient technology able to reduce or remove these waste components and to improve the utilisation of available nutrients in the water column is clearly needed to reduce effluent loading in the future.

Conclusions

The overall most important conclusions from the project are:

- The HOBAS technology, contrary to commonly employed technology, will sustain an eco-friendly production of shrimp
- The new technology has a strong ability and a high capacity to flush the possible toxic gasses carbon dioxide (CO_2) and ammonia (NH_3) from culture water in earthen pond systems
- The new technology renders farmers to intensify their production with higher stocking density at reduced risk of sub-optimal water quality conditions and disease outbreaks, and without sacrificing the welfare of the shrimp
- The new technology will work excellently in combination with ordinary paddlewheels and other diffuser aeration systems

Based on the technical results from the testing of the new technology in Sri Lanka, HOBAS has, in cooperation with Rogaland Research (RF) and the Norwegian Institute of Water Research (NIVA), started the process of initiating

Continued on page 40

Larval rearing and spat production of the windowpane shell *Placuna placenta*

S. Dharmaraj, K. Shanmugasundaram and C.P. Suja

Central Marine Fisheries Research Institute, Tuticorin Research Centre, 115, N.K.Chetty street, Tuticorin-628001 (India), e-mail:ttn_trccmfri@sancharnet.in

The windowpane shell, *Placuna placenta* is one among the pearl producing bivalves. It was identified as the second-priority mollusc species for research during the Second Conference on Aquaculture Development in Southeast Asia held in the Philippines in July 1994 and is the basis for a 'kapis' (windowpane shell) fishery in the Philippines. Windowpane shell provides fishermen an additional income-generating source through the sale of its pearls and shells. The empty shells are used as raw material in making shell craft products and are exported.

In India the distribution of the species is confined to the Kakinada Bay in Andhra Pradesh[1,2,3,4]; to the Okhamandal Coast in the Gulf of Kutch[5,6]; to the Nauxim Bay of Goa[7] and to Tuticorin Bay[8] and Vellapatti near Tuticorin[9]. The oysters were fished from these areas in considerable quantities every year for pearls and shells causing concern about over exploitation of wild stocks. The development of techniques on breeding, larval rearing and spat production of the species might eventually help to sustain the fishery. Hence efforts are made in different parts of the world to breed the windowpane shell in captivity and produce the seeds for replenishment of wild stocks. Previous research has documented the spawning and larval development of *P. placenta*[10]; documented the techniques in induced spawning and early embryonic and larval development[11]; studied the effect of salinity on the embryonic development, larval growth and survival at metamorphosis[12]; evaluated the effect of microalgal diets and rearing condition on gonad maturity, fecundity and embryonic development[13]; and reported on hatchery management techniques[14].

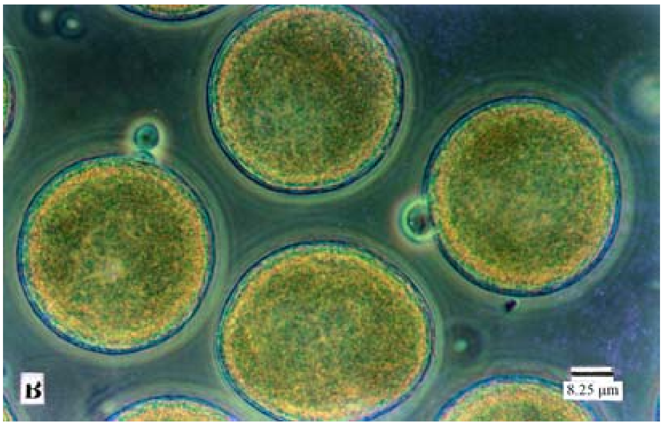
In Tuticorin Bay, the windowpane shell occurs in a 0.46 ha bed and its exploitation during the fishery is almost total leading to the depletion of stock in the bay. The natural population has to be augmented in order to meet the needs of mariculture. We therefore undertook to develop the technology for the production of seed of the species in the hatchery and to sea ranch them for the replenishment of wild stock. The report is the first to be published on larval rearing and seed production of *P. placenta* from India.

Techniques

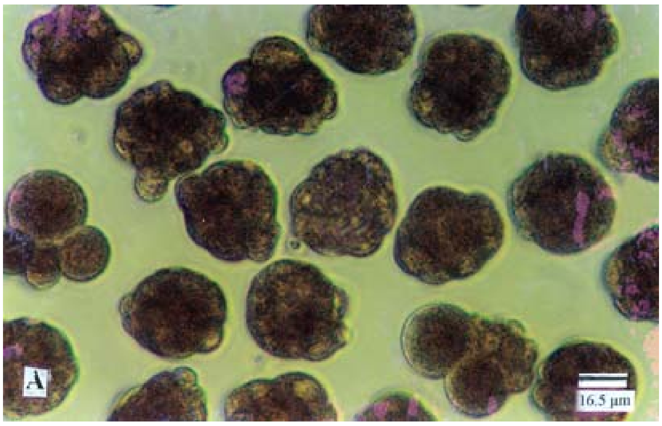
The windowpane shells, collected from the Tuticorin Bay in the Gulf of Mannar, were brought to the Shellfish Hatchery of the Tuticorin Research Centre of the Central Marine Fisheries Research Institute. Prior to the experiment, these broodstock animals were kept for 24 hours in aerated seawater held in a rectangular tank. The oysters were treated for spawning on the following day by thermal stimulation at 37ºC at 1445 hours. Males started to spawn at 1530 hours followed by females. When the spawning was over the brood stock animals were removed and the eggs allowed to fertilize. The eggs were yellow in colour.

We collected the fertilized eggs by gently siphoning through a 30µm sieve. The material collected in the sieve contained fertilized eggs, faecal matters, broken tissues, shell fragments and other waste materials. The contents of the sieve were passed through an 80µm sieve and the unwanted materials discarded. The fertilized eggs that passed through 80µm sieve were allowed to develop in the tank and the larval development was studied. No aeration was provided and antibiotics were not used during larval development. We observed the development under an inverted microscope using 10x10 magnification. After 24 hours straight-hinged larvae were collected in 40µm mesh sieve. The larvae were reared in two 75 liter rectangular fiberglass tanks. Feeding was initiated at veliger stage on day two. The unicellular microalga *Isochrysis galbana* was given as food to the larvae once in a day at a concentration of 5,000 cells larva^{-1} day^{-1} (10 cells µl^{-1}) from day two; 10,000 cells day^{-1} (20 cells µl^{-1}) from day five; 15,000 cells day^{-1} (30 cells µl^{-1}) from day seven; and 20,000 cells day^{-1} (40 cells µl^{-1} from day ten. The microalga was cultured in Conway medium[15] and harvested during its exponential phase. Algal density was assessed using haemocytometer and proportionate feed was given. Water change was done once in two days by siphoning the larvae through a sieve with the mesh size smaller than the larval size. Random sample of 50 larvae was measured along the dorsoventral axis (DVM) and anteroposterior axis (APM) as a parameter to assess the growth. The spat were allowed to settle free in the tank itself, as they did not have byssus thread or cement gland for attachment. No cultch material was provided for settlement of spat. Aeration was given only after spat setting. Unicellular microalga *I. galbana* was continued to be supplied as food for the spat up to 1.0mm and was gradually replaced afterwards by mixed algal food. The mixed algae, chiefly containing *Chaetoceros* sp.and other diatoms, were developed in outdoor tanks. During larval rearing the water temperature ranged from 28ºC to 30ºC; salinity 34.6 – 35.2 ppt. and pH 7.91-8.09.

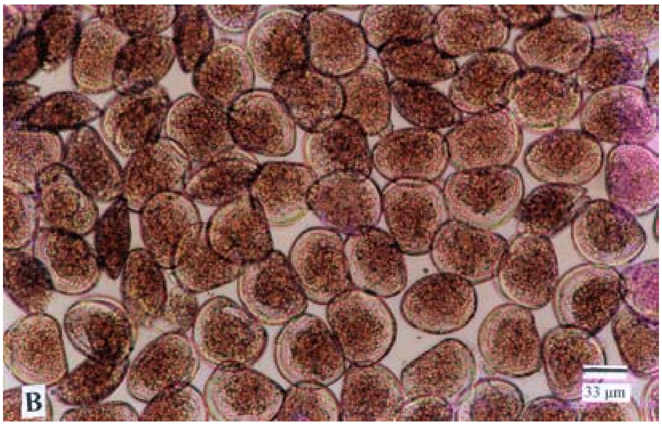
Window-pane shell Placuna placenta.



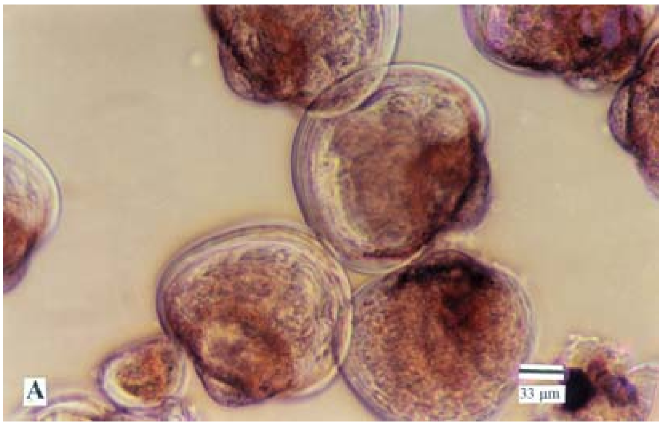
Fertilized eggs with polar body, size 50µm.



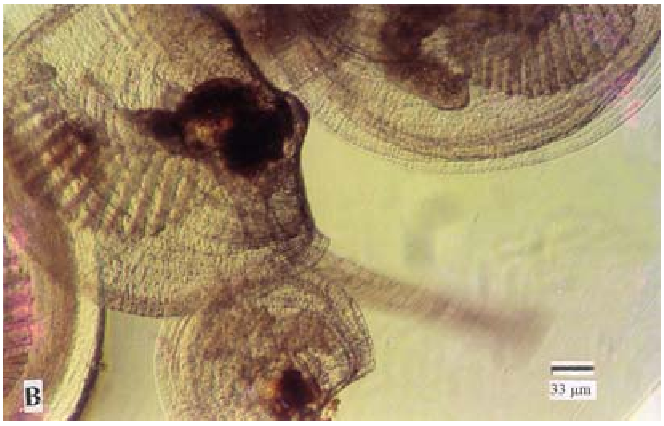
4-celled, 8-celled and 32-celled stages.



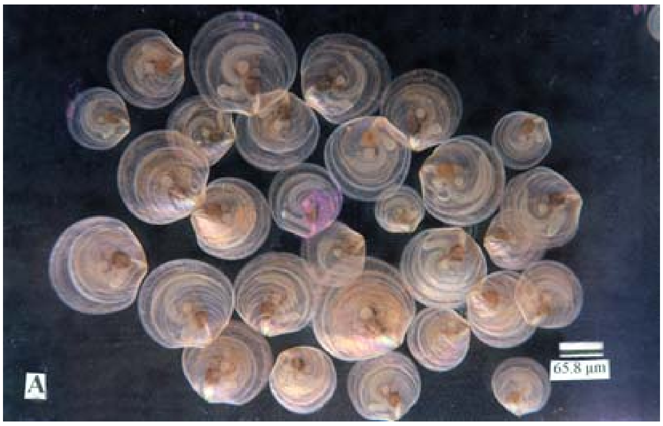
Straight-hinge larvae, average size 79.9 x 65.2µm.



Typical umbo stage, size 140 x 130 µm.



Spat with its transparent shell.



Hatchery reared juveniles of P. placenta*, average size 26.4 x 10.6 mm on day 135.*

Larval development

The spawned eggs are spherical in shape measuring 50µm. Fertilization was immediate and the first polar body was released 15 minutes after fertilization. First cleavage started after another 15minutes leading to the two-celled stage. The two-celled stage had a smaller micromere and a larger macromere along with a polar body at the furrow of cleavage. The trefoil stage, containing three micromeres and one macromere was obtained four minutes. After the two-celled stage. The cell wall of the 3 micromeres slowly disappeared and resulted in the four-celled stage 65 minutes after fertilization. The macromere did not take part in further cell divisions. The 8-celled, 16-celled and 32-celled stages are obtained in 80 minutes, 100 minutes and 155 minutes respectively after fertilization. Morula stage was reached in four hours and 45 minutes. The embryo began to move at the morula stage. As the larvae move in water column, the morula is transformed to a blastula stage by the development of a blastocoel, which opens to the exterior through blastopore. Gastrulation commenced at this stage by convolution of cells to interior through blastopore. After completion of gastrulation, the dermal layers namely ectoderm, mesoderm and endoderm are formed along with an archenteron. By the formation of single flagellum at the apical end, the embryo reached trochophore stage in 5 hours and 41 minutes. The ectodermal cells secrete embryonic shell material (prodissoconch 1) and formed a D-shaped veliger 18 hours and 45 minutes post fertilization and measured an average of 65.2µm in DVM or shell height and 79.9µm in APM or shell length. The shell valves of the veliger are equivalve and transparent with conspicuous granules. The time sequence of early embryonic development of larvae of *P. placenta* is given in Table 1 and the time series growth data of the species from veliger to spat is presented in Table 2.

Larval growth

The relationship between the larval shell length (APM) and shell height (DVM) is linear and is described by the equation:

$$Y=17.982 + 0.9595X \text{ with } r = 0.9981$$

Where Y represents APM and X represents DVM in µm.

On day three all larvae were at veliger stage and subsequently the D-shaped veliger became globular at 110µm APM x 100µm DVM resulting in the disappearance of straight hinge line. On day four the typical umbo stage constituted 90% of the population measuring 140 x 130µm. The late umbo stage is reached at 210 x 200µm on day five, pediveliger at 215 x 205µm on day seven, and plantigrade at 235 x 210µm on day eight. On day nine the umbo larvae constituted 14%, eyespot 28%, pediveliger 34% and plantigrade 24% of the population. The spat had grown to 340 x 300µm on day ten. On day thirteen the pediveliger formed 14%, plantigrade 36% and spat 50% of the population. In view of such heterogeneity in growth, the average size of larvae at different stages was taken into account in working out the growth rate. The average shell height on day one is 65.2µm; 81.6 µm on day three; 121.6 µm on day six; 205.8 µm on day nine and 300 µm on day thirteen. The average daily rate of growth of the larvae is 23.0 µm from day 0 to 13.

Spat setting and spat production

The larvae set as spat on day 7-8. The spat has neither byssus nor cement gland for attachment and hence they were allowed to settle on tank surface. The spat has an exceptionally long foot which would be of much use in burrowing. The shell is highly transparent with concentric growth line. The initial larval population in all the culture tanks was 1.5 x 10^5 in a total volume of 150 litres of seawater. The total number of larvae that metamorphosed as spat was 12,500, giving a survival rate of 8.3 % and production rate of 83.3 spat/liter.

Growth of spat

The average growth in shell height of spat was 0.300mm on day thirteen; 0.806mm on day 22; 3.09mm on day 36 and 12.44mm on day 80. The equation

Table 1. Time sequence of early embryonic development of larvae of *Placuna placenta*

Stage	Time after fertilization	
	Madrones-Ladja (1997)	Present study
Egg	0	0
First polar body	15 min	15 min
Second polar body	-	20 min
2-celled stage	30-40 min	30 min
Trefoil stage	40-50 min	34 min
4-celled stage	50-60 min	65 min
8-celled stage	115-120 min	80 min
16-celled stage	-	100 min
32-celled stage	120 min	155 min
Morula stage	-	285 min
Blastula stage	-	295 min
Gastrula stage	235 min	305 min
Trochophone stage	325 min	341 min
Water temperature Salinity	27 ºC 33 ppt	28 ºC 34.6-35.2 ppt

Table 2. Time series growth data of *Placuna placenta*. The larval measurements are in µm. Whenever two measurements are given with an X sign, the first is APM and the second is DVM. Time from fertilization is given in hours (h) and minutes (m) or in days (d).

