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AQUATIC ANIMAL HEALTH MANAGEMENT: OPPORTUNITIES AND CHALLENGES FOR RURAL, SMALL-SCALE AQUACULTURE AND ENHANCED-FISHERIES DEVELOPMENT: WORKSHOP INTRODUCTORY REMARKS[1]

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ABSTRACT

The potential contribution of aquaculture to national and household food security, poverty alleviation and income generation (both local and foreign exchange) in many parts of the world has now been well recognised. Similarly, the importance of prevention and control of diseases as a measure to reduce production losses in commercial and semi-commercial aquaculture systems has also been long realised. However, there is a considerable lack of knowledge, understanding and focus on the importance of managing health in rural, small-scale, subsistence-type aquaculture. Modern-day aquaculture practices (mainly semi-commercial and commercial) involve significant domestic and international movement of live aquatic animals and animal products, which has led to the movement and spread of associated pathogens. Such introductions of pathogens not only have caused losses and mortalities in commercial systems, but have also affected small-scale, rural aquaculture and fisheries operations. Besides the impacts of pathogen transfer, many other human activities (agricultural or industrial) can also have negative impacts on rural, small-scale aquaculture and fisheries that could eventually reflect in diseases, mortalities and losses. Since rural aquafarmers are generally resource-poor with little or no knowledge of health management, their ability to respond to such situations effectively is marginal. This paper presents some potential interventions that could assist rural, small-scale, resource-poor farmers to prevent and control disease outbreaks through better health management. The importance of development and implementation of appropriate national policies and regulatory frameworks that can significantly contribute to reducing risks to poorer households involved in rural aquaculture is emphasised.

[1]This paper was prepared from an introductory presentation made at the beginning of the Scoping Workshop, to provide initial ideas and thoughts for the participants and to lay the foundation for preceding discussions.

INTRODUCTION

Aquaculture, beyond doubt, is the fastest growing food-producing sector in the world. The important role of aquaculture in providing aquatic animal protein to make up for the shortfall in wild fisheries, and its socio-economic role in providing livelihood opportunities and economic security, particularly for the less-developed regions of the world, is now being strongly recognised globally. Small-scale farmers represent the backbone of many rural communities in both industrialised and non-industrialised countries, and the contribution of small-scale aquaculture to the livelihoods of people living in rural areas in many countries in Asia is significant.

THE IMPACTS OF AQUATIC ANIMAL DISEASES

The threat of disease has now become a primary constraint and risk to the growth of the aquaculture sector, significantly impeding both economic and socio-economic development in regions dependant on aquaculture and fisheries. The importance of prevention and control of disease risks as a measure to reduce production losses in commercial, semi-commercial and small-scale aquaculture systems has thus received increased attention. Many factors have contributed to the health problems currently faced by aquaculture, including those of the rural, small-scale sector. Over the past three decades, aquaculture has expanded, intensified and diversified, such that modern-day aquaculture practices often involve significant domestic and international movement of live aquatic animals and animal products. This has led to the movement and spread of associated pathogens, and such introductions of pathogens have not only caused losses and mortalities in commercial systems, but also affected small-scale, rural aquaculture and fisheries operations. There are many such situations which exist in most aquaculture-producing regions all over the world; epizootic ulcerative syndrome (EUS) in freshwater fish, white spot disease (WSD) in *Penaeus monodon*, and viral diseases affecting cultured marine fishes are classic examples.

Since rural and small-scale aquaculture and enhanced fisheries contribute a significant amount of production of freshwater and marine fish and penaeid shrimp, a significant percentage of disease losses appears to occur in the rural, small-scale sector. There are some examples that provide an indication of the impact. Losses due to EUS in several Asian countries before 1990 exceeded US$10 million (Chinabut 1994), while WSD-related shrimp losses ranged from US$400 million in P.R. China in 1993 (Wei 2000) to US$17.6 million in India in 1994 (Subasinghe *et al.* 1995). In southern Vietnam, approximately 1,200 families dependent on rice-shrimp culture have experienced annual losses of more than US$300,000 due to shrimp diseases. Between 1995-1997, the "red spot disease" of grass carp affected 4,000 of 5,000 cages in operation, with losses estimated at US$0.5 million in rural communities in the northern area of Vietnam (Subasinghe *et al.* 2001). In a survey on the impact of fish health problems on rural, small-scale farmers involved in grouper culture in the Philippines, 88.3% of 60 farmers interviewed experienced reduction in income due to fish health and disease problems. Farmers incurred increased household debt, particularly those who borrowed capital for investment (Somga *et al.* 2001). In a related survey in Thailand, where finfish cage culture of seabass and grouper is mostly comprised of small farms (one to five cages), all of 82 farmers interviewed reported losses due to diseases (Roongkamnertwongsa *et al.* 2001).

Such losses affect the livelihoods of people involved in aquaculture and the communities in which they occur through reduced food availability and loss of income and employment, as well as other associated social consequences (Subasinghe *et al.* 2001). Diseases can result in critical shortfalls in production which can lead to food shortages and market destabilisation, and in some cases, can trigger trade problems that may affect small-scale farmers. Besides the apparent impacts of pathogen introductions and transfer, many other human activities (agricultural or industrial) can also have negative impacts on rural, small-scale aquaculture and enhanced fisheries that increase the risk of disease problems and stock losses.

ADDRESSING DISEASE PROBLEMS IN SMALL-SCALE AQUACULTURE

Rural, small-scale farmers are generally resource-poor and have little or no knowledge of health management. As a result, their ability to respond to such situations effectively is limited. It is therefore important to better understand how the rural, small-scale aquaculture sector is managed, both by the farmers themselves and the others involved in the sectoral activities, and to develop appropriate interventions which can assist resource-poor farmers to prevent and control disease outbreaks through better health management. Some of these interventions that may improve the health management standards of the rural, small-scale aquaculture and enhanced fisheries sectors include:

- developing appropriate national policies, enforceable regulatory frameworks and legislation to prevent entry of pathogens and thereby safeguard farms from disease incursions;
- improving farmer access to basic aquatic animal health services;
- focussing on research that addresses the basic needs of the farmers;
- creating opportunities for farmers to practice preventative health management, by improving basic production and management skills;
- incorporating basic health management messages into small-scale aquaculture extension programmes;
- ensuring that basic health management measures are incorporated into programmes for fisheries enhancement and small-scale aquaculture within rural livelihood projects; and
- improving extension services and enhancing communication exchange to enable quick response to disease situations.

Understanding of the risks and impacts of diseases, not only on the rural, small-scale production systems, but also on the overall livelihoods of vulnerable communities, needs to be improved. Health management should not be considered as a separate entity within aquaculture and or rural development projects involving aquaculture or enhanced fisheries. It should be integrated within the overall context of rural development programmes.

PRIMARY HEALTH CARE

The emphasis of this workshop is “primary health care.” Primary health care is considered to be an appropriate approach for small-scale aquaculture. It should be practical, community-based, scientifically sound, socially acceptable and appropriate to the needs of small-scale farmers. The emphasis should be on preventative health care of aquatic animals and maintaining a healthy environment that reduces the risk of disease outbreaks or production losses, and promotes healthy production systems. The emphasis should also be on people and populations, and not narrowly limited to pathogens and technology.

The challenge of this workshop will be to shed some light on the scale of the existing aquatic animal disease problems and their impacts in order to gain a better understanding and further insights of their risks to rural livelihoods. There is opportunity to identify methods for monitoring the health of these systems at the farm level and to develop affordable interventions tailored for the needs of the poorer members of the rural aquaculture community. The opportunity also exists to reverse the trend of top down development in aquatic animal health management and to develop a holistic approach that will benefit small-scale producers and those who are most vulnerable.

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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

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ABSTRACT

There are many similarities between smallholder livestock and aquaculture systems where application of the same principles of health management will result in similar outcomes. Thus, it would seem appropriate that lessons learned from the livestock sector should be applied to aquaculture and vice versa. However, improving prevention and control of disease can only result from a clear understanding of what causes different disease syndromes and their epidemiology. Without this knowledge, little real progress can be made. For example, detailed epidemiological studies in northern Thailand identified three major reasons why some villages, and not others, had a problem with a particular livestock health problem known as foot and mouth disease. Once this was known, appropriate government control strategies and extension advice could be designed, applied and monitored. Controlling disease at the farm and village level extends to national programmes, whether they are for general disease surveillance or specific disease control initiatives. The basis of sound disease control programmes is good information about the diseases that are present. This can only be obtained through the combination of competent diagnosis, well-designed disease reporting systems and specific field surveys and other studies. In the livestock sector, information technology is being increasingly used to assist in the management and analysis of data. However, the primary constraint still lies in the quality of basic data collected from farms and villages and how representative it is.

Throughout Asia, there are various levels of capability of governments to improve the health of animals in the smallholder sector, resulting in improved production and increased trade. In some countries, such as the Philippines and Lao PDR, responsibilities for livestock and aquatic animal health lie in the same governmental department. In such instances, excellent opportunities exist to share experiences, expertise and resources. In some Asian countries, livestock health surveillance and control systems for smallholders are quite well developed. Where possible, advantage should be taken of this situation for improving aquatic animal health management.

There is now increasing pressure on governments to provide better quality information on the health status of livestock and aquatic animals. This will become increasingly important over the coming decade for those countries that export aquatic animal products, particularly live animals, as well as chilled and frozen product. *The International Aquatic Animal Health Code* of the Office International des Épizooties provides a guide to how surveillance should be undertaken and disease occurrences reported. Basic surveillance and reporting systems to meet international obligations can be put in place at little cost, with improvements to the

system coming as resources and capabilities improve. For example, in the Philippines, all the reporting needs for the national foot and mouth disease eradication programme are handled by a relatively simple database that has the capacity to quickly produce both tabular and map-based reports. The challenge for different countries will be to efficiently implement low-cost systems that are effective in addressing the goals of the various levels of government, as well as meeting international reporting obligations.

Some constraints specific to aquaculture (and in some instances, fisheries also) will mean that disease surveillance and control systems will be different from those in livestock. For example, sick and dead animals are more difficult to detect, there are fewer diagnostic tests available, and sampling from aquatic animal populations is more difficult than from livestock. Such constraints pose unique challenges, and solutions will not always be easily found.

INTRODUCTION

There are many similarities between smallholder livestock and aquaculture systems where application of the same principles of health management will result in similar outcomes. This is particularly true for the more intensive livestock systems, where increasing stocking densities combined with commercial pressures to continually make production efficiency gains have lead to increasing problems with infectious disease. A good example is the poultry industry. Through to the early 1960s in Australia, small, owner-operated farms dominated this industry, often with many aspects of the production cycle, such as breeding, hatching and growing, carried out on the one farm, with family members providing most of the labour. As profit margins came under pressure, outputs increased, with consequential increases in production stresses. Some diseases, which were previously not a concern, began to show more severe manifestations, and costs of control using antibiotics and disinfectants rose. This was not sustainable, and management solutions were eventually required. This led to a total restructuring of the chicken meat industry: “multi-age” farms were replaced by “all-in all-out” farms, where a single batch of chickens is raised, the farm totally depopulated, cleaning and disinfection undertaken to reduce the microbial load and then the next batch of chickens introduced. More recently, consumer concerns for animal welfare have led to new pressures on the poultry industry to reduce stocking densities and provide more natural housing conditions. A secondary consequence may well be an improvement in poultry health.

Global production from aquaculture is presently estimated to be increasing at approximately 13% per year. If this rate is sustained, production will double every six years. Additionally, the increases are not uniform and thus, in some countries, growth may be a lot higher than in others. In simple terms, this phenomenon of rapid growth means more susceptible hosts will be available for pathogens to infect, as well as more farms with less distance between them and possibly higher stocking densities. It follows that there are likely to be more disease problems, and the spread of epidemic diseases will be much more rapid, with potentially more devastating impacts, both on commercial and small-scale farmers. It would be wise to plan for this situation rather than respond once it happens.

In this paper, current issues from the livestock sector are outlined and consideration is given to how these might apply to the rural small-scale aquaculture sector.

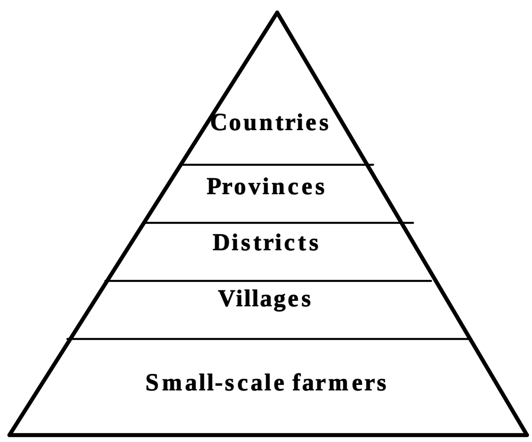
HOW IMPORTANT IS THE SMALL-SCALE LIVESTOCK SECTOR?

In developing countries throughout the Asian Region, the percentage of the population that is involved in agriculture ranges from 50-90% (FAO 1999). In these countries, 10-20% of gross domestic product (GDP) is derived from livestock, and small-scale producers raise 60-90% of the livestock. The annual increase in production ranges from 1 to 2.5% (Delgado *et al.* 1999). Thus, the small-scale livestock sector plays a vital role in the economy of the Asian Region and provides an important component of the livelihood of many people, particularly the rural poor.

HOW IS THE SMALL-SCALE LIVESTOCK SECTOR ORGANISED?

In farming systems, the obvious primary unit of interest to support services such as government agencies, is the individual farmer. This is particularly so for the small-scale farmer, who is responsible for virtually everything associated with his or her animals, including their health. If the individual farmer does not have the relevant knowledge, skills, resources and willingness, then the health of the animals will be at risk. In some cases, where factors beyond the control of the individual farmer, such as floods and drought, impact on the health of the animals, even this is insufficient. However, government and other sources of assistance often operate with groups of farmers, rather than individuals, as this is seen as a more effective use of resources. A useful first level of aggregation of individual farmers is the village. Plans and decisions on livestock disease surveillance and control programs involving the small-scale livestock sector often use the village as the main unit of interest, under the assumption that the animal health status among farms within the village will be more similar than between villages. In this instance, a village comprises families of people, some of whom raise livestock. A village group of livestock is, therefore, analogous to a "farm" in the commercial sector. There are a number of further hierarchical levels of administrative aggregation at which risks for animal health occur and disease surveillance and control measures may be applied. This hierarchical order of aggregation is represented in Box 1. Of course, different countries use different names for the different levels, and sometimes, there are additional levels, such as regions.

Box 1. Hierachical order of aggregation for farming systems.



MAJOR ISSUES FOR LIVESTOCK HEALTH

World Trade

International spread of disease impacts not only on the commercial livestock sector, but also on small-scale farmers. Globalisation means that the world is effectively becoming a smaller place in the face of continually expanding volumes of world trade, including livestock commodities. Such commodities are transported rapidly over large distances; genetic material is more accessible, with new breeds and species being introduced to different countries according to perceived needs; and animal health information is disseminated rapidly with equally rapid quarantine responses. To assist in managing these issues, we have seen the emergence of the World Trade Organization (WTO) as an important body responsible for the administration of a number of multilateral agreements, such as the General Agreement on Tariffs and Trade (GATT), Agreement on Agriculture and the Agreement on Sanitary and Phytosanitary Measures (SPS Agreement). These are meant to provide a framework to facilitate trade, while providing mechanisms to reduce risks associated with freer trade. In the case of livestock commodities, one of the greatest risks is an increase in the international spread of disease. The SPS Agreement provides core principles while the *International Animal Health Code* of the OIE (see OIE 2000) provides standards for management of these risks.

In recognising the international spread of disease as one of the potentially greatest downsides in the emerging changes to world trade, the Animal Health Service of the Food and Agriculture Organization (FAO) of the United Nations has consolidated its activities under EMPRES (Emergency Prevention System for Animal and Plant Pests and Diseases). The livestock component of EMPRES is known as EMPRES-Livestock. The purpose of EMPRES-Livestock is to promote the effective containment and control of the most serious epidemic livestock diseases–TADs (Trans-boundary Animal Diseases). These diseases, which include rinderpest, foot and mouth disease and Newcastle disease have their greatest impact on rural small-scale farmers in developing countries – the group least able to prevent and control such diseases.

Consumer Interests

Recent major livestock disease calamities, such as “mad cow” disease in the United Kingdom, Nipah virus in Malaysia and regular reports of food-borne illness, are resulting in greater consumer pressures for guarantees of “safe” livestock products. This has strengthened the move to on-farm, HACCP-based management of livestock, supported by accreditation of participants and audit systems to monitor compliance. There has also been a shift of some resources from disease control programmes to improved disease surveillance, where this is seen to be a better use of limited resources to safeguard consumer interests. For example, a new chapter of the OIE *International Animal Health Code* (OIE 2000] provides quite detailed specifications for national surveillance programmes for “Mad Cow” disease. The European Union requires that countries from which they import meat must comply with these specifications or face cancellation of trade agreements.

Reduced Government Involvement

In some countries such as Australia and New Zealand, government inputs into livestock disease surveillance and control are rapidly diminishing, with livestock industries expected to take more responsibility for their own problems. This is mainly because of reallocation of resources into more pressing areas, such as public health, education and welfare. It is interesting to note that this comes at a time when the need for animal health resources appears to be increasing. With these cost burdens now carried directly by livestock industries, trade competitiveness can be put at risk. In other countries, direct government assistance to small-scale farmers has been reduced. For example, in Zimbabwe, it was traditional that the government organised and met the cost of treating smallholder cattle for external parasites, many of which transmit serious, production-limiting diseases. This service has largely been dismantled, placing a vulnerable group at increased risk of substantial damage to their livelihood.

More Focused Services

In an attempt to contain costs, a more business-like approach to the prevention and control of livestock diseases is beginning to emerge in some countries. This involves clearly identifying high priority areas for attention, using targeted research and development to help solve problems and implementing routine programs within the framework of a business plan. For this to occur, high quality information on the occurrence, epidemiology and impact of disease is required.

In addition, more outsourcing of services is being undertaken based on competitive tendering. For example, in the State of Victoria in Australia, outsourcing to private laboratories, rather than undertaking the work in government laboratories has halved the cost of some routine serological tests. In New Zealand, some extension services that were formerly provided by government at no charge to farmers have been privatised and now operate on a fee-for-service basis.

In the Philippines, there is a national programme for the eradication of foot and mouth disease, which mainly affects pigs in that country. Careful monitoring of progress, and targeted research, have led to considerable cost savings and more rapid progress than would otherwise have been achievable. This is directly benefiting small-scale farmers, who are the ones most impacted upon by the disease. In Thailand, the same disease mainly affects cattle and buffalo. In this case, targeted research led to the identification of the three most important risk factors for disease outbreaks in smallholder herds. This has permitted development of both regulatory and extension services most likely to deliver effective outcomes. In addition, well-designed serological surveillance has enhanced the effectiveness of the national vaccination programme.

Animal Welfare

Animal welfare is emerging as a major issue, with growing impacts on livestock management practices. Livestock production in some countries must now comply with quite detailed animal welfare codes. For example, one consequence is the gradual disappearance, in some countries, of caged systems for laying hens. Although adding to the cost of production, such an initiative may result in substantial benefits for poultry health, but this has not yet been properly evaluated.

TRANS-BOUNDARY ANIMAL DISEASES (TADS)

Because of their seriousness (see Box 2) and the current FAO focus on their containment, it is worthwhile specifically discussing TADs as examples of the risks and impacts of diseases on livestock systems. Most TADs impact mainly on small-scale farmers, particularly the rural poor in developing countries. The following discussion is taken from an FAO paper by Baldock *et al.* (1999).

All animal diseases have the potential to adversely affect human populations by reducing the quantity and/or quality of food, other livestock products (hides, skins, fibres) and animal power (traction, transport) that can be obtained from a given quantity of resources and by reducing peoples' assets. Of these, trans-boundary animal diseases tend to have the most serious consequences.

Trans-boundary animal diseases may be defined as those epidemic diseases which are highly contagious or transmissible and have the potential for very rapid spread, irrespective of national borders, causing serious socio-economic and possibly public health consequences. These are diseases that cause a high morbidity and mortality in susceptible animal populations and they constitute a constant threat to the livelihood of livestock farmers. Furthermore, their potential consequences are of such a magnitude that their occurrence may also have a significant detrimental effect on national economies.

Box 2. Examples of the consequences of trans-boundary animal diseases.

- ***Foot and mouth disease*** (FMD). In 1997, the disease seriously affected the commercial pig industry in Taiwan, where 4 million pigs were slaughtered in order to control the epidemic.
- ***Rinderpest***. When this viral disease was first introduced to Africa in the late nineteenth century, it spread over almost the whole continent within ten years, killing an estimated 10 million cattle and untold numbers of wildlife – irrevocably changing livestock husbandry and wildlife ecology there. In 1994, rinderpest spread to previously long-time free, remote mountainous areas of northern Pakistan, killing an estimated 40,000 cattle and yaks.
- ***Rift Valley fever*** (RVF). The first recorded outbreak of RVF in Egypt in 1977 caused an estimated 200,000 human cases of the disease with some 600 deaths, as well as large numbers of deaths and abortions in sheep, cattle and other livestock species. An outbreak of the disease in East Africa in 1997-98 not only caused livestock losses and human deaths, but also very seriously disrupted the valuable livestock export trade to the Middle East.
- ***Contagious bovine pleuropneumonia*** (CBPP). There has been catastrophic spread of CBPP in Africa over the last few years, where it now affects some 27 countries and causes estimated losses of up to $2 billion annually. In 1995, the disease was re-introduced to Botswana for the first time in 46 years. As part of the eradication campaign, all cattle in an area of northern Botswana had to be slaughtered at a direct cost of $100 million, although indirect losses would have been much higher.
- ***Hog cholera (or classical swine fever)***. A recent serious outbreak of the disease in the Netherlands led to the death or slaughter of some 12 million pigs as part of the eradication campaign. The cost of the Dutch outbreaks was estimated to be $US 2.35 billion, half of which was public money. The effects of the epidemic were so severe that the Dutch government approved a national pig-restructuring plan that foresaw a reduction in the national pig herd of about 25% within two years.
- ***African swine fever.*** This disease occurred for the first time in Cote d'Ivoire in 1996, where it killed 25% of the pig population and cost the country, according to various estimates, between $US 13 and 32 million. It has since spread to other countries in the region, including Nigeria.
- ***Highly pathogenic avian influenza*** (HPAI)**.** An economic analysis of outbreaks of HPAI in Pennsylvania, USA in 1983-84 showed that the direct costs of eradication were $US 64 million, and the indirect costs to consumers were $500 million through increased prices of products. On the other hand, it was estimated that HPAI would have cost the US poultry industry $US 2 billion annually if it had become endemic. The influenza virus causing an outbreak of HPAI in Hong Kong in 1997 was found to be capable of transfer to humans and, as a consequence, a decision was taken to completely depopulate the 1.4 million chickens there.

Trans-boundary animal diseases have the potential to:

- Threaten food security through serious loss of animal protein and/or loss of draught animal power for cropping.

- Increase poverty levels, particularly in poor communities that have a high dependence on livestock farming for sustenance.

- Cause major production losses for livestock products such as meat; milk and other dairy products; wool and other fibres; and skins and hides, thereby reducing farm incomes. They may also restrict opportunities for upgrading the production potential of local livestock industries by making it difficult to utilise exotic, high-producing breeds that tend to be very susceptible to the trans-boundary diseases.

- Add significantly to the cost of livestock production through the necessity to apply costly disease control measures.

- Seriously disrupt or inhibit trade in livestock and livestock products, either within a country or internationally. Their occurrence may thereby cause major losses in national export income in significant livestock-producing countries.

- Cause public health consequences in the case of those trans-boundary animal diseases that can be transmitted to humans (i.e., zoonoses).

- Cause environmental consequences through die-offs in wildlife populations.

Trans-boundary animal diseases constitute only a small minority of the infectious diseases that afflict livestock. All of the infectious diseases cause some of the above adverse socio-economic consequences to a greater or lesser extent, and in fact, the cumulative production and economic losses that they cause are probably much greater than that of the so-called trans-boundary animal diseases. However, what sets the trans-boundary diseases apart is the suddenness, acuteness and widespread nature of the losses that they can produce.

Another important characterising feature of trans-boundary animal diseases is the rapidity with which they can spread in susceptible livestock populations. This renders individual farmers and private veterinary services relatively powerless to take effective action to avoid or overcome outbreaks of these diseases. The responsibility for prevention, control and elimination of trans-boundary animal diseases, therefore, falls squarely on the shoulders of the public sector, notably government veterinary services, and may require high public investment. Furthermore, these endeavours are only likely to be successful if government veterinary services are very well organised and prepared for these tasks.

As their name implies, trans-boundary animal diseases are no respecters of national or administrative borders. The control efforts of individual countries against these diseases may be continually frustrated by the fact that neighbouring countries are not taking equivalent action. Trans-boundary animal diseases, therefore, need to be tackled on a regional basis, with co-operation between countries and harmonisation of their prevention and response programmes. An international approach also allows better advantage to be taken of natural geographical barriers and broader epidemiological patterns for the diseases.

Some Major Trans-boundary Animal Diseases and Their Current Geographical Distributions

Viruses cause many trans-boundary animal diseases. Important viral diseases include:

Foot-and-mouth disease (FMD). FMD is perhaps the most contagious disease of animals, affecting mainly cattle, sheep and pigs. Although not generally a killing disease, it causes high morbidity and production losses, and is a major impediment to international trade in livestock and livestock products. The disease has been absent from southeastern Europe for over two years, and from the rest of Europe for much longer. Considerable progress has been made towards eradication in South America, with the southern countries of Chile, Argentina, Paraguay and Uruguay not having recorded outbreaks for two years or longer, and the southern states of Santa Catarina and Rio Grande do Sul having been declared "FMD free with vaccination." FMD is still endemic in many parts of Africa, the Middle East and Asia, but a regional control programme is in place in Southeast Asia.

Rinderpest (RP). RP is a generalised viral disease affecting mainly cattle and buffaloes. It usually causes a very high mortality, although less virulent strains circulating in East Africa have complicated eradication there. RP has been progressively eliminated in West Africa, but there are still three endemic foci in East Africa. Great progress has been made towards RP eradication in India, but the disease is endemic in Pakistan and has spread to Afghanistan. There are endemic foci in the Middle East. Sporadic outbreaks, the origins of which are unknown, have occurred in eastern Russia and Mongolia in recent years.

Peste des petits ruminants (PPR). PPR is a rinderpest-like disease of sheep and goats. In recent years, there has been serious spread of this disease from Africa to the Middle East, and in Asia as far east as India.

Rift Valley fever (RVF). RVF is a serious mosquito-borne viral disease of sheep, cattle and goats which causes very high mortality rates in young animals and abortion in pregnant animals. It is also transmitted to humans, causing a potentially fatal disease. Major epidemics have occurred at irregular intervals of 10-30 years in the eastern half of Africa, from South Africa to Egypt.

Lumpy skin disease (LSD). LSD is a disease of cattle that may cause serious production losses, through prolonged debility and loss of hides. LSD is mainly confined to Africa, where it has caused periodic, major epidemics in many countries.

Classical swine fever (CSF). CSF is a generalised viral disease of pigs that may cause high mortalities. It is endemic in much of South and Southeast Asia, where it is a constraint to the development of the pig industry. It is the most significant trans-boundary animal disease in Europe, where it caused 611 outbreaks in the European Community in 1997. These occurred in the Netherlands, Germany, Spain and Italy and are estimated to have cost these countries more than $7 billion. Recent outbreaks have also occurred in Latin America.