Stage	Madrones-Ladja (1997)		Present study	
	size	Time	Size	Time
Egg- spherical	0		50	
D-shape	89 x 75	18 h 20 m	79.9 x 65.2	18 h.45m
Early umbo	98 x 82	d 5	110 x 100	d 3
Umbo	138 X 105	d 7	140 x 130	d 4
Pediveliger	192 x 190	d 9	215 x 205	d 7
Plantigrade	232 x 225	d14	235 x 210	d 8
Spat	-	-	340 x 300	d 10
Water temperature Salinity	24.0-27 ºC 32.0-35.0 ppt		28.0-30 ºC 34.6-35.2 ppt	

for the growth of the spat from day 13 to 80 is described as:

Y = 0.1634 + 0.9754 X with r-value of 0.9998.

The spat was transferred to farm on day 80 and the growth rate of spat after 54 days in the farm was 0.59mm/day. During the same period the spat reared in the hatchery showed a growth rate of 0.08mm/day (average size 26.4 x 10.6 mm on day 135). The following equation was fitted to the spat growth data: $y = ae^{bt\,w}$ here y = DVM in mm and t = time in days. The fitted equation for hatchery reared spat was: Y = 0.6973 + 0.9365 X with r-value of 0.9998 and that for farm reared spat was Y = 0.3410 + 0.9955 X with r-value of 0.9984. It is evident from the equation that the farm reared spat had a higher instantaneous growth rate (b). The farm-reared spat attained juvenile stage with an average size of 44.4mm on day 135. The spat produced in the hatchery was ranched in the bay.

Applications

Regular fishing of windowpane shell is conducted in the Kakinada Bay in Andhra Pradesh and in Okhamandal Coast in the Gulf of Kutch. Huge quantities of these animals are exploited every year causing depletion of stock. In a notification dated July 21, 2001 the Ministry of Environment and Forests, Government of India, has included the windowpane shell in Schedule 1 of the Wildlife (Protection) Act, 1972. As a result the natural populations of *P. placenta* are protected against exploitation. While breeding of several species of bivalves has been achieved[16], this is the first report on breeding, larval rearing and spat production of windowpane shell from India.

Initial attempts to induce spawning windowpane shell were made using water manipulation techniques[10]. Others resorted to chemical and photochemical stimulations[11]. In the present study thermal stimulation was successful in the induction of spawning in *P. placenta* when water temperature was increased to 37ºC. The temperature at which *P. placenta* responded to spawning seemed to be high when compared to other bivalves studied from India such as the blood clam *Anadara granosa* which spawned at 32ºC after conditioning at 24.0-26.0ºC for 15 days[17]; the great clam *Meretrix meretrix* at 4-5ºC above the ambient level of 24.0-26.0ºC[18].

The easy response of induction of spawning by thermal stimulation and faster growth of larvae/spat has facilitated the scaling up of production of the seeds of *P. placenta* in India. The Shellfish Hatchery at Tuticorin had already demonstrated the production of pearl oyster seed to a maximum of 1.3 million per run[19]. An average survival rate of 5% of pearl oyster seeds was achieved. In the present study the rate of production of windowpane shell seed is 8.3%. The culture conditions (water temperature 28-30ºC and salinity 34.6-35.2 ppt) prevailing during this study seemed to be favorable for the production of seeds. Large-scale production of seeds of *P. placenta* to replenish natural stocks seems quite feasible.

Madrones-Ladja[12] reported the settlement after fourteen days in the salinities ranging from 22-34 ppt. The present investigation not only observed earlier settlement (between the day seven and eight) but also indicated faster growth of larvae/spat at a water temperature of 28-30ºC and salinity 34.6-35.2 ppt. The growth of larvae/spat up to day thirteen was 23.0µm day^{-1} whereas the same, as reported by others[14], was 11.0 µm day^{-1} up to the day fourteen. The faster growth rate in India may perhaps be related to higher water temperature. Madrones-Ladja[11] provided petri dish as cultch at the time of settlement and reported poor survival, which may be attributed to the lack of deficiency of essential nutrients in the microalgae fed to the larvae and the non-availability of suitable substrate. Similar results have been reported for tridacnid clams when suitable substrate is not available[20].

P. placenta has neither cement gland nor byssus thread for attachment. Hence at the time of settlement if a suitable substrate is provided, as in the natural habitat, high survival may be achieved. The foot of the windowpane shell is exceptionally long when compared to other bivalves, and facilitates in burrowing. In the natural habitat the lengthy foot may be beneficial in positioning the spat at the time of settlement in the clayey bottom. *P. placenta* is naturally found burrowing in muddy or sandy-mud substratum[21]. Provision of cultch material like glass or plastic items might not be useful for settling in *P. placenta*. Hence, in the present study no cultch materials were provided and therefore the larvae are allowed to set at the bottom of the fiberglass tank.

The rate, at which Madrones-Ladja[11] fed the larvae is higher than in the present study and still the growth and settlements are faster in India. The nutritional value of *Isochrysis galbana* may likely vary at different locations and this may reflect in the vigor, viability and growth of the embryo, larva and spat. Higher larval growth of *Ostrea edulis* has been reported when fed a microalgal diet of *I. galbana* and *Chaetoceros calcitrans*[22] Madrones-Ladja[12] reported the food value of *I. galbana* with 41 % crude protein and 23 % crude fat. In the present work the food value of *I. galbana* is 59.6 % crude protein (dry weight) and 14.4 % crude fat (dry weight). *I. galbana* is one of the most commonly used marine unicellular algae in mariculture and is rich in fatty acid C22:6[23]. However a detailed study is needed to determine the optimum algal cell ration to the larvae and its food value on the growth of larvae and spat.

Acknowledgements

The authors are grateful to Prof. (Dr.) Mohan Joseph Modayil, Director and Dr. K.K. Appukuttan, Head, Molluscan Fisheries Division, Central Marine Fisheries Research Institute, Cochin for their interest and encouragement. Our sincere thanks are due to Miss. Anu alias Meena, Senior Research Fellow, Tissue Culture Project, Tuticorin for the help in computerization of data.

References

1. Narasimham, K.A. 1973. On the molluscan fisheries of the Kakinada Bay. *Indian J. Fish.,* 2(1):209-214.
2. Murthy, V.S.R., Narasimham, K.A. and Venugopalan, W. 1979. Survey of windowpane oyster *(Placenta placenta)* resources in the Kakinada Bay. *Indian J. Fish.,* 26(1&2): 25-132.
3. Narasimham, K.A., Selvaraj, G.S.D. and Lalitha Devi, S. 1984. The molluscan resources and ecology of Kakinada Bay. *Mar. Fish. Infor. Serv.*, T & E Ser., No.59:1-16.
4. Syda Rao, G. and Somayajulu, K.R. 1996. Resource characteristics of exploited bivalves and gastropods of Kakinada Bay with a note on stock assessment. *Mar. Fish. Infor. Serv.,* T & E Ser., No.144: 25-28.

Continued on page 28

Trans-boundary aquatic animal diseases: Focus on Koi herpes virus (KHV)

Melba G. Bondad-Reantaso

Dr. Melba G. Bondad-Reantaso was NACA's Aquatic Animal Health Management Specialist from 1999 to 2002. Dr. Reantaso organized and led the Emergency Disease Control Task Force on a serious disease of common and koi carp in Indonesia. She now works as Aquatic Animal Research Pathologist at the Cooperative Oxford Laboratory of the Maryland Department of Natural Resources in Oxford, Maryland.

Chris Baldock of Ausvet (Australia) defined 'trans-boundary animal diseases' (TADs) as epidemic diseases which are highly contagious or transmissible, with the potential for very rapid spread irrespective of national borders and cause serious socio-economic and possibly public health consequences[1]. Some of the most serious problems currently faced by the sector are those pathogens and diseases spread and introduced through movements of hatchery produced stocks, new species for aquaculture and development and enhancement of the ornamental fish trade. Aquaculture is faced with what is known as trans-boundary aquatic animal pathogens/diseases (TAAPs/TAADs), similar to the TADs in the livestock sector. Minimizing the risks of introduction and spread of TAAPs/TAADs through responsible movement of live aquatic animals has been the main subject of technical support and regional/international cooperation when the regional aquatic animal health management program of FAO/NACA[2-4] started since 1999. The program received enhanced support from a number of regional/international organizations such as the Australian Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC)[5,6], the Association of Southeast Asian Nations (ASEAN), the Officer International des Epizooties (OIE) and the Southeast Asian Fisheries Development Center (SEAFDEC)[7].

Melba Reantaso presenting KHV information during the National Strategy Development Workshop, June 2002. On right is Ahmed Rukyani.

Attentive participants during the National Strategy Development Workshop, Bogor, Indonesia, June 2002.

The OIE[8] lists some 30 pathogens/diseases of finfish, molluscs and crustaceans as either 'Notifiable' or 'Significant' fitting the criteria of being of socio-economic and/or public health importance and significant in the international trade of aquatic animals and aquatic animal products. These diseases are known and affect the most commonly traded species such as salmonids, catfish, oyster and shrimps. The Asia-Pacific Quarterly Aquatic Animal Disease Reporting System (QAAD), established in late 1998 by FAO/NACA/OIE-Tokyo, covers the OIE listed diseases and an additional six diseases deemed important to the Asia-Pacific region[9,10]. In addition to the OIE-listed and the NACA/FAO listed diseases, there are many more diseases of regional and national interests which have impacted Asian aquaculture[11] and some are newly emerging in the region.

In early January 2002, during NACA's 12th Governing Council Meeting (GCM-12, Langkawi, Malaysia), a Hungarian colleague, Andreas Peteri, asked whether I was aware of some Koi Herpes Virus (KHV) report in Asia. I wasn't fully cognizant of this disease at that time! During the World Aquaculture Society (WAS) meeting in Bejing in April, I chanced upon Dr. Ra'anan Ariav, one of my fish disease teachers who spoke about Koi herpes virus (KHV) experience in Israel. He predicted that it will only be a matter of time when the disease will spread to the Asian region.

In June 2002, while arranging for a mission to assist in the development of Indonesia's National Strategy on Aquatic Animal Health[12], Dr. Rukyani of Indonesia's Ministry of Marine Affairs and Fisheries (MMAF) consulted regarding an on-going disease outbreak affecting common and koi carps. Based on the clinical signs described, patterns of mortality and specificity to koi and common carp, I strongly suspected Koi Herpes Virus (KHV). During the National Strategy Development workshop, a small session regarding the current disease outbreak was held where Dr. Rukyani and I made presentations, my presentation was based on materials kindly provided by Dr. Ariav with additional information from the scientific literature. There was no doubt from both presentations that we were talking about a very similar disease. Most of the participants during the workshop were convinced that that the on-going mass mortality in Indonesia was similar to KHV.

The pattern of mortality, rapid spread, specificity to koi and common carps and clinical signs were characteristics of the outbreaks of KHV reported in 1999 in mid-Atlantic and in 1998 and 1999 in Israel[13,14]. Clinical signs from the current Indonesian outbreaks were characterized by severe branchial hemorrhage and necrosis, and hemorrhages on the body surface. The affected populations, limited to koi and common carps, were also suffering from non-specific secondary infections of bacterial, parasitic and fungal origin. Internally, the kidney and liver consistently showed abnormal conditions and extensive abdominal adhesions. The disease, reportedly first observed in April 2002 affecting East Java, had subsequently spread to West and Central Java where many koi and common carp farms were affected. Losses were estimated at US$ 5.5 M (50 B Rupiah, 1 US$ = 9,000 Indonesian Rupiah conversion rate at the time of the outbreak).

Immediate positive responses were received from the ACIAR, the Aquatic Animal Health Research Institute (AAHRI, Thailand), Intervet Norbio (Singapore), University of California, (UC Davis, California, USA), and the Institute of Aquaculture of the University of Stirling (IA, Stirling University, Scotland). The Food and Agriculture Organization of the United Nations (FAO) and OIE (Tokyo) provided valuable advice to the organization and development of the terms of reference of the Task Force and also pledged support to follow-up actions.

Koi and common carps showing clinical signs of the disease, i.e. branchial haemorrhage and necrosis, focal dermal hemorrhages on body surface.

The Local Task Force was headed by Dr. Rukyani with staff members from the Fish Health Research Laboratory, Central Research Institute for Aquaculture (Jakarta, Indonesia) and the Directorate of Fish Health and Environment, Directorate General of Aquaculture (Jakarta, Indonesia), both of the MMAF, and researchers/ scientists from the Fish Disease Laboratory and Faculty of Veterinary Medicine, Bogor Agricultural University (Bogor, Indonesia).

Field visits were undertaken from 8-12 July and laboratory examination of collected samples followed shortly. The focus of the Task Force investigation was to assess the disease situation, determine the possible involvement of KHV[13,14], and provide advice and recommendations to the Government of Indonesia on how to control the epizootic. The scope of the investigation included field observations (i.e. field visits, local/ district officials and farmer interviews) and collection of samples for laboratory examinations (e.g. histopathology, virology, polymerase chain reaction (PCR) and electron microscopy (EM)).

The Task Force findings revealed that an infectious agent/s is involved in the outbreak (from previous and recent epidemiological observations of sudden onset, rapid spread, specificity to koi and common carp, analogy with KHV outbreaks), that the disease was introduced to Indonesia through fish importation and spread into other areas through fish movements. This national epizootic, which occurred in ponds, raceways, and floating cages in open waters has spread both north and southward directions creating significant concern for a real international epizootic which may affect several neighboring countries.

The clinical signs, consistent in all cases, include branchial hemorrhage, necrosis and focal dermal ulceration.

Common carps exhibiting typical signs of branchial necrosis.

Koi carp showing typical signs of necrotic gills.

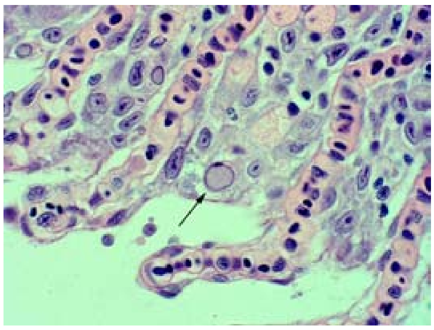
The level of morbidity and mortality reported by farmers ranged from 50 to 100%; water temperatures during the outbreak period ranged from 19-23°C. Water temperature has been suggested to be a principal environmental factor influencing the onset and severity of KHV infection[15].

While the Task Force recognized the important role that KHV played in the outbreak (based on the detection of viral DNA through PCR[16,17] from all case samples), there was no confirmation whether the agent responsible was KHV (due to absence of typical KHV pathology, failed viral isolation and non-observance of typical EM virions). Because this is a first time diagnoses of a disease problem of significant magnitude, it is essential that all available diagnostic techniques be used in order to confirm the involvement of KHV. A careful diagnosis is required and this is currently the subject of future follow-up work under an FAO project as a matter of priority. The Task Force findings recommended that this serious outbreak of koi and common carp be called ***'Mass mortality of koi and common carp'*** until a clear association with KHV or any other specific disease can be established.

This suspected KHV introduction to Indonesia presents a huge trade implication for the high value ornamental koi carp and the regionally important food fish common carp. KHV is a serious disease condition causing significant losses and has been reported from countries such as Israel[13,14], the United Kingdom, Germany, Netherlands, Belgium, Denmark[18,19] and the United States[13]. It is now clear that unregulated trade in ornamental fish is responsible for the escalating global spread of the disease[15].

Most recently, carp populations in two major lakes in Japan (Lake Kasumigaura and Lake Kitaura) were affected by this devastating disease with losses estimated at 150 M yen (approximately US$ 1.4 M) (Pro-Med News, November 4, 2003). Japan's Ministry of Agriculture, Forestry and Fisheries is considering suspension of carp exports (http://www.practicalfishkeeping.co.uk/pfk/pages/item.php?news=119). Outbreaks, which have reached epizootic proportions during the past two months, have been reported by 22 prefectures since May 2003 (http://www.practicalfishkeeping.co.uk/pfk/pages/item.php?news=139).