African swine fever (ASF). ASF is another generalised viral disease of pigs that is endemic in much of sub-Saharan Africa. There have been very serious outbreaks over the last few years in previously free areas of West Africa. ASF has shown great propensity for inter-continental spread, and outbreaks have occurred at different times in parts of Europe and Latin America.

Newcastle disease (ND). ND is a viral condition that is perhaps the most lethal disease of poultry. Outbreaks of ND have occurred in most parts of the world, including two major pandemics during this century. It is a major constraint to the development of village chicken industries, particularly in Asia and Africa.

Highly pathogenic avian influenza (HPAI). HPAI is another serious viral disease of poultry that may produce high mortalities. There is some concern about the potential for the appearance of avian influenza strains transmittable to humans following recent cases in Hong Kong. Wild water birds constitute the major reservoir for avian influenza viruses, and HPAI outbreaks in domestic poultry may occur suddenly anywhere in the world. There have been a number of outbreaks in recent years in North America and Australia.

There is one important mycoplasmal trans-boundary animal disease. This is *contagious bovine pleuropneumonia* (CBPP). Although this is an insidious disease in areas where it is well established, it causes serious epidemics with high mortality rates in cattle when it moves into new areas. Major CBPP epidemics have been experienced in eastern, southern and West Africa over the last few years. The disease is also endemic in some parts of Asia.

Trends Affecting Trans-boundary Animal Diseases

Trans-boundary animal diseases exhibit a great deal of dynamism. New diseases emerge, and old diseases re-emerge. They show a great propensity for sudden and unexpected spread to new regions, often over great distances. These trends are likely to continue and even accelerate in the future.

The last 30 years or so have been remarkable for the emergence of apparently new infectious diseases. This has been spectacular in the medical field, with the appearance of diseases such as AIDS, Lassa fever, and Ebola. The same has occurred with animal diseases, with the appearance of bovine spongiform encephalopathy ("mad cow" disease), porcine reproductive and respiratory syndrome (PRRS), post-weaning mortality and wasting syndrome (PMWS) of pigs, Nipah virus infecting pigs and humans, and equine morbillivirus affecting horses and humans but now known as Hendra virus. Not only do new infections emerge, but also new biotypes or antigenic types of existing infectious diseases. A notable example has been the hypervirulent form of infectious bursal disease that has swept across much of Europe and Asia in recent years, causing devastating losses to poultry industries there.

There are a number of factors contributing to the dynamic nature of trans-boundary animal diseases. These include:

- *Increasing globalisation and international transport.* The most important method of spread of trans-boundary animal diseases is by movement of potentially infected livestock and meat and other animal products. There have been very substantial increases in such international movements due to better sea, land and air transport of people, animals and goods and in response to marketing opportunities for livestock and their products. Nomadism, trans-humance, and the movement of refugees and their animals away from wars and civil disturbances also contribute very substantially to the spread of infectious animal diseases. These all place a great strain on countries in maintaining effective quarantine barriers at airports, seaports and along international borders.

- *Changes in livestock production systems*. In many countries, there is a trend towards increased intensification and commercialisation of livestock production, particularly in peri-urban areas. The greater concentration of animals that this entails means that there is far greater opportunity for trans-boundary animal diseases to move very rapidly, and for greater economic losses to occur.

- *Decline in government veterinary services and other infrastructure*. Also, in many countries, public funding of veterinary services is poor and even declining, resulting in uncontrolled livestock movements, poor diagnostic capacity and the inability to react quickly and effectively to disease outbreaks. Farmers are usually not compensated for disease losses and thus, when a disease problem is occurring on their farm, they often tend to sell still healthy-looking livestock to reduce their financial losses. As a proportion of these apparently healthy animals may be in the early stages of infection where clinical signs are not yet apparent, this behaviour of farmers may significantly contribute to the spread of disease.

- *Spread of livestock farming into new ecosystems*. In some regions of the world, tropical rain forests and other wilderness areas are being converted to livestock farming. This places human communities and their farm animals into close contact with a completely new range of infectious diseases which may have previously only circulated in wildlife reservoirs and which may be completely unknown. Some of these diseases may be transmittable to humans and/or livestock, in which they may spread very rapidly in the new, fully susceptible hosts.

- *Global warming* trends may change rainfall and weather patterns in a number of regions, affecting particularly the global distribution of insect vectors e.g., mosquitoes and *Culicoides* midges, and the important viral and protozoal trans-boundary animal diseases that they transmit.

Combating Trans-boundary Animal Diseases

An effective national animal quarantine system should always be the first line of defence against the entry and establishment of trans-boundary animal diseases. However, even the most sophisticated quarantine service cannot provide an absolute barrier. Countries, therefore, need a second line of defence, which is the development of contingency plans and capabilities to respond quickly to high-threat diseases, should they enter.

If an introduced trans-boundary animal disease can be recognised early whilst it is localised, and a disease control programme can be quickly implemented, the prospect for eradication of the disease with minimal production losses and other costs is markedly enhanced. Conversely, if the disease is allowed to become well established in the country, eradication may be very costly and difficult, or even impractical (particularly if the disease becomes established in wildlife). Thus, the two key principles in combating trans-boundary animal diseases are:

1. *Early warning*. This is to rapidly detect the introduction of, or sudden increase in the incidence of any disease of livestock that has the potential of developing to epidemic proportions and/or causing serious socio-economic consequences or public health concerns. It embraces all initiatives, mainly based on disease surveillance, reporting and epidemiological analysis, that would lead to improved awareness and knowledge of the distribution and behaviour of disease outbreaks (and of infection) and which allow forecasting of the source and evolution of the disease outbreaks and the monitoring of the effectiveness of disease control campaigns.

2. *Early reaction*. This is to carry out without delay the disease control activities needed to contain the outbreak and then to eliminate the disease and infection in the shortest possible time frame and in the most cost-effective way or, at least, to return to the status-quo which existed previously and to provide objective, scientific evidence that one of these objectives has been achieved.

The Application of Appropriate Technology in the Fight against Trans-boundary Animal Diseases

The last 20 years or so have seen exceedingly rapid advances in scientific knowledge. This has been due, in no small part, to the revolution that has occurred in the fields of genetic engineering and computer science. Much new technology can now be applied to combat trans-boundary animal diseases. The areas in which technical advances to combat these diseases have been most pronounced are:

- disease surveillance and animal health information systems;
- other methods for studying the epidemiology of disease outbreaks;
- disease diagnosis and methods for the characterisation of aetiological agents; and
- better vaccines for disease control and eradication programmes.

All of the technology that is available will not be appropriate for all countries or all circumstances. Indeed, many of the more sophisticated techniques may only be suitable for specialist institutions such as International Reference Laboratories. It is important that an appropriate level of technology be selected for each situation, but that there should be a conscious effort on the part of national veterinary services to progressively improve their technical capabilities.

HOW ARE DISEASES AND OTHER ISSUES CHANGING LIVESTOCK HEALTH SYSTEMS?

It is difficult to ascertain exactly what cause leads directly to what result. However, there are some general trends in livestock industries that are at least partly due to the diseases and issues described above. Some of these are:

- Increasing implementation of HACCP-based quality assurance systems applied at the farm and processing level.

- Increasing emphasis on good disease surveillance systems based on farm identification (and in some cases individual animal identification) supported by sophisticated animal health information systems.

- Wider application of inexpensive screening tests which are accurate and provide rapid results.

- More sophisticated and reliable analysis of disease risks and their management, particularly to prevent the international spread of disease.

- Where freedom from a specific pathogen or disease is being claimed, there is increasing pressure to provide "evidence of absence" rather than merely state that there is "absence of evidence."

SOME SIMILARITIES AND DIFFERENCES BETWEEN LIVESTOCK PRODUCTION AND AQUACULTURE

Box 3 summarises the similarities and differences between livestock production systems and aquaculture systems.

Box 3. Similarities and differences between livestock production and aquaculture.

Similarities	Differences
• Organised similarly • Often the same farmers involved • Source of food and income • Disease can have huge impact	• Environment in which animals live • Management techniques • Large livestock more often used as a "bank," though aquatic animals provide a "flexible savings account" • Export patterns – developing countries export more aquatic animal commodities than livestock while, for developed countries, the reverse is probably true • Wider range of diagnostic tests available for livestock • Smaller range of known pathogens in aquatic animals • In many countries, management systems are not as well developed for aquaculture • Bodies of water can act as a quarantine barrier for livestock diseases but may facilitate the spread of aquatic animal diseases • Conversely, land can act as a quarantine barrier for aquatic animal diseases but not for livestock diseases

POSSIBLE LESSONS FOR AQUATIC ANIMAL HEALTH

Based on what is happening in the livestock sector, some areas where new initiatives are warranted are:

- Systematic research to identify factors other than pathogens that contribute to the occurrence and severity of disease.

- Research and extension to develop and implement on-farm quality assurance systems, where appropriate.

- A more systematic approach to disease surveillance, with the focus on early detection followed by rapid response.

- Improved understanding of the theory and application of risk analysis as it is applied in animal health.

- Strengthened quarantine arrangements aimed at reducing the international spread of disease in aquatic animals.

CONCLUSIONS

There is no doubt that there will be more, rather than less, disease in small-scale aquaculture systems as they expand. Increases will be in the level of underlying endemic disease that must be managed at the farm level, as well as the emergence of new, sometimes rapidly spreading, epidemic diseases. The impacts from these will be severe and will threaten industries if planning and actions are not initiated now. In doing this, there are valuable lessons to be learned from the livestock sector that has been engaged in this battle for many years.

Solutions are likely to lie in improved management at all levels of the production, marketing and policy chains. Chemical treatment of diseases (including use of antibiotics) as they occur is often not sustainable in the long term. The fight to control disease as aquaculture expands and intensifies will eventually depend on finding management solutions based on good hygiene, sound biosecurity and early detection of disease with appropriate responses. This will require that all levels of the sector, from small-scale farmers through to government policy makers, have a good understanding of the critical points in the system which need to be controlled, as well as the means to control them. If this issue is addressed in a systematic manner, then the impacts of endemic disease and the risk of impacts from devastating epidemic diseases will be reduced.

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AN OVERVIEW OF THE SOCIAL AND ECONOMIC IMPACT AND MANAGEMENT OF FISH AND SHRIMP DISEASE IN BANGLADESH, WITH AN EMPHASIS ON SMALL-SCALE AQUACULTURE

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ABSTRACT

In Bangladesh, increasing population pressure, with increased demand for fish, has made fisheries a lucrative sector for the present generation. Fish culture in the country has been progressing towards semi-intensive culture, while shrimp culture moves towards an improved traditional system. However, indiscriminate and unplanned use of feed and fertiliser, with subsequent effects on water quality in pond ecosystems correspondingly increases stress on fish and accelerates susceptibility to pathogens. The effects of disease in improved culture systems are significant; however, proper systematic information on disease outbreaks is not yet available. The most obvious effect of the occurrence of disease is mortality, followed by economic losses. Mass mortalities of carp fry and fingerlings due to protozoan and metazoan parasites are frequently reported. A small initial infection gradually leads to a serious outbreak of disease, resulting in large mortalities and great economic loss for small-scale farmers. The most common disease problem in the country is epizootic ulcerative syndrome (EUS). There is a lack of technical knowledge in the management of shrimp farming. In Bangladesh, outbreaks of disease in shrimp caused by white spot syndrome virus (WSSV) (reported as systemic epidermal and mesodermal baculovirus – SEMBV) alone caused a 44.4% production loss in 1996; although the incidence of outbreaks has reduced considerably since then. It has been estimated that the shrimp culture industry provides direct employment to some 350,000 persons, who are engaged in fry collection and transportation, nursery and grow-out operations, and handling and processing. It is obvious that disease outbreaks in fish and shrimp culture systems have a great impact on low-income groups.

INTRODUCTION

Aquaculture production continues to expand in an attempt to meet the needs of developing countries like Bangladesh. However, population pressure and a shortage of alternative employment opportunities in the country increase the attraction of fisheries as a form of employment. Bangladesh faces many challenges and constraints in the sustainable management of aquatic resources. Aquaculture production in the country has been facing problems from outbreaks of disease, lack of up-to-date management practices, and lack of awareness on the part of fish growers. Information on emerging problems needs to be communicated to the aquaculture and fisheries sector.

Freshwater Fish

There is widespread agreement that there is a need to enhance the contribution that fisheries makes to national economic, social and nutritional goals. Fish culture in Bangladesh has been progressing towards semi-intensive culture, and inland fisheries, especially freshwater fish, are exploited for local consumption. Some 43 million ha is used for inland fisheries, of which ponds and tanks cover an area of 147,000 ha. Indiscriminate and unplanned use of feed and fertiliser and overstocking increase stress on fish and increase their susceptibility to pathogens. The effects of disease on improved culture systems are significant, however, outbreaks of disease are poorly reported and documented. The most obvious effect of disease is mortalities in the fish population, followed by economic losses. Although the country is facing serious problems in fish production due to disease outbreaks, production has still slowly increased (Table 1).

Table 1. Fish production in ponds in Bangladesh (1993-1998).

Type of Pond	Area (ha)	Production (mt)				
		1993-94	1994-95	1995-96	1996-97	1997-98
Ponds under cultivation	76,643	167,973	211,544	242,905	269,875	330,975
Cultivable ponds	44,814	41,631	42,615	53,192	65,304	72,856
Derelict ponds	25,435	12,932	13,132	11,877	14,822	12,489
Total	146,890	222,542	267,282	307,974	350,101	416,320

Shrimp Farming

It has been estimated that more than 380,000 people are directly or indirectly involved in the shrimp culture industry. They are engaged in shrimp fry collection, nursery operation, fry transportation and depot operations, such as de-heading shrimp before sending them to processors. Before December 1993, there were no reports of mass mortalities due to disease in semi-intensive or traditional shrimp farming. During the past four years, however, the shrimp farming industry in Bangladesh has suffered severe problems, mainly due to disease outbreaks caused by white spot syndrome virus (WWSV, often reported as systemic ectodermal and mesodermal baculovirus, SEMBV).

Farming systems

Three different systems of shrimp culture are practised in the country. These are traditional or extensive, improved extensive and semi-intensive culture systems. The extensive system operates with minimal inputs and depends on tidal rise and fall for the intake and discharge of water. In traditional systems, a single canal is used for the supply of water. Because the farmers typically lack knowledge about the disease risks posed by the introduction of potential disease carriers, there is no screening at the inlet and outlet points, and thus predatory fish and potential carriers of pathogens can freely enter the system. The improved extensive system is similar to the above, however, inputs such as lime, fertiliser and feed are used. Semi-intensive systems operate with higher inputs than those of traditional and improved extensive systems, and they have separate inlet and outlet canals. Disease outbreaks occur in all three farming systems.

Apart from white spot syndrome, a number of other problems occur. These include the occurrence of significant mortalities at low temperature and low salinity, especially during the rainy season; black gill and red gill disease; black spot disease and necrosis; soft-shelling and parasitic infections.

SOCIO-ECONOMIC AND OTHER PROBLEMS

Given the importance of foreign exchange earnings, the Government of Bangladesh has made extending the area of shrimp culture to increase shrimp production a priority. The problems faced by the shrimp farmers are as follows:

- shortage of seed,
- land lease and land-use conflicts,
- short-term land leasing,
- lack of technical knowledge to increase production, and
- lack of sufficient credit facilities.

Land leasing is one of the major social problems in shrimp culture in Bangladesh. In most cases, land for shrimp culture is leased from small farmers who are unable to bargain and do not have the capital to set up a shrimp farm for themselves. Fry collection became an occupation for a large number of people only after the culture of penaeid shrimp (*Penaeus monodon*, known locally as "bagda") proved profitable as an export commodity. Fry are sold mainly to fry traders on the shore. About 60% of survey respondents (Hoq *et al.* 1995) sold their fry to traders, while 37.7% sold directly to shrimp farms and 2.7% to the markets. The price of shrimp fry fluctuates with demand from farms.

Seasonal Occupation of Landless Farmers

In Bangladesh, almost 80% of the population is poor, and a great number are landless. The life of the landless people is uncertain, and they are always on the move in search of better living conditions, often migrating to the urban areas where there are better economic opportunities. Some rural people settle in uninhabited lands, called char lands. Fishing is one of the main sources of income of people living in char areas, and it is seasonal. During the fish-breeding season (February-July), they set traps in rivers to catch fingerlings of carp species, such as catla (*Catla catla*) and mrigal (*Cirrhinus cirrhosis*). The catch is usually sold to pond owners on the mainland. Fishing in canals and open waters is also carried out by landless people during the flood season.

Fishery-dependant Communities

Fishery-dependent communities live on boats or floating houses or on the banks of rivers. They rely exclusively on fishing and fishing-related activities, such as fish growing, processing, gear manufacture and fishing boat construction. The socio-economic circumstances of these communities are very poor.

AQUACULTURE DEVELOPMENT AND DISEASE PROBLEMS

Aquaculture development in the country has intensified recently through increased stocking densities and artificial feeding and fertilisation. Intensification is increasing fish production but may lead to deterioration of water quality and increased susceptibility to infections.

Freshwater Fish

Fish disease in carp farms has been reported in up to 31% of extensive farms and 24% of semi-intensive farms (Chowdhury 1997). The most common disease problem in freshwater fish is epizootic ulcerative syndrome (EUS). Common diseases of freshwater fish in Bangladesh are as follows:

- Diseases caused by protozoan parasites, mainly due to *Trichodina, Chilodonella, Ichthyobodo, Ichthyophthirius multifiliis*, *Myxobolus*, and other myxosporideans (Banu *et al*. 1993).

- Diseases caused by metazoan parasites, mainly due to infection by *Dactylogyrus*, *Gyrodactylus*, *Argulus*, *Piscicola*, and *Lernaea*.

- Bacterial diseases, such as infectious dropsy of carps (Hossain *et al*. 1994); columnaris disease; edwardsiellosis in *Pangasius hypophthalmus*, *Anabas testudineus* and *Channa punctata;* and bacterial gill disease caused by *Flavobacterium branchiophylum*.

- Red spot disease in *Barbodes gonionotus* and *Clarias batrachus* caused by *Pseudomonas* sp. (Banu *et al*. 1997).

- Fungal disease, mainly caused by *Saprolegnia* and *Branchiomyces*.

- Nutritional deficiency disease - one of the major constraints in freshwater fish farming.

The occurrence of disease in farmers' ponds and related problems are recorded regularly at the Bangladesh Fisheries Research Institute (BFRI), where necessary suggestions and advice are given. After receiving samples, water quality is tested and specimens are examined in the laboratory.

Shrimp

The success of shrimp farming is measured by its rate of return on investment, which mainly depends on the yield, capital investment, international demand and market price, and the production cost. This, in turn, is affected by a number of factors, the most important of which are farm operation and management. Disease is one of the major factors affecting productivity. Damage caused by disease was estimated to affect 50-60% of the semi-intensive shrimp farms in Cox's Bazar in 1994, and monetary losses were estimated to be Tk 50 crore (US$10 million) (M.S. Islam, unpublished data). According to the Department of Fisheries (DOF), Bangladesh suffered a 44.3% production loss in 1996, leading to a reduction in foreign income of 42.3% from shrimp exports (Siriwardena 1997). Disease is a major concern, and was reported in 13% of extensive shrimp farms and 74% of semi-extensive farms. In another report, the estimated average financial loss per affected farm was estimated to be as high as US$832/yr for extensive and

US$3,928/yr for semi-intensive farms (Chowdhury 1997). Illiterate, and even literate, shrimp farmers are unable to point out the real cause of shrimp diseases. However, nowadays, they are more aware of shrimp diseases and take precautionary measures whenever possible.

CONCLUSIONS AND RECOMMENDATIONS

The socio-economic circumstances of small-scale aquaculture holders are poor. Moreover, they have no chance to set up farms, especially shrimp farms, as rich and influential local person(s) control the industry in their locality. Disease is one of the major constraints of fish and shrimp farming in the country. Considering the above, the following recommendations are made:

- Awareness of disease problems of small-scale aquaculture needs to be raised.
- Reports of any kind of mass mortality should reach the nearby Tana Fisheries officer (TFO)/Farm manager or Fisheries Research Institute as soon as possible.
- TFO/Farm managers must be vigilant and give periodic service to small-scale aquaculture holders in order to mitigate fish and shrimp disease problems.
- A line of communication between small-scale aquaculture holders, the Department of Fisheries (DOF) and the Bangladesh Fisheries Research Institute (BFRI) needs to be established.

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RISK FACTORS AND SOCIO-ECONOMIC IMPACTS ASSOCIATED WITH EPIZOOTIC ULCERATIVE SYNDROME (EUS) IN BANGLADESH

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ABSTRACT

An interview-based questionnaire survey of a fish farmer and a fisher randomly selected from each of the 64 districts of Bangladesh was carried out to study risk factors associated with outbreaks of epizootic ulcerative syndrome (EUS). The survey was undertaken during the EUS season, December 1998 to April 1999. Data showed that there is a significantly higher relative risk of EUS occurring in farmed fish when wild fish are present in the pond; EUS occurred in the previous season; pond embankments are not high enough to prevent in-coming flood water; ponds are connected to natural waters; ponds are not dried or limed prior to stocking; ponds are not limed post-stocking; nets are not dried or disinfected; and pond water colour is black, indicating high levels of organic waste. Of the wild caught fish, those sampled from haors[1] had a significantly higher relative risk of getting EUS. Fish from rivers and flood plains were at a lower risk of EUS infection.

Out of 64 districts, fish with lesions were recorded from fish farms in 32 districts (50%), and 30 (47%) were confirmed EUS positive, and from wild fisheries 52 districts (81%) demonstrated lesions and 49 (77%) were confirmed as EUS positive. However, the percentage of infected fish was quite low in some sites. A total of 6,433 wild fish and 6,401 farmed fish were examined for lesions, and average prevalence was 16.0 and 15.5%, respectively. Thirty-one species of fish were confirmed as being EUS positive out of 40 recorded with lesions.

Eighty-eight percent of farmers interviewed had between one and four ponds. These small-scale farmers, in particular, are at risk from suffering serious financial difficulties from sudden disease losses, or from reduced production levels due to disease. Losses in wild fisheries could deprive the poorer sections of the community from access to cheap sources of animal protein.

The present study demonstrated that EUS is still the most damaging disease among freshwater fishes in Bangladesh, and probably has significant effects on fish production, although no direct information on mortalities was obtained. Eighty-six percent of farmers and 89% of fishers interviewed considered EUS to be a major problem. Total fish loss due to EUS for 1998-99 is estimated as 39,797 mt and US$3.97 million using the prevalence data obtained from this study.

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[1]Depressions in floodplains located between two or more rivers, which function as internal drainage basins.

INTRODUCTION

There is a Bengali proverb "Mache bhate Bangalee," which means Bangladeshi people cannot survive without fish and rice. Approximately 1.4 million people earn their livelihood from fisheries, and another 11 million people are involved in seasonal or part-time fishing and other ancillary activities (Mazid 1995). Eighty percent of the population lives in villages and catch wild fish from ditches, canals, rice fields, floodplains, beels[2], haors, and baors[3] for their normal diet. Fish is the main source of protein for the rural poor, but they don't have enough money to purchase it for daily consumption. Most of the urban people also prefer a diet of wild fish.

With an increase in unemployment, small-scale fish farming is becoming very popular among the unemployed as a source of earnings. Some of the small-scale farmers have their own ponds, but most of them rent ponds for fish culture business. Consequently, fish disease, and epizootic ulcerative syndrome (EUS) in particular, has a severe socio-economic impact on public life, and especially on rural life.

EUS was a very new phenomenon at the time of the first outbreaks in Bangladesh, and it caused great concern because of the perceived dangers to both staple food crops and to human life. The widespread fear of disease transmission to consumers, although unfounded, led to a drastic decrease in market demand for food fish, including marine species, which were not affected by the disease. Usually, the only animal protein available to accompany the rural people's rice diet is derived from fish, and therefore, an inadequate intake of fish could result in nutritional deficiency. It has been estimated that 250 million families in the Southeast Asian Region depend on rice as a main crop, and much of the incidental fish harvests from these paddies are an important part of the family's diet (Macintosh 1986). The economic loss due to EUS was estimated at 118.3 million Taka (US$3.4 million; 1 US$=35 Taka) during 1988-89. In the second year the disease occurred with lower severity, and the economic loss was estimated at 88.2 million Taka (US$2.2 million). Fish price dropped to 25-40% of the pre-disease level during the first outbreak (Barua 1994).

Since 1988, EUS has been considered the most serious epidemic disease affecting freshwater fish in Bangladesh. As with most other diseases, there is strong evidence that EUS outbreaks occur only when a number of determinants or causal factors combine. A number of factors are considered to be acting at the same level and ultimately lead to the exposure of dermis. These exposed sites could provide the point of attachment and entry for spores of *Aphanomyces invadans*, regarded as the essential component in all EUS outbreaks (Lilley *et al.* 1998). Recent studies suggest that there are a number of other sufficient causes for EUS outbreaks. Although every set of sufficient causes for EUS is different from one another, each combination has the common result of exposing the dermis and allowing entry of *A. invadans*. Callinan *et al.* (1996), reported outbreaks of EUS in estuarine fish in Australia associated with acid-sulphate soil areas, and reproduced EUS by exposing susceptible fish to acid water and spores of *A. invadans*. Kanchanakhan (1996) has shown that EUS can be reproduced when susceptible snakeheads (*Channa* sp.) are injected with a particular strain of rhabdovirus and bathed in spores of *A.*

[2]Floodplain lakes, which may hold water permanently or dry up during the winter season.
[3]Oxbow lakes.

invadans. Demonstration of the highly invasive abilities of EUS fungus in tissues like bone, gizzard and spinal cord provides an indication that under certain circumstances, the fungus may be able to invade the healthy skin of fish (Vishwanath *et al.* 1998).

The epidemiology of EUS is poorly studied in many affected countries, including Bangladesh. However, a number of factors have been hypothesised as either risk factors or determinants for EUS outbreaks in Bangladesh. These factors are based on observations of the mode of disease transmission, the species, habitats and culture systems affected by EUS; human interventions; movements of animals; and seasonality of EUS outbreaks. Identifying true risk factors for EUS allows rational control measures to be developed. EUS research requirements, as recommended by FAO (1986), included the need for a greater understanding of the influence of environmental factors and pollutants on the disease and the identification of causative agent(s). During an EUS survey of Bangladesh, Roberts *et al.* (1989) stressed the need for an epidemiological study of individual waters to collect information on disease transmission, relative species susceptibility, mortality and recovery rate in different species and ages of fish, fish losses and economic impact. The present cross-sectional survey aimed to quantify the degree of the present EUS problem, and also identify risk factors that affect outbreaks. Fish farmers and fishers were interviewed and the information was used to measure the strength of association between EUS and hypothesised risk factors.

MATERIALS AND METHODS

A cross-sectional, interview-based survey was conducted in a thana[4] selected from each of the 64 districts of Bangladesh from December 1998 to April 1999. This period is the recognised "EUS season." Three M.Sc. students from Bangladesh Agricultural University interviewed a fish farmer and a fisher randomly in each thana and examined 100 fish for EUS-type ulcers.

Survey Areas

One thana known to have adequate fisheries resources was randomly selected from each of the 64 administrative districts. In August 1998, a letter was sent to the Thana Fisheries Officers (TFO) requesting a list of categorised fish farms (both registered and unregistered) and wild fisheries areas in their respective thanas. From these lists, one fish farm and one wild fishery were randomly selected.

Development of Questionnaire

The questionnaire development procedure followed the methods described by Thrusfield (1995). Both fish farmer and fisher questionnaires were designed to record information in a standard format with in-built error checks. Closed questions were used, wherever possible, to give data in a yes/no/don't know or categorical format to facilitate ease of coding and analysis. Attempts were made to make wording unambiguous, brief, polite and non-technical. Both questionnaires were prepared in English and Bengali, and the Bengali version was used for interviewing. Before starting the survey, questionnaires were pre-tested two times by interviewing target people to identify ambiguous and irrelevant questions.

[4]Sub-district.

Interviewing and Sampling

The three interviewers were trained together to minimise differences in technique. Training also included examination of fish for EUS-type ulcers and sampling for histology. Each interviewer covered one third of the total districts. TFOs were requested to aid and co-operate with the interviewers. Each interviewer carried with him the required number of questionnaires, fish sampling sheets, photographs of EUS-affected fish, 10% buffered formalin, vials, marking pen, scalpels, cast net and hapa. After completion of the interview, at least 100 susceptible fish from each farm or fishing site were examined for EUS ulcers, irrespective of species, and information recorded on the sampling sheet. One fish of each species recorded with lesions was sampled for histology. Tissue samples were fixed in 10% buffered formalin. In case a sampling net was unavailable, the interviewer supplied his own net for catching fish. During farm visits, in order to avoid re-counting the same individuals, fishes, once examined for ulcers, were separated into the hapa until 100 individuals had been examined. Nets were disinfected between sites. A fish farm or wild fishery was classified as affected with EUS if the presence in one or more fish of any species of characteristic mycotic granulomas was confirmed histologically.

Database Preparation and Analysis

Two MS Access™ databases (for fish farmer and fisher data), and two MS Excel™ spreadsheets (for fish species data) were used to enter the information. Univariate analyses were undertaken using Epiinfo™ to examine the association between EUS occurrence and putative risk factors using crude relative risk (RR) as the measure. Fish farm and wild fishery data were analysed separately.

Histology

Formalin-fixed blocks of lesions and underlying muscle were processed, embedded in paraffin wax and sectioned at 5 µm. The sections were stained with haematoxylin and eosin (H&E) to visualise granulomas, and Grocott's silver stain was used to confirm the mycotic involvement.

RESULTS AND DISCUSSION

Variables were analysed for their effect on the relative risk (RR) of EUS (Tables 1 and 2). RR > 1 indicates that the variable is a putative causal factor of EUS; RR = 1 indicates no association exists between the factor and EUS; and RR < 1 indicates the variable is a sparing factor for EUS (i.e., that it reduces the chance of EUS occurring). Where the lower confidence limit is above 1, there is 95% confidence that the variable is a risk for EUS; where the upper confidence limit is below 1 there is 95% confidence that the variable is a sparing factor for EUS.

Data from Fish-farmer Interviews

Pond connections

The analyses showed that there was over 10 times more chance of EUS occurring in culture ponds containing wild fish. This was the highest RR measured out of the variables examined. The data also show that there was a significantly lower RR (0.39) of EUS occurring on farmed fish when pond embankments were high enough to prevent incoming waters. Similarly, ponds that had been flooded that year showed a significantly higher RR (2.33). Fish farms directly connected to water bodies that allowed the entry of wild fishes also showed a significantly higher RR (2.63) of EUS. Each type of connecting water body (i.e., rice-field, ditch and beel) provided a similar level of risk. Ponds containing water sourced from underground wells or only from rain were at much lower risk of EUS (RR=0.91, 0.52), compared to ponds with water sourced from ricefields (RR=2.36). These results equate with those of Hossain *et al* (1992) which, when recalculated for RR, show a significantly lower risk of EUS-type lesions occurring on fish from rainfed ponds (0.65) than from flooded or irrigated ponds.

Floodwater and entry of wild fish are risk factors probably because they are routes of entry for pathogens (Kabata 1985). Roberts *et al*. (1989) described floodwater as a powerful means for spreading EUS throughout Bangladesh. Changes in water quality and agricultural run-off due to floods may cause stress for the farmed fish, and may be a component cause for EUS. There is an absence of parasites and microbial flora in underground water, and the exclusive use of rainwater and underground water would reduce the risks described above (Munro and Roberts 1989).

Pond preparation

Complete draining of pond water, drying, bottom mud removal and liming during pond preparation were found to result in low relative risks of 0.55, 0.41, 0.17 and 0.42, respectively. Fertilisation during pond preparation also resulted in a low, but non-significant, RR (0.50).

Pond preparation techniques described above will exclude *A. invadans*, and many other pathogens, from the pond environment. It is interesting that the "removal of bottom mud" resulted in a very low RR. Unlike other oomycete fungi, *A. invadans* does not appear to show strong negative geotaxis, and may possibly accumulate on the pond bottom, although soil assays have not succeeded in isolating *A. invadans* (Willoughby 1999). *Aphanomyces invadans* can feasibly survive the warmer months of summer in the thick bottom mud of older or derelict ponds, which generally possess a temperature below 31°C, and with declining temperature or rainfall disturbance, the fungus might be activated to grow. This theory is supported by Ahmed and Rab's (1995) study, which showed that fish cultured in previously derelict ponds had a significantly increased probability of EUS.

Post-stocking management and hygiene of habitat

Post-stocking liming also gave a significantly low RR of 0.46, and again, fertilisation after stocking did not significantly affect RR. Pond-water colour indicating high levels of phytoplankton or zooplankton had low, but not significant, RRs. However, ponds black with high levels of organic waste showed significantly higher RR (2.21).

Table 1. Variables affecting relative risk (RR) of EUS in fish farming areas, giving 95% confidence limits (lower<RR<upper). RR>1 indicates the factor is a putative causal factor of EUS; RR=1 indicates no association exists between the factor and EUS; and RR<1 indicates the factor as a sparing factor for EUS.

Variable	Relative Risk (RR)	Lower Limit	Upper Limit
POND CONNECTION			
Wild fish observed in ponds[1]	10.09	1.62	74.27
Pond has high embankment	0.39	0.25	0.62
Holes observed in the pond bank	1.79	1.08	2.98
Pond connected to other water body allowing entry of wild fish	2.63	1.69	4.08
Other water body = ricefield	2.73	1.81	4.13
Other water body = ditch	2.26	1.70	2.99
Other water body = beel	2.21	1.68	2.91
Water supply = ricefield water	2.55	1.84	3.53
Water supply = only rainfed	0.52	0.31	0.88
Water supply = underground	0.91	0.49	1.71
Pond is close to other water body	1.84	0.94	3.62
Floodwater enters the pond	2.33	1.27	4.29
PRE-STOCKING POND PREPARATION			
Water is drained from pond	0.55	0.30	1.01
Pond is dried	0.41	0.18	0.92
Bottom mud is removed	0.17	0.03	1.09
Pond is limed	0.42	0.21	0.83
Pond is fertilised	0.50	0.21	1.21
POST-STOCKING MANAGEMENT			
Pond is limed	0.46	0.30	0.71
Pond is fertilised	0.93	0.40	2.17
Black water colour (high organic debris)	2.21	1.68	2.91
Transparent pond water	1.07	0.26	4.38
Greenish water colour (phytoplankton)	0.84	0.47	1.51
Reddish water colour (zooplankton)	0.74	0.32	1.70
HYGIENE			
Fry source water released in pond	2.00	1.09	3.66
Cattle wash/drink at pond after grazing or ploughing in the field	2.90	1.46	5.77
Farm nets are dried/disinfected	0.59	0.35	1.01
Buyers use dried/disinfected nets	0.14	0.02	0.90
Parasites observed on fish	2.65	1.45	4.86
CLIMATE / SEASONALITY			
EUS occurred in the previous season	3.00	1.64	5.49
Temperature unusually low prior to disease	3.83	2.36	6.23
Rain unusually heavy prior to disease	2.48	1.81	3.40

[1]62 farmers answered this question (64 farmers answered all other questions).

Table 2. Variables affecting relative risk (RR) of EUS in 64 fishing areas, giving 95%confidence limits (lower<RR<upper). RR>1 indicates the factor is a putative causal factor of EUS; RR=1 indicates no association exists between the factor and EUS; and RR<1 indicates the factor as a sparing factor for EUS.

Variable	Relative Risk (RR)	Lower Limit	Upper Limit
	TYPE OF HABITAT		
River	0.54	0.26	1.14
Floodplain	0.63	0.28	1.42
Ricefield	0.98	0.55	1.75
Beel	1.04	0.79	1.37
Haor	1.33	1.15	1.54
	STOCKING		
Water body is artificially stocked	1.08	0.81	1.44
	HEALTH		
EUS occurred in the previous season	2.19	1.17	4.11

Liming increases pH, hardness, alkalinity and the buffering system of pond water and also reduces stress for fish, thereby reducing the risk of EUS. Exposure of fish to low pH might be one of the causes of skin damage, necessary for fungal entry to cause EUS. In aquarium trials, EUS lesions were induced in fish exposed firstly to acidified water, and then to spores of *A. invadans*, and thus, confirming these two factors in combination as a sufficient cause of EUS (Callinan *et al.* 1996). It is possible that the increase in calcium and magnesium in the pond will also have a more direct effect by benefiting fish skin and inducing encystment in fungal zoospores, thereby making them fall out of suspension.

Hygiene/other disease

Allowing cattle to wash and drink in the pond after ploughing or grazing in other areas gave a high RR (2.90), possibly due to the transport of pathogens with the cattle. Netting with dried or disinfected nets, and requiring buyers to do the same, contributed much lower RR values (0.59 and 0.14, respectively). The use of equipment that has been transported between farms (e.g., by buyers) is likely to provide a source of infective material, and drying or disinfection is recommended.

A high RR (2.65) was also demonstrated in ponds where the farmer said fish were affected by parasites. A number of parasites have been isolated from EUS-affected fish (Tonguthai 1986) and may either be possible vectors for the pathogen, or a stress-inducing factor in EUS outbreaks. Subasinghe (1993) demonstrated such an association between the level of infection by *Trichodina* sp. and the susceptibility of *Channa striata* to EUS infection. The mechanism of attachment of these parasites can cause skin rupture, and might facilitate infection by the EUS fungus.

Climate/seasonality

Farmers that reported EUS in the previous season were shown to be at higher risk of EUS (RR=3.00). Reports by farmers that there was unusually low temperature or heavy rainfall 3-15 days prior to the interview were also correlated with EUS occurrences.

EUS has been associated with low temperature, and has often occurred after periods of heavy rain. Phillips and Keddie (1990) observed from data from 1988-89 that EUS outbreaks occurred during months when the mean daily temperature was below the annual mean temperature in Bangladesh, China, India and Lao-PDR. However EUS outbreaks in the Philippines and Thailand were also recorded in warmer months. Chinabut *et al.* (1995) challenged striped snakehead (*Channa striata*) by injecting with zoospores of *A. invadans* and found a weaker inflammatory response, higher mortality rate and more extensive fungal invasion in fish held at 19°C compared to fish held at 26 and 31°C.

Data from Fisher Interviews

Types of habitat

Among the different types of fish habitat sampled, haors showed the highest RR (1.33) and rivers showed the lowest RR (0.54). A haor is the biggest natural depression between two or more rivers, and is lower than the adjacent floodplains. It functions as a small internal drainage basin and receives upland runoff water (Khan 1997). Chemicals, waste and pathogens may enter the haor through the river systems. At the onset of the dry season, the water level of the haors decrease and the aquatic animals and plants are concentrated, often resulting in stressful conditions for fishes. The presence of a wide range of EUS-susceptible fishes under these circumstances make haors susceptible areas for EUS outbreaks. The active movement of the water in rivers may lessen the chances of the fungal pathogen attaching to fish, thereby resulting in the lower RR recorded for EUS in rivers. There was no significant association between artificial stocking of natural water bodies and occurrence of EUS. Water bodies that fishermen reported had been affected the previous season, were at higher risk of EUS (RR = 2.19).

General Observations

During the period of survey, interviewers recorded farmers' general observations and opinions, which are summarised here. Some of these points have been demonstrated by the present study, whereas others require further work investigate possible associations.

- EUS outbreaks have occurred every year since 1988 and affect most of the freshwater fish. Initially the severity of disease was very high, but this has shown a decreasing trend.
- Wild fisheries are much more affected than farmed fishes. Farmers and fishers from beel areas reported that an outbreak occurs every year in their local beels as the temperature begins to fall. It affects snakehead, *Puntius*, *Mastacembelus*, escaped farmed fish and others. Later, fish farms very close to those affected wild fisheries become affected, and then more distant farms are affected.
- EUS often occurs in culture ponds directly connected to ricefields through drainage, but other nearby ponds not linked through drainage systems are usually unaffected.

- Some farmers and fishers opined that aquatic birds, fish-eating birds, reptiles and mammals might transmit the disease from one place to another by preying on easy to catch EUS-affected fish and dropping uneaten portions in unaffected water bodies. They may spread the pathogen by repeatedly preying and washing alternately between affected ponds and unaffected ponds.

- Most farmers and fishers believe that floods play a vital role in spreading EUS throughout the country.

- Some observers recorded that moderately affected snakeheads, walking catfish and climbing perch might transmit the disease by entering an unaffected water body.

- Some farmers commented that their unaffected pond became affected after they spread duckweed from a wild water body.

- A remarkable number of older ponds with very high bottom deposition and shade were reported to be repeatedly affected over several years, although not in anyway connected to wild or affected fisheries. It appears, therefore, that the fungus may survive in isolated water bodies under particular conditions.

- Ponds with a high stocking density were observed to be more affected by EUS.

During a separate case-control study of ponds in Mymensingh District undertaken concurrently with the cross-sectional study, the following observations were made:

- A series of adjacent fish ponds were found affected with EUS in late winter, and it was difficult to find an unaffected "control" pond in that area.

- Some ponds, with a common embankment located near to a particular beel, were all affected. However, newly constructed ponds with very high embankments near to the same beel were unaffected

- On a number of occasions, affected ponds were separated from unaffected ponds with similar culture characteristics by a highway or high embankment.

- Unaffected farms with ponds nearby an EUS-affected beel usually became affected within a week. It was thought this was after cattle and items used in the beel were washed in the pond. Some farmers reported that after fishing in EUS-affected beels, ricefields and other ponds, EUS occurred in their fish farms when they washed nets, wild-caught fishes, and themselves in the ponds.

Socio-economics

Out of the 64 districts, fish with lesions were recorded from fish farms in 32 districts (50%) and 30 (47%) were confirmed EUS positive. From wild fisheries, 52 districts (81%) demonstrated lesions and 49 (77%) were confirmed as EUS positive. Thirty-one species of fish were confirmed as being EUS positive out of 40 recorded with lesions. Totals of 6,433 wild fish and 6,401 farmed fish were examined for lesions, and average prevalences were calculated as 16.0 and 15.5%, respectively. Eighty percent of 471 ulcerated fish sampled were confirmed as EUS positive.

EUS commonly affects small wild fishes e.g., *Channa* spp., *Puntius* spp., *Mastacembelus* spp, *Colisa* spp., *Mystus* spp., *Nandus* sp., *Anabas* sp., *Heteropneustes* sp., *Clarias* sp. and *Ambassis* spp. Rural poor people catch these species of fish as a main source of animal protein, as they usually cannot purchase fish or other animal products. People involved in this activity range from small children to professional fisherfolk. Of the fishers interviewed, 89% considered EUS to be a major problem.

Box 1. Socio-economic data.

- 95% of farmers and fishers interviewed reported use of EUS-affected water for domestic purposes.
- 54% reported a fall in price of table fish in an EUS-affected locality.
- 75% of farmers reported a fall in price of healthy fish fry in an EUS-affected locality.

Major carps are the most significantly affected farmed fish. Once an outbreak occurs in a carp pond, EUS can damage the entire crop and, as a result, small-scale poor farmers can fall into serious economic crisis, particularly farmers who rent ponds. Of the farmers interviewed, 86% considered EUS to be a major problem. The majority of farmers said that the price of fish dropped during the EUS season and in EUS-affected localities (Box 1). Fish prices given by the interviewees indicated that prices dropped by more than 50% when fish were slightly ulcerated, or when there was an EUS outbreak in the locality (Table 3). Despite the potential dangers, most of the farmers interviewed considered fish farming to be a profitable business.

Economic loss was estimated by relating the present prevalence of lesions on fish to five-months projected fish production data for 1998-99 obtained from the Fisheries Resources Survey System, Directorate of Fishery, Bangladesh (FRSS 1998). The estimate excludes hilsha, shrimp and production from the Sunderbans area. It is also adjusted to exclude the 20% of fish with lesions that were not EUS-affected; another 20% of EUS-affected fish that would be consumed anyway; and a further 10% to allow for recovered fish. Total fish loss for 1998-99 is estimated at 39,797 mt, at a value of US$3.97m (at Tk 50/kg fish and 1 US$=50 Tk). Farmed fish account for 18,140 mt of this figure, and wild fish account for 21,657 mt. The estimated loss is higher, although the severity of the disease is lower, as compared to 1988 and 89, due to the two-fold increase in fish production over the last 10 years.

Table 3. Average fish prices indicated by interviewees.

Subject	Price (Tk)	Comment
Table-size healthy fish per kg	63	-
Table-size slightly affected fish per kg	29	54% price fall in slightly ulcerated table fish
Price of healthy fish fry per thousand	587	-
Price of healthy fish fry per thousand in EUS-affected locality	144	75% price fall in EUS-affected locality

CONCLUSIONS AND RECOMMENDATIONS

Prevention of disease is always more economical than cure. On the basis of risk analysis and general observation, the following precautionary measures could be adopted to prevent EUS:

- Repair and raise pond embankments above the flood level and close inlets and holes on the bank to prevent entry of flood water.
- Dry and lime ponds.
- In the case of old and derelict ponds, bottom mud should be removed.
- Ponds should be supplied with rainfed, underground or purified water.
- Suitable resistant species might be substituted for susceptible species in severely affected areas.
- Ponds should be stocked with healthy hatchery-reared fish fry. Wild fry should be avoided.
- Fish fry could be treated with 2.5% NaCl for at least 15 minutes before release in ponds. Fry source water should not be released into ponds.
- All wild fish (e.g., snakeheads, catfish, *Puntius* spp, *Mastacembelus* spp and *Anabas* sp.) should be removed and excluded from ponds.
- Avoid washing of ploughing equipment, cattle and people in fish ponds following work in other water-filled areas (e.g., ditches, paddy fields or beels) in winter.
- Nets and other equipment should be disinfected (e.g., using bleaching powder or iodophore), or sun dried, prior to re-use.
- Ideally, feet/boots of farm workers and visitors should be disinfected at the farm entrance.
- Good plankton bloom should be maintained. The water should not be allowed to go black with high organic waste.
- Periodic liming during stocking should be done (depending on pH and alkalinity).
- Severe parasitic infestations should be treated.

Winter is the most common period for EUS outbreaks, therefore particular measures should be taken at this time. Fish farms should be monitored regularly. Liming prior to winter (at 1kg/decimal[5]) is recommended. Awareness of fish health management should be created among fish farmers. Regulations concerning transportation of fish from affected/suspected affected zones to unaffected zones might be effective, although the present study demonstrates that EUS is endemic to a large proportion of Bangladesh. Regulations against the indiscriminate use of

[5] 1 decimal = 40.48 m^2.

chemicals and antibiotics against EUS are necessary to prevent detrimental effects to the environment, fish and ultimately, the consumer.

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AQUATIC ANIMAL HEALTH MANAGEMENT ISSUES IN RURAL AQUACULTURE DEVELOPMENT IN LAO PDR

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ABSTRACT

This paper describes the role of small-scale aquaculture in subsistence farming systems in rural Lao PDR. Small-scale aquaculture is a popular component of subsistence farming systems in Lao PDR; however, rice cultivation is the principle activity during the monsoon season and collection of aquatic products from rice fields is common. Results from a consumption and production survey of rural Lao subsistence farmers, many of whom were engaged in fish culture (84%), are presented. Consumption of fish and aquatic products was estimated to be between 13-48 kg/*capita*/yr, representing between 22%-55% of animal product consumption. Livestock and fish production are the principal forms of income generation, and the average value of fish production was $81 per household. Overall family income ranged between $372-$594/household/yr.

Minimising risk is a principal strategy in subsistence farming, and this is reflected in the low input and low productivity of Lao rural aquaculture. Average pond size ranges between 550-1,520 m^2, with water depth of about 50 cm. Productivity is low (417-708 kg/ha/yr) due to low stocking densities (1-4 fish/m^2) and limited feeding. Low-input aquaculture systems are not disease prone, but may become so during the dry season, or when increased inputs are applied.

Livestock production is perceived as high risk due to disease, whereas the lack of significant losses in aquaculture is seen as a positive feature. Shortage of fingerlings for stocking ponds and rice fields encourages importation from neighbouring countries. These imported fingerlings are often of poor quality, and survival appears to be low. There is also a potential risk of introduction of diseases present in the countries of origin. Production of fingerlings within Lao PDR is limited to provincial hatcheries and a few private entrepreneurs. This activity is increasing and is susceptible to health management-related problems. Health management issues limit production in Lao PDR, and thereby, constrain development, but are not causing direct economic loss. This may not be the case with respect to impacts on wild fisheries and fish movements. The lack of baseline information on aquatic animal health issues available for Lao PDR limits the ability to assess risk in the aquaculture and fisheries sectors.

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INTRODUCTION

Lao PDR is a landlocked country with an area of over 236,800 km^2. Approximately 80% of the country is mountainous, and an estimated 54% is still covered with forest or woodland. Agriculture accounts for 59% of GDP and within that, forestry is extremely significant.

There are two principal climatic types that depend upon elevation. There is a lowland type climate that is similar to that found in neighbouring Thailand and Cambodia and a cooler highland climate. There are three distinct seasons: hot monsoon (May–September), cool dry (October-January) and hot dry (February–April). There is very little rainfall during the dry seasons.

The population of Lao PDR is currently around 5 million and is projected to double within the next three decades. Of the total population, the majority live in rural areas (78%) and most of these are subsistence farmers.

The estimated average annual household income in Lao PDR by 1995 was $350 (UNICEF 1996). This means that 50% of households were below the arbitrary World Bank poverty line of $1 per day. Cash income is a poor indicator of poverty for rural farmers in Lao PDR, since their livelihood is almost entirely self-sufficient. Literacy rates are estimated at 50% (women and men, 15-40 years) and life expectancy at birth is 53 years for women and 50 years for men (UNICEF 1996). Medical and educational facilities are rudimentary in most rural areas.

1997 PROVINCIAL AQUACULTURE DEVELOPMENT PROJECT SURVEY

During start-up activities for the Provincial Aquaculture Development Project (LAO/97/007), livestock and fisheries counterparts conducted a baseline survey to collect information on livestock and agricultural consumption and production in the five project target provinces. This was conducted because of the general lack of reliable information nation-wide concerning all types of production and consumption. As a result, the questionnaire attempted to cover all aspects of household consumption and production (including foods, crops, livestock and commodities) and also, basic information regarding the composition of the households.

In total, over 375 farmers were interviewed. Farmers in each area were from the same village and had been gathered by the village headman. Farmers attending on the day of surveying were more likely to have an interest in fish culture, and in many cases, already had fish ponds (84%). In this respect, farmers surveyed were not a random representation of villagers, but relative homogeneity within villages probably offset significant bias.

The survey was conducted during the dry season, when road travel is most convenient and farmers are least active in the rice fields. The questionnaire required significant recall from farmers regarding consumption habits, and generally, responses were given as quantities per week or month and then extrapolated over a year by the surveyors. In this respect, wet season consumption is probably underestimated.

Farmers were able to recall production quite accurately, especially regarding rice, fish and livestock. Income from sale of these commodities was also relatively easy for the farmers to recall. Since the majority of food produced is consumed within the household and surplus is sold, overall consumption could be derived as the difference between production and sale or as consumption returned by the respondent.

Answers provided by respondents varied widely in terms of measures given (e.g., bags, baskets, cans, jars or value). A database was constructed to preserve the original quantities provided by the respondents, and this also allowed all the data to be used. Subsequent application of conversions allowed standard weights or values to be derived. Wherever possible, local prices were also recorded to reduce error.

The results generated from the survey generally agreed with field observations (i.e., with common sense) and trends in consumption reflect what is known about Lao rural households. Under-estimation of wet season activities such as aquatic product consumption is possible. The time to construct the database and analyse the data was considerable; a more focused, less structured interview approach would have yielded better results in much less time.

Simple quantification of consumption and production does not reveal essential characteristics of subsistence livelihoods. An example of this is the issue of the relative importance between diversity in the farming system, spreading of risk and productivity. The information required to put the survey data in context has been gathered during participatory interviews, training activities and conversations during the past two years.

RURAL LIVELIHOODS AND FARMING SYSTEMS

Following large movements of people during the wartime period, and subsequent breaking up of land packages within families, land holdings are relatively similar. It is unusual to find farmers with very large land packages, and similarly, landlessness is uncommon. What differs between land holdings is the quality of the land and the type of crops that can be cultivated

Rice is the food staple in Lao PDR and is grown as wet rice or hill rice. Most areas produce an annual crop of rice, which is usually a glutinous variety (annual productivity is 2,000-3,600 kg/ha/crop). Flat or terraced rice paddy is typical in most valleys, and this land is at a premium. For five provinces, the range of family (wet) rice paddy holding was 0.9-1.7 ha/household. Apart from rice production, wet rice paddy is also a significant source of aquatic products that are foraged or captured during the monsoon season.

Hillsides are cultivated for hill rice, corn and cassava, and this may complement wet rice paddy or form part of a shifting cultivation lifestyle. Pressure on hills from shifting cultivation is increasing, and the cycle between cultivation and fallowing is steadily decreasing. This is raising concern over issues such as erosion and soil deterioration. Stabilisation of shifting cultivation is seen as a potential solution, but in other cases the relocation of peoples into lowland areas has occurred.

There is a limited area of irrigated paddy that is principally confined to the lowland provinces that border the Mekong River. This allows production of a second rice crop. In flood-prone provinces, some irrigation has been installed to allow dry season cultivation as a single annual crop.

AGRICULTURAL INPUTS

Two principal agricultural feedstuffs produced by the Lao farming system are rice bran and cassava. In some areas, corn surplus may be produced. Rice bran may be used by farmers to pay for the cost of rice milling, although it is more desirable to retain the bran and use it as a supplementary feed for livestock. Cassava is eaten or fed to livestock in upland areas.

Fertilisation of rice fields is minimal due to lack of manure from penned livestock, and chemical fertilisers are rarely used. The cost of fertilisers is a principal constraint to their use. Chemical fertilisers and pesticides may be used in irrigated areas where there is greater promotion of more intensive methods of rice production.

There is no intensive livestock production in rural areas due to lack of animal feedstuffs. This is partly due to limited production area and marketing difficulties, but also due to the fragmented nature of subsistence farming. Livestock are usually left to forage around farms or stray into local forests. Imported starter feeds are available in most areas, and there is local production of chicks, piglets and calves. There is no intensive in-country production of young livestock for on growing. The livestock strains common in rural Lao PDR are mostly local varieties. Some entrepreneurs who have started to farm using more intensive chicken varieties have encountered problems with marketing their animals due to poor consumer acceptance. In peri-urban lowland areas, intensive livestock production is becoming more common, and imported breeds can be found.

Livestock production is one of the few forms of income-generating activity that is available to farmers in rural Lao PDR. Buffalo are a considerable investment and used principally as draft animals. In times of economic stress, or for special occasions, a buffalo may be slaughtered for income. More typically, pigs and chickens are kept for food and sale. Being smaller, these animals are more convenient and can be sold gradually. Fish culture is an alternative or supplementary activity to small livestock production.