Barry Hill (of the Centre for Environmental, Fisheries and Aquaculture Sciences (CEFAS) and OIE's Aquatic Animal Health Standards Commission), was correct when he said during his plenary talk at the Fifth Symposium on Diseases in Asian Aquaculture in Queensland, Australia in November 2002, that one of the possible reasons for the emergence of a new disease in a country is 'slow



KHV gill pathology. Hyperplasia and fusion of secondary gill lamellae; intranuclear inclusion (arrow) in the branchial epithelium (gill section stained with hematoxylin and eosin). Photo courtesy of Prof. R. Hedrick, UC Davis.

Farmers administer antibiotic treatment (tetracycline) with poor success.

awareness on emerging diseases by the exporting country', citing KHV as an example. This is an important lesson.

The Government of Indonesia was advised to temporarily restrict the movement of koi and common carps and a Ministerial Circular took effect in July 2002. Intensive information dissemination was also undertaken to raise awareness and inform the public sector about relevant information, including risks to human health, available at that time.

Since the completion of the Task Force work and perhaps due to the impacts of the Japanese outbreak as well as increasing KHV reports from many countries, concerted actions from various stakeholders are now taking place.

In October 2002, FAO responded immediately and positively by providing an emergency assistance through a Technical Cooperation Project (TCP) "Health management in freshwater aquaculture' to further assist Indonesia in finding resolution to this emergency situation.

The First Meeting of NACA's Regional Advisory Group on Aquatic Animal Health held in November 2002 recommended the inclusion of 'Koi mass mortality' under the category 'Unknown diseases of serious nature' of the Quarterly Aquatic Animal Disease report (QAAD) of NACA/FAO and OIE[20]. Several countries (e.g. Hong Kong SAR, Japan and Thailand) now have an on-going surveillance for KHV using Levels II, I and III diagnostics[4], respectively[20]. The disease is not currently listed under OIE's 'Notifiable Diseases', however, an emergency notification was provided to OIE by the Indonesian Government in June 2002 as suggested by NACA. This mass mortality of koi and common carp is currently being reported by at least 21 countries in Asia-Pacific under the Asia-Pacific QAAD.

Japan's largest koi-grading show scheduled to be held in January 2004 has been cancelled by the All Japan Nishikigoi Promotion Association (http://www.practicalfishkeeping.co.uk/pfk/pages/item.php?news=139).

Later during 2004, FAO is proposing to hold a regional workshop on "Emergency Preparedness and Response to Aquatic Animal Diseases in Asia" (R.P Subasinghe, FAO, pers. comm.). The Workshop will review the regional experiences in responding to disease emergencies, including the work accomplished through an FAO TCP project in Indonesia aimed at providing technical assistance to improve national capacity to respond to the ongoing carp disease epizootic. The Workshop envisages to improve the national and regional understanding and knowledge on the importance of preparedness and response to diseases emergencies, discuss approaches for reducing such risks to cultured and wild aquatic fauna, and to establish an action plan to provide guidance and assistance to the countries in the region to move forward on this important issue.

The experience on emergency response in dealing with this recent epizootic provided some valuable insights[21]: (a) the importance of regional and international cooperation; (b) the need to increase awareness on emerging diseases in other parts of the globe and the risks of it's spreading to the Asian region; (c) the need to improve diagnostic capabilities at both national and regional levels; (d) pro-active reporting of serious disease outbreaks as a mechanism for early warning; (e) the need to have contingency plans both at national and regional levels; (f) the need to improve compliance and implementation of policies reached at regional and international levels; (g) emergency preparedness as a core function of government services; and (h) financial planning towards immediate provision of funds for emergency disease situations be seriously considered both at national and regional levels. It is essential that appropriate health management and biosecurity measures

Members of the Emergency Disease Control Task Force (Drs. Somkiat Kanchanakhan, MB Reantaso and Angus Cameron, second, fourth and fifth from left) during a courtesy call to Indonesian officials, Director Dr. Fatuchri Sukadi, Director General of Aquaculture, Ministry of Marine Affairs and Fisheries (third from left) and Dr. Ahmed Rukyani (sixth from left).

are continuously put in place and effectively implemented. Otherwise, the risks of major disease incursions and newly emerging diseases will continue to threaten the sector. Sometimes I wonder whether doing something or doing nothing at all can make a difference. Glenn Hurry, of AFFA (Australia) when I reported to him about these seemingly incessant disease incursions, commented 'not bad, especially when governments are told what to and what not to do!'. There are many lessons from the past and hopefully our memories will not be too short to forget the events caused by various trans-boundary aquatic animal disease epizootics (e.g. epizootic ulcerative syndrome of fresh and brackishwater fishes, viral nervous necrosis of marine fish, viral diseases of shrimps, haplosporidiosis in oysters, akoya pearl oyster mortalities, etc.). These lessons can assist us towards preparing better and improving responses to similar events when they occur in the future.

References

1. Baldock, C. (2002). Health management issues in the rural livestock sector: useful lessons for consideration when formulating programmes on health management in rural, small-scale aquaculture for livelihood. pp. 7-19. *In:* J.R. Arthur, M.J. Phillips, R.P. Subasinghe, M.B. Reantaso and I.H. MacRae. (eds.). Primary Aquatic Animal Health Care in Rural, Small-Scale, Aquaculture Development. *FAO Fish. Tech. Pap.* No. 406. Rome, FAO. 2002. 382 p.
2. FAO/NACA. (2000). Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy. FAO Fish. Tech. Pap. No. 402. Rome, FAO. 2000. 53 p.
3. FAO/NACA. (2001). Manual of Procedures for the Implementation of the Asia Regional Technical uidelines on Health Management for the Responsible Movement of Live Aquatic Animals. FAO Fish. Tech. Pap. No. 402. Suppl. 1. Rome. FAO. 2001. 106 p.
4. Bondad-Reantaso, M.G., McGladdery, S.E., East, I. and Subasinghe, R.P. (eds). (2001). Asia Diagnostic Guide to Aquatic Animal Diseases. *FAO Fish. Tech. Pap.* No. 402, Supplement 2. Rome. FAO, 236 p.
5. APEC/AAHRI/FHS-AFS/NACA. (2001). Report and proceeding of APEC FWG 02/2000 "Development of a Regional Research Programme on Grouper Virus Transmission and Vaccine Development". In: Bondad-Reantaso, MG, J. Humphrey, S. Kanchanakhan and S. Chinabut (eds). Report of a Workshop held in Bangkok, Thailand, 18-20 May October 2000. Asia Pacific Economic Cooperation (APEC), Fish Health Section of the Asian Fisheries Society (FHS-AFS), Aquatic Animal Health Research Institute (AAHRI) and Network of Aquaculture Centres in Asia-Pacific (NACA). Bangkok, Thailand. 146 p. (http://www.enaca.org/Grouper/Publications/ResearchProgramOnGrouperVirus.pdf; 1.49 MB)
6. APEC/FAO/NACA/SEMARNAP. (2001). Trans-boundary aquatic animal transfer and the development of harmonised standards on aquatic animal health management. Report of the Joint APEC/FAO/NACA/SEMARNAP Workshop, Puerto Vallarta, Jallisco, Mexico, 24-28 July 2000. Network of Aquaculture Centres in Asia-Pacific, Bangkok, Thailand. (http://www.enaca.org/Shrimp/Publications/Other1.pdf, 1.07 MB)
7. Inui, Y and E.R. Cruz-Lacierda (eds.). (2002). Disease Control in Fish and Shrimp Aquaculture in Southeast Asia – Diagnosis and Husbandry Techniques
8. OIE. (2003). International Aquatic Animal Health Code. 6th edn. Office International des Épizooties, Paris. (http://www.oie.int/eng/normes/fcode/a_summry.htm)
9. NACA/FAO. (1999). Quarterly aquatic animal disease report (Asia-Pacific Region), 98/3. October-December 1998. FAO Project TCP/RAS/6714, Bangkok, Thailand. 42 pp.
10. OIE. (2000). Quarterly aquatic animal disease report (Asia-Pacific Region), April – June 2000 (2000/2). Tokyo, OIE Regional Representation for Asia and the Pacific, 41 p.
11. Subasinghe, R.P., Bondad-Reantaso, M.B. and S.E. McGladdery. (2001). Aquaculture development, health and wealth, pp. 167-191. *In:* R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery and J.R. Arthur (Eds.) Aquaculture in the Third Millenium. Technical Proceedings of the Conference on Aquaculture in the Third Millenium, Bangkok, Thailand, 20-25 February 2000. 471 p.
12. Bondad-Reantaso, M.G. 2004. Development of national strategy on aquatic animal health management in Asia. *In* J.R. Arthur and M.G. Bondad-Reantaso. (eds.). 2004. Capacity and Awareness Building on Import Risk Analysis for Aquatic Animals. Proceedings of the Workshops held 1-6 April 2002 in Bangkok, Thailand and 12-17 August 2002 in Mazatlan, Mexico. APEC FWG 01/2002, NACA, Bangkok In press).
13. Hedrick, R.P., Gilad, O., Yun, S., Spandenberg, J.V., Marty, G.D., Nordhausen, R.W., Kebus, M.J., Bercovier, H., Eldar, A. (2002). A Herpesvirus Associated with Mass Mortality of Juvenile and Adult Koi, a Strain of Common Carp. *J. Aquat. Anim. Health* 12, 44-57.
14. Ariav, R., Tinman, S., Paperna, I. and Bejerano, I. (1999). First Report of Newly Emerging Viral Disease of *Cyprinus carpio* Species in Israel. 9th International Conference on Diseases of Fish and Shellfish. European Association of Fish Pathologists, 19-24, September 1999, Rhodes, Greece.
15. Gilad, O., Y. Sun, M.A. Adkison, K. Way, N.H. Willits, H. Bercovier and R.P. Hedrick. (2003). Molecular comparison of isolates of an emerging fish pathogen, koi herpesvirus, and the effect of water temperature on mortality of experimentally infected koi. *J. Gen. Virol.* 84:2661-2668.
16. Gilad, O., S. Yun, K. B. Andree, M.A. Adkison, A. Zlotkin, H. Bercovier, A. Eldar and R.P. (2002). Initial characteristics of koi herpes virus and the development of a polymerase chain reaction assay to detect the virus in koi, *Cyprinus carpio koi*. *Dis. Aquat. Org.* 48: 101-108.
17. Gray, M., S. LaPatra, Groff and A. Goodwin. (2002). Detection of Koi Herpes virus DNA in tissues of infected fish. *J. Fish Dis.* 25: 171-178.
18. OATA. (2001). Koi Herpes Virus (KHV). Ornamental Aquatic Trade Association (OATA). United Kingdom. 33 pp.
19. Ariel, E. (2002). Ornamental disease vectors. *In:* Book of Abstracts, Fifth Symposium on Diseases in Asian Aquaculture, P 102, 25-28 November 2002, Brisbane, Australia. Fish Health Section, Asian Fisheries Society, Manila, Philippines.
20. NACA/FAO. (2003). Quarterly Aquatic Animal Disease Report (Asia and Pacific Region), 2003/1, January to March 2003. NACA, Bangkok, Thailand. 53 pp.
21. Bondad-Reantaso, M.G. and R.P. Subasinghe. (2004). Minimizing the risks of aquatic animal disease incursions: current strategies in Asia-Pacific. Proceedings of the Fifth Symposium on Diseases in Asian Aquaculture (DAA V) held in Queensland, Australia in November 2002. (in preparation).

Continued from page 23

5. Varghese, M.A. 1976. Windowpane oyster *(Placenta placenta* L.*)* of the Gulf of Kutch, *Seafood Exp. Jour*., 8(5): 25-28.
6. Pota, K.A. and Patel, M.I. 1988. Fishery and biology of the windowpane oyster *Placenta placenta L.* on Poshitra, Gulf of Kutch. *Natl. Semi. Shellfish Resour. &Farming, CMFRI, Bulletin,* 42(1): 163-!66.
7. Achuthankutty, C.T., Sreekumaran Nair, S.R and Madhupratab, M. 1979. Pearls of the windowpane oyster *Placuna placenta*. *Mahasagar-Bulletin of the National Institute of Oceanography*, 12 (3):187-189.
8. Dharmaraj, S., Chellam, A., Shanmugasundaram, K. and Suja, C.P. (MS). On a small scale fishery of windowpane oyster *Placuna placenta* (Linnaeus) in the Tuticorin Bay, Gulf of Mannar. *J. Mar. Biol. Asso. India.*
9. Dharmaraj, S and Sreenivasagam M.K. 2002. Exploitation of windowpane oyster *Placuna placenta* Linnaeus at Vellapatti area near Tuticorin. *Mar. Fish. Infor. Serv., T&E Ser., No. 174, pp. 9.*
10. Young, A.L. 1980. Larval and post larval development of the windowpane shell, *Placuna placenta* Linnaeus (Bivalvia: Placunidae) with a discussion on its natural settlement. *Veliger* 23(2):141-148.
11. Madrones-Ladja, J.A. 1997. Notes on the induced spawning, embryonic and larval development of the windowpane shell, *Placuna placenta* (Linnaeus,1758), in the laboratory. *Aquaculture*,157:137-146.
12. Madrones-Ladja, J.A. 2002. Salinity effect on the embryonic development, larval growth and survival at metamorphosis of *Placuna placenta* Linnaeus,1758, *Aquaculture*, 214: 411-418.
13. Madrones-Ladja, J.A., de la Pena, M.R. and Parami M.R. 2002. The effect microalgal diet and rearing condition on gonad maturity , fecundity and embryonic development of the windowpane shell, *Placuna placenta* Linnaeus, *Aquaculture* 206 (3-4): 313-321.
14. Madrones-Ladja, J.A. and de la Pena, M.R. 2000. Hatchery management for the windowpane shell, *Placuna placenta* Linnaeus, 1758. *Phuket. Mar. Biol. Cent., Spec. Publ.* 21(1): 189-194.
15. Walne, P.R. 1970. Studies on the food value of nineteen genera of algae to juvenile bivalves of the genera *Ostrea, Crassostrea, Mercenaria* and *Mytilus. Ministry of Agriculture, Fisheries and Food: Fishery Investigations,* Series II, 26(5) Her Majesty's Stationery Office, London, 61pp.
16. Loosanoff, V.L., and Davis,H.C.1963. Rearing of bivalve molluscs. *In: Advances in Marine Biology,* Vol.1. Academic Press, London.1-136.
17. Muthiah, P., Narasimham, K.A., Gopinathanan, C.P., Sundararajan, D. 1992. Larval rearing, spat production and juvenile growth of the blood clam *Anadona granosa. J. Mar. Biol. Ass. India,* 34 C (1& 2): 138-143.
18. Narasimham, K.A., Muthiah, P., Gopinathan, C.P. and Gandhi, A.D. 1988. Larval rearing and spat production of the great clam, *Meretrix meretrix* (Linnaeus). *Indian J. Fish.,* 35(2):107-112.
19. Alagarswami, K. (Ed.). 1987. Pearl culture. *Bull. No. 39*. pp. 1-136. CMFRI, Cochin.
20. Gwyther, J and Munro, J.L. 1981. Spawning induction and rearing of larvae of tridacnid clams (Bivalvia: Tridacnidae), *Aquaculture, 24: 197-217*.
21. Rosell, N.C. 1979. A study on the biology and ecology of *Placuna placenta L. Natl. Appl. Sci. Bull. 31 (3-4): 203-251.*
22. Enright, C.T., Newkirk, G.F., Craigie, J.S and Castell, J.D. 1986. Evaluation of phytoplankton as diets for juvenile *Ostrea edulis L. J. Exp. Mar. Biol., 96:1-13.*
23. Whyte, J.N.C. 1987. Biochemical composition and energy content of six species of phytoplankton used in mariculture of bivalves. *Aquaculture, 60:231-241.*

HACCP in shrimp farming

Siri Tookwinas and Suwimon Keerativiriyaporn

Department of Fisheries, Thailand

The authors conducted a training workshop on the application of HACCP in shrimp farming in Chennai, India on the request of MPEDA and NACA. This article is based on their resource paper.

The Thai shrimp aquaculture industry has had an excellent record in the production of safe products of consistent quality. However, as aquaculture production expands, the industry and regulatory agencies become more concerned with hazards that impact on people's health and safety. Specific problems which may be encountered in shrimp aquaculture products include:

- Contamination by microbial pathogens *e.g.* Salmonella, *Vibrio cholerae.*
- Presence of veterinary drugs (and other substances) that may have hazardous effects on consumers, handlers, and the environment.
- Residues of aquaculture chemicals or other environmental contaminants.

A surveillance program for cultured shrimp can include HACCP at all operations, including the production and handling of raw materials, processing operations, the processing environment, handling and storage practices, and distribution activities. This approach reduces reliance on analytical tests and the need for comprehensive inspection of finished aquaculture products by dealing with a hazard before it impacts on processors and consumers. Hazards in shrimp aquaculture include microbiological and chemical hazards associated with the inappropriate use of drugs and chemicals in aquaculture.

Processing cocktail shrimp. Taken inside the Union Frozen Food Products Public Company in Samut Sakhorn Thailand. The company sources out raw materials from shrimp farms observing good aquaculture practices or CoC in shrimp aquaculture assisted by the Department of Fisheries

Background

Production from shrimp aquaculture in Thailand has increased from 1.2 million kg in 1986 to 3.3 million kg in 2003 (Fisheries Information Center, 2004). The industry involves 80% small-scale farmers and 20% intensive scale aquaculture. Shrimp has become a major port commodity and its production, processing and marketing a major source of income of people in the industry.

Environmental impacts of shrimp have been an increasing concern of government and the public. The impacts include mangrove removal, salinity intrusion on ground waters, impacts on coastal environment and resources, and effects of residues of chemical and drugs on health and the environment. In order to maintain trust on safety, quality and environmental concerns, preventive measures are taken to reduce the above hazard to environment and maintain the survival of aquaculture species. These measures include ICZM, farm design and management techniques, seawater irrigation systems, establishment of farmer associations, treatment of shrimp pond effluent, supportive government policies and regulation.

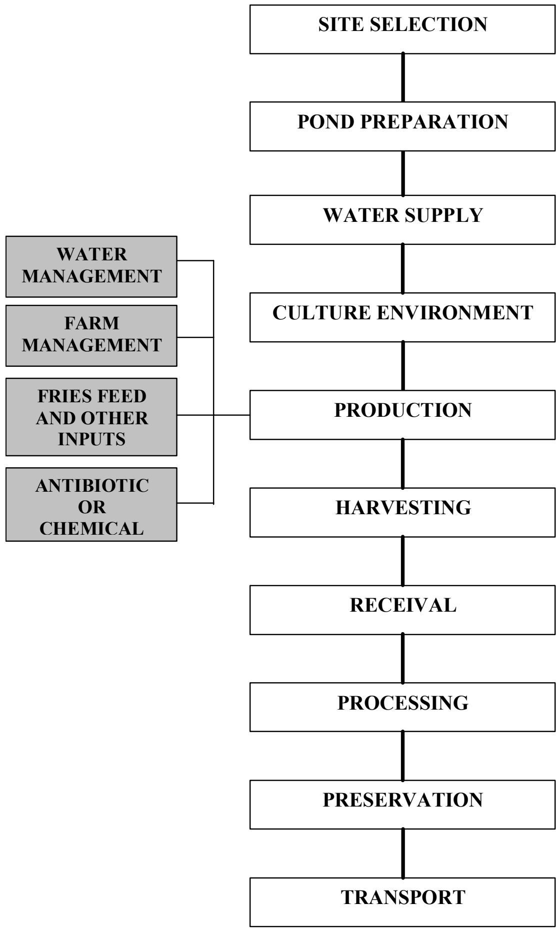
The Thai shrimp aquaculture industry has had an excellent record for the production of safe products of consistent quality. Techniques such as surveillance and inspection of final products do little to assure the food safety. The hazard analysis critical control point system (HACCP) enables aquaculturists and processors to exercise more control over food safety. HACCP is essentially a technique based upon anticipation and prevention of food safety hazards and it may be applied throughout the food chain from producer through to final consumer, leading to enhanced food safety and better use of resources.

The Department of Fisheries together with the aquaculture industry and processing industry has jointly developed preventive approaches to assure control over raw materials, the manufacturing process, the production environment, and personnel. It is based on the identification of potential hazards, application of control measures at critical control points (CCP), and monitoring and verifying of CCPs thereby enabling the assurance of food safety during culture and processing.

Application in shrimp farming

Black tiger shrimp *(Peneaus monodon)* is cultured for four to five months in earthern ponds and fed with formulated pellet feed. Water can be either changed continually throughout culture period or not at all i.e zero water discharge system. Permitted antibiotics or chemicals may be used to treat shrimp at larval stages or when shrimp are found infected. Shrimp is harvested manually. Harvested shrimp is put in ice within 15 minutes after catch, it is then sorted and packed in ice and shipped to the processing factory. The process is depicted by Figure 1.

Figure 1: Generic aquaculture process flow chart and critical control points.



Note : Fry, feed, and other materials input such as lime, bacteria, premix, chemicals and permitted antibiotics are assessed as control points

Haszard analysis

Specific hazards that may be encountered in shrimp aquaculture are shown in Table 1:

Applying HACCP

The potential hazards in aquaculture should be identified, and all activities associated with production, harvesting, processing, storage, distribution, and marketing evaluated. This includes a review of:

- The use of antibiotics, and other veterinary chemicals.
- Potential sources and specific points of bacterial contamination during production and processing.
- The potential for microorganisms to survive or multiply in aquaculture products.
- The risks and the severity of all hazards identified.

It is necessary to establish whether:

- Pathogenic microorganism/toxins may be present in raw materials.
- Pathogens may contaminate aquaculture products after harvest.

In Thailand it is recognized that specific hazards that may be encountered in shrimp aquaculture products include: Contamination by bacterial and viral parthogens e.g. Salmonella, *Vibrio cholerae*, and presence of antibiotics (and other substances) which may have potentially hazardous effects on consumers, handlers, and the environment.

It is largely accepted that the microbiological quality of the production environment impacts on the microbiological quality of the fish and ultimately the processed product. They represent a threat to human health when they are consumed raw, hence there is needed for control over production, harvesting, processing, and distribution.

Claims on the potential hazards from *Salmonella* and *Vibrio* species in the context of shrimp are conflicting. *Salmonella* and *Vibrio cholerae* are known to be part of the natural microflora of brackish water cultured shrimp, and pose a major concern for processors and exporters (Reilly and Kaferstein, 1997). In contrast, Salmonella has not been recovered

Table 1: Hazards associated with cultured shrimp

Category	Examples of hazards	
Biological hazards	Pathogenic bacteria	Salmonella, Shigella, *E.coli, Vibrio cholerae, V.parahaemolyticus, V.vulnificus, Listeria monocytogenes,* etc
Chemical hazards	Veterinary residues	Hormones, growth regulators, antibiotics such as chloramphenical, nitrofuran and its metabolites and permitted antibiotics which residue is not over MRL.
	Pesticide residues	Herbicides, fungicides, insecticides, etc
Physical hazards	Glass, wood, metal, etc	

This is the company's newly acquired 18 million baht equipment for LC-MS-MS nitrofuran and metabolites analysis. The company's staff have been training with the fisheries department

Clearly, cultured crustaceans may present a threat to public health if they are not grown and harvested under hygienic conditions. Once harvested, aquaculture species are at risk from contamination in the processing plant with a wide range of pathogenic bacteria derived from the processing environment, water used in processing, equipment, and food handlers. There is need for more research to identify and assess potential hazards and to quantify the risks.

Antibiotic residues became of concern in 1992, when Japan's health authority rejected some shipments of shrimp products from Thailand and other Southeast Asian countries that were contaminated with oxytetracycline and oxoloinic acid. In 2002, Nitrofuran and chloramphenicol came under the spotlight of the European market. The US Food and Drug Authority expressed concerns over residues in shrimp. These prompted studies and a surveillance program to prevent these hazards initiated by the Department of Fisheries.

Preventive measures

Preventive measures, using HACCP concept, can be developed specifically to prevent drug residue and chemical contamination in aquaculture products and to prevent microbiological contamination at the farm and processing plants. Those measures are outlined as follows:

Controls at farm level

Measures taken:

1. Register farms
2. Control the uses of feed/antibiotics
3. Monitor residue in products from farm
4. Mobile unit control of diseases, use of antibiotic and feed
5. Monitoring the quality of water (both inlet and outlet of farms)
6. Inspect farm hygiene and post-harvest handling practices.
7. Train farmers on good aquaculture practices (GAP), safe use of chemotherapeutic agents and good handling practices

Farm registration

All shrimp farms must be registered and obtain permits to operate. General requirements include: Establishment of water treatment ponds; lay out approval by DOF; quality of water outlet does not exceed a biological oxygen demand of 20 mg/l; drainage of mud and brackish water to public water ways is not allowed; application of good farming practices; and farm hygiene and handling practices should be at a satisfactory level (based on Codex Guidelines on hygienic practices for the product of aquaculture).

Farm inspection

Farm inspection ensures that the farm observes required sanitation and operational standards. A farm sanitation checklist was developed based on Codex Guidelines and used in inspection. The criteria for inspection are:

Large scale farms of more than 8 ha must institute a farm management program which is approved by DOF. Farms are inspected by DOF two to four times a year to verify farm records.

Small farms (less than 8 ha.) are visited by a mobile unit inspection service. DOF operates 22 mobile units in major aquaculture areas, the units inspect approximately 8 farms a week and rotate their visits until all areas are covered, which often means not less than 5 inspections per farm over a year.

Table 2

Potential Critical Control Points	Preventive Controls	Responsible Division
Farm management	farm registration	Coastal Aquaculture and Fisheries Research and Development Bureau
Feed production	feed control	Feed Research and Control Institue
Farming practices	control uses of antibiotics	Coastal Aquaculture Health Research Institute
Farming practices	mobile unit control (monitor quality of water, antibiotic residue, shrimp) monitoring residue in raw material	Coastal Aquaculture and Fisheries Research and Development Bureau
Processing plants	inspection of processing establishment pre shipment inspection of finished products	Fish Inspection and Quality Control Division

Table 3

Country	Name	Maximum level (ppb)
EU	Nitrofuran (Metabolites)	(ppb)
	shrimp, prawn, fish	SEM = 1.00
		AHD = 1.00
		AOZ = 0.30
		AMOZ = 0.30
	References except Germany SEM 0.50 ppb	
	Chloramphenicol	(ppb)
	shrimp, prawn, fish	0.30
	References except Germany 0.20 ppb	
	Oxolinic acid	(ppm)
	fin Fish (only forzen fish)	0.30
	3-MCPD	(ppm)
	Fish sance, Oyster sance	0.02
Japan	Oxytetracycline	(ppm)
	shrimp, prawn, fish	0.20
	Oxolinic acid	(ppm)
	shrimp, prawn, fish	Not detected
Switzerland	Nitrofuran (Metabolites)	(ppb)
	shrimp, prawn, fish	SEM = 1.00
		AHD = 1.00
		AOZ = 0.30
		AMOZ = 0.30
	Chloramphenicol	(ppb)
	shrimp, prawn, fish	0.30
China	Nitrofuran (Metabolites)	(ppb)
	Culture shrimp, surimi	SEM = 1.00
		AHD = 1.00
		AOZ = 0.30
		AMOZ = 0.30
	Chloramphenicol	(ppb)
	Culture shrimp, surimi	0.30
USA	Chloramphenicol	(ppb)
	Culture shrimp	0.30
	Oxytetracycline	(ppm)
	Salmon, Catfish and Lobster	2.00
Canada	Nitrofuran (Metabolites)	(ppb)
	shrimp, prawn, fish	SEM = 1.00
		AHD = 1.00
		AOZ = 0.30
		AMOZ = 0.30
	Chloramphenicol	(ppb)
	shrimp, prawn, fish	0.30
	Oxytetracycline	(ppm)

Feed quality control

In order to prevent the use – inadvertent or intentional - of feed containing antibiotics, the following control measures are enforced: Registration of feed formulas; sampling feed/analysis for antibiotic residue (from plants and farms); and inspection of feed mills.

Farm monitoring

Twenty-two mobile units operated by them Coastal Aquaculture and Fisheries Research and Development Centers conduct surveillance and provide technical advice on: Farm sanitation monitoring; disease control; water quality monitoring at inlet and outlet; soil quality inspection and determination; quality of surrounding water; antibiotic residue in shrimp from pond; and use of feed and antibiotics. A farm sanitation rating report has been developed following the Codex Code of Hygienic Practices for the product of aquaculture.

Raw materials control

The effectiveness of the surveillance program at farm level is verified by determining the level of drug residue in shrimp raw materials from farms. The 17 units equipped with HPLC were set up in major aquaculture areas to inspect the quality of shrimp prior to harvesting. The activities include: Establish record of farm; sampling shrimp from farm (> 3 months) prior to harvesting to determine level of drug and chemical residue using microbioassay. A certificate of antibiotic-free raw materials will be given for shrimp that are drug free. One unit equipped with LC-MS-MS was set up to inspect nitrofuran in shrimp before harvesting.

Processing plant monitoring

To prevent microbiological hazards such as *Salmonella*, monitoring of processing plants are conducted. In addition to microbiological hazards, chemical hazards such as antibiotics and chemical residues, which are of concern to a verification program are prevented through monitoring of sanitation, hygiene and processing (p48)

Asia-Pacific Marine Finfish Aquaculture Network

Magazine

Contents

First Breeding Success of Napoleon Wrasse and Coral Trout

Sih Yang Sim (editor)

The Research Institute for Mariculture – Gondol, Bali, Indonesia - has successfully bred Napoleon wrasse, a premium species in the live reef fish market, commanding prices as high as US$100 per kg. Captive breeding of Napoleon wrasse has long been one of the "holy grails" of marine fish culture and NACA and the APMFAN congratulates the Gondol researchers in achieving this breakthrough. Many others have tried, but this is the first reported success.

The spawning took place around December 2003, via combined hormone treatment and environmental control. Larviculture is still at a very early stage and survival rate of the larvae is currently low. The larvae have a small mouth so first feeding is still the main issue to be tackled. SS-rotifer seems to be a suitable first feed for Napoleon wrasse.

So far (April 17, 2004) around 100 small juveniles have survived at around 2-3 inches. The growth rate for this species is very slow; at 5 months old the fish only reach a maximum of 3 inches. However, slow growth is a common issue when a new species is bred for the first time, and will likely improve as the nutritional needs of this species are better understood.

Researchers at Gondol have also had some success in breeding coral trout (*Plectropomus leopardus*). The spawning took place in January 2004 and by April 2004 around 100

More photographs overleaf...

Handling male *Cheilinus undulatus* broodstock.

Network Sponsors:

Australian Government
Australian Centre for International Agricultural Research

APEC

fingerlings of 2 inches are kept in the research facility. Similar to Napoleon wrasse, coral trout also have small mouths and require very small first feed, such as SS-rotifers.

Marine Finfish Aquaculture Magazine
An electronic magazine of the Asia-Pacific Marine Finfish Aquaculture Network

Contact
Asia-Pacific Marine Finfish Aquaculture Network
PO Box 1040, Kasetsart Post Office
Bangkok 10903, Thailand
Tel +66-2 561 1728 (ext 120)
Fax +66-2 561 1727
Email grouper@enaca.org
Website http://www.enaca.org/marinefish

Editors
Sih Yang Sim
Asia-Pacific Marine Finfish Aquaculture Network, c/o NACA
sim@enaca.org

Dr Michael J. Phillips
Environmental Specialist & Manager of R&D, NACA
Michael.Phillips@enaca.org

Simon Wilkinson
Communications Manager, NACA
simon.wilkinson@enaca.org

Dr Mike Rimmer
Principal Fisheries Biologist (Mariculture & Stock Enhancement)
DPIF, Northern Fisheries Centre
PO Box 5396, Cairns QLD 4870
Australia
Mike.Rimmer@dpi.qld.gov.au

Canulating female C. undulatus broodstock

Above / below: Coral trout broodstock (Plectropomus leopardus) from the Gondol Research Institute for Mariculture. Coral trout can change colour in just a few seconds. In the wild they usually adopt a smooth, even tone while swimming (which may be light or dark, depending on their surroundings). They swiftly shift to a disruptive pattern with spots and saddles when threatened, or when settling on the bottom to ambush their prey.