Disease in livestock is widespread and is a risk to farmers who borrow to engage in this activity. Vaccines are rarely used and poor storage and quality of vaccines, where administered, limits their effectiveness. The risk of disease in livestock is significant, and currently, borrowing for livestock production is one of the few forms of credit available to rural farmers. Whilst lending for livestock production, the Agriculture Promotion Bank has not yet recognised that fish culture is suitable for lending to small-scale farmers.

SOCIO-ECONOMICS

Lao rural families tend to be large, with surveyed households averaging 6.7–8.3 persons/household. The age structure also reflects the national averages with 50% of household members younger than 15 years and only 10% older than 51.

Ethnicity

Lao PDR is home to a large number of ethnic groups (>40), with different livelihoods and traditions. The government separates these ethnic groups into three major groups (high, middle and lowland Lao) according to their tendency to inhabit different parts of valleys, slopes and mountains. Within a mountain and valley system, it is quite possible to have all three groups present. All three groups are currently engaged in aquaculture to some degree, and LAO/97/007 is working with farmers from 17 different ethnic groups.

Gender Issues

Lowland Lao tend to be matrilineal and matrifocal; this means that land inheritance and land rights are accorded to women. This is not so clear in other ethnic groups. Labour divisions exist, although there is no definite exclusion of women from engaging in any activity. Handling of money, family savings and marketing of produce is often a woman's activity, but there are differences according to ethnicity.

Women can engage in aquaculture, and this is demonstrated by their participation in LAO/97/007 (about 8%). There are constraints to women's participation, in particular the distance of the house to the fishponds. The women that are members of farmers groups in LAO/97/007 all have ponds close to their home. If the fishpond is not conveniently close, it is unlikely that a woman would have the time available to include this activity. Other significant daily activities include water carrying, care for babies, food collection/foraging, firewood collection and cooking. Elder children usually also help with all of these activities (Murray *et al.* 1998).

Due to security concerns, it is still uncommon to find houses located away from villages. As such, fields and ponds usually surround a village and are often some distance from the house.

Economics

The self-sufficiency of Lao farmers means that whilst they are largely able to feed themselves, they do not generate significant income. Income generation is via production of agricultural products and livestock, and the income is largely spent on household commodities. Table 1 below indicates the average incomes for five provinces generated by the families surveyed by LAO/97/007. The table also includes the theoretical income attributed to the value of their unsold production (i.e., the value of the food they produce and consume). Since the farmers surveyed were mainly wet rice farmers (rainfed rice 90%, irrigated rice or both 17%) and many had fish ponds (84%), they are representative of farmers that have a relatively good resource base. Hill farmers are less likely to engage in aquaculture, due to unsuitability of terrain, although there are examples of ponds made from dammed streams. These are more difficult to construct and may collapse under runoff water in the monsoon season.

Table 1. Income and expenditure for households surveyed by LAO/97/007 (range of averages for five provinces)[1]

	$/household/year
Household income (sale of livestock/rice etc., pension, relatives)	$372-594
Purchase of foods & commodities	$302-447
Self-produced foods (theoretical value - no actual income)	$313-543
Net cash income	$70-261
Theoretical income (including self-produced)	$413-638

[1]For November-January 1997; 1 $US=2,400 Kip.

Diet

Lao PDR has extensive water resources during the monsoon season - rivers, wetlands and paddy fields. Aquatic foods gathered from these seasonal water bodies are preserved for use during the long dry season when food is less abundant. Rice, also produced during this season, is similarly stored for the coming dry season. Consumption of rice for five provinces was estimated at 189-458 kg/*capita*/yr. Lowest values were returned in provinces where farmers' groups have marginal farmland and small land holdings (Sekong, Sayaboury) and highest values in areas with relatively good soils or larger land holdings (Xieng Khouang, Oudomxay).

Since livestock is grown for income generation, meat is often eaten sparingly and augmented with fermented fish and vegetables. Wild game, reptiles and insects are foraged extensively in forests and woodlands, although pressure on this resource has resulted in depletion. The ability to produce fish through aquaculture is extremely popular, since it provides food for the house, a supply of fresh fish into the dry season and can also generate income. The total *per capita* consumption of animal products was estimated at 37-64 kg/*capita*/yr. Of this animal product consumption, aquatic products (17-23 kg/*capita*/yr) provided 22-55% (Table 2). Actual fish consumption ranged between 10-19 kg/*capita*/yr.

Table 2. Consumption of animal products by type.[1]

Animal Products Consumed	% Consumed
Fish (fresh, dried, fermented, pickled, tinned), amphibians, molluscs, crustaceans	37
Chicken, duck, eggs, turkeys, other birds	24
Pork, buffalo, beef, goat, dried meat	23
Reptiles, forest game, insects	15

[1]From 1997 survey data, LAO/97/007.

A further breakdown of the aquatic products consumed by the farmers surveyed is presented in Table 3. The recruitment of fish to paddy fields during the monsoon season appears to differ from lowland countries such as Thailand and Viet Nam. This is possibly because, unlike these two countries, flooding of paddies in Lao PDR occurs as runoff from hillsides, rather than as flooding from rivers and streams. The long dry season and deep river courses do not provide habitats for some of the more usual ricefield fishes found in other countries. This may explain the apparently large quantities of amphibians that are taken from paddies. This also explains, in part, the attraction of rice-fish culture where practised, since, without actual intervention by stocking fish, the fish production from paddies might be rather low and comprise mainly small *Rasbora* species (Pa sieuw). The high values for fish consumption in the table above may reflect the contribution of fish production from farmers' ponds in the group surveyed. The fish produced from 152 farmers' ponds had an average value of $81 per household (median $31). Fresh fish consumption as a proportion of the total value of food consumption was between 10–26% (average 16%) for the five provinces surveyed.

Table 3. Annual consumption of aquatic products (kg/capita/yr).[1]

Products consumed	Average	Range of Average
Fresh fish	9	6.3-12.7
Dried fish	2	1.8-3.5
Fermented fish	3	1.2-5.6
Canned fish	0.5	0.3-0.7
Snails, crabs, shrimp, frogs, tadpoles, insects	7	4.4-7.7
Province totals	22	13.5-47.8

[1]From 1997 survey data, LAO/97/007.

Pond Aquaculture

The majority of Lao fishponds are hand constructed by excavation, damming small streams, or by converting terraced paddy fields. Machine-dug ponds exist and are usually the result of earth borrowing for road construction. Unfortunately, such machine-constructed ponds are in locations convenient for roads but often not ideally suited for aquaculture. The characteristics of rural farmer's ponds are presented in Table 4.

The shallow nature of ponds means that they usually only hold water for part of the year, usually drying up during January or February. As ponds become progressively shallower, water quality deteriorates, especially if the ponds are being fed or fertilised. This may predispose fish to a range of water quality-related health problems.

Table 4. Pond characteristics of rural Lao PDR.[1]

Pond Characteristics	
Average depth	50 cm
Average size	550–1,520 m^2
Stocking density	1–4 pieces/m^2
Productivity	417-708 kg/ha/yr
Production	20–60 kg/household/yr

[1]From 1997 survey data, LAO/97/007.

Fertilisation of ponds is variable and depends upon availability of manure. The presence of livestock makes fertilisation more convenient, especially if the animals are kept in the vicinity of the pond. Ponds that are supplied by streams are often clear water due to the washing out of nutrients. Supplemental feeding is practised to varying degrees and depends upon the availability of rice bran or other agricultural bi-products. Aquaculture production may compete with livestock for supplemental feeding, and the extent to which one or the other is prioritised will depend upon a farmer's perception of the relative value of the two activities. The extent to which fish production is income generating will certainly influence the decision about the amount of feed applied to a pond.

Exclusion of wild fish entry from the ponds is recommended in extension messages, but in practice is often difficult to implement. Snakehead, catfish and eels will enter ponds if they are near to water courses, and *Rasbora* spp. inevitably enter if there is flowing water. *Rasbora* spp. do not predate fish, but will compete for rice-bran, especially if it is floated on the surface of the pond. Wetting feeds so that they sink is a simple method for improving feeding of more valuable larger fish in the pond. In some cases *Rasbora* spp. production will exceed that of stocked fish, but since this fish is acceptable to farmers for domestic consumption, this is often not perceived as a constraint. Carnivorous wild fish in the ponds also predate this species.

Risk

In subsistence farming systems, minimisation of risk has a priority over productivity. Risk factors identified in discussions with farmers include loss of money, excessive use of time or labour, and theft. Loss of fish to disease is not commonly identified as a risk; indeed, the fact that fish kills are rarely observed is seen as an indication that cultured fish culture are less susceptible to disease than are livestock.

It is interesting to note that the failure to recapture fish that have been stocked, or poor production of stocked fish from a pond, is rarely attributed to predation, disease or poor feeding. Theft of fish is frequently cited as an explanation for low production.

Even though fish culture may be low risk, increased investment in the form of feeding and pond inputs is something that farmers will only adopt gradually. It is unlikely that a farmer will invest time, money and feed, only to have the fish poached. Increased inputs to the system become more acceptable once fish production becomes income generating. Income generation from fish culture appears to be dependent upon other factors, such as the ability to guard a pond and the experience that the crop is worth protecting. Low productivity from subsistence farmer ponds is, therefore, an inherent feature of low-risk production.

In Lao PDR, the starting point for improving stocked fish production is minimisation of the impact of predation through stocking large fingerlings (ideally, 5 cm). The production of large fingerlings is a major constraint in most provinces, which leads to most farmers stocking fish at 3 cm or whatever length is available. Nursing of small fish in cages prior to release to the pond has been pioneered by the Asian Institute of Technology (AIT) Outreach Project in Savannakhet and is also an integral activity of LAO/97/007.

REPORTED FISH HEALTH ISSUES

Subsistence fish culture in seasonally stocked ponds, with low nutrient inputs and low stocking densities has few of the predisposing features that cause losses in intensive aquaculture in Asia. Although farmers rarely observe mass mortality, 28% of farmers interviewed in 1997 responded that they had observed fish mortality. The conditions related by farmers are presented in Table 5. It should be noted that, in most cases, the farmers did not distinguish between diseases observed in their ponds and diseases in wild fish found in paddies or water bodies.

Table 5. Fish mortality reported by farmers (1997 survey)[1].

Cause of Mortality	Number of Respondents
Unspecified mortality	40
Unspecified disease	29
Ulcerated bodies	14
Red spots	5
Spots	4
Red scales	1
Predation	2
Mortality at stocking	2
Water too hot	2
Low oxygen	3
Insufficient water	2
No disease observed	269
Total	373

[1]From 1997 survey data, LAO/97/007.

During the survey, the majority of farmers did not explain the cause of fish mortality or the disease that they had observed. When questioned directly regarding health problems, farmers are usually quite informative regarding location, species affected and nature of the problem and can often describe external signs of disease.

Epizootic Ulcerative Syndrome

Ulcerated bodies are frequently mentioned by farmers, and specifically in relation to catfish or snakeheads (in ponds or otherwise). This is consistent with what is known about epizootic ulcerative syndrome (EUS). Farmers report that ulcerated fish occur at the beginning and end of the cool season (November and February) in Lao PDR. From this survey, the majority of responses (13) indicating signs of EUS came from the three districts surveyed in Xieng Khouang Province.

Stress-related Disease

Stress in shallow seasonal ponds, or over-fertilisation, may lead to haemorrhages on the fish, and this may lead to reports of "red spots, spots and red scale." This problem has been observed subsequently in farmers' ponds where project staff have recorded additional information, such as excessive fertiliser application and shallow water. In cooler, upland areas of Lao PDR, fish may eat less over winter, but farmers may not reduce inputs. In small ponds, this may adversely affect water quality and fish health.

Trematodes

More recently, one provincial hatchery has requested investigation of broodstock mortality and suspected fry mortality in nursery ponds. In-country facilities for identification of aquatic animal disease do not currently exist. Gill samples were sent to the Aquatic Animal Health Research Institute (AAHRI) in Bangkok, where it was determined that the fish were heavily infected with trematode metacercariae.

The tradition of eating raw, partly cooked and preserved fish in Lao PDR results in high human infection rates with trematodes. Three separate government studies of liver fluke infection in villagers found infection rates of 43%, 36% and 55-60%, respectively (unpublished data, 1991 and 1999). Lack of latrines and runoff into paddies and ponds is probably the mechanism by which trematodes are transmitted between humans, snails and fish . The movement of infected fish between areas may also be a route for introduction of the disease, and provincial hatcheries may play a role in this. Cultured fish that are not infected could provide a safe source of fish for raw consumption.

PROVINCIAL HATCHERIES

Annual demand for fish fingerlings nationally has been variously estimated, but is considered by the Department of Livestock and Fisheries to exceed 60 million. This value is based upon estimated areas of fish culture and assumed stocking rates for ponds and rice-fish culture. Provincial hatchery production exceeds 10 million, and there is limited production from the private sector. Importation of fingerlings from neighbouring countries during the peak stocking season goes some way to fulfilling this demand. There are no reliable figures for the numbers of imported fingerlings, but unofficial estimates for two provinces alone exceed 12 million.

The low production levels achieved by the provincial hatcheries are founded in a variety of problems that are related to both physical and management factors. Poor pond management results in low survival from nursery ponds, which is where greatest mortality occurs in the system. Estimated survival from egg to fingerling is below 5% (hatchery managers' estimates during LAO/97/007 workshops on hatchery management 1999) and can be attributed to poor broodstock quality, poor hygiene, poor water quality, underfeeding and predation. Fish disease is an uncertainty in this system, since screening of provincial hatcheries has yet to be performed. Broodstock management is often poor, since fish need to be held at the hatchery for a minimum of one year before they mature. A significant feature of the hatcheries is that they have perennial water, and broodstock ponds are rarely dried out and cleaned. This inevitably leads, at some stage, to health problems in fry or broodstock. This problem is compounded in some hatcheries where water reservoirs are stocked with grow-out fish. A further consideration with respect to the provincial hatcheries is that they are likely to be the source of fish that will ultimately be used as broodstock by small hatchery producers.

FINGERLING MOVEMENTS AND IMPORTATION

Responses to a survey question regarding source of fish for stocking in ponds are presented in Table 6. The high number of respondents that obtained their fry locally were principally from Xieng Khouang, where self-production of common carp in paddy fields is traditional. Provincial hatcheries are still an important source of fingerlings, although the importation of fingerlings ranks third. Fingerlings sold in local markets may also be imported, as may as a proportion of those obtained from other villages.

Table 6. Source of fingerlings for stocking in ponds.[1]

Source	No.
Local village	46
Provincial hatchery	45
Vietnam/China/Thailand	22
Own production	20
Local market	16
Another province	7
Wild caught	7
Total	163

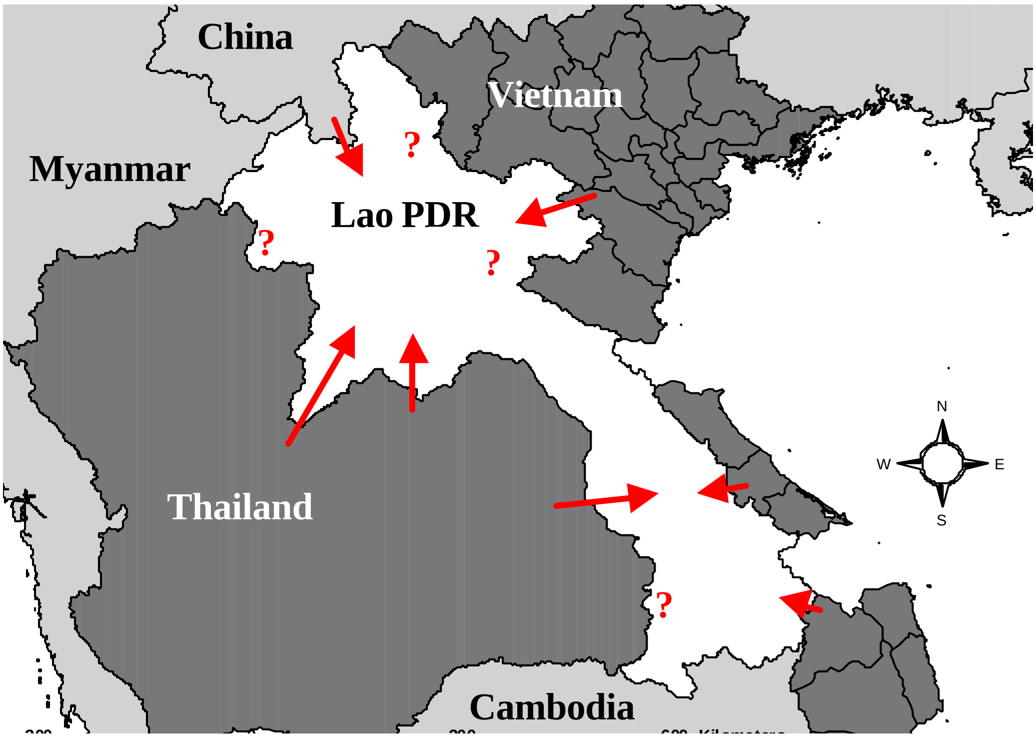
[1]From 1997 survey data, LAO/97/007.

Imported fish are thought by farmers to be of low quality. One of the principal complaints is that, after stocking, the farmers have very few of the stocked species in their ponds, but plenty of the small *Rasbora* spp. Their conclusion is that the fry traders are mixing the *Rasbora* (which look rather like carp fry) in with the Chinese or Indian major carps that they are selling. An alternative explanation is that low survival after stocking results in few stocked fish being harvested and that the *Rasbora* spp. enter through the usual water inlets.

Long transportation times and poor handling will affect imported fish. The sale of poor quality fish that cannot be marketed in the country of origin is another consideration. Farmers express a preference for fish produced locally and will pay more if they can obtain them. It is significant to note, that where LAO/97/007 activities increased fingerling supplies locally, there was a decrease in demand for fry from the Chinese traders who had previously been importing fish. Targeting of assistance to small-scale fry and fingerling producers is a priority LAO/97/007 activity. Figure 1 shows the known entry points for fry importation into Lao PDR. Other possible entry points are marked “?.”

There is considerable potential for Lao PDR small-scale aquaculture to be impacted by diseases of intensive aquaculture from neighbouring countries. Reliance on geographical isolation and annual dryout may decide the extent to which a disease may spread in aquaculture, but this does not consider impacts on wild ricefield and riverine fisheries, which are less discrete systems.

Figure 1. Known and potential points of fish fingerling importation to Lao PDR.



STOCKING OF WATER BODIES

Lao PDR has numerous water bodies, both natural and man-made. Occasional stocking of these is carried out as part of provincial activities. In cases where access can be controlled, villagers or individuals may stock to enhance fisheries or to establish species such as silver barb and common carp. The source of the fish in these cases is usually the provincial hatchery. Due to constraints on fingerling supply, provincial government stocking activities are largely ceremonial, and significant numbers are not released. Table 7 gives a list of the area of water bodies currently present in Lao PDR. Most of these areas have some form of fisheries activity. In terms of risk to fisheries, current stocking practice is probably not significant, but should be considered.

Table 7. List of areas of large and small water bodies in Lao PDR.

Type	Area (ha)
Irrigation reservoirs	34,480
Hydro reservoirs (Nam Ngum ~ 40,000 ha)	48,196
Natural ponds & lakes	7,019
Wetlands (seasonal)	27,029

HEALTH MANAGEMENT OPTIONS

Limited management options are available to subsistence farmers engaging in aquaculture. Investment in feeds and lime are unacceptable if the fish are mainly consumed in the home. Water quality problems that develop as rainfed ponds become increasingly shallow cannot be improved by water exchange. Specific disease conditions such as bacterial infections, or parasites such as trematodes or *Lernaea,* are untreatable due to cost or unavailability of therapeutants.

As health related problems occur, farmers continue to farm until it is necessary to harvest the crop. The cost-benefit of fish culture is such that a survival of less than 20% (typical size of fish at final harvest is 150 gm) is required to offset the cost of stocking and the opportunity cost of rice bran. Since a yield such as this is almost guaranteed whatever the final condition of the pond, farmers can tolerate poor productivity.

A positive health management feature of rainfed ponds is that they dry completely for some period of the year, and therefore, transmission of disease may be limited. This may currently be the most significant form of health management in this type of system. Stocking of infected fish will negate any advantage gained from pond dry-out, highlighting the critical value of good quality fingerlings.

Perennial fishponds exist in Lao PDR, although these can be separated into deep rainfed ponds (undrainable) and irrigated ponds. Undrainable rainfed ponds are still limited in terms of improvement of water quality through water exchange. Paradoxically, irrigated (stream fed) ponds usually suffer from excessive flushing of nutrients, resulting in slow fish growth due to low water fertility.

A precautionary approach is required when advising farmers on fertilisation rates and integration of livestock. What may be acceptable fertilisation inputs to full ponds may be excessive when they are half-dry. The low amounts of feed available for livestock, and the tendency not to pen them, generally limits farmers' tendencies to over-fertilise ponds. In 1998, it has been seen that following training with LAO/97/007, over-application of feed and manure resulted in water quality deterioration and fish disease in several farmers' ponds. Farmers often ask if, once water quality has deteriorated, is there a method to improve it. If water exchange is not an option, the only solution is to harvest.

Exclusion of wild fish is often recommended in more intensive aquaculture systems, since they compete with stocked fish for feed in the pond. A secondary potential benefit may be that the chances of introducing disease from outside the pond will be reduced. The relative risk between transmission of disease from cultured to wild stocks and *vice versa* is still uncertain. The additional catch of wild fish that enter fishponds may actually increase the overall production from a low input pond; thus, there may not be an apparent benefit from wild fish exclusion.

Nursing of fry to fingerling size reduces predation risks at stocking and also shortens the grow-out time in seasonal ponds and rice-fish culture. Low-risk, low-cost net-cage nursing systems have been field tested in southern Lao PDR through the activities of AIT Outreach/Regional Development Committee activities, and are also part of LAO/97/007 extension activities in five provinces.

There is scope for action in government hatcheries, in terms of quantification of risk and improvement of health management. A baseline survey of health problems in provincial hatcheries would be a reasonable indicator of potential risks to farmers. Similarly, knowledge of specific diseases in neighbouring countries provides some idea of the possible impacts of fry importation.

The relative contribution of private-sector fingerling supply is significant, as high prices and economic liberalisation make this an attractive proposition. This is already evident with fry importation, but in-country production can be expected to make an increasing impact in the future.

Recently, government policy has emphasised the importance of fish fingerling production. Hatchery improvements and the establishment of new hatcheries are currently being planned. As irrigation and peri-urban aquaculture is increasing and intensifying, more problems can be expected in this sector. Hatcheries supplying this market will inevitably also start to supply rural areas; in-country diseases of intensification may, therefore, be passed on to rural areas.

The current state of rural aquaculture in Lao PDR indicates that disease contributes to lost potential rather than to actual crop losses. This lost potential is severely influencing the availability of fish fingerlings and encouraging importation. The impact of fish health can thus be seen as a constraint to the further development of low risk aquaculture.

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SOCIAL AND ECONOMIC IMPACTS OF AQUATIC ANIMAL HEALTH PROBLEMS IN AQUACULTURE IN CHINA

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ABSTRACT

The rapid development of fisheries in China has been noted worldwide in recent years, and aquaculture has played a very important role. In 1998, aquaculture production was 21.8 million mt, which accounted for more than 55% of total fisheries production. However, the negative impact of disease is becoming increasingly serious. Finding an effective resolution to this problem is the main topic for many international and regional activities, and the Government of China has paid great attention to management of aquatic animal health. The fisheries authorities at both the national and local levels in China have been closely assessing the disease situation, with the co-operation and support from the concerned institutions and academic bodies. An initial framework for aquatic animal disease control and a fish disease reporting system have been set up. In order to protect the livelihoods of the vast rural population, regional co-operation, intensive training and extension are urgently required.

BACKGROUND

The fisheries sector in China made rapid progress during the 1990s. The annual yield of aquatic products increased from 12.4 million mt in 1990 to 39.1 million mt in 1998 (see Fig. 1). The rapid development of the fisheries sector is closely related to the remarkable development of aquaculture, and the area under production is 1998 was around 6 million ha (Fig. 2). Of the total production in 1998, 17.2 million mt was from capture fisheries, while 21.8 million mt was from aquaculture, accounting for 44.2% and 55.8% of the total fishery production, respectively. The *per capita* supply of fisheries products in China reached 31.3 kg/annum in 1998. Aquaculture has been the key to the successful development of China's fishery. National production figures for 1998 are given in Table 1, and production by species is given in Table 2.

Currently, fisheries in China is one of the most important components in agriculture. In 1998, the total foreign trade volume of aquatic products was 2.14 million mt, with a value of US$3.86 billion. Apart from earning foreign currency, fisheries also provide the rural population with employment. In 1998, the fisheries population and fisheries labour were 19.32 million and 12.37 million people, respectively. The average *per capita* income for the fisheries population was 4,323 Yuan (US$522), while *per capita* income for fisheries labour was 7,285 Yuan (US$879), an increase of 349 Yuan (US$42) and 439 Yuan (US$53), respectively, from 1997 (Fig. 3). The average income of fish farmers is higher than for others living on the land. Fisheries, especially aquaculture, has always played a very important role in the development of the rural economy and poverty alleviation, as well as food security in China.

Figure 1. Annual yield of aquatic product in China, 1990-1998.

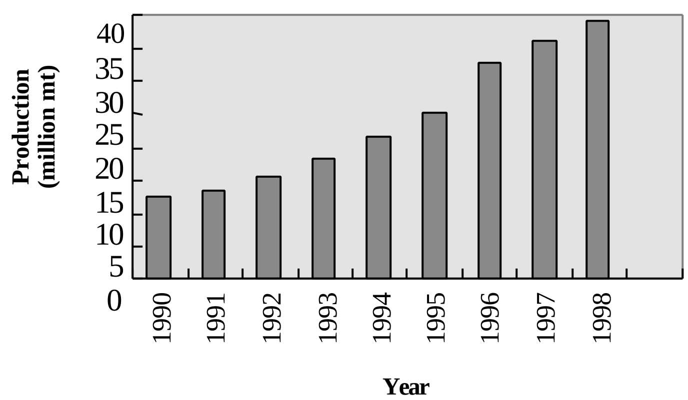

Figure 2. Aquaculture area in China, 1990-1998.

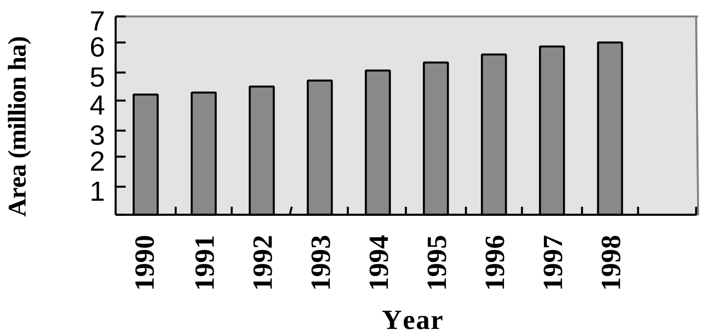

Figure 3. Per capita income (US$) of fisheries population and of fisheries labour, 1994-1998.

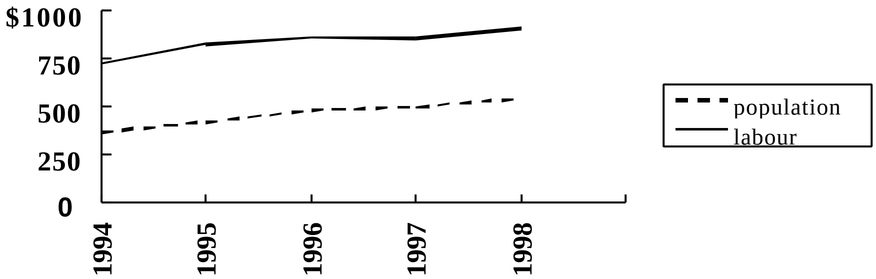

Table 1. National aquaculture production by culture environment, total area and average production per unit area for 1998.