Welcome to the magazine

Issue 1, 2004 (April-June)

Welcome to the new quarterly Asia-Pacific Marine Finfish Aquaculture Magazine. This is a new publication of the Asia-Pacific Marine Finfish Aquaculture Network (APMFAN), coordinated by NACA, in cooperation with ACIAR, APEC, Queensland DPI&F, and SEAFDEC Aquaculture Department.

This magazine builds on the successful electronic newsletters of the marine fish network. The regular marine fish "eNews" will continue, complemented with this new "e-magazine". The magazine provides the opportunity for researchers, development projects, and industry, to share experiences and report progress in research and development of marine fish aquaculture in the Asia-Pacific region. The editors welcome articles on breakthroughs in marine fish culture research, case studies of successful development initiatives, examples of better farming and marketing practices, and other interesting new developments.

In each edition the magazine emphasizes different themes in marine finfish aquaculture. This edition provides an update on recent progress in marine fish hatchery and nursery development. Future editions are planned on marketing, trade and economics, nutrition and feeding, and environment and health themes.

The next issue of the magazine will be focused on markets and trade in marine fish, and the economics of marine finfish farming in Asia. If you would like to contribute to the magazine, please send your article – short or long – to the editors at the address in the side panel. Contributions are very much appreciated.

The Editors

Above: And here they are...the world's first hatchery-reared Cheilinus undulatus fingerlings. Below: Hatchery-reared juvenile coral trout.

Above and below: Live reef fish holding facilities for the export trade

Regional Developments & Update

Sih Yang Sim

NACA, PO Box 1040, Kasetsart Post Office, Bangkok 10903, Thailand, Tel: (66-2) 5611728 (ext 120), Fax: (66-2) 5611727, E-mail: sim@enaca.org

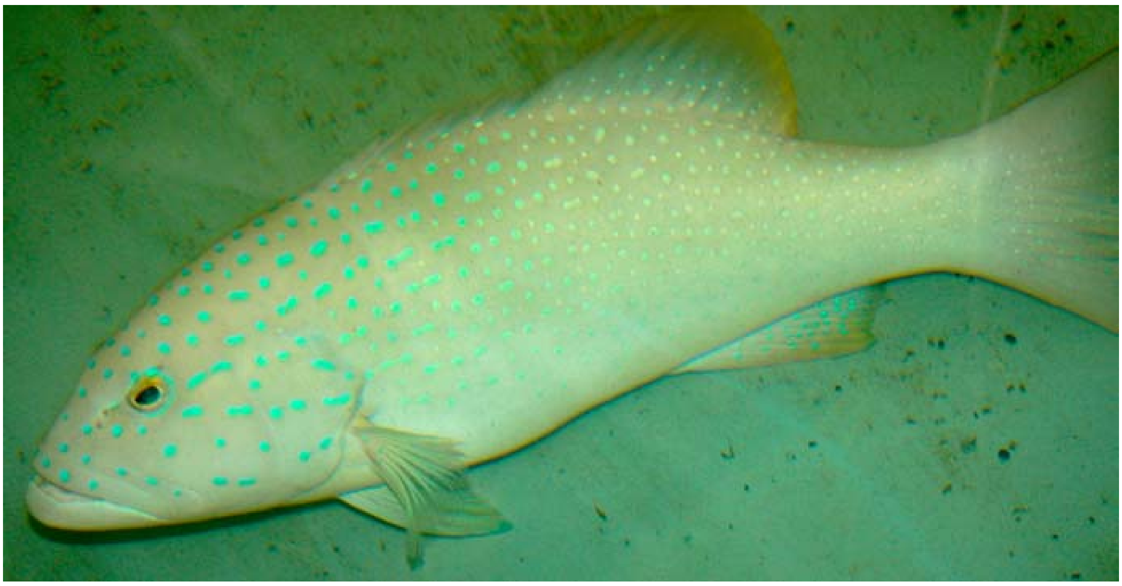
With recent progress in grouper hatchery and nursing technologies and techniques, hatchery reared groupers are increasingly contributing to the aquarium trade or grow-out industries. Training in grouper hatchery and nursing technologies has been one of the activities of the Asia-Pacific Marine Finfish Aquaculture Network through the coordination of the Network of Aquaculture Centres in Asia-Pacific (NACA) in cooperation with Northern Fisheries Center, Queensland, Australia (QDPI) and Research Institute for Mariculture-Gondol (RIM-Gondol). Two regional grouper hatchery training courses were conducted in 2002 and 2003. The support for this training came from the Ministry of Marine Affairs and Fisheries, Indonesia, the Network of Aquaculture Centres in Asia-Pacific (NACA), the Australia Centre for International Agricultural Research (ACIAR), the Asia-Pacific Economic Cooperation (APEC) and the Japan International Cooperation Agency (JICA). The training courses have successfully trained 28 people from 10 countries, with some trained participants already reporting success in grouper fingerling production and improved hatchery techniques, from Australia, India, Malaysia, Thailand and Vietnam.

Indonesia has been leading in the production of mouse and tiger grouper fingerlings, with most of these fingerlings now supplying domestic grow-out. This development is due to the increasing focus on marine finfish aquaculture development in Indonesia by the government. However, increasing concern also been raised for the quality of seed produced from some of the hatcheries in Indonesia. There are some 50 and 3 grouper hatcheries in Bali and Lampung respectively. Although some other species of groupers such as *E. coioides* and *E. polyphekadion* are also reported to be produced, the commercial interests are not strong. *E. coioides* fetches a lower price and wild fingerlings are abundant, so hatchery operators are not expressing strong interest. While for *E. polyphekadion*, although it commands a relatively higher wholesale price in Hong Kong (US$25) and Southern China (US$27) markets, the fact is that it grows very slowly for grow-out stage, and economic returns become a problem for small-scale farmers who do not have strong cash flow.

Recently, preliminary success in *Plectropomus* spp. breeding is also opening up a new potential for these species to be produced in hatcheries. Although at an early stage of research and development, promising results have been archived in Indonesia and Thailand. *Plectropomus maculatus* has been reported to be produced in Lampung, Indonesia (Ref: Marine Finfish Aquaculture Newsletter No. 6, July-September, 2003) while *Plectropomus leopardus* was been produced in Trad, Thailand (Ref: article below). Both places are government research facilities and the number of fingerlings produced is still relatively low, about 100 and 49, respectively. Many research institutes in the region also targeting *Plectropomus* spp. as part of their grouper breeding programs.

Increasing research interest is focusing on the CITES listed species of Napoleon wrasse (*Cheilinus undulatus*). Several countries, such as Indonesia, Malaysia and Thailand are collecting broodstock and aiming at breeding this species in captivity.

Other high value species, such as tuna are also moving toward hatchery technology development. A large tuna hatchery facility in Indonesia was completed in 2003 and collection of yellowfin tuna broodstock has been achieved. Breeding trials are expected to begin in 2004.



Plectropomus maculatus at the Trad Research Station, DOF, Thailand. Photo by Hassanai Kongkeo.

A Guide to Small-Scale Marine Finfish Hatchery Technology

The guide provides an outline of the requirements to establish a small-scale marine finfish hatchery, giving attention to both technical and economic aspects. It is intended to provide sufficient information for potential investors to decide whether investment in such ventures is appropriate for them. The guide provides some basic technical information to help indicate the level of technical expertise necessary to operate a small-scale marine finfish hatchery. It is not intended as a detailed technical guide to the operation of small-scale hatcheries but additional information sources on technology, including training courses are provided.

This guide has been written by a team of experts in marine finfish aquaculture who have been involved in a multinational collaborative research project since 1999. This research project *Improved hatchery and grow-out technology for grouper aquaculture in the Asia-Pacific region*, funded by the Australian Centre for International Agricultural Research (ACIAR), has made an important contribution to improving the sustainability of marine finfish aquaculture by improving hatchery production of high-value species, particularly groupers.

The second phase of the ACIAR project will commence in July 2004 and information and progress on this project will be available from the project web site: http://www.enaca.org/grouper/

Thailand Success in Culture of Coral Trout (*Plectropomus leopardus*)

(Based on a translation of an article in the agriculture & scientific column, Thairath Newspaper, 9th March 2004 by Mr. Hassanai Kongkeo)

Blue-spotted grouper is the Thai local common name of coral trout. There are many species and families of grouper with different sizes varying from 5 cm up to 200-300 kg. Groupers in Thailand are usually named after their appearance such as red-banded, duskytail, yellow, greasy, green eye, humpback, etc. Due to their high value in both domestic and export markets, scientists have been attracted to conduct research on artificial breeding and culture. There has been success with some species such as *E. coioides*.

It is locally believed that eating leopard coral grouper will have aphrodisiac effects, creating high demand for this fish in local markets with prices of up to Baht 800-1,000/kg. This in turn has led to overfishing and fishermen have reported difficulty in catching this fish over the past 1-2 years.

Mr. Thawat Sriveerachai, Chief of Trad Coastal Aquaculture Station of the Department of Fisheries reported that research carried out in Trad has provided information on the life history and behaviour of coral trout. This species is easily frightened, lives in very clean water, and the larvae feed on very tiny aquatic organisms. He collected wild fish with assistance from offshore fishermen and now there are 20 broodstock available in the Trad station.

An artificial breeding programme commenced at Trad station in 2002. The first spawning occurred in July 2003 but the newly hatched larvae only survived three days. A second batch was spawned in August 2003, and this time larvae only survived six days. Another 17 trials had been conducted up to October 2003.

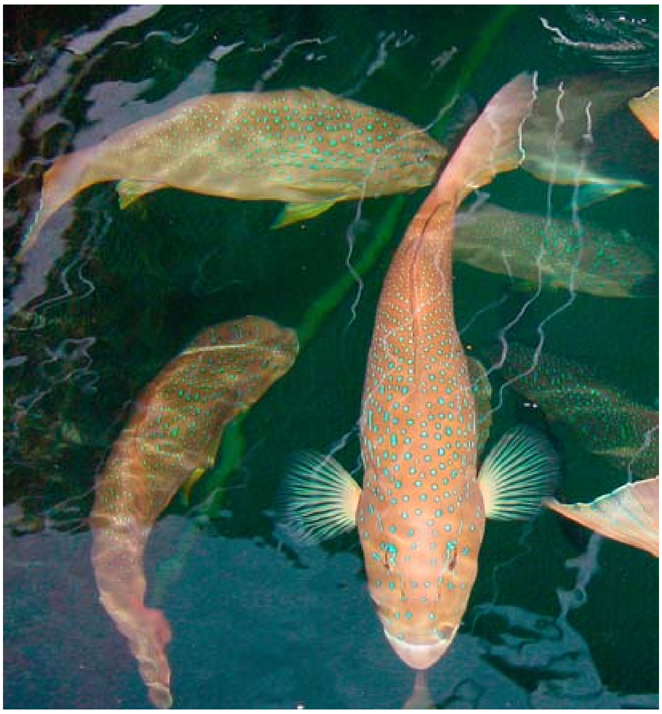
The first successful batch yielded 49 surviving fingerlings at 100 days with average of 6 cm body length and 3.5 g body weight. It is accepted that 100 day fingerlings have passed the critical juvenile period. This is the first success in Thailand for breeding of this grouper.

Indonesia Pushing for Commercial-scale Grouper Farming

Indonesia has been leading the region in production of grouper fingerlings, particularly for mouse and tiger grouper. This success has in part been due to support from grouper projects by organizations such as ACIAR & JICA to the Research Institute for Mariculture – Gondol since 1999. Mass production of hatchery techniques for these two grouper species are now relatively well developed and have been adopted by small-scale hatcheries, however larger scale operations are also increasingly emerging.

Indonesia is expecting to see grouper aquaculture accelerate over the next few years. The government research centers, located at Gondol, Lampung and Surabaya, are playing key roles in providing technical support to the industry as well as supplying eggs, fry and fingerlings to the industry. There has been a lot of development in Lampung Bay, South Sumatra for grouper grow-out, particularly cage culture operations.

However, development of the industry is not without problems and constraints. Diseases such as VNN and iridovirus have been causing mass mortality at hatchery and grow-out stages. In addition, parasitic diseases (benedenid monogeneans and *Cryptocaryon* sp.) are also major issues. There is increasing concern about the possibility of spreading these diseases to wild grouper populations.



Coral trout broodstock at Lampung station. (Photo: S.Y. Sim)

However, protocols are being developed to reduce the risk of these diseases and their economic impacts.

Continued research on formulated feed for grouper grow-out is been carried out in RIM-Gondol. The second phase of the ACIAR Project "Improved Hatchery and Grow-out Technology for Grouper Aquaculture in the Asia-Pacific Region" will commence in the second half of 2004 and this 3.5 year project will continue to support the development of the formulated feed for grouper aquaculture.

Some research activities have been prioritized by the Indonesian government including focus on the development of reliable methods and techniques for improving nutrition (live feeds; feeding of larvae, fingerlings, juveniles and broodstock) and disease control. Genetic improvements and disease resistance are also come under consideration.

A further proposal from the Australian Institute of Marine Science and Indonesia's Directorate of Aquaculture on GIS/Database computer models to identify best sites for aquaculture and mariculture along the Bali coastline is currently also under consideration for funding by ACIAR.

Submitted on 8 February 2004 by Seamus McElroy, contact: Dr Seamus McElroy, AMSAT Ltd, Wisma BNI 46 Level 43, Jl. Jendral Sudirman, Kav 1, Jakarta 10220, Email: amsat4@attglobal.com

Indonesia Gearing up for Yellowfin Tuna Breeding

The Research Institute for Mariculture–Gondol (RIM-Gondol), Bali, Indonesia began constructing a yellowfin tuna hatchery facility in 2001, which was completed in 2003. At the NACA TAC 7 meeting, July 2003, a field trip was arranged to visit RIM-Gondol facilities which had already started to collect yellowfin tuna broodstock for their breeding program.

In early 2004, at a press conference Dr Adi Hanafi (Director of RIM-Gondol) stated that RIM-Gondol currently has 43 yellowfin tuna broodstock in the holding tanks, and they are expecting to conduct the first spawning trial in June 2004.

This yellowfin tuna project is partly funded by Overseas Economic Cooperation Fund (OECF) of Japan in a four year project with the objective to successfully spawn, fertilize and hatch yellowfin tuna in captivity. If breeding is successful, this may bring farming of yellowfin tuna to commercial farmers in Indonesia.

Submitted on 8 February 2004 by Seamus McElroy, contact: Dr Seamus McElroy, AMSAT Ltd, Wisma BNI 46 Level 43, Jl. Jendral Sudirman Kav 1, Jakarta 10220, Email: amsat4@attglobal.com

Gemma Micro – Leaving Artemia Behind

Trine Karlsrud

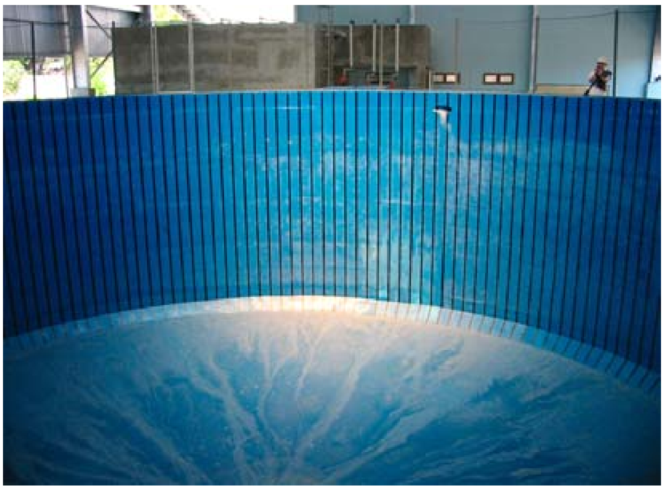
SKRETTING - Australia, 26 Maxwells Rd., Cambridge, Tasmania, 7170, Australia, Tel: +61 3 6216 1211, Fax: +61 3 6216 1234, E-mail: trine.karlsrud@nutreco.com

A novel technology is employed for making Gemma Micro and this article outlines some of the concepts and results behind that product.