	Production (mt)	Total Area (ha)	Production/Unit (kg/ha)
Mariculture	8,600,403	1,004,407	8,563
Inland aquaculture			
Pond culture	9,511,502	2,085,568	4,561
Lake culture	854,788	881,081	970
Reservoir culture	1,293,655	1,596,400	810
Culture in rivers & canals	642,091	377,111	1,703
Food fish culture in paddy	551,407	1,320,681	418
Others	365,693	140,465	2,603
Total inland aquaculture	13,219,136	5,080,625	-
Total	**21,819,539**	**6,085,032**	-

OVERVIEW OF SOCIAL AND ECONOMIC IMPACTS

With the development of intensive aquaculture and the appearance of more serious environmental pollution in recent years, aquatic animal disease has become a major problem. There are currently more than 200 diseases that have been identified in cultured aquatic species. Some diseases have caused serious damage, not only to the livelihood of fish farmers, but also to the future development of the industry. It is estimated that around 10% of the culture area is suffering from disease, with annual production losses of around 15%.

Freshwater Aquaculture

In freshwater aquaculture, apart from many bacterial, viral, fungal, protozoan and other diseases, bacterial septicaemia is considered to be one of the most important diseases in the history of Chinese aquaculture. From 1990 to 1992, it occurred widely in almost all major aquaculture provinces and regions in China. This disease mainly affected silver carp, bighead carp and crucian carp, which are the major species cultured in China. The main pathogens identified include *Aeromonas hydrophila, Yersinia ruckeri* and *Vibrio fluvialis*. When this disease first appeared in 1985, it did not attract much attention from scientists and farmers. From 1988, it quickly spread throughout the main culture area. Many small-scale fish farmers especially suffered because of it. By the early 1990s, the annual economic loss was estimated to be more than 1 billion Chinese Yuan (US$120 million). Since control methods have been devised following urgent scientific research, the prevalence has decreased, and the annual economic loss has decreased to about 600 million Yuan (US$72.4 million).

Marine Aquaculture

In marine and brackishwater aquaculture, shrimp disease is the major problem. In 1993, as with other major shrimp culture countries, China suffered a serious outbreak of white spot disease in the coastal provinces. The affected shrimp-pond area totalled 112,000 ha, or 76% of the total culture area. More than half of the shrimp ponds were unable to harvest anything, and shrimp production in 1993 dropped by 120,000 mt. The direct economic loss was estimated at more than 3.5 billion Yuan (US$420 million).

Table 2. Aquaculture production by species or species group in 1998.

Type of Production	Production (mt)
Mariculture	
Finfish	306,697
Crustaceans	214,300
Molluscs	7,002,498
Seaweeds	1,024,172
Others	52,736
Total	**8,600,40**
Inland aquaculture	
Black carp	152,646
Grass carp	2,807,514
Silver carp and bighead carp	4,699,554
Common carp	1,927,973
Crucian carp	1,032,030
Chinese breams	449,282
Tilapia	525,926
Mandarin fish	83,074
Eel	163,098
Freshwater prawn (*Macrobranchium rosenbergii*)	61,868
Chinese river (mitten) crab	123,241
Soft shell turtle	61,881
Others	1,131,049
Total	**13,219,13**

In China, mollusc culture is another major component in marine aquaculture. Cultured shellfish production accounts for nearly 40% of total marine aquaculture production. However, in recent years, high mortalities have occurred during the culture period in Shandong and Liaoning provinces, where the main shellfish farms are located. Losses have been very significant. With scallop, for instance, production in 1998 was only 629,373 mt, 33% less than in 1997. So far, the cause of these losses has not been identified.

Culture of Non-traditional Species

As well as the upward trend in traditional aquaculture, so called "specialist species aquaculture" has developed very rapidly in recent years. Along with the movement from a planned economy to a market economy, Chinese customers now prefer high quality species, such as soft-shell turtle, freshwater prawn, Chinese mitten crab and mandarin fish. Marine finfish cage culture has also been widely practised along the coastal provinces. As these culture techniques are comparatively new, farmers frequently encounter disease problems. An assessment of economic and social impact is difficult to carry out; however, estimated as a whole, the economic loss caused by disease is higher than that for traditional aquaculture, because of the higher value of the species cultured, and the situation is becoming more serious.

According to available estimates, the annual economic loss in Chinese aquaculture due to disease is more than 10,000 million Yuan (US$1.2 billion).

DETAILED CASE STUDIES

Case One. From 1995 to 1997, in order to promote the recovery of Chinese shrimp culture, a three-year shrimp health management demonstration project was carried out through the Budget of National Harvest Program. This project covered almost all the provinces where shrimp culture had been conducted. The main objective of this project was to promote awareness of shrimp health management among shrimp farmers. The key techniques included pond system reform, stocking healthy larvae, installation of aeration units, water quality monitoring and use of high quality pelleted feed. With financial and technical support from the project, the average per unit production of the experimental ponds was 133% higher than those ponds that continued with the old culture methods. Results of the project are given in Table 3. The economic benefits gained by the farmers convinced others to adopt the new technology. The shrimp culture industry in China has now begun to recover.

Table 3. Shrimp health management demonstration project (1995-1997).[1]

	Project Ponds	Total Culture Area	Percentage
Coverage area	414 ha	153,119 ha	2.7%
Production/ha	1,365 kg	585 kg	233%
Benefit/ha	42,000 Yuan (US$5,072)	-	-

[1]All figures are average yearly values.

Case Two. An aquatic animal disease investigation examining the current freshwater fish disease situation was conducted in Chongming County, Shanghai City. Results are given in Table 4.

Table 4. Statistics for diseases of adult fish in Chongming County, June and July 1999.

	Infected Area (ha)		Prevalence (%)		Production Loss (kg)	
Disease	**June**	**July**	**June**	**July**	**June**	**July**
Bacterial septicaemia	212	827	10	39	15,870	153,474
Gill rot	150	81	7	9	8219	8,691
Intestinal inflammation	195	14	9	4	3,852	16,078
Sinergasilus	172	298	8	14	2,947	19,971
Lernaea cyprinacea	98	42	5	2	1,052	331
Oxygen deficiency	12	125	1	6	11,407	54,225

INVESTMENT

Together with aquatic seed and broodstock management, aquatic animal health management is regarded as one of the top priorities by the fisheries authorities. In order to maintain the fast and sustainable development of aquaculture, the Chinese government has devoted significant funds and manpower to aquatic animal disease control and health management. Since 1995, the central government has continuously invested more than 23 million Yuan (US$2.7 million) to support the establishment of 29 provincial disease control centres and stations. It should be noted that investment figures do not include counterpart-fund input from local governments. According to latest statistics, in 1998, more than 24 million Yuan (US$2.9 million) of funding was invested in the improvement of disease control facilities. The establishment of a national aquaculture disease control centre has also been approved. With the main objectives of aquatic animal disease monitoring, environmental assessment, feed quality control, aquatic animal seed quarantine and information exchange, an initial framework for disease control and information feedback has been established.

Aquatic animal disease control is difficult to implement without the active involvement of all relevant personnel and organisations. In 1992, a national network for aquaculture disease control and prevention was formed, and it acted as a consultant or advisory body to the national Bureau of Fisheries and now, also, the National Fisheries Extension Centre. The members of this network were drawn from different organisations, including government, universities, research institutes and extension units. Many experts, not only from aquaculture, but also from the feed industry, marketing, environmental science and other related sectors, joined this network. This is critically important in order to ensure that information provided to policy makers is reliable and comprehensive.

FUTURE DIRECTIONS

The importance of aquaculture to the rural economy, poverty alleviation and food security has been demonstrated in many countries and regions. There is no doubt that aquaculture will further develop in the coming millennium. As there is more frequent exchange of aquatic animals between countries and regions, and, as aquaculture expands and intensifies and as more new and exotic species are introduced into aquaculture, disease problems, and the social and economic impact caused by them, will also increase greatly. In view of this, a strong commitment from government, and more intensive and comprehensive co-operation, public training and technology extension, are urgently needed.

RECOMMENDATIONS

There are many strategies that need to be further developed:

- International and national legislation to facilitate the implementation of aquatic animal health management should be established.

- A professional corps of experts should be established to carry out aquatic animal disease control and prevention to meet the increasing demands of fish farmers in rural areas for the improvement of their livelihoods.

- More funding for research in disease control and prevention should be obtained. For newly domesticated species, more attention should be given to possible disease introduction.

- A fully functioning quarantine system, serving equally importing and exporting countries and the domestic movement of aquatic animals, should be established.

SOCIAL AND ECONOMIC IMPACTS OF AQUATIC ANIMAL HEALTH PROBLEMS ON AQUACULTURE IN INDIA

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ABSTRACT

Assessing the socio-economic impact of disease on rural aquaculture is vital in order to implement primary health care. However, because of the complexities surrounding such an assessment, it is not an easy task. Rural aquaculture includes culture-based capture fisheries, trapping systems, traditional fish farming in family ponds and modified extensive or semi-intensive culture systems. The impact of disease may differ in each of these systems. To understand the impact, it is vital to understand how the different culture systems work and how fish health influences the performance and yield in these systems. Mechanisms for assessing the impacts of disease in different culture systems should be based on well thought-out protocols. More often, the concept of socio-economic impact assessment is lost when assessments are carried out for only those epizootic diseases that result in total mortality and crop loss.

This paper examines health problems in aquaculture, constraints to implementation of adequate health management in different aquaculture systems, and protocols for quantification and assessment of health-related losses, and attempts to define health management costs. The socio-economic impact of epizootic ulcerative syndrome (EUS) and white-spot disease on rural aquaculture is examined in detail using primary and secondary information. Four case studies from different rural aquaculture systems look into the socio-economic impact of disease.

INTRODUCTION

Twenty years ago, aquaculture in India was a subsistence activity. Now, in many parts of the country, it has also transformed itself into a commercial activity. Realising the contribution of aquaculture to the national economy, rural employment, poverty alleviation and food security, several policy changes have been brought about at the macro-economic level, giving a new impetus to freshwater aquaculture.

India has vast resources with potential for aquaculture. Aquaculture production in India was 1.77 million mt in 1996, with 1.68 million mt coming from freshwater fish and the rest (O.09 million mt) from shellfish. Carps are widely cultured, and in 1996, they contributed some 1.56 million mt i.e., 88.5% of the total aquaculture production of the country (Ayyappan 2000). Freshwater aquaculture depends mainly on carp-culture practices that have proved sustainable at different levels of production over the years. Production comes from over 2.25 million ha of ponds and tanks, 1.3 million ha of oxbow lakes, 3 million ha of reservoirs and 1.2 million ha of coastal brackishwater area.

The expansion and intensification of aquaculture is bound to bring problems, and disease may be very significant. Epizootic ulcerative syndrome (EUS) of fish and white-spot disease of cultured shrimp have amply demonstrated the socio-economic impacts of aquatic animal disease on rural aquaculture. Economic losses due to disease are likely to increase as aquaculture expands and intensifies. Systematic assessments of the social and economic impacts of disease on rural aquaculture are needed, as they may bring to light the need for adoption of farmer-oriented, environmentally friendly, integrated primary health management packages for rural aquaculture. Impact assessments focused on small-scale rural aquaculture are lacking, and consequently, there is lack of prevention, diagnosis and treatment of diseases in rural aquaculture. As a consequence, significant losses are impacting on small-scale, rural aquaculture development in India.

Different aquaculture systems will experience different types of health problems, the majority of which will produce chronic mortalities. Unlike the acute losses associated with disease epizootics, chronic mortalities often go unnoticed. Acute losses attract the attention of fishers, fish farmers, socio-economic analysts, planners and administrators, and it is usually only these losses that are analysed for their impact on rural aquaculture. The socio-economic impact associated with chronic losses may be many times higher than that resulting from the routinely assessed acute losses. As a first step, it is necessary to understand which pathogens and what types of disease can cause significant socio-economic impacts in culture-based capture fisheries and culture fisheries and affect the livelihoods of fishers and farmers dependent on rural aquaculture.

HEALTH PROBLEMS IN CULTURE-BASED CAPTURE FISHERIES

There are several aquatic animal health problems in culture-based capture fisheries that influence production from such systems. The disease that has made the greatest impact is EUS. Since 1988/89, EUS has caused significant production losses in many of the culture-based capture fisheries in reservoirs, lakes, beels (floodplain lakes cut off from river meanders), brackish waters and irrigation tanks (Mohan and Shankar 1994). A detailed analysis of the impact of EUS is presented later in this paper. Several bacterial, parasitic and fungal diseases have been documented in open-water systems practising culture-based capture fisheries. Ulcerative bacterial diseases, myxozoans, monogeans, digeneans, larval cestodes and ectoparasitic crustaceans have been regularly reported. Reports of mortalities associated with these pathogens are few; however an absence of recognisable acute mortalities does not mean that these pathogens do not have an impact. Some of these pathogens are certainly responsible for significant chronic mortalities and poor growth that will be reflected in low survival and poor yield. Some of the larval digeneans and cestodes present in the body cavity and muscle of large fish can affect marketability.

Another serious problem observed in some of these systems is acute mass mortalities associated with domestic sewage and industrial effluent discharge. Every year several cases occur; however, unless strict regulatory measures are in place, little can be done. Sudden unseasonal rains bringing large quantities of silt or pesticides from the catchment areas into these water bodies can cause sudden mass mortalities. Fish health problems in culture-based capture fisheries may thus have serious socio-economic impacts. Little can be done in terms of management, in this multiple-user common resource. However, there are some areas where interventions can be attempted. These include the stocking of advanced fingerlings instead of spawn, fry or early fingerlings; stocking of resistant varieties; development of stocking policies and science-based fishing regulations to encourage the development of sustainable multi-species fisheries; and application of measures to avoid using these water bodies for sewage and industrial effluent discharge.

DISEASE PROBLEMS IN POND CULTURE

Aquatic animal health problems in pond culture and their impacts on yield are well known, but are not often quantified due to the difficulties in collecting accurate and reliable quantitative information. Traditional rural carp culture in ponds was an ancient practice in the states of West Bengal, Orissa, Assam and Tripura. Now, scientific culture of Indian major carps has become a common practice in many parts of Andhra Pradesh, Punjab, Haryana, Orissa, West Bengal and Karnataka, where aquaculture is becoming the main occupation. Traditional pond culture as a secondary occupation to agriculture is also very common in various parts of India.

Diseases of varied aetiology are a serious constraint to the success of many of these culture systems. EUS has had a significant impact on pond-cultured fish in many parts of northern India. Primary and secondary bacterial infections, opportunistic fungi, ectoparasites (e.g., protozoans, monogeans, fish lice and anchor worm) and endoparasites (e.g., myxosporeans) are some of the pathogens that have had a significant impact on the yield and performance of these pond-culture systems. Many of these pathogens are also important in carp hatcheries and seed production centres. It is increasingly recognised that disease syndromes with mixed aetiology play a more important role than previously thought. In the carp-culture systems of Andhra Pradesh, much of the chronic mortality can be attributed to primary damage caused by ectoparasites and secondary infection by bacteria and fungi.

Compared to carp culture, the impact of diseases on shrimp culture has been more significant. Prior to July 1994, Indian shrimp farms did not experience serious disease problems. Conditions such as external fouling, shell and appendage necrosis, luminescent vibriosis, systemic and enteric vibriosis, soft-shelling and monodon baculovirus (MBV) were regularly reported from farms along the east and west coasts. These diseases were responsible for low levels of mortality in several farms, but not for mass mortalities over large areas. Since July 1994, diseases of viral aetiology, notably, white-spot disease, have had a disastrous impact on the shrimp farming activity of the country.

Assessing the impacts of disease, even in aquaculture systems, is not easy, as only acute losses are recognised and quantified. Chronic mortalities and poor growth caused by disease are not recognised; hence, there is a strong need to use indicators to assess these chronic losses.

CONSTRAINTS TO HEALTH MANAGEMENT

Compared to culture-based capture fisheries, health management in pond aquaculture should be feasible and easy to implement. The major problem, however, is the lack of an holistic health management approach, health management often being equated with chemotherapy. It is essential that fish farmers be made aware that simple husbandry practices could significantly reduce disease-related losses. These include pond drying, liming, selecting good seed, using proper size at stocking, applying prophylactic treatment of seed at stocking, and assuring periodic sampling, good pond productivity, good feed, and regular monitoring of fish health and water quality. Farmers should become well versed in farm-level diagnostics and health management. Surprisingly, only a small percentage of farmers are able to diagnose health problems and rectify them. The vast majority simply resort to the indiscriminate use of antibacterials and pesticides at the first sign of mortality (Rao *et al.* 1992). Lack of diagnostic capability, coupled with misuse of chemicals, can have serious repercussions. Many health problems originate in the seed-rearing farms but manifest themselves clinically, producing mortality, under farm conditions (Mohan and Shankar 1995, Mohan *et al.* 1999a). In such cases, farmers, in spite of applying adequate primary health care, can lose their entire crop. To ensure sound farming with minimal disease losses, primary health management should start with seed production.

QUANTIFYING DISEASE LOSSES

Quantifying losses caused by disease should be the first step towards assessing the socio-economic impact of disease on rural aquaculture and culture-based capture fisheries. In order to quantify disease losses, fishers and farmers should be able to identify disease as the reason for crop loss, slow growth or poor harvest. The primary task should be to train farmers to carry out field-level diagnosis and assess the likely impact of disease. Several indicators may be used to quantify health-related losses in aquaculture and capture-based fisheries. Differences between expected yield and actual yield, percentage survival and growth rate may give some indication regarding health related-chronic losses in aquaculture systems. Such estimates will be crude, since many other factors can contribute to poor survival, poor growth and production loss.

Assessing losses in culture-based capture fisheries is also difficult. Species composition in commercial landings, species-wise size distribution, annual landings and catch per unit effort (CPU). may give some indirect indication of disease losses. For example, in some fresh- and brackishwater systems catches of snakehead (*Channa* spp.) and pearlspot (*Etroplus*), respectively, have declined considerably. This could be a direct consequence of EUS in natural water bodies.

The indirect effects of aquatic animal disease may also have negative socio-economic impacts. The zoonotic potential of some fish pathogens, bacterial drug resistance in human pathogens, and tissue residues of chemotherapeutants are all-important. Health management strategies should aim to minimise the indirect socio-economic consequences of aquatic animal disease.

DEFINING HEALTH MANAGEMENT COSTS

Identifying health management strategies and defining health management costs to reduce or prevent disease losses are very important. Under the broad definition of rural aquaculture, it is necessary to see where, and in which culture systems, health management strategies can be employed. It should be possible to introduce health management strategies in all farmer-controlled aquaculture ponds and tanks. In culture-based capture fisheries, as in reservoirs and large irrigation tanks, it may not be possible to introduce any standard health management package. However, under species enhancement programmes, stocking of selective disease-resistant species and larger-sized fish could be explored.

It is difficult to define what should be included under health management costs. Often, only the cost of chemotherapeutants used during or prior to disease outbreaks is included under health management costs, a gross underestimation in any aquaculture system. Health management costs will vary in relation to the farming system and species cultured. Aspects of management that have a bearing on the health of the animals cultured should be considered. Broadly speaking, health management costs would include a proportion of the cost that is incurred towards the following: farm siting and layout, water source, seed screening systems, pond reparation, feed quality, pond management, prophylaxis and chemotherapy.

SOCIO-ECONOMIC IMPACTS OF EUS AND WHITE-SPOT DISEASE

Capture Fisheries Sector

EUS, since its first appearance in India in 1988 in the northeastern states, has spread to the rest of the country, and still occurs in wild fishes during winter months in fresh water and during monsoon in brackishwater systems. EUS had a very strong socio-economic impact within the first few years of its appearance. The most severe impact has been on small-scale, mixed-species, capture fisheries from rivers, reservoirs, oxbow lakes, irrigation tanks, estuaries and backwaters. This impact was primarily felt by the fishers who depended on capture fisheries as their only source of livelihood. The disease caused large-scale mortalities and loss of valuable edible fish. In addition, most of the wild fish caught were affected and could not be marketed because of the unsightly ulcers on the body surface. At the same time, other unaffected, healthy fish species, caught from affected waters during the EUS season, could not be marketed, as people were afraid to buy fish. The public scare this disease created compelled many district and state administrative authorities to impose a temporary ban on capture fisheries in many water bodies and on the sale of fish brought from such sources. Consequently, poor fishers throughout India faced extreme hardship during the initial years of EUS.

Several estimates were made of the socio-economic impact of EUS during its initial two to three years of occurrence. The economic loss in Bihar during 1990 was estimated at US$150,000; in Orissa during 1989-91, it was estimated at US$95,000; and in Kerala during 1991-92, at US$625,000 (Das 1994). However, earlier estimates considered almost every freshwater fish as susceptible and affected.

Several issues surrounding EUS are now better understood, and the negative socio-economic impacts experienced earlier are now no longer seen. There is a growing opinion that EUS is not as severe as it was, and it is now taken for granted. There is a degree of complacency, and this may cause some problems. The socio-economic impact also seems to have reduced; however, this widely held belief should be viewed with some caution. Closer examination of the relationship between EUS and the population density and structure of susceptible fish populations in natural waters is needed. Even now, during the EUS season, small numbers of affected fish are caught from natural waters. The number of affected fish caught from a natural water body should not be used to assess the biological impact of the disease and the virulence of the pathogen. Little information is available on the species composition and landings of susceptible populations for the years before and after the highest prevalence of EUS. It is becoming increasingly clear that populations of highly susceptible species like *Channa*, *Puntius*, and *Etroplus* are dwindling in many of the natural water bodies. As a result, smaller numbers of susceptible species are seen to die during the EUS outbreak season, giving the impression that the disease is not severe. The disease certainly has had a major impact on the population density and structure of susceptible species, and hence, on aquatic biodiversity, although this has not been examined in detail. Fishes like *Channa* and *Etroplus* – fetch a very good market price in many parts of India, and the dwindling catches of these species are affecting the fishing population, who are dependant on fresh- and estuarine capture fisheries for their livelihoods. An integrated study is needed to look into the impact of EUS on species diversity and the population structure and density of susceptible fish species in natural waters. The biological and socio-economic impacts could be very significant.

Carp Culture Ponds

Available data on the impact of EUS on carp culture in ponds are highly varied and inconsistent, and it is, therefore, difficult to draw conclusions about the socio-economic impact. Bhaumik *et al.* (1991) reported that 73% of the culture ponds in West Bengal were affected, most ponds having lost 30-40% of their stock. On the contrary, although EUS appeared in the natural waters of Andhra Pradesh, reports of the disease in the well-developed, semi-intensive aquaculture ponds are unknown. Earlier reports from India considered all ulcerative skin conditions in major carps as EUS, and this has led to confusing impact assessments and generalisations. This was partly because there was, at that time, no case definition for EUS and much less was known about the disease. Now, much new information has emerged on the susceptibility of different freshwater fishes to EUS. Several studies suggest that Indian major carps are either less susceptible or refractory to infection (Mohan and Shankar 1994). Of the three Indian major carps, mrigal is considered more susceptible than catla and rohu. Histopathological studies of natural outbreaks have clearly shown that Indian major carps are able to mount a better inflammatory response and resist the fungal invasion better than the more susceptible *Channa* and *Puntius*. Experimental infections have also shown that the typical clinical and pathological features of EUS can be induced in snakehead in seven to ten days following co-habitation or injection, while it is not possible to reproduce the disease in the same time period in major carps (Mohan *et al.* 1999b). In light of this latest information, retrospective analysis of Indian major carp culture in Andhra Pradesh during earlier EUS outbreaks suggests that EUS was not that significant in producing crop losses in culture ponds. Several surveys carried out since the occurrence of EUS in the carp-farming belt of Andhra Pradesh have identified only parasitic and bacterial diseases as major causes of crop loss.

In view of their relative resistance to EUS, the following strategies are suggested for managing EUS in cultured Indian major carps:

- avoid parasite-induced or other forms of dermatitis and stress during the EUS season;
- eliminate the highly susceptible *Channa* and *Puntius* from ponds culturing Indian major carp;
- replace mrigal with the more resistant common carp;
- use chemical interventions prior to and during the EUS season to kill the infective stages of the fungus; and
- use immunostimulants in feed prior to and during the EUS season.

Culture-based Capture Fisheries

Culture-based fisheries are capture fisheries that are mostly or entirely maintained by the regular stocking of seed. These culture-based fisheries rely entirely on the natural productivity of the water body for growth and on artificial stocking for recruitment. Such fisheries exist in several lakes and reservoirs in India, with Indian major carps and common carp increasingly being stocked. In many of the reservoirs, this practice is well established, resulting in positive socio-economic benefits to fishers.

During the initial two to three years of its occurrence in India, EUS had a significant socio-economic impact on culture-based capture fisheries. Massive mortalities decreased the production from many water bodies, a large proportion of the fish landed were affected, and even healthy fish caught from such water bodies could not be marketed. As a result, private and government species enhancement programmes were abandoned. However, culture-based capture fisheries have since recovered and are now the mainstay of many fishers and fish farmers. Selective decimation by EUS of susceptible species like snakehead may have had a positive impact on carp fisheries in some of these culture-based capture fisheries, however, this needs to be examined in greater detail.

Coastal Shrimp Farming

Traditional shrimp trapping systems have been used in the low-lying brackishwater areas of Kerala, Karnataka and West Bengal for several years and are largely seasonal in nature. Auto-stocking, aided by tides, is practised, and production is very low, averaging 100-500 kg/ha/crop. India has vast potential for the development of commercial shrimp farming, having 1.2 million ha of coastal brackishwater area. Realising the enormous potential, the government identified aquaculture as a "thrust area" to augment exports and earn much-needed foreign exchange. Between 1988 and 1994, the shrimp farming industry experienced phenomenal growth. The booming industry encouraged the development of several hatcheries, feed mills, and other aqua-related ancillary industries. The total area presently in use is estimated to be 120,000 ha, of which around 50,000 ha is still under traditional systems producing, in total, about 95,000 mt of cultured shrimp.

In less than ten years, serious viral diseases and environmental issues have threatened the industry. The direct and indirect socio-economic impacts of diseases in shrimp farming are difficult to quantify. The economic loss in 1994 alone was put at US$17.6 million (Alagarswami 1995, Venkatesan 1996). The indirect effects were felt by the hatcheries, feed companies, aquaculture chemical companies and other ancillary industries. The collapse of the industry has caused job losses at both the technical and non-technical levels. As more than 80% of the farms are owned by small operators, there has been a significant socio-economic impact on small-scale farmers in coastal regions. Continuous crop failures, high lease values and erosion of profits have forced some operators to abandon their shrimp farms. These abandoned shrimp farms present a major challenge to both coastal resource managers and pond owners, because of their limited land-use prospects.

CASE STUDIES

Information from four case studies from different types of rural aquaculture systems, including commercial carp farming, is presented in order to understand the socio-economic impacts of aquatic animal disease on rural aquaculture.

Case Study 1 - Commercial Carp Farming Systems of Andhra Pradesh

Carp farming in Andhra Pradesh has redefined the concept of carp farming in India. The three to six species used in traditional polyculture systems have been replaced by only two species. This practice has become well established in large areas of Andhra Pradesh, and successful farming has now been going on for more than 15 years. Carp farming in Andhra Pradesh is now regarded as sustainable and is contributing, both directly and indirectly, to the livelihoods of several thousand people. Examining aquatic animal health problems in these scientific carp farming systems provides some insight into the likely socio-economic impacts of fish disease on commercial rural aquaculture.