Production of marine fish juveniles in commercial hatcheries still depends on the supply of live feed. Until now, dry feed substitution for live feed (weaning) is only performed after some weeks of life in marine fish hatcheries. Weaning is crucial for lowering production costs and to meet the demand for high and constant quality juveniles.

As cultivated live feed is similar to natural plankton, this can have some advantages for example; live feeds stimulate feeding behaviour by chemical and tactile cues. Cultivated live feed is not optimal, as it needs to be enriched to meet the nutritional requirements of larvae. Moreover, quality of live feed is variable, and use carries microbial risks. From a practical point of view, live feed requires separate biological production systems to that of larval rearing. This increases the complexity and uncertainty of juvenile production and

Above: The tuna hatchery situated on the bay. Below: One of the huge tuna broodstock tanks (Photo: S.Y. Sim)



40 days old sea bream larvae fed Gemma Micro

from an economic point of view, live feed supply and purchase price both vary widely.

One of Skretting's products launched in 2003 for marine fish is Gemma Micro, a feed developed to replace *Artemia* in most marine fish larvae (barramundi, yellowtail, grouper, etc.). Developed by INRA/IFREMER Skretting in France started the exclusive manufacture of Gemma Micro on a commercial scale from summer 2001. Both laboratory and commercial tests have given very good results (growth, survival and improved development) for several marine fish species.

Gemma Micro has some revolutionary thinking behind it: it corresponds to the specific requirements of marine fish during very early development. The INRA/IFREMER Nutrition team studied digestive enzymatic activity onset during larval development. These studies defined optimal protein, dietary fat and phospholipid levels both from the quantitative and qualitative points of view.

202,000 barramundi (Lates calcarifer) weaned larvae were produced using Gemma Micro with minimum use of Artemia at Darwin Aquaculture Centre in Australia

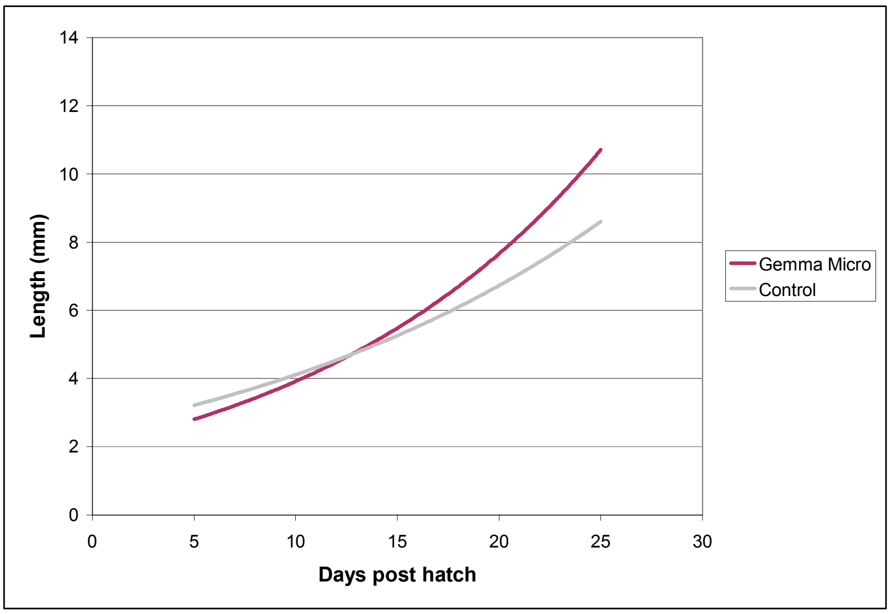
Jerome Bosmans and his team at Darwin Aquaculture Centre, Northern Territory Fisheries, in Australia, have recently tested Gemma Micro in barramundi larvae. Larvae were stocked in two square 5-ton intensive recirculated tanks (water exchange of 15-30 %/hour, water temperature of 29.5-30^{0}C) at a density of 80 larvae per liter.

Photoperiod was 12 hours/day. Both the experimental and control tanks were fed rotifers only from 36 hours post-hatching until day 5. Then the experimental tank (Gemma Micro) was fed Gemma Micro and rotifers until day 12 when a small amount of *Artemia* was introduced with Gemma Micro. The control tank (Control) was fed employing the standard weaning protocol using rotifers, *Artemia* and a commercial weaning diet. *At day 25 larvae fed Gemma Micro were on average 35 % bigger than larvae in the control tank (Figure 1).*

In the experimental tank only one can (0.44 kg) of *Artemia* was used to wean 202,000 fish using Gemma Micro. This means that *only* 2.2 kg of *Artemia* was used per million larvae weaned over the larval rearing period (20-30 kg *Artemia* per million larvae is considered to be excellent in similar systems using the standard weaning protocol).

On the basis of results obtained in this trial, Jerome Bosmans is now confident that they can completely eliminate the use of *Artemia* in their intensive larval rearing system.

Figure 1 - Relationship between average length (mm) and days post hatch for larvae fed Gemma Micro and the control tank



28,000 barramundi juveniles (Lates calcarifer) were produced without any Artemia *in Indonesia*

At Fega Marikultura located in Jukung Island, Pulau seribu, Indonesia, barramundi larvae were reared using *only* Gemma Micro - no *Artemia*.

One 10 m^3 tank was stocked with about 100,000 2-day old barramundi larvae. The experimental tank was fed rotifers and Gemma Micro until day 9 (larvae length about 4 - 4.5 mm), while the control tank was fed only rotifers. The larvae in the experimental tank showed normal feeding behaviour and microscopic analyses showed that larvae had feed in their digestive system. The results showed that larvae fed rotifers and Gemma Micro grew better than larvae in the control tank.

On day 9 the experimental tank was split into two (experimental and control) 10 m^3 tanks by siphoning. The experimental tank was fed Gemma Micro followed by routine weaning diet, while the control tank was fed *Artemia* followed by routine diet until day 25. It was observed that larvae in the experimental tank became brown (a sign of metamorphosis) at 8 mm length compared to 11 mm length in the control tank. This is clear proof of the superior nutritional value of Gemma Micro compared to *Artemia*. At the end of the experimental period (day 25), they counted 28,000 high quality barramundi juveniles. The survival rate was the same in both the experimental and control tanks.

6 day old barramundi larvae (photo: Sagiv Kolkovski)

Conclusion

Gemma Micro has really proved itself as an effective *Artemia* replacement diet for barramundi and a number of other marine species. This will prove a valuable tool for the marine hatchery wishing to reduce costs, improve quality and to put juvenile production onto a more convenient and cost-effective footing. Gemma Micro will give marine fry a 'flying start' and provide a valuable foundation for the next feed in Skretting's product range: Gemma.

For more details please contact the author Trine Karlsrud at Skretting in Australia trine.karlsrud@nutreco.com.

Editors note: We do not endorse any commercial product, the article is merely the view of the author.

Reference

Skretting Outlook Magazine, Number 19, Spring 2003 pp. 7 - 10.

Hobas...continued from page 19

a skill enhancement programme for shrimp farmers in Sri Lanka (Drengstig *et al*. 2004). This project focuses on communicating Codes of Practices and Best Management Practices, and to facilitate a practical implementation of such voluntary standards among farmers in Sri Lanka. It is beyond all doubts that more efficient technology in combination with an improved understanding of these complex systems will contribute to a more viable shrimp farming industry.

Moreover, NIVA, RF and HOBAS is also cooperating in a major R&D project in India together with the National Institute of Oceanography (NIO), Goa were the HOBAS technology is being tested under commercial conditions. Finally, the HOBAS technology is being tested in Spain under commercial terms for production of the carp tench (Tinka tinka) in earthen ponds. The technology seems highly suitable for pond farming either in brackish or freshwater systems producing fish or shrimp.

Note: Cited references are available from the corresponding author.

Report of the Komodo fish culture project

Trevor Meyer MSc & Peter J. Mous PhD

TNC Southeast Asia Center for Marine Protected Areas, Jl Pengembak 2, Sanur, Bali, Indonesia, Tel: +62-(0)361-287272, Fax: +62-(0)361-270737, E-mails: tmeyer@tnc.org; pmous@tnc.org

A pilot project to establish a multi-species reef fish hatchery in Loh Mbongi and village-based grow-out farms in communities surrounding Komodo National Park, West Flores, Indonesia. Report from The Nature Conservancy, Southeast Asia Center for Marine Protected Areas in collaboration with the Komodo National Park authority.

The main objective of the fish culture project is to provide sustainable fish culture as an alternative livelihood to non-sustainable fishing practices in and around Komodo National Park. A secondary objective relates to the Hong Kong based trade in live reef fish. Currently, the live reef fish trade is rapidly depleting the Indo-Pacific stocks of Napoleon wrasse (*Cheilinus undulatus*) and groupers (Serranidae). It is hoped that the Komodo fish culture project can demonstrate how fish culture of groupers can be done in a sustainable and environmentally sound manner, thereby contributing to the market transformation of the live reef fish trade from unsustainable, capture-based to sustainable, culture-based.

The Komodo fish culture project aims to involve local communities in the grow-out of estuary grouper *Epinephelus coioides*, mouse grouper *Cromileptes altivelis*, tiger grouper *Epinephelus fuscoguttatus*, sea bass *Lates calcarifer* and mangrove jack *Lutjanus argentimaculatus*, which can be marketed as live product to the Hong Kong - based live reef fish trade.

Fingerlings are produced from captive broodstock in a hatchery situated in Loh Mbongi (ca. 6 km North of Labuan Bajo). The pilot project aims to produce 25 tons of live fish yearly, to be realized over 3-4 harvests per year per grow-out unit. A grow-out unit consists of a complex of 16 floating cages, varying in size between nine and 25 m^2 surface area. In the pilot phase, four grow-out units will be deployed near the villages that are participating. The produced volume will consist of a mix of the five species for which broodstock is presently secured. This multi-species approach reduces risks related to species-specific vulnerability to disease and to fluctuation in consumer preference and price. The species composition of initial batches of fingerlings will depend on hatchery practicalities, as this batch will be used for training in grow-out in village-based fish farms rather than for the generation of revenue.

In the pilot phase (i.e. production capacity of 25 tons annually) the project will involve ca. 20 villagers on a full-time basis, but many more will be trained in grow-out techniques. Once economic viability and environmental sustainability have been demonstrated, a carrying capacity analysis will be carried out to determine the optimal production capacity, after which a private business partner will be invited to upscale and develop the project into a triple bottom-line business – economically viable, socially responsible and environmentally sound.

As culturing of grouper still poses some technical challenges, the fish culture project created partnerships with institutes that can provide the necessary know-how. The main partners in the Komodo fish culture project are the Research Institute for Mariculture in Gondol (Bali, Indonesia), the Department of Primary Industries & Fisheries, Queensland (Australia) and the Network of Aquaculture Centers in Asia-Pacific (NACA).

By March 2003 construction was completed, and the hatchery at Loh Mbongi was officially inaugurated in July 2003 by the Minister of Fisheries and Marine Affairs of Indonesia. This event was attended by senior local government officials and key stakeholders.

Full operational capability of the hatchery was reached by March 2003. The first batch of eggs that were transferred from the broodstock facility to the hatchery were of estuary grouper, collected during March 2003. Larval survival reached 3.7%, an encouraging result for the first production. This batch had been successfully stocked into grow-out cages by June 2003 and had reached an average weight of 350g by February 2004. Since hatchery production commenced, all of the five species of fish maintained at the Komodo Fish Culture Project have been successfully reared to the grow-out phase.

Hatchery production, however, has not been without its challenges, and survival rates have varied considerably. To date, the best survival rate achieved has been 7.6%, for a batch of mouse grouper produced in July 2003. During July 2003, a batch of 20,000 mouse grouper were reared in the nursery, representing the first production of a commercial-sized batch by Loh Mbongi.

An assessment of suitable sites for the installation of cage fish farms around the Komodo area was completed by the end of October 2002, with the most suitable sites being found close to the villages of Boleng, Medang, Sape and Menjaga. Subsequently, other suitable sites have been identified at Warloka and close to Pulau Misa. At present, no aquaculture development is envisaged within the national park boundaries.

The first of the four planned community grow-out units was installed and stocked with fish during December 2003, in the village of Warloka. This site was chosen due to the considerable interest shown by the community in

Cromileptes altivelis fingerlings produced at Loh Mbongi

involvement in the Fish Culture Project, and by its suitability for cage culture.

Community members of all targeted villages have visited the facility at Loh Mbongi and discussed the aims of the Fish Culture Project. To date, most have shown considerable interest in the project, and efforts are now underway to install the second community-based grow-out unit.

The Komodo Fish Culture Project is now entering its most critical phase, that of its transfer to a private business partner, to allow for its upscaling to a commercially viable business. The pilot project has demonstrated the viability of community-based grouper culture in the Komodo region, and a massive demand for hatchery-reared juvenile grouper and snapper exists in eastern Indonesia at the present time. Existing Indonesian commercial hatcheries are unable to meet this demand.

The Komodo Fish Culture Project is currently seeking a business partner to assist in the transformation of this pilot project to a financially sustainable enterprise, whilst conforming to the primary project aims of social responsibility and environmental soundness. All interested parties are invited to contact Dr. Peter J. Mous (Science and Training Manager) or Mr. Trevor Meyer (Mariculture Manager).

Conclusion of Research on Capture and Culture of Pre-settlement Fish for the Marine Aquarium Trade in Solomon Islands

Cathy Hair, Warwick Nash, Peter Doherty

Ms Cathy Hair: Senior Fisheries Biologist, Agency for Food and Fibre Sciences, Department of Primary Industries & Fisheries, Northern Fisheries Centre, PO Box 5396, Cairns QLD 4870, AUSTRALIA, Tel: 617 4035 0150, Fax: 617 4035 6703, E-mail cathy.hair@dpi.qld.gov.au

Between February 1999 and December 2003 the WorldFish Center, Solomon Islands, carried out research on a new artisanal fishery based on the capture and rearing of pre-settlement coral reef fish (Hair et al. 2002). This work was funded by the Australian Centre for International Agricultural Research (ACIAR). Environmentally friendly methods (light traps and crest nets) were used to capture postlarval fish as they settled from the plankton. Simple aquaculture techniques were used to grow these fish to marketable size. The key factor is that fish are plentiful at this stage of their life cycle, but high mortality accompanies the transition from a planktonic to benthic lifestyle (i.e. settlement) (Doherty et al. 2004, Phillips et al. 2003). By harvesting fish immediately prior to or at settlement, adequate numbers of pre-settlers can be taken for aquaculture without affecting natural replenishment to the reefs since the large majority of those harvested would not have survived to adulthood anyway. The new fishery can therefore assist in addressing concerns of over-fishing for marine ornamentals (Sadovy and Vincent 2002, Wabnitz et al. 2003) and has potential to provide a vital source of cash income for coastal communities in the Pacific and Asian regions.

In the first phase of the research light traps and crest nets sampled postlarval supply for a week before and a week after the new moon every month from October 1999 to September 2001. Light traps were deployed in shallow water near submerged reefs and predominantly sampled competent, positively phototactic pre-settlers (Doherty 1987). Crest nets were set behind the surf zone on a shallow reef to capture fish passing between oceanic and lagoonal habitats (Dufour 1993). Very few species of value to the live reef food fish trade were recorded but ornamental species comprised 15% and 5% of the light trap and crest net catches, respectively. Only one species, lobster (*Panulirus* sp.) showed any seasonal trend in settlement rate, being more common from June to September in both years. Grow-out to market size was initially done in land-based concrete raceways, but later in sea-cages as this is a more appropriate technique for a village situation. Growth and survival of all teleosts (i.e. fin-fish) improved when rearing was transferred to floating sea-cages, although survival of crustaceans was higher in stationary, benthic cages. Fish and crustaceans were fed small amounts of minced fish, fish roe, crustacean and mollusc meat – items readily available in a coastal village.