In an International Development Research Centre (IDRC)-sponsored survey of carp farming practice, information was collected from 189 farms from four districts of Andhra Pradesh during 1991-93 (Veerina *et al.* 1993). About 50,000 ha is under scientific carp farming in the Kolleru Basin. The average farm size is 10.5 ha [0.3–81 ha), while that of a culture pond is 3.9 ha (0.3-20 ha) and that of a rearing pond is 0.6 ha (0.04-3.O ha). Nearly 75% of the farmers follow a two-species system comprising catla (23%) and rohu (77%). Bottom dwelling mrigal have been eliminated because of the difficulty in harvesting and the low market demand. Total elimination of mrigal from culture systems may also have hidden advantages in terms of preventing EUS outbreaks in culture ponds. The mean stocking density is around 2,900 stunted yearlings per hectare. The ponds are heavily fertilised with organic (19,000 kg/ha/yr) and inorganic (2,323 kg/ha/yr) manures. De-oiled rice bran and groundnut oil cake are fed at about 27,000 kg/ha/yr. Salt is regularly used as a feed additive. Liming is routine and CaO is used at the rate of 940 kg/ha/yr. The average culture period is 10 months, but varies from 6-15 months, as farmers practice phased harvesting. The average size at harvest is 1.8 kg for rohu and 2.7 kg for catla. The average gross yield for this two-species system is 5,890 kg/ha/yr, the best production being 7,900 kg/ha/yr. The return on investment (ROI) is 1.65. A major proportion (76%) of the farmers were rice cultivators before their entry into aquaculture.

Diseases are one of the major constraints, and most farmers are aware of the consequences of disease on growth, survival and final production. A small percentage of farmers are able to identify disease problems and quantify disease-related losses, while the majority are dependent on friends, consultants, salespersons or pharmacists for advice on diagnosis and medication. This well-planned and executed study has identified the major health problems in carp farming but was not able to quantify either health-related losses or the health management costs incurred by farmers.

In another study carried out to prepare a country-status paper in 1990 on the use of chemotherapeutants in fish culture in India, information was collected from 200 farm ponds in Andhra Pradesh. Details of the disease problems, chemicals used, treatment methods followed, problems and constraints are highlighted in Rao *et al.* (1992). The present situation remains much the same concerning occurrence of disease, farm-level diagnostics, and use of antibacterials and pesticides. Ectoparasitic diseases account for 70% of the problems, while bacterial and fungal diseases account for 27.5% and 2.5%, respectively. Losses of 40 million Rupees (Rs) (US$1 million) due to disease-induced mortality and impaired growth are incurred annually in Andhra Pradesh.

Chemotherapy, based mainly on trial and error, has been developed using locally available antibacterials, pesticides and other common chemicals. On average, farmers spend 10% of production costs on disease treatment. Farmers have become completely dependent on chemotherapy; resorting to treatment at the first sign of mortality or reduced feeding. Easy access to antibacterials and pesticides has increased their misuse.

A wide range antibiotics, sulpha drugs and nitrofurans are used in feed to treat presumptive bacterial diseases. Organophosphorus pesticides like nuvan, malathion and cythion are routinely used to treat for ectoparasites such as *Argulus* and *Dactylogyrus*. However, the efficacy of these treatments has never been evaluated. Multifactorial diseases, characterised by primary ectoparasitic infections followed by secondary bacterial infections, have further complicated the success of chemotherapy. Lack of diagnostic skills, coupled with easy availability of chemotherapeutants, has led to indiscriminate use of these chemicals in farmed food fish. Problems of drug resistance in pathogenic bacteria and tissue residues of pesticides have already attracted the attention of planners and the general public.

Immersion treatments with pesticides are routinely followed for ectoparasitic problems. The current application method involves dissolving the required quantity of the pesticide in 10-20 L of water and spraying the solution over the pond surface with a hand-held agricultural sprayer. In large fish-ponds, the sprayers are operated from motor boats. This method is very popular with farmers using nuvan, malathion and cythion to combat *Argulus* infection. Systemic antibacterial therapy is normally given through feed. The feeding bag method followed in Andhra Pradesh appears to be effective. Normally, for each hectare of pond, 10-20 bags of 50-75 cm size with two rows of perforations at the bottom are tied individually to bamboo poles fixed at regular intervals in the pond. Up to 12 kg of normal or medicated feed can be kept in each bag. Within two hours, most of the feed will be utilised by the fish, a method resulting in minimal feed wastage and antibacterial leaching. The dose used to treat systemic and surface bacterial disease is more or less standardised at around 7-10 gm active concentration/100 kg fish/day for 7-10 days.

These two studies show clearly that disease has a serious impact on rural aquaculture in Andhra Pradesh. It is also clear that health problems are evident only when the intensity of farming operations increases. At the same time, some of the novel changes that have taken place in Andhra Pradesh carp farming have had a positive impact on health management. These include reduction in stocking densities; reduction in the number of species; stocking of large-sized stunted yearlings, use of feeding bags, use of salt in feed, and prophylactic immersion in salt or potassium permanganate solution before stocking.

The first development, unique to Andhra Pradesh and now slowly becoming popular in other parts of India, is the stocking of "stunted yearlings." In this technique, fry procured during the breeding season are held at very high densities (50,000-100,000/ha), fed at 1-2% body weight, and grown for 6-12 months. The farmers assume that the weak and sick fry will die and the healthy ones will become stunted. At the end of one year, the surviving fish attain a size of 100-200 gm. These stunted yearlings are stocked in grow-out ponds at the rate of 3,000/ha. They are normally given a prophylactic bath with potassium permanganate or salt before stocking. Survival rates of 85-95% are very common in these systems, and the average production is 5,360 kg/ha/yr. These stunted yearlings grow to 1.5-2.5 kg in 8-12 months. This practice has completely replaced the earlier system of stocking fingerlings, and there is a considerable improvement in health, survival and production

The second development is the unique "bag feeding technique," previously described. This method allows the farmers to monitor feed consumption, which is a good indicator of health. At the first indication of a drop in consumption, farmers cut down feed and apply chemotherapy. The use of medicated feed in this bag feeding technique is more effective, and the leaching of antibacterials is less.

Case Study 2 - Carp Culture in Water Storage Tanks of Raichur

The development of carp culture in the Riachur area has an interesting background. Large tracts of agricultural land are dependent on Thungabhadra Canal for irrigation. Water is released from the reservoir from July onwards of every year, however, only agricultural lands near the head of the canal get the water without any problem. Land in at the middle and tail end of the canal get water only during July to September and do not get sufficient water at regular intervals to meet their agricultural needs. This has led many farmers at the tail end of the canal to convert a significant portion of their agricultural land to water-storage tanks. These tanks are filled by pumping water from the canal and storing it for year-round agricultural use. These storage tanks are constructed by excavating 2-2.5 m from the original paddy fields and raising the bunds from their original level by another 2.5-3.5 m. The tanks have water depths ranging from 4.5-7 m. A subsidy from the government, at the rate of Rs 10,000/acre (US$217/acre) of constructed pond area, has also encouraged many farmers to convert part of their land to water storage tanks.

These water storage tanks are increasingly being used for farming of catla and rohu. Their culture involves stocking fingerlings in August and September, when the water depth is at its highest (4.5-7 m), and feeding with de-oiled rice bran using the bag feeding technique. Water from the tanks is regularly let out to meet the agricultural needs of the farmer, and by June-July of the subsequent year, the water level will have dropped to 1.25-1.5 m and the fish will have completed 10-11 months of growth. The water is then pumped out, and the fish harvested. Water storage for the next season starts immediately, with little or no time for drying the tanks. The income generated from farming fish in these water storage tanks forms a major portion of the total income of the farmer. This system has been going on for the last three to five years, and more such systems are coming into operation every year. The success of this type of fish culture is encouraging farmers in this region to convert agricultural land to aquaculture operations.

There are about 300 fish farmers in this region, with about 500 ha of water area being used for culture. This case study collected information from 32 farms from eight areas. The farming practices, stocking densities, size at stocking, species stocked, feeding practices, harvest methods and production figures appear to be very consistent. Farmers spend, on average, 10-15% of their time on aquaculture operations. Pond-size ranges from 0.8 to 2.8 ha. On average, 16% (8-30%) of the total land area has been converted to water storage tanks. The experience of farmers in aquaculture ranges from two to four years. Catla, rohu and common carp fry of 5-7 cm length are stocked at an average of 5,000-6,250/ha. Manure is applied at a rate of 1,000-2,000 kg/ha/yr. On average, farmers harvest 4,650 kg/ha of 1.2-1.8 kg fish after a growing period of one year. The income generated from this secondary occupation is substantial (20-40% of the total income). This needs-based practice appears to be sustainable and contributes significantly to the overall income of the farmer. In addition, the farmer is also safe from the uncertainties of water supply for agriculture. A major portion of the agricultural land (70-80%) is used for cultivation of rice and cotton.

Case Study 3 - Small Carp Ponds of Mysore

This example of small-scale, rural aquaculture development has taken place primarily because of the government-subsidised aquaculture popularisation programme. Information collected from 35 farmers is summarised below. All the farmers are primarily agriculturists cultivating rice, coconut and banana. The total land holdings of individual farmers ranges from 2-4 ha. Under the government scheme, for every acre of pond area, a subsidy of Rs 10,000 is given (US$217). Almost all the farmers surveyed had excavated 0.3-0.4 ha ponds in their agricultural land. Water for the ponds is taken from wells or irrigation canals, and the ponds are stocked with about 4,000 catla, rohu, mrigal and common carp fry of 2.5-3.0 cm in length. The ponds are manured with 2,000-3,000 kg of farmyard manure during the culture period, and about 500-800 kg of rice bran is used for feeding for the entire culture period. A small percentage of the farmers add 125-250 kg/ha lime to the pond. Production from these 0.4 ha ponds ranges from 1,850-2,500 kg, and the monetary gain is substantial. For a single farmer, the income generated from fish (1,950 kg; Rs 58,500 (US$1,272)) is much more than that generated from rice production (4,500 kg; Rs 45,000 ($US978)) from one hectare of land or from coconut production (10,000 nuts; Rs 40,000 [$US870)) from one hectare. The financial benefit that can be gained from growing carp in small ponds in rural areas is making this form of aquaculture a popular activity that is attracting an increasing number of agricultural farmers .

In both the Raichur and Mysore case studies (Case Studies 2 and 3), none of the farmers surveyed experienced total crop losses. The majority of the farmers were unaware of fish health problems and the likely impact they can have on fish growth, survival and yield. Some of the reasons suggested by farmers for poor yield are low fertilisation, irregular feeding, low stocking density and poaching. No farmers suggested the possibility that disease might be a reason for low yields. At the same time, farmers observed low-level mortalities during the colder months of the year and believed that low temperature was killing fish.

Case Study 4 - Shrimp Trapping in Gazani Systems of Karnataka

Karnataka has 4,000 ha of brackishwater area, of which about 2500 ha is gazani lands (original and reclaimed estuarine and river-basin lands are called gazani or khar lands). Through collective farming, small groups of farmers were using these lands for growing salt-resistant rice during the rainy season and for natural shrimp trapping during the dry season. Shrimp trapping during the dry season was considered an economic boon for small subsistence farmers. This traditional resource management was able to convert a common property into a productive, more sustainable community resource. However, this changed dramatically with the advent of commercial shrimp farming. Lured by higher returns, gazani farmers leased their lands to commercial shrimp farms. This led to large-scale conversion of gazani lands to shrimp ponds. Of the 2,500 ha of gazani land, only 700 ha is still under traditional farming practice, the rest having been converted to shrimp ponds. Initially, gazani farmers were getting higher monetary benefits through receipt of rents; however, all this changed with the occurrence of white-spot disease. Since 1995, large tracts of former gazani lands are lying as abandoned shrimp ponds. The failure of shrimp farming meant loss of lease revenue to the gazani landowners. During 1994-95 and 1995-96, about 1,000 ha of shrimp ponds were affected by the disease, with an annual input loss of Rs 10 million (US$0.23 million) and an output loss of Rs 25 million (US$0.58 million).

The major problem now is the irreversible land development that has taken place. Once excavated and converted, gazani lands are not easily restored to their original natural state or function. The breakdown of traditional methods of community resource management and the subsequent loss of income to gazani farmers is a direct impact of white-spot disease. The direct and indirect socio-economic impacts of white-spot disease on traditional gazani farmers are very evident, but they need to be properly quantified before alternative resource-use programmes for improving the livelihoods of the hundreds of gazani farmers can be developed. The use of abandoned shrimp ponds for fish culture and mangrove plantation are some of the ways by which productive, traditional resources can be put back to use.

CONCLUSIONS

The impact of disease on rural aquaculture and fisheries cannot be underestimated. EUS in wild fish and white-spot disease in cultured shrimp have amply demonstrated the potential for aquatic animal diseases to cause significant negative socio-economic impacts on the rural fishers and small producers who dominate much of the aquaculture in India. Continued expansion of carp production for an increasing population is a reality. Economic losses are likely to increase as aquaculture expands and intensifies, impacting on large-scale commercial operators and small-scale farmers alike. The impact of disease on production becomes more evident as small-scale operations transform into commercial operations. In traditional rural aquaculture, there is a serious under-reporting of diseases and a consequent lack of prevention, diagnosis and treatment. As can be seen from the case studies, this is due to a lack of awareness and monitoring, and indicates that avoidable losses are occurring.

There is a wide variation in the perception of the importance of disease-associated losses in aquaculture. Significant, avoidable, chronic losses are commonplace in nursery and carp-rearing farms in India. Most chronic losses are taken for granted, and their impacts are never assessed. There is, therefore, a need for better social and economic assessment so that the cost-benefits of alternative strategies can be evaluated. The stunted-yearling stocking practice could be one such alternative strategy to minimise the socio-economic impacts of disease on rural aquaculture. Better frameworks and methodologies should be developed for routine data collection on socio-economic impacts of aquatic animal diseases. It is essential to redefine some concepts like loss perception, disease-related loss, health management costs, externalities associated with diseases, and indicators of disease loss. Through co-ordinated efforts, it should be possible to assess and quantify the socio-economic impact of disease on rural communities dependent on rural aquaculture and culture-based capture fisheries. Such assessments would make primary aquatic animal health care a priority, and such a strategy would be more cost effective, focused and beneficial to rural aquaculturists.

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JAUNDICE DISEASE IN CATFISH, A CASE STUDY DEMONSTRATING A DECLINE IN INCIDENCE AS A RESULT OF RESEARCH OUTPUT

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ABSTRACT

The catfish cultured in Thailand is a hybrid of the male African catfish, *Clarias gariepinus*, and the female of the native catfish *C. macrocephalus*. Farmers were initially using chicken offal as a substitute for trash fish or commercial pellet because the market price for catfish had reduced. A severe outbreak of catfish jaundice was reported in the summer of 1992 that caused 20-100% mortality. The economic loss due to this disease was estimated at US$360-1,800/farm or US$4.3-21.3 million for the whole country. Research indicated that rancid chicken offal was the cause of this disease. Farmers were advised to improve the quality of the chicken offal and the water quality in the ponds, and, subsequently, the incidence of jaundice declined dramatically. Recommendations based on research resulted in improved fish health and reduced economic loss due to disease.

INTRODUCTION

Catfish culture in Thailand has been developed for more than half a century, and the walking catfish (*Clarias batrachus*) was the species first cultured in ponds. After success in induced spawning and mass production of the seed of *C. macrocephalus*, another native catfish, this species became more popular, as it has a more palatable taste. However, this species is slow growing and susceptible to many infectious diseases. Following this, the African catfish, *C. gariepinus*, which is a fast-growing species, was introduced into Thailand; however, the flesh is not firm and aquaculturists, therefore, attempted to cross breed these three species to obtain a hybrid with better qualities. Finally, the ideal hybrid catfish was developed by cross breeding male African catfish and female *C. macrocephalus*. Since then, farmers have cultured culture only the hybrid catfish because of its better taste and faster growth.

Hybrid catfish fry can grow from1-2 gm to 200-300 gm within a four-month culture period. Trash fish, commercial pellets or a combination of these two feeds has been used routinely in catfish farms. Successful catfish culture resulted in an over-supply of the product on the market, causing a decrease in the wholesale price. Farmers, therefore, needed to reduce production costs, the major cost being feed. Some farmers began to use chicken offal from the processing plants as a supplementary feed. They found that catfish fed in this manner developed a light yellow colour on the body, similar to that of the preferred *C. macrocephalus*, and, that as a result, they obtained a better price in the market. The exclusive use of chicken offal increased as the market price of catfish fell. Offal was transported from the factory in un-refrigerated lorries and could take many hours to reach its destination. Some feed was kept overnight for the following days' feeding programme and, when temperatures were high, the feed was likely to become rancid before it was fed to the fish.

Jaundice is yellow coloration of the skin and other tissues due to an excess of bile pigment present in the blood and lymph. The condition described in catfish as “catfish jaundice” was first observed in central Thailand in early 1990, and by the summer of 1991, several farms reported the problem in fish over four-five months of age. In 1992, signs of jaundice were observed from March onwards in fish over four months of age. Affected fish usually ranged from 150-350 gm, which is the market size. Eighty percent of affected farms were using chicken offal as the only source of feed in an attempt to decrease feeding costs. The first indication of the disease was that farmers observed reduced appetite and the fish became lethargic. Following this, the fish became anorexic, and clinical signs of jaundice were observed. Mortality rates increased and, in some cases, over 90% of affected fish on the farm died. Jaundiced fish proved more susceptible to stress and tended to die before they got to the market.

When farmers have problems, they contact local fisheries officers, nearby diagnostic laboratories, or the salespersons who supply them feed or chemicals. For simple cases, the problem can be solved at the site or through a telephone discussion with a disease expert. In the case of a new disease, with which they have no experience, such as jaundice in catfish, they require the services of the staff at the central laboratory (the Aquatic Animal Health Research Institute, AAHRI), where investigation and research can be carried out. With the close relationship between the diagnostic service, farmers, fisheries officers, salespersons and researchers, problems can be effectively researched and solutions found. Research conducted at AAHRI is generally initiated by problems that occur on farms.

GROSS PATHOLOGY

Affected fish showed yellow colour of the skin and gills. By the time the fish showed clinical signs, they were usually anorexic and moribund. Gill rot was a frequent finding. The spleen, kidney and liver were enlarged and a pale-yellow colour. The gall bladder was also enlarged, with yellowish bile. Most fish had a yellow ascitic fluid, which, on exposure to air, solidified faster than ascitic fluid from other septicaemic fish. The fat tissue in the abdominal cavity was also yellow in colour.

MICROBIOLOGY

No bacteria, viruses or fungi of known pathological significance were consistently isolated from any of the fish sampled.

HAEMATOLOGY

Serum from jaundiced fish was bright yellow to orange in colour. Haematocrit levels from jaundiced fish were markedly reduced (10-16%) from normal (34-37%).

PATHOLOGY

The most obvious pathological changes were observed in the liver, kidney and spleen. Examination of the livers revealed varying irregular vacuolation of the cytoplasm of the hepatocytes; however, catfish livers tend to be highly vacuolated, so this was within the normal range of variance. Two types of pigment were found as deposits in the liver. One was amber in colour and scattered intercellularly throughout the liver parenchyma and also within the lumen of the bile duct and blood vessels. In addition, a lighter yellow-brown pigment, with a more granular texture, was observed accumulated in the macrophages, which were in clumps associated with the portal vessels.

Pigment deposits were also widespread throughout the haemopoietic tissue of the kidney and spleen. Large accumulated deposits of yellow-brown pigment were observed within macrophages associated with the melanomacrophage centres of the spleen. Intracellular pigment was observed in individual cells scattered throughout the pulp. Degenerative changes in the cells associated with the melanomacrophage centres were observed in some sections.

Kidney sections revealed the presence of amber pigment within the tubule lumen. Deposits of intracellular pigment of varying size were observed scattered throughout the haemopoietic tissue within individual cells and clumps of cells. Protein droplets had accumulated in the epithelial cells lining the renal tubules. Degeneration of the tubule walls was observed in some samples.

These pigments were identified as ceroid and haemosiderin. Ceroid is a brown-yellow, acid-fast, lipid-positive pigment, resistant to organic solvents, which accumulates in the livers of fish during lipoid liver degeneration (LLD). Haemosiderin is a breakdown product of haemoglobin.

Results from farm information and pathological investigation indicated that the fish were suffering from a haemolytic anaemia and jaundice. The cause of the disease was thought to be nutritional in origin, due to the feeding of rancid chicken viscera. Therefore, an experimental trial was conducted. Five groups of catfish were fed with different types of feed as follows: 1. fish pellet, 2. chicken offal kept in the refrigerator during transportation and before use, 3. rancid chicken offal with fish pellet, 4. rancid chicken offal with vitamin E, and 5. rancid chicken offal. The results demonstrated that catfish fed with rancid chicken offal developed jaundice disease.

Rancid fats in the diet result in high levels of free radicals and peroxides that cause oxidative damage to biological membranes and organelles. Polyunsaturated fatty acids (PUFAs) are essential components of all biomembranes. Fish tissues typically contain large quantities of highly unsaturated series fatty acids and may be more at risk from peroxidative attack than are mammals. Vitamin E is an important antioxidant and protects biological membranes from lipid peroxidation by acting as a scavenger of free radicals. The presence of rancid fats however depletes the diet of vitamin E and other antioxidants, leaving the biological membranes vulnerable to oxidation.

RECOMMENDATIONS TO FARMERS

All kinds of media were used to disseminate information to the farmers: articles in newsletters and radio and television programmes on agricultural news. Fisheries extension officers are the other vehicle for transmission of the message directly to the farmers, as they normally work closely together. Therefore, the results of this study were communicated to the farmers, with advice to be careful regarding the quality of chicken offal, or to use chicken offal along with fish pellets, to prevent jaundice disease.

After 1993, the incidence of jaundice disease in catfish declined dramatically to almost zero percent, as farmers improved the quality of the feed as recommended. This case study demonstrates that results from research work can quickly reach farmers and help prevent losses caused by disease.

ECONOMIC IMPACT

The size of catfish farms in Thailand is very variable, the smallest being one pond of 400 m^2; however, the average size of ponds is 1,600 m^2. Production after 3-4 months is 20 (16-24) mt/1600 m^2 (125 (100-150) mt/ha) and the price is US$0.6/kg. During the outbreak of jaundice in catfish in 1992, average production declined significantly, even though the number of farms operating increased to 11,855 farms (Table 1). Loss due to jaundice disease was 20-100%. Based on fisheries statistics, the average production of catfish between 1988-1995 was 3 (2-4) mt/farm. Therefore, the economic loss due to this disease was US$360-1,800/farm or US$4.3-21.3 million for the whole country.

Table 1. Production of cultured hybrid catfish in Thailand between 1988-1995.[1]

Year	Production (mt)	Average Production /Farm (mt)	Value (US$)	Number of Farms
1988	12,550	3.3	9,890,533	3,751
1989	12,382	2.9	9,386,942	4,253
1990	17,908	3.6	12,029,986	4,989
1991	29,135	3.9	18,379,409	7,393
1992[2]	23,775	2.0	14,771,356	11,855
1993	31,063	2.0	19,461,162	15,727
1994	34,663	2.0	20,712,357	17,448
1995	44,119	2.1	28,322,190	20,919

[1]Data from Fisheries Statistic Division, Department of Fisheries, Thailand.
[2]Indicates year in which severe jaundice outbreak in catfish occurred.

IMPACTS OF DISEASE IN SMALL-SCALE AQUACULTURE IN THAILAND: CASE STUDIES

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ABSTRACT

Small-scale aquaculture is an important activity in Thailand, particularly for low-income people throughout the country. People culture fish as a low-cost protein source and for family income. Although it has been recognised that disease has an impact on aquaculture, the extent of this impact on small-scale aquaculture is not well documented. Here, the socio-economic impact of disease on small-scale freshwater aquaculture in northeast, central and southern Thailand was studied using questionnaires. A total of 74 farmers from nine provinces were interviewed. The species cultured were ornamental fishes, such as angelfish, goldfish and guppies, and foodfishes such as catfish, snakehead, carp and tilapia. Frog and soft-shell turtle culture was also included, as culture of these animals has increased rapidly over the past three years to become a major source of household income. It was found that disease problems had an impact by reducing production, which, in turn, caused a decline in income and increased debt. Flooding was also one of the major problems causing serious losses.

BACKGROUND

Fish as a source of protein for low-income groups in Thailand normally comes from small-scale aquaculture production or fisheries. The impact of health problems in small-scale aquaculture is recognised, however, there are few published documents or statistics to indicate the extent of this problem. Therefore, a questionnaire survey to gather such information was conducted. This paper presents the results of analysis of these data from small-scale freshwater aquaculture in Thailand.

Sampling sites were selected to cover small-scale freshwater aquaculture throughout the country. A total of 74 farms from nine provinces were sampled. The farms were divided into three groups: grow-out ponds or cages, fingerling production and hatcheries. Among these farms, the operation could involve monoculture, polyculture, integrated farming or polyculture with integrated farming. The species of aquatic animals cultured included hybrid catfish, snakehead, climbing perch, gourami, carps, tilapia, sea bass, giant freshwater prawn, frogs, soft-shell turtles and ornamental fishes.

SOCIO-ECONOMIC CIRCUMSTANCES

The income of the farmers can be divided into three groups as shown in Table 1. The average income per person was US$874. Using the figure of 1 US$/day as the poverty line, 34 out of 74 samples were below an annual *per capita* income of US$365/yr. All members of this group were involved in fish culture. The better off individuals tended to be involved in ornamental fish culture, or turtle/frog culture.

Farmers were growing fish as a source of income and food, some were growing fish as a hobby or for status, others to supplement income from growing rice, working in the city, or growing fruit, vegetables or livestock.

Table 1. Groups of small-scale farmers divided by income.

Income Group	Farm Type
<US$365/caput/annum	Hybrid catfish, striped snakehead
	Common carp, tilapia
	Red tilapia, sea bass
	(plus various combinations of the above)
US$365-800/caput/year	Fish culture (as above) (16 farms, including two culturing giant freshwater prawn)
	Frog culture (1 farm)
>US$800/caput/year	Fish culture (as above) - 12 farms
	Frog/turtle culture – 6 farms
	Ornamental fish - 4 farms

Time Spent on Different Activities

Most of the farmers have experience or have been involved in aquaculture for around four years. The wife and children spend more time looking after the fish than does the husband.

Where Did Farmers Learn to Raise Fish?

Initially, farmers coming into aquaculture will try to learn how to grow fish by themselves. Later, they may get more information from their neighbours, friends or other farmers. The government is involved in transfer of knowledge about aquaculture through the organisation of training courses or workshops once or twice each year.

PROBLEMS

The major problem for small-scale aquaculture in Thailand is related to the amount of water supply. Flooding is an uncontrollable problem that causes serious loss in aquaculture. Farmers rank disease second as a problem, along with various other problems.

Around 65% of the farmers surveyed thought that aquaculture, especially small-scale aquaculture, was profitable. Fifty-seven percent of the farmers ranked disease as an important issue in aquaculture. Less than 50% of the farmers thought that aquaculture was a risky business. Some of the farmers indicated that having a fishpond gave them high status in the community.

Information from the group that earned less than US$365/*capita*/year, is slightly different from the overall data. Fifty-nine percent of the farmers in this group thought that aquaculture is profitable. However, 49% of farmers still recognise that disease is an important issue.

Normally, farmers can choose fry for stocking. However, during the peak season for stocking fish, they may have to take whatever is available because of the higher demand. Most of the farmers cannot tell the difference between healthy and unhealthy fry.

In general, farmers can recognise sickness in the fish on their farms. Partial mortality and abnormal behaviour are the most common signs of sickness. Sickness normally occurs during the rainy and cold season, with some farmers facing problems just before harvesting. In this case, it will cause more financial loss due to feeding costs.

EFFECTS OF DISEASE IN FRESHWATER FISH CULTURE

Disease problems will reduce the household income because the market price of the fish will decline. An indirect effect of disease in aquaculture is increased family debt. After experiencing disease, there is a strong desire among farmers to change the species cultured. Some farmers may stop promoting the business, however, none of them thought about ceasing to practice aquaculture.

Economic loss due to disease was reported as 38%. Low-income groups (<$365/*capita*/yr) were also affected by disease problems; of the eight farms within this group that reported losses due to disease, the average loss was US$148, or around 64% of the reported average household income.

MANAGEMENT INTERVENTIONS

Most farmers will contact local government extension officers when they face a disease problem. Some of them will discuss problems with their neighbour, fry trader, feed salesperson, hatchery owner or drug salesperson. Farmers feel that information from government extension officers is useful and reliable.

On encountering a disease problem, most of the farmers (54%) attempted to treat the animals. Some of farmers sought help or conducted emergency harvesting and marketing. The most common types of treatment used are chemicals and antibiotics. The average cost of treatment is US$46, and only three farmers said that the treatment was “always successful.”

CONCLUSIONS

About 50% of the target group of this survey are categorised as poor, based on an income of less than US$1/day/person. The major problem that causes severe loss for small-scale aquaculture in Thailand is flooding. Disease is another important factor affecting the income of small-scale farmers. Fisheries officers at the provincial level have good connections with farmers; therefore, regular training programmes on general fish health and basic disease diagnosis for fisheries officers is a means to disseminate information to farmers.

A SURVEY OF DISEASE IMPACT AND AWARENESS IN POND AQUACULTURE IN BANGLADESH, THE FISHERIES TRAINING AND EXTENSION PROJECT - PHASE II

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ABSTRACT

A survey of the importance of fish disease to 257 farmers from six districts in Bangladesh was carried out during September 1999. The farmers interviewed were selected from a general baseline study of 2,500 farmers who were about to undergo training with the Fisheries Training and Extension Project - Phase II (FTEP-II). FTEP-II is a bilateral aid project between the governments of the United Kingdom (Department for International Development, DFID) and the Department of Fisheries (DoF) of the Government of Bangladesh. The primary stakeholders of the FTEP-II project are poor and carry out “low input, carp polyculture.”

The interviewed farmers were capable of identifying, at most, nine major causes of fish death in their ponds. The most common causes of death were a "red spot” disease referred to as EUS (epizootic ulcerative syndrome), “fin/gill rot,” “air gulping” and “cotton fungus.” No laboratory diagnosis of these diseases was possible. In terms of constraints to production, the majority of farmers did not think that fish disease was important. Rather, they identified issues such as “lack of personal knowledge of fish pond management,” “credit and financial problems” and “fry/fingerling supply” as being more important.

The effect of fish disease on the farmers' ponds and livelihoods was limited. Fish seldom died off all at once, and 47% of farmers were able to either eat or sell the dead fish. Most farmers turned to other farmers for advice when disease occurred in their ponds but had a limited range of treatments, with potassium permanganate being the most popular (although most farmers simply harvested all the fish). In terms of financial loss, only 4% of the farmers said fish disease losses were “big and unacceptable.” Average Losses were estimated as 3% of total “on-farm” income, and equal to around US$31 per year.

Although fish mortality is clearly a problem for a few farmers (<6%) who experience complete loss of a crop, for the majority, the usual pattern of loss was a few fish weekly, and these were either consumed, sold or thrown away. This pattern would be expected in such systems with low stocking densities. Farmers ranked their own lack of knowledge about fish culture and credit as the main factors limiting production (above disease). Consequently, for these farmers, the FTEP-II project focuses it’s extension messages on better pond

management techniques such as green water management, stocking and pond preparation, with fish disease issues discussed during sessions dealing with risks.

INTRODUCTION

The Fisheries Training and Extension Project Phase–II (FTEP-II) is a bilateral aid project between the governments of the United Kingdom (Department for International Development, DFID) and Bangladesh (Department of Fisheries, DoF). The goal of the project is to increase sustainable aquaculture production by poor farmers in Bangladesh through building the capacity of the DoF to deliver, directly and/or indirectly, appropriate support to them. In particular, FTEP-II helps develop skills in training of trainers and the delivery of basic pond aquaculture techniques. A wide range of additional project activities are undertaken, such as the development of training and extension networks; training of nongovernmental organisations (NGOs), school and bank staff; and newsletters.

The principal beneficiaries of the FTEP-II project are poor fishfarmers, and the project targets 108,000 farmers who will take part in training in basic carp polyculture. Of these, 40% must have less then 0.5 acres of fishpond area, 20% must have less than 0.5 acres of crop land and 10% must have less than US$400 (20,000 Bangladesh Taka) per year total household income. The project aims to improve the livelhoods of these target beneficiaries through increasing fish production from 49 to 146 gm/m^2 for seasonal ponds and from 146 to 245 gm/m^2 for perennial ponds. It is predicted that at least 30% of these farmers will adopt the guidelines given for better fish culture.

The FTEP-II project adopts a “demand led” approach to extension and responds directly to the needs of farmers. With the exception of outbreaks of diseases such as epizootic ulcerative syndrome (EUS), the project beneficiaries do not consider disease to be a serious risk to their aquaculture activities. Because of this demand-led approach, the project, therefore, does not prioritise training in disease management for these farmers, rather it is dealt with during discussions on risks and hazards in aquaculture.

METHODS

The results presented herein are from a field survey of 257 farmers from six districts in Bangladesh (Rajbari, Madaripur, Bogra, Lakshimpur, Feni and Comilla). The survey was carried out by the FTEP-II project “field enumerators” between August and September 1999. This survey was carried out as part of the routine socio-economic “baseline survey” of farmers who had been selected to take part in training.

In all cases, only the one main pond owned by the farmer was used for calculation of stocking densities, production etc.

RESULTS

Socio-economic Profile of the Surveyed Farmers

Gender, family and education

The majority of farmers interviewed were male (93%), with an average age of 36 years and a family size of seven. Most male farmers are educated to secondary school level and considered themselves to work in agriculture. The female respondents interviewed considered themselves to be housewives and were mainly educated to primary school level (Table 1).

Table 1. Gender, age education and occupation of interviewed farmers.

	Male Respondents	Female Respondents
Percentage (%)	93	7
Age (years)	36	36
Family size (average)	7	6
Educational level (main)	Secondary school	Primary school
Occupation (main)	Agriculture	Housewife

Land and pond ownership

The average total land holding of the male farmers interviewed was more than double that of the female farmers (21,680 m^2 and 8,160 m^2, respectively) (Table 2). However, the pond area of male farmers was only 1.5 times that of female farmers.

Table 2. Average land/pond area (m^2) of respondent farmers.

Land Type and Area	Male Respondents	Female Respondents
Homestead land	1,640	1,120
Crop land	12,880	5,040
Ponds (total of all ponds)	1,960	1,280
Leased land	5,200	720
Total	21,680	8,160

Sources of income

As is typical in Bangladesh, the household income of respondents was found to be derived from a wide variety of sources, with 76% reporting that their main income came from between two and four sources. The most frequently reported sources of income for these farmers were fish production, rice (and other field crops), small business enterprise (such as rickshaw pulling), fruit and vegetable production and significantly, full time work (Table 3). Fish production contributed 9% of the total cash household income per year, excluding the notional value of fish which were consumed by the household. On average, the most important sources of income were field crops sales, small business enterprise and full time work.

Table 3. Sources of income for respondent farmers.

Income Source	Farmers with Main Income from Source (% of Total)	Average Income/ Farmer According to Source (Per Capita)[1]	Fraction of Total (%)[2]
Fish production(main pond)	75	219 (31)	9.0
Field crops (rice)	74	515 (74)	20.0
Business	40	1369 (196)	29.0
Fruits and vegetables	34	94 (13)	1.5
Full time work	32	1529 (218)	27.0
Livestock sale	29	381(54)	5.0
Fish production (other pond)	18	475 (68)	4.0
Wage labour	7	569 (81)	2.0
Others	4	838 (120)	2.0
Pond leases	2	66 (9)	0.5

[1] Average income/household/yr according to income source in USD, figures in parentheses are income per capita.
[2] Fraction of contribution to the sum of the total ave. income/household/yr for each income source.

Aquaculture Practices

The production methods of the respondents can be summarised as "improved, low-input carp polyculture." Farmers stock regularly and occasionally use feed and fertiliser. The majority of the ponds were individually owned and managed by the interviewee (55%). Flood affected only 3% of the ponds, and 17% were classed as seasonal. The average pond area was 1,093 m^2.

Ponds of this size in Bangladesh have many (and sometimes competing) uses in addition to fish production. For example, over 60% of respondents reported that their ponds had at least three important uses. These were fish production (99%), bathing (household, 88%) and domestic use (cooking/cleaning, 77%). Other uses reported were bathing cattle (10%), drinking for cattle (13%) and crop irrigation (5%). These ponds should therefore be looked on as an important part of the total household and only seldom drained for cleaning or removal of silt.

Before production (and without training), few farmers used either lime or fertiliser (Table 4). The main inorganic fertiliser was cow dung, with only very few (2%) using poultry manure.

Table 4. Main pre-stocking inputs of surveyed farmers.

Fertiliser Type	Percentage of Total Farmers Using (%)	Dosing Rate (gm/m^2)
Cow dung	21	109
Urea	24	11
TSP	14	8
Lime ($Ca(OH)_2$)	29	32

Planned stocking was carried out by 98% of farmers during April. May and June, with up to 16 different species used. However, the majority of farmers (75%) used between three and five species, which included "rui" (*Labeo rohita*), "catla" (*Catla catla*), "mrigal" (*Cirrhinus cirrhosus*), "silver carp" (*Hypophthalmichthys molitrix*) and "carpio" (*Cyprinus carpio*). Most farmers (52%) could choose where they bought fry and commonly bought from different sources. For example, 64% of all farmers purchased from fry traders, 41% from private hatcheries, 27% collected from the wild and 24% purchased from government hatcheries. When asked to express a preference for the source of fry, 25% of farmers stated that "wild caught" was best, with only 12% opting for traders, 13% for private hatcheries and 17% for government hatcheries; the remainder expressed no preference. On the whole, most farmers (56%) were happy with the quality of the fry they purchased.

After stocking, not only did the number of farmers reporting that they applied fertiliser increase significantly, but so too did the application rates (Table 5). However, the application of lime after stocking was lower than before stocking, with both reduced frequency of use and dosing rates. The majority of farmers used supplemental feeds after stocking. The four most favoured feeds were oil cake, rice bran and wheat bran, whilst duckweed was used by only 3% of farmers.

All farmers consumed fish from their ponds during the production cycle. On average, 17% of the harvest was consumed, but this ranged from 0.5% to 100% per year. Average production was 64gm/m^2. If farmers carried out a final harvest, it took place during December and January.

Table 5. Main post-stocking inputs of surveyed farmers.

Input	Percentage of Total Farmers Using (%)	Rates (gm/m^2)
Fertiliser Type		
Cow dung	60	213
Urea	52	23
TSP	16	18
Lime ($Ca(OH)_2$)	14	14
Feed Type		
Rice bran	54	-
Wheat bran	16	-
Oil cake	65	-
Duckweed	3	-

Results of the Fish Health Survey

When asked about disease occurrence and mortalities in their fishponds, farmers were allowed to express their observations in their own words. Although the names for these diseases and abnormalities have been translated into English, some of them probably do not represent true cases of "clinical" disease.

Occurrence of disease and mortalities

When asked whether the farmers had problems with fish dying of whatever cause (including disease), 6% reported that they had problems during that production cycle and 42% reported that they had problems during the last year. This apparent discrepancy was due to the timing of this survey, as farmers were only at the start of their current cycle and disease problems were yet to manifest themselves. Only 21% of the farmers could recall having disease problems more then two years ago. Significantly, 31% of farmers reported that they had never had problems with fish death/disease.

Of the farmers that reported mortalities or disease in their ponds, most were able to describe the common characteristics of a wide range of conditions resulting in fish death (Table 6). However, without proper laboratory diagnosis, it is clearly not possible to say with certainty that the terms that they used are accurate.

The most commonly reported conditions were "red spot/EUS" (78%), "fin/gill rot" (46%) "gulping for air" (30%) and "cotton fungus" (20%) (Table 6). Red spot/EUS as the most common disease was confirmed by the opinion of farmers, with 52% feeling that it was the most often seen disease in their ponds. Of these diseases, morphological and behaviourial abnormalities, some are almost certainly linked to poor pond management. For example, "gulping" is likely to be due to water quality problems resulting in low dissolved oxygen (DO) levels whilst "big head" may be due to insufficient feeding/fertilisation. Poisoning refers to killing of ponds by jealous neighbours and is a common problem for successful fish farmers in Bangladesh.

Table 6. Frequency of diseases causing fish death reported in farmers' ponds.

Abnormality/Disease	Percentage of Farmers (Over All Years)	Percentage of Farmers (This Year, 1999)
Red Spot (EUS)[1]	78	1
Rot (fin rot/gill rot)	46	4
Gulping air	30	4
Cotton fungus	20	3
Dropsy	17	10
Big head	14	4
Whirling	11	16
Parasites (external)	4	0
Poisoning	4	14

[1]Red spot/EUS was used by farmers to describe any ulcerative disease and thus should not be construed as true epizootic ulcerative syndrome, as laboratory diagnosis was not carried out.

Once disease was present in their ponds, farmers reported that fish seldom died off all at once. Only "whirling" (5.3% of farmers), gulping (3.8%), cotton fungus (2.9%), fin/gill rot (2.5%) and red spot (1.6%) caused complete pond die off. This is not surprising considering the low intensity of production. Most commonly, a few fish died on a daily or weekly basis (Table 7). Some of the diseases caused more frequent weekly losses than daily losses, such as bighead, red spot, cotton fungus and gulping. Only whirling and parasites caused significantly more frequent daily than weekly losses.

With such sustained frequent losses, it is not surprising that 47% of farmers utilised the dead/diseased fish. Overall, 17% reported that they consumed them, whilst 22% were able to sell all the dead fish. Only 8% both sold and ate the dead fish. Surprisingly, 44% of farmers reported that they threw away all the fish that died from disease. A minority (9%) left the fish in the ponds.

Table 7. Pattern of fish death due to diseases.

Abnormality/Disease	Percentage of Farmers Losing a Few Fish Daily	Percentage of Farmers Losing a Few Fish Weekly
Red spot (EUS)	34	64
Rot (fin rot/gill rot)	50	47
Gulping air	33	64
Cotton fungus	26	71
Dropsy	56	44
Big head	17	83
Whirling	56	37
Parasites (external)	67	33

Treatments and advice for fish disease

When asked whom they turned to for advice when they had fish disease problems, most farmers (55%) indicated that they went to other farmers. However, a significant number went to government officers (Assistant Fishery Officer, 15%; Upazilla Fisheries Officer, 13%) and fry traders (12%). The remainder (5%) turned to other sources, including NGOs, medical doctors, television, hatcheries and textbooks. The majority of the farmers (60%) said they trusted only their own judgement with the advice, and 62% considered the advice they received to have been useful.

Farmers reported relatively little scope in terms of options for treatment of diseased fish. Most farmers (52%) used potassium permanganate ($KMNO_4$) as a treatment, whilst lime was used by 40% of farmers and salt by 11%. Nearly half the farmers (47%) harvested the pond when they had disease problems. The remaining farmers (0.6%) used a variety of other treatments, such as disinfectants (Savlon, Dettol), banana leaves, fertiliser, alum and water exchange. Of the farmers expressing an opinion about the treatments, potassium permanganate was considered by 32% of farmers as the best treatment, whilst 26% felt harvesting was best.

Half of the farmers reported that they obtained these treatments from other farmers, whilst fry traders, shops and the DoF supplied the remaining 9%, 3% and 10%, respectively. A minority of the remaining farmers (11%) made their own treatments, and 17% sourced from elsewhere (hatcheries, NGOs).

In terms of treatment efficacy, only 21% of farmers reported success, while 49% reported partial success and 11% reported failure.

Importance of fish disease to farmers

Farmers were asked to rank the technical importance of fish disease during production by marking which other issues were clearly more important (Table 8) (these issues were described by the farmers as important constraints on production during group meetings).

Table 8. Ranked frequency of farmers responding "yes" to whether the subject is "more important than fish disease."

Subject/Topic	Percentage of Farmers Responding "Yes"
Own knowledge of fish farming	79
Investment /finance shortage	51
Supply of fry	50
Lack of feed/fertiliser	37
Time spent looking after fish	35
Theft	33
Predators	32
Drought	25
Flooding	23
Marketing/sale of harvest	16

Farmers therefore perceived that their own lack of knowledge and investment/credit problems were more important constraints to production than disease. Fry supply problems (quality and quantity) were seen by farmers as of equal importance to disease.

When asked whether the loss of money or food was more or less important when fish died due to disease, 20% of the farmers responded that the loss of food was more important, 17% said that the monetary loss was more important and 56% said that they were of equal importance (7% had no opinion).

Farmers were also asked to rank the general loss they had due to fish disease. Twenty percent felt that it was of no importance, 34% felt it was minor, 22% felt that it was moderate but acceptable, 19% felt it was big but acceptable, and 4% felt it was big and unacceptable.

The average "on-farm" income for respondents was US$1,017 per year. Losses due to fish disease made up, on average, 3% of this total on-farm income (US$31), which corresponded to 18.5% of the total average yearly income from fish production.

CONCLUSIONS

Most of the farmers interviewed in this survey can be considered as poor and operate "low-input" carp polyculture production systems. Most farmers stock, lime and fertilise ponds at some point during production, and many use supplemental feeds. Significantly, when considering the impact of disease on these farmers, most consume a considerable amount of fish they produce.

Although unable to describe the detailed clinical signs of diseases, a significant number of farmers reported death of fish from a number of causes. The most frequently reported were called, in Bangladeshi, "red spot/EUS." gill/fin rot, air gulping and cotton fungus.

For affected farms, losses to disease were not significant in terms of money or food, and most farmers either simply sold or ate the dead fish. Very few farmers reported a total loss of their crop, and this was not surprising considering the low-intensity, low-risk systems they operate. Of those that had experienced a loss, only a minority (4.2%) felt that it was unacceptably large. In financial terms, the losses were also small, relating on average to only 3% of total "on-farm income."

In the farmers' opinion, it was their lack of understanding of fish culture and their inability to access credit that were the main constraints to their fish production. It is likely that once farmers have a better understanding of low-input carp polyculture methods, the likelihood of diseases occurring and their impacts will be reduced. However, should these farmers intensify their production the incidence and impact of fish diseases will increase.

For extension service providers, the key message from this survey is that farmers are interested in better basic training in aquaculture, rather than specific information regarding fish diseases. Key routes for information dissemination could be directly through extension agents, but because farmers generally go to other farmers for information, the use of indirect farmer-farmer extension approaches would be effective in this case.

A SURVEY OF HEALTH ISSUES IN CARP/*MACROBRACHIUM* CULTURE IN RICE FIELDS IN BANGLADESH

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ABSTRACT

During July and August 1999, a survey was conducted involving 105 farmers culturing giant freshwater prawn (*Macrobrachium rosenbergii*), locally known as "golda," and carp in "gher" (modified rice fields with high, broad peripheral dikes) in southwestern Bangladesh. The survey gathered information on the socio-economic circumstances of the farmers, their farming practices, and their perception of disease and its affect on their livelihoods. Information was also gathered regarding the farmers' response to disease, treatment and prevention, and sources of information and assistance. If specific diseases were reported, further information was gathered regarding impact, response and outcome.

The conditions reported as disease by the farmers mainly occurred late in the culture cycle when conditions were poor and the prawns were territorial, resulting in damage from fighting and subsequent infection. The response to disease problems was generally application of chemicals, with little understanding of their effectiveness, when better results might have been obtained by changes in management practice. Much of the advice received by farmers was from feed and chemical sales persons, whose advice may have been biased, and which generally involved the sale and application of chemicals. Advice from non-governmental organisations (NGOs) and Government Extension Officers ranked low in comparison, indicating that efforts were required to increase their profile in this area; which would hopefully reduce the input of ineffective chemicals and so reduce farmers' costs. Farm record keeping was not common, and encouragement of this by the CARE GOLDA Project is seen as a strategy that will lead to better management. Farmers' expectations were generally unrealistic, leading to poor management decisions.

BACKGROUND

"Gher" are modified rice fields with high, broad peripheral dikes. They are found throughout southwestern Bangladesh in areas that are seasonally or perennially inundated. The word "gher" literally means perimeter. A trench dug inside the dikes is designed to retain water in the dry season, while the high dike protects the gher from flooding during the summer.

During the rainy season, the entire rice field, which is generally not planted, is used for the cultivation of giant freshwater prawn or "golda" (*Macrobrachium rosenbergii*), a species native to Bangladesh, and fish. In the dry season, however, boro rice is planted and only the trenches are used for fish and prawn cultivation. At all times of year, the dikes can be used for growing vegetables, fruit, wood and fodder.

Since 1991, the expansion of gher operations has been huge, with the focus of this farming system being the prawn component. Little emphasis has been given to rice, fish, and the cultivation of fruit and vegetable crops.

The production of golda in Bangladesh is still dominated by very small producers, typically farming less than one acre, producing a crop that is sold on the international market. In southwestern Bangladesh, vulnerable farmers routinely take out huge loans in order to stock their gher with *M. rosenbergii*. The potential for high profits has drawn farmers into the practice; however, largely because of the loans, increasing input costs, uncertain markets and natural disasters, their exposure to risk has increased dramatically. By diversifying production components and thereby, reducing investment in the *Macrobrachium* component, and improving household financial and gher management skills, the CARE Greater Options for Local Development in Aquaculture (GOLDA) Project aims to reduce the vulnerability of gher households.

The project, funded by The Department for International Development, United Kingdom (DFID), began work with 30,000 marginal and vulnerable farmers in 1996, to diversify and stabilise their gher systems to decrease exposure to risk. A major aim of this project is to increase the ability of these farmers to make more informed decisions in order to make their systems sustainable. This survey examines the risks that aquatic animal disease pose to these already vulnerable households.

METHODS

The objective of the survey was to collect information on the impact of disease on production of *Macrobrachium*/carp farming in ghers; the species of carp stocked in the ponds are silver carp (*Hypophthalmichthys molitrix*), catla (*Catla catla*), rui (*Labeo rohita*) and grass carp (*Ctenopharyngodon idellus*). A survey questionnaire was prepared and a survey carried out over a period of three weeks between 2 and 23 August 1999 in 12 thana[1] in five districts of Bangladesh. The survey form was in two parts. The first part gathered data on the socio-economic circumstances of the farmers and the production techniques that are employed. Some questions related to health issues, management, knowledge and contact with extension services and other forms of assistance; the initial form contained 64 questions. If specific diseases were mentioned, the second part was completed, which contained

[1]A thana is an administrative subdivision of a district; there are 490 thanas in Bangladesh..

questions relating to occurrence, frequency, farmers' perceptions and knowledge of disease, treatments applied and types of assistance available. One hundred and five forms were completed.

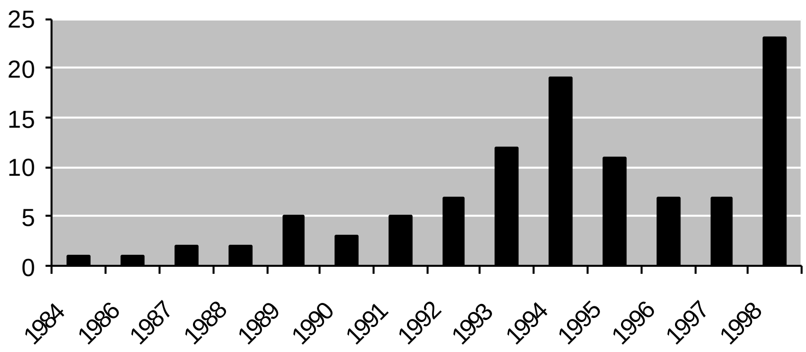
In the limited time available, the forms were not adequately tested and some difficulty was subsequently encountered in the analysis of the data. Had time been available, a pre-survey would have been useful to establish likely responses to questions, and so allow better construction of the survey and easier analysis. In addition, many farmers were unable to state the costs and amounts of farm inputs or to to describe the clinical signs of disease. Many farmers were also reluctant to respond to the questionnaire.

RESULTS

General

Of the 105 farms surveyed, all were gher farms growing *M. rosenbergii* and carp. The average age of the farms was 4.8 years, with the oldest being 15 years and the newest being one year old. The growth in gher farming among the farms surveyed is shown in Figure 1.

Figure 1. Number of farms started/yr, 1984-1998.



The total water area of the farms varied from 0.04 ha to 1.31 ha, the average being 0.36 ha. The majority of the farms utilised all available water area. Thirty-one farms utilised part of the farm as a nursery, growing the prawns from an average of 0.55 cm to an average of 3.53 cm. All fry were wild caught, although a large percentage (90%) was obtained from fry traders.

Household Information

Details of family size, general income and income from aquaculture are given in Table 1. It should be noted that 79 respondents (77%) reported a daily *per capita* income of less than US$1.

There was a wide range of experience in aquaculture, with the maximum time involved being 35 years. The minimum was two years and the average was 5.8 years. The majority of the farmers (81) stated that they learned aquaculture from other farmers; 42 learned from friends and neighbours, 24 were self taught, five learned from Government Extension Officers and four learned from non-governmental organisations (NGOs).

Table 1. Household size and income.

	Range	Average
Family size	2-17	6
Household income (US$)	396–5,137	1,535
Per capita income per day (US$)	0.16–3.51	0.74
Income from aquaculture (%)	4.3-98.0	46.4
Income from aquaculture (US$)	23.77–3,855	779.36
Per capita income per day from aquaculture (US$)	0.016–10.56	2.13

The majority of farmers grow prawns for income. The only other first-ranked reason was status (9 responses). The second-ranked response (79) was for food; however, it is likely that this refers to the fish that are also grown in the ponds. Interestingly, the third-ranked reason was status (27 responses).

The other main activity that supports the family was rice growing on their own farm. Fruit and vegetable growing on farm and fruit growing off farm are important secondary activities. Labouring off farm and raising livestock, both on and off farm, were also important.

The two major activities of the household are aquaculture and rice growing, with the majority of the time spent on aquaculture. Other activities, including business (16), service (10), betel farming (7), sugar cane (4) and van driving or pulling (3), were also significant to the household. The husband spent more time per day working in aquaculture activities (average 4.8 hr/day) than the wife or children (average 1.1 and 1.6 hr/day, respectively). Other labour averaged 2.3 hr/day.

Farm Costs and Revenue

Production and operating costs are given in Tables 2 and 3.

Table 2. Production costs.

	Production Costs (US$)		
	Average	Minimum	Maximum
Pond digging (n=29)[1]	203.46	1.50	701.03
Liming (n=82)	6.91	0.22	86.60
Fertiliser (n=50)	15.23	0.52	154.60
Mud removal (n=15)	191.76	4.12	2,474.00
Sediment removal (n=9)	83.07	7.42	226.80
Dike repairs (n=8)	41.76	8.24	103.09
Other repairs (n=15)	76.76	20.60	278.00
Labour (n=4)	39.20	20.00	90.00

[1]N = number of farmers indicating expediture.

Table 3. Operating costs.