In the first phase of the study a suite of species suitable for capture, rearing and sale to the marine aquarium trade were identified. Surprisingly, although the study originally proposed to catch and rear teleosts, banded cleaner shrimp (*Stenopus* spp.) and lobster (*Panulirus* sp.) were the most valuable component of the catch in Solomon Islands. Crest nets were chosen as the method with most potential for an artisanal fishery as they caught significant numbers of high-value crustaceans, yet were relatively cheap and simple to build and operate. Unfortunately, mortality in the nets was very high because animals caught in the soft cod-end either dried out at low tide or were crushed against the mesh during strong current flow. The second research phase was carried out in 2003 with the principle aims of (i) developing a cheap and simple "fish-friendly" harvest method for village use (based on the crest net); and (ii) developing ways to enhance survival and growth rates of fish in sea-cages.

Several modifications of the crest net were tested in an effort to improve survival at capture. The cheapest and most versatile of these comprised a cod-end constructed from a plastic bin or wooden box with mesh sides and roof. The solid cod-end retained water at low tides and provided shelter for fish during strong currents. Fish were guided into the cod-end via a hand-sewn, knotless 3 mm mesh net attached to the front of the box (Fig. 1). The effectiveness of the new "fish friendly" cod-end was well demonstrated by the improved survival rates: teleosts increased from 5 to 64%, shrimp from 10 to 97% and lobster from 85 to 97%.

A novel technique used to boost catches of lobster pueruli in 2003 was coconut logs drilled with holes (Fig. 2) and deployed in approximately 2 m depth on the reef flat behind the crest nets. The logs were a modified form of a fishing method used in Vietnam (K. Williams, pers. comm.). This was the first time the method had been used in the Pacific and it was very successful. The log collectors were mostly occupied by clear pueruli, although occasionally a pigmented puerulus was recorded. Logs were checked every morning during the new moon sampling periods of July, August and September 2003. During August, the peak recruitment month for lobster, abundance in the crest traps and logs was the same (mean = 1.8±0.3 se per device per night). The highest overnight log catch was 31 pueruli (mean = 6.0±1.7 per log). Floating artificial seaweed puerulus collectors were also deployed during the lobster recruitment season but were unsuccessful, possibly due to insufficient conditioning or strong currents.

Efforts to enhance the survival and growth of valuable species through improved grow-out techniques had mixed results. Banded cleaner shrimp were the most abundant and valuable species collected. With careful handling they were easily kept in good condition between collection at the reef crest and transfer to their grow-out habitat. Rearing cleaner shrimp was problematic due to fierce intra-specific aggression. All attempts to grow them en masse resulted in poor survival (12-60% in three weeks); the best survival was achieved through growing them individually in jars (80-100% in four weeks). The highest survival and growth were obtained in jars that were painted black to reduce exposure to sunlight that caused algal growth on the exoskeleton. The jar-rearing technique, however, was only suitable for *Stenopus hispidus* (banded cleaner shrimp). Two of the less abundant but higher-value species of banded cleaner shrimp, *S. zanzibaricus* and *S. tenuirostris*, survived but did not grow well in jars. Future work will investigate whether a combination of jar culture to nurse them through the first week, followed by rearing on an artificial reef is more appropriate for these species. Lobster were generally easy to rear and were successfully grown en masse in cages on the seafloor as long as sufficient food was provided (average survival was greater than 70% over three weeks). Problems with teleost grow-out were experienced due to the location of the sea-cage in deeper, exposed water. Small fish in the floating cages were subjected to strong currents moving through the nets and further disturbance in rough seas, forcing them to swim vigorously for extended periods to maintain their position in the water column. During rough sea conditions, mortalities in sea-cages were higher than in

Figure 1: Larvae trap

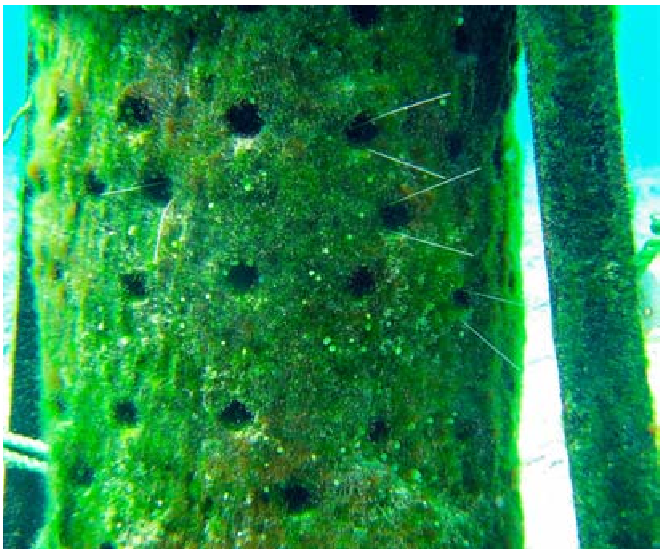


Figure 2: Lobster pueruli trap

calm weather. A fixed sea-cage in shallow, sheltered water near-shore is proposed as a more acceptable alternative.

A draft manual explaining how to catch and rear these species has been produced and the methodology will be proposed for Marine Aquarium Council approval under the Mariculture Standards that are to be drafted soon (P. Holthus, pers. comm.). A computer model of the fishery using estimated start-up costs, production (calculated from three years of fish collection) and local farmgate prices indicated that a fishery for marine ornamental species based on pre-settlers is economically viable. Furthermore, similar fisheries are operating commercially in other areas of the Pacific (Dufour 2002, X. Neyrat pers. comm.). The Solomon Islands artisanal model is based on fishing with two crest traps that would sample a total of three metres of reef. However, these methods are yet to be tested in a village situation and at a profitable scale (i.e. production of 200-300 high-value animals per month). A new project to support aquaculture development in the Pacific is commencing in early 2004. The project, funded by ACIAR and run jointly by Queensland Department of Primary Industry Northern Fisheries Centre, Secretariat of the Pacific Community and the WorldFish Center, will oversee transfer of the postlarval fish capture and culture technology to a demonstration farm in a Solomon Islands' village. This exciting stage of the work will be the ultimate proof of the feasibility of the new fishery. The draft manual will be rewritten to reflect the lessons learned during this process and be made available to assist in adoption of the techniques by other Pacific Island and Asian countries.

References

Doherty, P.J. (1987) Light traps: Selective but useful devices for quantifying the distributions & abundances of larval fishes. Bulletin of Marine Science 41:423-431.

Doherty, P.J., Dufour, V., Galzin, R., Hixon, M.A. and Planes, S. (2004) High mortality during settlement bottlenecks the abundance of a coral reef fish. Ecology (in press)

Dufour, V. and Galzin, R. (1993) Colonization patterns of reef fish larvae to the lagoon at Moorea Island, French Polynesia. Marine Ecology Progress Series 102:143-152.

Dufour, V. (2002) Reef fish post-larvae collection and rearing programme for the aquarium market, report on the first year of operations at the AquaFish Technology farm in French Polynesia. SPC Live Reef Fish Information Bulletin 10:31-32.

Hair, C.A., Bell J.D. and Doherty, P.J. (2002) The use of wild-caught juveniles in coastal aquaculture and its application to coral reef fishes. Pages 327-353 in R.R. Stickney and J.P. McVey (Eds) Responsible Marine Aquaculture. CAB International.

Phillips, B.F., Melville-Smith, R. & Cheng, Y.W. (2003) Estimating the effects of removing *Panulirus cygnus* pueruli on the fishery stock. Fisheries Research 65:89-101

Sadovy, Y.J. and Vincent, A.C.J. (2002) Ecological issues and the trades in live reef fishes. Pages 391-420 in Coral Reef Fishes: Dynamics and Diversity in a Complex Ecosystem (edited by P.F. Sale). Academic Press, San Diego.

Wabnitz, C., Taylor, M., Green, E. and Razak, T. (2003) From Ocean to Aquarium. UNEP-WCMC, Cambridge, UK.

Seed Production of Sand Bass (*Psamoperca weigensis*)

Le Dinh Buu

Support to Marine and Brackishwater Aquaculture - SUMA, 78 Thong Nhat St, Nha Trang, Khanh Hoa, Vietnam, Tel : +84 058 822941, Fax: +84 058 822921, E-mail: lbuu.suma@fsps.com.vn

The Fisheries University of Nha Trang, Vietnam, with funding support from the "Support to Brackish and Marine Aquaculture Component (SUMA)" component of the DANIDA/Ministry of Fisheries Sector Program Support has successfully produced the seed of sand bass (*Psamoperca weigensis*, Cuvier & Valennciennes). The local names for this fish in Vietnam are "ca chem mom nhon" (pointed snout fish) or "ca thay boi" (fortune teller fish). The species belongs to the Centropomidae family and is found in Indopacific region. In the wild, it lives in schools near coral reefs, in bays or associated with seaweed or sea grass in lagoons. This fish has a good taste with a price in Vietnam of around USD 5-6 / kg.

The experiment involved a total of 34 broodstock collected from the wild. Two females and two males were reared in a 12m^3 tank with the following water quality - salinity 22-34 ppt, temperature 22-32^{0}C, pH 7-8.9, with tank is aeration.

Broodstock were injected with the hormone LRHa. The fertilized eggs are around 0.8 mm in diameter. They were incubated in a tank with water temperature between 28-29^{0}C, salinity 33-35 ppt and pH 7.6-7.8. The eggs hatched after 14 hours and the hatching rate was 86%.

The larvae were reared in tanks ranging from 200 litres, 2 m^3, and 12 m^3. *Nanochloropsis occulata* was mass produced in 1 m^3 volume containers for rotifers that were enriched with squid oil before being used to feed larvae.

The density of rotifer used for various stage of larvae culture was as follows:

- 3 rotifers/ml for larvae of 1.5 days age
- 3-5 rotifers/ml for larvae of 2.5–9 days age

The fish larvae were fed with *Artemia* nauplii and rotifers from 10 to 50 days old. Artificial feed was used from 51 day onwards. The growth rate of fish is slow, around 0.04-0.06 cm/day and the survival rate to 50 days around 5.8 %.

Fingerlings of 50-51 day old were nursed both in earthen ponds and floating cages. Fish reared in cages were found to do better than in ponds. The conditions in rearing ponds were as follows:

- Salinity – 27-30 ppt
- Temperature – 30-38°C

- pH 8-8.5
- Fish stocking density - 40/m^2
- Feeding - trash fish (4 times/day, 20-40% of fish weight)
- Survival rate from stocking - 50% (4 months)

The conditions in floating cages were as follows:

- Salinity - 35-36 ppt
- Temperature - 27-29°C
- PH - 7.9-8.5
- Density - 30/m^3
- Feed - trash fish and artificial feed
- Survival rate - 70% (4 months)

The success of seed production of sand bass will enable farmers in Khanh Hoa coastal area and other places in Vietnam to have the opportunity to culture another valuable marine fish for seafood markets.

ACIAR Project "Improved hatchery and grow-out technology for marine finfish in the Asia-Pacific region"

The second phase of the ACIAR marine fish project has been approved and is due to commence in July 2004. The project will continue to support the Asia-Pacific Marine Finfish Aquaculture Network and its activities. This is a 3.5 year project and the activities will covers Australia, Indonesia, Philippines, Thailand and Vietnam.

The overall objective of the project is to enhance the sustainability of marine finfish aquaculture in the Asia-Pacific region by improving hatchery production technology and facilitating the uptake of compounded feeds for grow-out. Progress and development of the project will be reported and made available to wider audience through the network website and newsletter. A brief project summary is given below.

Marine finfish aquaculture is an important contributor to the economies of coastal communities throughout the Asia-Pacific region. Although production of hatchery-reared fingerlings is increasing, much of the seedstock supply for this sector continues to be dependent on capture of wild fry and fingerlings, which limits fingerling availability and contributes to over-harvesting. Grow-out operations use 'trash' fish, which results in localised pollution and competes with other needs for fishery products. The previous project *Improved hatchery and grow-out technology for marine finfish aquaculture in the Asia-Pacific region* made substantial improvements to the sustainability of marine finfish aquaculture in the Asia-Pacific region. This follow-on project will continue lines of research that demonstrated maximum benefits in the earlier project, and will continue to support the synergies that were developed between partner agencies in the earlier project through collaborative research activities.

The follow-on project will focus on improving survival of hatchery-reared high-value marine finfish larvae, and increasing the reliability of hatchery production. Larval rearing technologies will be expanded to other high-value species such as coral trout (*Plectropomus* spp.). The grow-out diet development component of the project will focus on promoting uptake of compounded pellet diets at the expense of 'trash' fish use. Research activities will focus on identifying ingredients likely to lower diet cost and reduce environmental impacts (nutrient outputs).

A third component of the project will evaluate the socio-economic constraints to uptake of the technologies (hatchery production, artificial diets) and develop strategies to overcome these constraints. The communication and coordination strategies developed under FIS/97/73 will be continued and the Asia-Pacific Marine Finfish Aquaculture Network will be strengthened and expanded through a process of formalisation of participating agencies and individuals. Enhanced industry involvement in the network will be encouraged, and long-term network sustainability will be enhanced, by accessing corporate sponsorship of network activities.

These outputs will contribute to the development of sustainable marine finfish aquaculture in the Asia-Pacific region by increasing the supply of hatchery-reared fingerlings to support increasing demand for high-value marine finfish species for aquaculture. The use of compounded grow-out diets will reduce 'trash' fish utilisation and reduce pollution associated with the use of 'trash' fish as a feed source. The project will link closely with two other ACIAR projects: *Environmental impacts of cage aquaculture in Indonesia and Australia* (FIS/2003/027) and *Feasibility study of economic impacts of developments in the live reef fish food trade in the Asia-Pacific region* (ADP/2003/022).

NACA/DOF/TDH* Workshop on Seafarming and Seafood Markets

A one day workshop was held in NACA Secretariat Office at Bangkok, Thailand on March 25, 2004. The purpose of this workshop was to conduct a review of seafarming experiences and start to identify opportunities for future development in Thailand. The workshop was attended by some 50 participants.

The workshop aimed to assist the Department of Fisheries to prioritise future research and development activities in seafarming in Thailand, and provide opportunities for further cooperation with NACA, TDH and other stakeholders to strengthen research and development for seafarming in Thailand.

The workshop covered the following themes:

- Regional overview of mariculture
- Markets and demand trends for mariculture products
- Marine fish farming in Thailand
- Mollusc farming in Thailand
- Seaweed farming in Thailand
- Other seafarming species

The report of this workshop is available on the NACA website.

**TDH - Terre des Hommes Foundation-Italy. NACA has started cooperation with TDH project in Phanga Nga Bay, Southern Thailand entitled "Children of the Sea – Requalification of Small-scale Fisheries Micro-enterprises and Ecosystem-based Innovation of Aquatic Production Systems for the Sustainable Development of Thai Coastal Communities". The cooperation involves simultaneous studies of seafarming technology and markets in southern Thailand, Bangkok live fish markets and trading networks,* *regional markets and a status review of regional seafarming production technologies. Further information on the project will be made available through a new web site and a report expected to be available in July 2004. In the meantime, further information can be obtained from Paolo Montaldi or Sandro Montaldi at a.montaldi@tdhitaly.org.*

Collaborators

The following organizations and contacts have been designated as focal points for communication in the marine fish network.

Hong Kong

Dr Jim Chu,
jim_cw_chu@afcd.gov.hkIndia

Dr Mohan Joseph Modayil,
mdcmfri@md2.vsnl.net.in

Indonesia

Dr Ketut Sugama, crifidir@indonet.id

Dr Muhammad Murdjani,
lbapstbd@radnet.id

Iran

Dr Shapour Kakoolaki,
bsh443@yahoo.com

Malaysia

Marine fish culture in coastal areas - Mr Ali bin Awang,
ppbuk@po.jaring.my
Fish quality - Mr Ismail Ishak & Mr Hamdan Jaafar,
anasofiah@hotmail.com /
hamdanj@yahoo.com

Low food chain species - Mr Hussin bin Mat Ali
pppil@po.jaring.my

Philippines

Ms Prescilla B. Regaspi,
pregaspi@bfar.da.gov.ph

Ms Marygrace C. Quintero,
mgquintero@bfar.da.gov.ph

Collaborating organisations

Aquaculture Calendar

For more events listings the NACA Events & Training page at

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

Aquaculture Europe 2004 conference on "Biotechnologies for Quality", 20-23 October 2004, Barcelona, Spain

This European and international meeting will bring together participants from as many as 40 countries to address the key issues and discuss some of the most advanced scientific results and technological tools. Aquaculture Europe 2004 will be organized through plenary thematic sessions, parallel sessions, poster sessions and a workshop. Although emphasis will be given through the plenary sessions to "Biotechnologies for Quality", other challenges for aquaculture development will also be approached during parallel sessions. On the first day of Aquaculture Europe 2004 (October 20), the EAS and the Spanish Aquaculture Society (SEA) will jointly organize the workshop "Challenges for Mediterranean Aquaculture Products". The workshop is designed to facilitate exchange of information between producers, researchers and others associated with the industry in an informal setting. The event is based at the first-class facilities of the Universitat Politècnica de Catalunya in the wonderful city of Barcelona. More details on the programme together with the "Call for Contributions Form" and other information can be found at the Aquaculture Europe website http://www.easonline.org/agenda/en/AquaEuro2004/default.asp. A paper version of the brochure can be requested through ae2004@aquaculture.cc.

Workshop on environmental issues of marine fish farming in the Mediterranean, 20 October 2004, Barcelona, Spain

There will be a 1-day workshop in connection with the Aquaculture Europe 2004 At the University of Barcelona, Spain, on 20th October, 2004 presenting results from on-going EU marine environmental research projects. The workshop will focus on new directions in monitoring, management tools and bioremediation techniques, including coverage of the following topics: Use of bio-assays to monitor release of nutrients in the Mediterranean; effects of Mediterranean fish farming on the seagrass *Posidonia oceanica*; monitoring of seagrasses around Mediterranean fish farms; predicting impacts on seagrass meadows through modeling Sensitive tools to detect organic enrichment of fish farm sediments (use of meio- and macrofauna); comparison of aquaculture monitoring methodologies; modelling cage aquaculture impacts; measurable aquaculture impacts; cage aquaculture and wild fish interactions; MERAMED recommended monitoring methods; the succession dynamics of naturally settled mixed heterotrophic and autotrophic communities and their potential for nutrient capture in differing environments; the economics of biofiltration; and the potential for a secondary harvest using co-culture in differing environments. The workshop is free of charge. If you would like to register to attend the workshop, Please inform either Marianne Holmer, holmer@biology.sdu.dk or Patrick White, pwhite@hol.gr

Training Course on Mangrove-Friendly Shrimp Aquaculture, 23 October – 11 November 2004, Philippines

The goal of the course is to provide participants with a basic understanding of the mangrove ecosystem, and technical knowledge and skills on shrimp culture so that they can grow shrimp in a sustainable and mangrove-friendly manner. At the end of the training course, the participants should be able to demonstrate the basic concepts of the mangrove ecosystem; explain the interrelationships between mangroves and shrimp culture; apply sustainable culture methods and management techniques; and prepare a feasibility study of a mangrove-friendly shrimp aquaculture project. Participants must be nominated by their respective governments; presently engaged in aquaculture extension or research work; with at least 2-3 years experience in aquaculture; under 45 years old; good command of English language; and with good physical and mental condition. For more information and a detailed propsectus visit the SEAFDEC AQD website.

Global Shrimp Outlook 2004, 9-12 November, Bangkok, Thailand

GAA presents the Global Shrimp Outlook series to help international shrimp marketers gain vital perspectives on the future of the shrimp industry. During this year's focused morning meeting sessions, industry experts and executives will report on current shrimp production and demand, and project shrimp prices for 2005 and beyond. Afternoons will remain free for business interaction and relaxing social activities. The GSOL schedule also includes panel discussions that will allow participants to actively address such issues as antidumping, antibiotic residues, product traceability and facility certification. Given the timing of the preliminary antidumping duties on imported shrimp recently established by the U.S. Department of Commerce, this Global Shrimp Outlook meeting will likely be even more strategically important than usual. Global Shrimp Outlook: 2004 is a by-invitation meeting for major international shrimp buyers, producers and related suppliers. Due to the proprietary nature of the conference content, registration is not available to members of the media. If you have not received an invitation to GSOL, please visit http://www.gaalliance.org/gsol.html online or contact the GAA office to request further information. To reach GAA, telephone +1-314-293-5500, fax +1-314-293-5525 or e-mail gaa.admin@attglobal.net.

Women in Fisheries and Aquaculture, 10-13 November 2004, Spain

The international conference AKTEA "Women in Fisheries and Aquaculture: Lessons from the past, current actions and dreams for the future" will take place in Santiago de Compostela (Galicia, Spain). Women in fisheries and aquaculture and researchers working on women issues from all parts of the world are all invited to visit our website: http://conference.fishwomen.org

International Conference on Aquaculture Production and Marketing of Shrimp and Finfish and Bangladesh Seafood Expo 2004, 28-29 November, Dhaka, Bangladesh

The conference will focus on the latest developments in aquaculture production and marketing of warm water shrimp and finfish species with special reference to freshwater prawns *Macrobrachium rosenbergii*, tiger shrimp *Penaeus monodon*, white shrimp *P. vannamei*, tilapia and marine finfish. The conference will also focus on environment friendly production techniques including organic production systems, emerging product quality/safety assurance approaches including traceability and labeling with emphasis on product presentation as well as marketing in the major markets, EU, US and Japan. For more information and registration email infish@tm.net.my or infish@po.jaring.my, or visit www.infofish.org. The organizers may also be contacted at INFOFISH, PO Box 10899, 50728 Kuala Lumpur, Malaysia.

7th Asian Fisheries Forum 2004, 30 November – 4 December 2004, Malaysia

The Asian Fisheries Society endeavors to make the 7th Fisheries Forum the largest fisheries event in Asia, in terms of the number of participants and impact. Working on the theme "New Dimensions and Challenges in Asian Fisheries in the 21st Century", the status of Asian fisheries will be elevated to a new level, providing ideas and solutions to overcome the inherent and unique challenges in Asian fisheries and generating technical advancement in tandem with global development. The programme will include: How to Make a Difference: Research for Impact on Fisheries and Aquaculture; recent Advances in Biotechnology; Globalization and its Impact on Asian Fisheries: Implications for Fisheries Management; Restoration and Management of Small-Scale Fisheries: Meeting the Challenge. A number of special symposia will also be held concurrently including on Gender in Fisheries; Advances in Shrimp Biotechnology; Restocking the Stock Enhancement of Coastal Fisheries: Potential Problems and Progress; Technology Needs and Prospects for Asian Aquaculture: Participation of the Poor; Biotechnology for Growth and Reproduction in Fish; and Aquatic Ecosystem Health. For further information, please contact: The Secretariat, 7th Asian Fisheries Society, School of Biological Sciences, Universiti Sains Malaysia,11800 Minden, Penang, Malaysia, Tel: +604-6533888 ext. 3961/2932/ 4005/ 4009, Fax: +604-6565125, Email: 7aff2004@usm.my, Website: http://www.usm.my/7AFF2004.

Practical Application of Food & Feed Extrusion Technology, 1-3 December 2004, Bangkok, Thailand

The three day program with be held in Bangkok, Thailand, and is aimed at providing participants with a practical knowledge of current industrial extrusion technology. The course takes participants from the basics of extrusion through to an understanding of rheology and flow in the extruder barrel. The role of different ingredients, extruder configurations, and die effects, are also covered. The content of the course covers both single and twin screw extrusion technology. The course is relevant to a range of human and pet foods, as well as to the production of aquafeeds. Offered by Food Engineering Pty Ltd in conjunction with the Food Research and Product Development Institute at Kasetsart University in Bangkok. Further information is available from the web at www.fie.com.au/extrusionasia/, or contact Gordon Young, email gyoung@fie.com.au.

International Workshop on Culture, Fisheries and Stock Enhancement of Portunid Crabs, 20-22 January 2005, Iloilo, Philippines

The workshop will include sessions on broodstock nutrition; larval culture and nutrition; nursery grow-out; fisheries and stock enhancement; genetics and taxonomy. The proceedings will be published in special edition of a peer-reviewed journal. Registration fee: $150. For more information please contact INCO_CAMS@bigfoot.com.

What's New on the Web

Australian Aquaculture Portal

The Australian Aquaculture Portal has been developed in an attempt to centralise the growing body of information, research and business opportunities in the Australian Aquaculture Industry. An initiative of the Australian Aquaculture Council with funding from the Department of Agriculture, Fisheries & Forestry, this Portal is an essential reference tool for all those working in the Aquaculture Industry. It contains an overview of the major Australian industry sectors, contact details for industry associations and a comprehensive collection of links to relevant Australian and overseas sites for those wishing to 'dig a little deeper' into the complexities and opportunities this industry offers.

The member's section contains valuable information, research, contacts and dynamic information relating to what is currently happening around Australia. A comprehensive 'conference portal' is also included to keep members and others 'updated' with current and upcoming conferences. Here portal users can access information and register online as well as refer to white papers prepared by past and current conference speakers. As information in the public, members and conference parts of this site is updated weekly.

Commercial aquaculture farm owners and workers, students, vets, teachers, government bodies and advisors should all find this portal a valuable resource containing information that is 'database driven', therefore updated in a timely and systematic manner. http://www.australian-aquacultureportal.com/

Asian Fisheries Society

The new AFS website highlights fisheries events and publications, and abstracts of papers from the AFS journal Asian Fisheries Science are provided.

AFS is a scientific society organized in 1984 for fishery professionals in Asia to communicate, share information and cooperate with each other. Since its establishment, the Society has grown from the 14 charter members who signed the constitution to over 2,800 members from 75 countries and territories. Asia has been the leading world producer of fish. Its long history of fishing and fish farming has attracted several thousand scientists, researchers and students to the field of tropical fisheries and aquaculture. As their numbers grew, the need to improve interaction and cooperation among fisheries scientists and institutions became more apparent. Thus, the seeds for the Asian Fisheries Society were sown. http://www.asianfisheriessociety.org/

Continued from page 32

practices of the plant and verification of end product quality. Monitored are:

- Sanitation, hygiene, good manufacturing practice as a basic quality control program.
- Processors must demonstrate a Quality Control program based on HACCP.
- Quality system verified by DOF.
- Processing plants are inspected 2-4 times/plant/year, for sanitation, hygiene practices, quality control system, laboratories and record at Critical Control Points and sanitation record. Those that pass the grade are included in the List of Approved Fish Processing Plants and issued an Approval Number.
- Sanitary Certificate and Certificate of Analysis of the shipment are issued, on request, to processing establishment and shipment that meet standard requirements.

Product monitoring

As required still, by import authorities, shipment of fishery products must be accompanied with a certificate stating the quality or laboratory results. This requires sampling and analysis of end products for safety, quality and wholesomeness.

For drug residue, shipments are examined by:

- Sampling for antibiotic residues of the group of tetracycline, penicillin and others using micro-bioassay
- Sampling for oxolinic acid using HPLC
- Sampling for chloramphenicol using HPLC
- Sampling for nitrofuran and its metabolites using LC-MS-MS

For microbiological hazards, shipments are determined for pathogenic bacteria and other microorganisms based on the requirements of the market. The maximum level for antibiotics and other contaminants imposed by a number of importing countries or blocks are as per table 3.

Conclusion

Preventing hazards to people's safety and health to human from cultured products can be made more effective by the application of HACCP at the farm, in other words, before the raw material even goes into the processing plant. Lima dos Santos (2002) said that HACCP can be applied through the food chain from primary production to final consumption but stressed that its implementation should be guided by scientific evidence of risks to human health.

A combination of measures are observed to prevent or control disease outbreaks. HACCP would be an effective complement to health management practices. HACCP application, along with observance of Good Aquaculture Practice (GAP) or Code of Conduct for sustainable aquaculture (CoC), enhance the overall effort at promoting sustainable and profitable aquaculture.

References

Tookwinas, S. and S. Suwanrangsi 1996 Hazard Control in Aquaculture. Page 338-391 *in* R.E. Martin, R.L. Collette and J.W. Slavin, editors. Fish Inspection, Quality Control and HACCP ; A Global Focus, Proceeding of the Conference Held in May 19-24, 1996 Arlington, Virginia, Techinnomic Pub. Co., INC. USA.

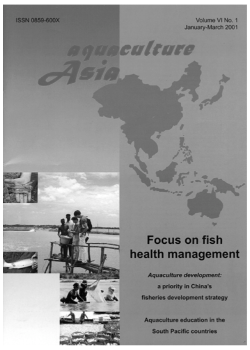
Fish Inspection and Quality Control Division. 2004. The Maximum Level for Antibiotic and Contamination Sustance in Fisheries Products, Department of Fisheries, Bangkok.

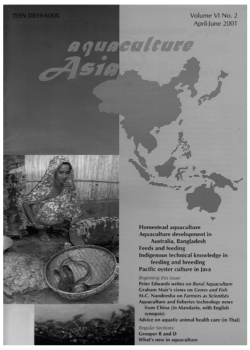
Fisheries Information Center. 2004. Fisheries Statistic of Thailand, Department of Fisheries, Bangkok (contact information).

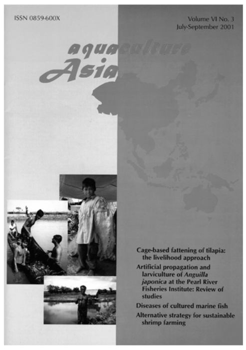
Lima dos Santos, C.A. 2002. Hazard Analysis Critical Control Point and Aquaculture. Page103-119 *in* M.L. Jahneke, E.S. Garrett, A. Reilly, R.E. Martin and E. Cole, editors. Public Animal and Environmental Aquaculture Health Issues, Wiley-Interscience, Inc.

Reilly, A. and F. Kaferstein. 1997. Food Safety Hazards and the Application of the Principles of the Hazard Analysis and Critical Control in Aquaculture Production. Aquaculture Res. 1997(28): 735-752.

Aquaculture Asia

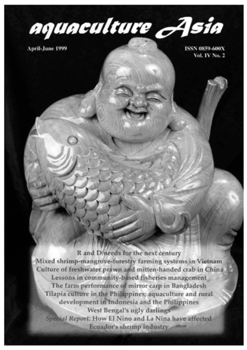




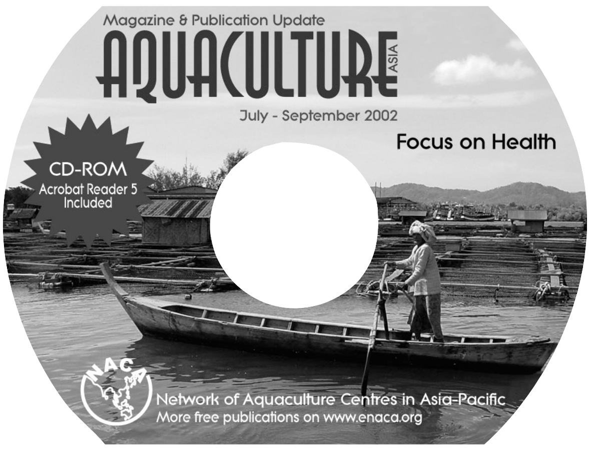


Delivered four times per year

Send your order to:
The Editor, Aquaculture Asia
Kasetsart Post Office Box 1040
Ladyao, Jatujak, Bangkok 10900
Thailand
Fax +66 (2) 561 1727
Email publications@enaca.org



Or get the CD version - includes a free Quarterly Publications Update



US$ 15/year in NACA member countries

US$ 25/year elsewhere


Research has shown that you are what they eat.
A well-balanced diet is essential for our health. Hence the saying "you are what you eat". However accurate this phrase may be, it does not cover the whole story. Because an important part of our daily diet is produced by animals. A diet for which fish and shrimp are of increasing importance. And, as you well know, their health also depends strongly on their diet.
In other words: the better the feed, the better the food. Therefore, we promote the production of prime quality fish and shrimp through improving the nutritional value and guaranteeing the safety of our feeds and concentrates. As our studies have revealed that this leads to less stress and diseases, in animals as well as in human beings. A result we always strive for. Because we care.
INVE GROUP
INVE
Advanced Solutions
for animal rearing
www.inve.com
INVE is the proud gold sponsor of
WORLD AQUACULTURE 2003