Item	Operating Costs (US$)		
	Average	Minimum	Maximum
Feed (n=103)[1]	256.19	6.19	1,855.60
Seed (n=103)	287.15	4.50	2,886.60
Drugs (n=41)	9.66	0.22	62.00
Chemicals (n=5)	6.95	2.00	14.43
Water (n=17)	17.34	2.00	61.86
Electricity (n=1)	6.50	6.50	6.50
Broodstock	0.00	0.00	0.00

[1]N = number of farmers indicating expediture.

As can be seen from Table 4, the farmers' expectations of profit and yield for both carp and prawns were much higher than that realised. Expected profit from prawns ranged from US$469 to 24,160, the average expected profit being US$4,749. A similar picture emerged for carp. Of the 105 farmers interviewed, only two achieved more prawn production that they had expected, whereas seven farmers exceeded expectations with carp production.

Table 4. Production against expectation.

	Prawns						Carp					
	Expected Harvest[1]			Actual Harvest			Expected Harvest			Actual Harvest		
	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max	Ave	Min	Max
Kg/ha	831	80	1,536	119	0	600	676	28	2,688	93	2	589
US$	4,828	266	25,436	691	0	3,612	676	28	2,688	93	2	589

[1]Three outliers, 6,175, 4,116 and 3,140 kg/ha, were not included in this calculation.

When farmers were asked if the crop did as well as expected, 90% of them indicated that they were disappointed (Table 5). This might indicate that farmers have unrealistic expectations.

Table 5. Farmers' expectations.

Did the Crop Do As Well As Expected?	Number Responding	%
As well as expected	7	6.7
Not as well	95	90.5
Better than expected	2	1.9

When production is graphed against expectation, the shortfall is quite clear (Figs. 2 and 3).

Figure 2. Expected and actual prawn production.

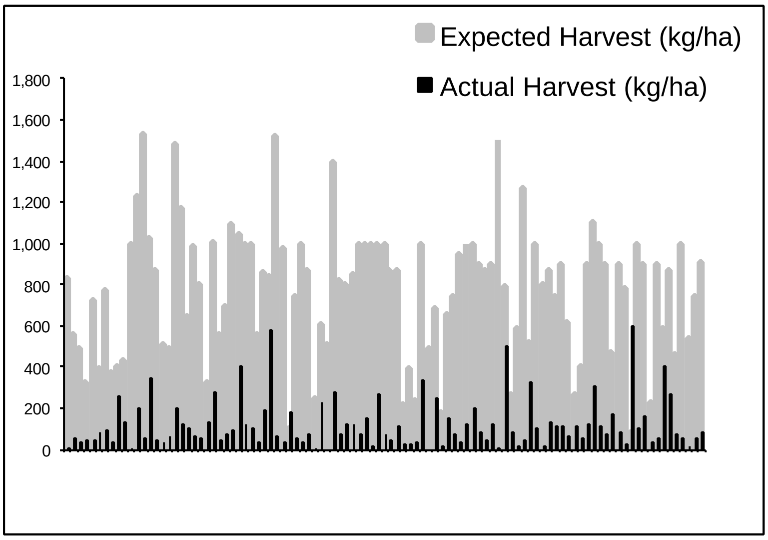
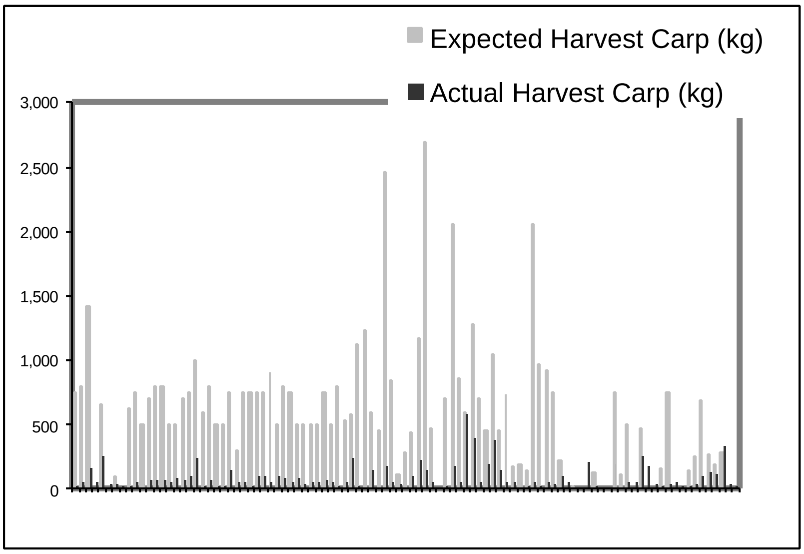


Figure 3. Expected and actual carp production.



Reported survival rates are given in Table 6, along with prices for carp and prawns.

Table 6. Survival rates (%) and prices (US$) for carp and prawns.

	Average	Minimum	Maximum
Survival rate-prawns (n=103)[1]	37.8	0.1	94.0
Survival rate-carp (n=98)	57.3	0.1	96.8
Price-prawns (n=101)	5.89	0.67	9.28
Price-carp (n=62)	0.84	0.61	1.24

[1]N = number of farmers indicating expediture.

Problems Faced by Farmers

Farmers were asked to rank, in order of significance, the problems that they encountered (Table 7). The major problem was flooding, followed by too little water. Disease was ranked third. Theft figured highly in the second ranking.

Table 7. Problems encountered by farmers.

Ranking	1	2	3	4	5	6
Too little water	18	12	18	4	1	0
Too hot	0	9	6	10	4	1
Too cold	0	0	0	1	0	0
Theft	5	21	9	5	1	0
Disease	16	28	11	4	0	1
Predation	0	3	4	2	0	1
Flooding	57	10	6	4	3	0

Farmers' Perceptions of Aquaculture

Farmers were asked what they thought about aquaculture; responses are presented in Table 8. Although farmers acknowledged that aquaculture is a risky business, they still considered it to be profitable and to have a high status. Disease was also seen as an important issue.

Table 8. Farmers' perceptions of aquaculture.

Question	Number Answering Yes
Aquaculture is a risky business	101
Aquaculture is profitable	105
Aquaculture has high status	72
Aquaculture is only profitable for large-scale farmers	4
Disease is an important issue	58
Disease doesn't occur in small-scale farms	8

Fry Selection

The majority of farmers (94) said that they were able to choose fry, and the majority (94) also considered that the fry were healthy. Three farmers considered that the fry were not healthy and seven did not know.

Disease Occurrence

Of the 105 farmers interviewed, 42 reported that they had experienced disease problems in the last year, three said that they had problems in the last four months, and four said that they had problems in the last eight months. The outcome of the majority of the problems encountered was that "some" of the prawns or fish died; only two farmers reported that "all" the prawns or fish died. The significance of disease to the household, as felt by the farmers, is given in Table 9.

Table 9. Economic result of problems.

	Yes (N[1])	No (N)
Reduced price at market	44	10
Increased debt	39	16
Reduced household income	51	5

[1]Number of responses.

Patterns Associated with Disease

Farmers were asked if they associated any particular pattern with disease occurrence. Results are given in Table 10.

Table 10. Pattern associated with disease.

Pattern	Yes (N[1])
During dry season	17
During rainy season	36
During hot season	8
During cold season	8
Just after stocking	1
Just before harvesting	9
Just after drought	0
Others	0

[1]Number of farmers observing pattern.

Farmers were asked if the occurrence of disease changed their attitude to aquaculture. Responses are summarised in Table 11.

Table 11. Summary of farmers' responses to the question "Did the problem result in a change in attitude towards aquaculture?"

Change in Attitude	Yes (N[1])	No (N)
Resistance to continuing aquaculture	6	48
Stopped aquaculture	0	53
Changed species	0	53
Reduced importance	0	53
Stopped promoting aquaculture	6	47
Other	2	18

[1]Number of farmers responding.

Information Sources

When farmers were asked if they contacted anyone when they had a problem, 38% said that they did. The majority (31) contacted other farmers for information, 10 contacted feed salespersons, six contacted Government Extension Officers, five contacted drug and chemical salespersons, and five contacted NGOs. When requests for assistance were made, 34 farmers said that response was prompt, three said that it was slow, and one farmer said that no response was received.

Other farmers were considered to be the most useful source of information, with CARE Bangladesh the second most useful source. Friends and neighbours were also considered good sources of information, while Government Extension Officers ranked fourth.

Disease Recognition

Farmers were asked about their ability to recognise disease. Forty-six farmers said that they could recognise some diseases, and 12 said that they could not recognise any diseases. Only one farmer said that he could recognise all diseases, and two said that they could recognise most diseases. The ability to recognise that disease was present was based on a number of factors, the most frequently cited being reduced growth, although mortalities, abnormal behaviour and abnormal appearance were all only slightly less significant.

Response to Disease

When farmers were asked what they did in response to disease, 38 said that they would attempt treatment, 19 said that they would conduct an emergency harvest, five would do nothing, and three would seek help. If treatment was attempted, it was generally involved the use of chemicals (35 of 41 responses). Two farmers would use antibiotics, two would change water, one would stop fertilising and one would stop feeding. When asked where they learned about this treatment, the majority (25 of 36 responses) said that they learned from other farmers. Eight learned about the treatment from feed salespersons and three learned from drug and chemical salespersons. The average cost of the treatments applied was US$5.30, the maximum was $20.60, and the minimum was $0.22. Eighteen farmers said that the treatment was "sometimes" successful, eight said that it was "usually" successful, eight that it was "never" successful, and only seven said that it was "always" successful.

Specific Disease Problems

Three of the most common diseases described are antenna and rostrum rot; *jatha* – infection and ulceration of the antennae that may eventually spread to the head; and *dhari jhara* – removal of the rostrum. These three conditions may possibly be the same problem. Other diseases reported include *karat baka or* curved rostrum, which may also lead to head ulcers; *shuga or sponge rog*, a syndrome in which affected prawns become shrunken and hard, with the flesh shrinking away from the carapace; and *shadla pora* - external fouling and softening of the muscle resulting in poor growth and failure to moult, said to be due to malnutrition.

Black gill disease, generally caused by precipitating nitrogenous wastes in ponds with high levels of ammonia and nitrite, usually occurs towards the end of the growing cycle when the water quality has deteriorated. The only remedy is to change the water.

Epizootic ulcerative syndrome (EUS) is a seasonal (winter) epizootic condition of freshwater and estuarine fish characterised by the presence of the invasive fungus *Aphanomyces invadans*, typically leading to a granulomatous response. There are a large number of ulcerative conditions of fish, and EUS can only be positively confirmed by histological examination. Chinese carps appear to be unaffected by EUS, and Indian major carps may suffer large mortalities as fingerlings; however, larger fish, although they are ulcerated, do not die in large numbers. Four farmers reported EUS in *Hypophthalmicthys molitrix*, *Catla catla*, *Barbodes gonionotus*, *Cirrhinus cirrhosus*, *Mugil* sp. and *Labeo rohita*. The fish were around eight months old, and two of the farmers reported that the problem was caused by cold weather. There is no remedy for EUS, other than to prevent the incursion of wild fish that are carriers.

Tail rot in prawns is a condition that also arises from initial infection and ulceration exacerbated by poor pond conditions or aggressive behaviour.

A breakdown of the problems encountered by the farmers is provided in Table 12. Most of the problems occurred towards the end of the growing cycle (the average for all diseases reported was 237 days and the minimum was 60 days). This would be at the period in the grow-out cycle when the prawns are at their largest, the water conditions have deteriorated, and the stocking densities are at their maximum. All the problems appear to be associated with poor pond conditions, lack of food or the aggressive behaviour of large prawns. Farmers should consider harvesting earlier, as the pond conditions begin to deteriorate.

Table 12. Frequency of disease.

Disease	Frequency (N)	Age of Prawns/Fish (Days)		
		Average	Minimum	Maximum
Antenna &/or rostrum rotting	16	176	80	375
Jatha	13	360	350	370
Virus	11	144	90	375
Shuga or sponge rog	8	394	285	515
Shadla pora	7	291	180	370
Black gill disease	5	184	60	320
Dhari jhara	5	220	100	300
Epizootic ulcerative syndrome	4	227	210	240
Curved rostrum	2	170	90	250
Tail rot	1	210	210	210

The diseases did not seem to cause catastrophic losses, most farmers reporting that only a few animals died. There were, however, three reports of total loss, one from dhari jhara and two from "virus." In terms of overall loss, this may not appear to be a major problem; however, it would have had a significant impact on the livelihoods of the three farmers involved. It is possible that the farmers were relating their problems to viral diseases of marine shrimp, such as white spot disease and yellowhead disease, which do not affect *Macrobrachium*. Losses are measured by mortalities, and it is not possible to estimate the loss of production due to reduced growth. The various causes of disease, according to the farmers, are listed in Table 13.

Table 13. Cause of disease.

Cause of Disease	Frequency (N)
Cold	4
Hot	3
Drought	11
Insects	2
Bad food	17
Virus	13
Malnutrition	9
Excess mating	5
Bad water quality	2
Bad management	2
Excess sediment	10
Unknown	6
Other	4

Treatment

A diverse number of treatments were reported, many involving multiple combinations of chemicals. Liming was the most common treatment applied (20 specific cases, 15 in combination with others), and Aquanourish was common in combination. Potassium permanganate, potash alum, silica powder, Aquaclean and methylene blue were also cited as treatments. In an attempt to assess the value of these treatments, more information was sought on the dose rates, frequency of application and their relative merits (see Table 14).

It was not possible to find out the active ingredients of the proprietary chemicals Antibacter, Y Organ, Aquanourish and Molt-7; however, if the gher is at least one metre deep, Antibacter, Y Organ and Molt-7 are employed at doses that equate to 0.65 ppm. It is unlikely that any proprietary chemical will have a significant effect at this concentration. Aquanourish is used at a rate of 22.5 ppm; however, as the ingredients are not known, it is difficult to make an assessment. As it is used to improve water quality and may be a fertiliser, it is possibly no more useful than urea or TSP and is a little more expensive. In general, it is best to exclude any substance from a pond unless its constituents and potential effects are known.

Copper sulphate, generally in the chelated form, is used at a rate of 0.25 ppm to induce moulting. Higher doses are used to control algae and plankton; however, these treatments must be followed by water exchange. Copper sulphate is very toxic, and there is a narrow range between its effective treatment dose and the dose that will be toxic to animals. Toxicity varies with alkalinity of the water and is higher at low alkalinity. In water of high alkalinity, the effectiveness of copper sulphate treatment will also be greatly reduced.

Methylene blue is reportedly used at a rate of 1.25 to 2.5 ppm. It is often used for the treatment of aquarium fish at doses ranging from 1-2 ppm as prolonged baths, to 8-10 ppm as short baths; however, its efficacy in pond situations is uncertain.

Table 14. Merits and costs of treatments.

Chemical	Application Rate[1]	Frequency of Use	Cost/Unit (Tk[2])	Perceived Merits	Average Expense /Yr/Acre (US$)
Aquaclean/ Aquanourish	6-9 kg/acre (22.5 ppm)	4-6 times/yr	16/kg	Improves water quality; moderate merit.	12.5
Copper sulphate	10 gm/decimal (0.25 ppm)	1-2 times/yr	250/kg	Controls phytoplankton bloom; works well.	3.75
Fertilisers	Urea, 8-10 kg/acre	2-3 times/yr	5-6/kg	Increases natural feed, enhances moulting; positive merit.	2.5
	TSP, 3-4 kg/acre		12-14/kg	Increases natural feed, enhances moulting; positive merit.	2.4
Lime	35-40 kg/acre	3-4 times/yr	5/kg	Increases water quality; positive merit.	13.6
Methylene blue	50-100 gm/acre (1.25-2.5 ppm)	Whenever needed	520/kg	Bacterial & other infections; merits not significant.	0.81
Molt-7	250 mL/acre (0.65 ppm)	2-3 times/yr	200/L	Enhances moulting, merits not satisfactory.	2.3
Potash alum	2 kg/acre	1-2 times/yr, if needed	20/kg	Improves water quality; positive merit.	1.25
Potassium permanganate	2 kg/acre (50 ppm)	Rarely	120/kg	Bacterial & other infections; merits not significant.	5
Salt	2-4 kg/acre	Generally 1 time/yr, if needed	10/kg	Bacterial & other infections; merits not significant.	0.65
Silica powder	4-6 kg/acre	1-2 times/yr (occas.)	20/kg	Increases water quality; moderate merit.	3.13
Y organ	250 mL/acre (0.65 ppm)	2-3 times/yr	480/L	Increases natural feed, enhances moulting; moderate merit.	6.25
Antibacter	250 mL/acre (0.65 ppm)	1 time/yr	540/L	Bacterial & other infections; merits not significant.	2.81
				Total	56.95

[1]1 acre = 400 m^2; 1 decimal = 40 m^2.
[2]US$ 1 = Taka 48.

Potassium permanganate is used at a rate of 50 ppm, and in the highly organic environment of these ponds, is likely to be inactivated very rapidly after application. As an indication, the effective dose for treatment of fungus is 75 kg in a 1,000 m^2 pond; this is 25 times the dose rate used by the *Macrobrachium* farmers. To be used effectively to oxidise organic matter in the pond, the potassium permanganate demand (PPD) must first be calculated, and a dose rate 2-3 ppm greater than that should be used for treatment. High dose rates will also lower dissolved oxygen and may produce a toxic end product, manganous dioxide, from the reaction with organic material.

Farmers generally use two or more chemicals at a time for any disease problem, according to the recommendation of chemical suppliers. There is very little evidence of recovery from diseases after application of these chemicals.

Liming was the most common treatment used and was reported to be "sometimes successful" by 11 farmers.

The majority of farmers (28) learned about the treatment that they used from other farmers. Feed salespersons (7) and NGOs (5) were also a source of information, while chemical salespersons (4) and government extension services (3) were less frequently consulted. Five farmers reported that they learned the treatments themselves.

Occurrence of Disease

When farmers were asked when diseases were last seen, they indicated that the majority of diseases occurred within the last year (Table 15).

Table 15. When disease was last seen.

Disease	Within Last 2 Mon	Within Last 4 Mon	Within Last 8 Mon	Within Last Year
Antenna &/or rostrum rot		2	1	13
Black gill disease		1	1	3
Curved rostrum				2
Dhari jhara			1	4
Epizootic ulcerative syndrome			2	2
Jatha				13
Shadla pora				7
Shuga or sponge rog		1		7
Tail rot				1
Virus	1			10

Frequency of Disease

When asked how often these diseases were seen, the farmers responded that most were seen every year, but not more frequently. When asked when in the growing cycle the disease occurred, they responded that there was no distinct pattern of occurrence; however, as can be seen from Table 16, the dry and wet season was cited as the most likely time for disease to occur.

Table 16. When in the growing cycle disease is likely to occur.

	Dry & Wet Season	Dry & Just Before Harvest	Dry Season	Wet Season & Winter	Wet Season	Winter	Winter & Just Before Harvest	After Stocking	Just Before Harvest
Antenna &/or rostrum rotting	1		2		10			1	2
Black gill disease			1		3				1
Curved rostrum					1		1		
Dhari jhara			1				1		
Epizootic ulcerative syndrome			1						
Jatha	12								
Shadla pora	4		1						1
Shuga or sponge rog		1	1	1	4				1
Tail rot									
Virus	9				2				

Lost Production

Farmers were asked if they lost production due to disease; responses are given in Table 17.

Table 17. Loss of production and additional inputs due to disease.

Disease	Was There Any Loss of Production?		Were Additional Inputs Required?	
	Yes	No	Yes	No
Antenna &/or rostrum rotting	16	0	2	13
Black gill disease	5	0	1	4
Curved rostrum	2	0	0	2
Dhari jhara	5	0	0	5
Epizootic ulcerative syndrome	4	0	1	2
Jatha	13	0	0	1
Shadla pora	7	0	0	2
Shuga or sponge rog	8	0	2	6
Tail rot	1	0	0	1
Virus	10	1	0	1

Farmers’ estimates of the value of lost production and the cost of additional inputs to control disease are given in Tables 18, 19 and 20.

Table 18. Value of lost production.

Disease	Value of Lost Production (US$)				
	No of Farms	Total	Average	Minimum	Maximum
Antenna and or rostrum rotting	14	1,700.47	121.46	0.50	1,030.00
Black gill disease	5	1,258.15	251.63	8.25	1,111.00
Cannot identify	1	412.00	412.00	412.00	412.00
Curved rostrum	1	16.74	16.74	16.74	16.74
Dhari jhara	5	371.45	74.29	10.46	196.39
Epizootic ulcerative syndrome	4	125.76	31.44	1.24	61.85
Jatha	13	213.18	16.40	4.60	41.23
Shadla pora	6	573.07	95.51	6.18	412.37
Shuga or sponge rog	8	648.71	81.09	12.88	185.50
Tail rot	1	10.30	10.30	10.30	10.30
Virus	10	775.02	77.50	2.95	494.00
Total	68	6,104.85			

Table 19. Cost of additional inputs.

Disease	Additional Costs (US$)				
	No of Farms	Sum	Average	Minimum	Maximum
Antenna &/or rostrum rotting	2	247.00	123.50	82.00	165.00
Black gill disease	1	309.00	309.00	309.00	309.00
Shadla pora	1	20.61	20.61	20.61	20.61
Shuga or sponge rog	2	371.10	185.55	144.30	226.80
Total occurrences	6	947.71			

Table 20. Loss of income in relation to household income.

	Average	Minimum	Maximum
% loss reported	9.6	0	100
Value lost (US$)	83.63	0	1,111.00
Household income (US$)	1,406.40	406.00	5,137.11
Value of loss as % income	5.8	0	67.3

Farmers were asked if they would eat fish or prawns from a pond with sick fish or prawns; 40 replied that they would and 18 replied that they would not.

Case Studies

In order to examine the impact of disease on individual farmers, two case studies were extracted from the data (see Boxes 1 and 2).

Box 1. Case Study 1: Mr. Ratan Kumar Roy of Miximil Village

Mr. Ratan Kumar Roy of Miximil (Khya Ghut) Village, Khulna District, has been farming *Macrobrachium* in gher systems since 1996 and has four years experience in aquaculture. The total water area of his farm is 0.57 ha, and he also stocks *Catla catla, Ctenopharyngodon idellus* and *Hypophthalmichthys molitrix*.

Mr Roy's family consists of six members, and their family income is US$1,650.00, 68% of which ($1,122) comes from aquaculture. He adopted aquaculture because he saw it as a way out of indebtedness; he also relies on business for income. He learned to farm *Macrobrachium* from an NGO and from his neighbours, and believes that aquaculture is profitable but risky.

From the last crop that he farmed, he expected to harvest 865 kg/ha prawns (493 kg), but he did not estimate the likely carp crop. He actually harvested 343kg/ha (196 kg) of prawns and 25 kg of carp. He said that the crop had not done as well as expected. The estimated survival rate was 36% for the prawns and 45% for the carp.

Mr Roy had expected a profit of US$618. Although he sold his crop for an average of US$5.67/kg ($1,111), he also spent $577 on feed, $226 on seed, $38 on liming and labour for pond preparation, and $54 on other costs. This left him with a profit of US$216.

Mr Roy said that disease was the number one problem, and that his farm suffered from four disease problems during this period, antenna or rostrum rot (estimated losses of 5%, US$4.60); "jatha" (estimated losses of 4%, $20.00), "shadla pora" (estimated losses of 1%, $10.30); and black gill disease, the most serious of the problems, which caused estimated losses of 50%, valued at $1,111. Mr Roy's total losses amounted to 60% of the crop and a total estimated value of US$1,145. This amounted to about 67% of Mr Roy's family income. Also, he spent an estimated US$309 on unspecified disease control measures.

Mr Roy says that he is unable to identify specific diseases, but can recognise problems when there are mortalities, abnormal appearance or reduced growth. He believes that bad management caused the black gill disease, virus caused the rostrum rot, bad food and excess mating caused the jatha, and drought caused the shadla pura. Mr Roy says that these diseases resulted in reduced price, reduced income and increased debt for his family. It did not change his attitude about aquaculture, and he will continue to farm.

Box 2. Case Study 2: Mr. Hari Dash Mandal of Shahera Village.

Mr. Hari Dash Mandal of Shahera (East) Village, Bagerhat District, has been farming *Macrobrachium* in gher systems since 1987 and has 13 years experience in aquaculture. The total water area of his farm is 0.37 ha, and he also stocks *Labeo rohita, Catla catla, Cyprinus carpio* and *Cirrhinus cirrhosus*.

Mr Mandal's family consists of six members; their family income is US$1,026 and 16.6% of this ($170) comes from aquaculture. Other income is derived from unspecified business. He learned to farm *Macrobrachium* from a relative and from a neighbour and believes that aquaculture is profitable but risky and that disease is a problem.

From his last crop, he expected to harvest 543 kg/ha prawns (200 kg) and 543 kg/ha (200 kg) carp. He actually harvested 47 kg/ha (17.2 kg) of prawns and 162 kg/ha (60 kg) carp. He said that the crop had not done as well as expected. Survival rates were estimated at 63% for the prawns and 75% for the carp.

Mr Mandal had expected a profit of $1,030. He sold the resulting crop for an average of US$7.22/kg ($124). He spent $14 on feed, $151 on seed and $22 on other costs. According to these figures, he incurred a loss of US$63.

Mr Mandal said that disease was the number one problem, and that his farm suffered from a single disease problem during this period, shuga or sponge rog, that accounted for estimated losses of 5% (US$50.52). This disease occurred when the prawns were around 285 days old. This accounted for an estimated 4.9% of Mr Mandal's family income. This disease alone would not account of the lost production reported by Mr Mandal, and this is not explained.

Mr Mandal says that he recognises some diseases and can recognise sickness when there are mortalities, abnormal appearance or reduced growth. He believes that bad food and too little water caused the disease. He reports that he sees this disease every year at the dry season and just before harvest. Mr Mandal contacts a relative if he has problems, and this is the person whose advice he relies on most.

Mr Mandal says that disease resulted in reduced price and reduced income, but no increased debt for his family. As a result of these problems, Mr Mandal has stopped promoting aquaculture.

CONCLUSIONS

Farming *Macrobrachium* is a risky practice, a fact that the farmers largely acknowledge; however, they also see it as being potentially very profitable. By borrowing money to stock *Macrobrachium*, already vulnerable farmers are putting themselves at even greater risk. Given the farmers' intentions to continue prawn/fish aquaculture, even those farmers who sustain significant losses, the strategy of crop diversification being promoted by GOLDA is essential. In addition to this, there are some other lessons to be learned from this study:

- The conditions farmers describe as diseases are reported as occurring largely in the latter stages of culture, when water quality is at its lowest and stocking density is highest. The prawns will, by this time, be territorial, and some antenna and rostrum damage will undoubtedly be caused by fighting and exacerbated by the poor water conditions.

- The farmers' understanding of disease is limited, and their main response is to apply chemicals, the majority of which are likely to be ineffective. The amount of money reportedly spent on some of these chemicals is significant in terms of the returns that these farmers are making, and they would be better advised to restrict the use of chemicals. A better strategy might be to carry out an early harvest; however, this may require a better understanding of the potential risks and the economics at the time of harvest. There is a need to properly assess the disease prevention and treatment strategies used by farmers in order to provide them with reliable and cost-effective advice. Farmers will need to be convinced that the treatments advocated will be effective or that the withdrawal of presently used, ineffective treatments, will not be detrimental.

- A large number of the farmers surveyed are obtaining advice on disease and disease treatment from other farmers and chemical and feed salespersons, with advice from NGOs and Government Extension Officers ranking low in comparison. The information passed on by farmers is likely to have originated from the feed and chemical salespersons, and is likely to be biased and involve the purchase of chemicals, many of which will be unnecessary or useless. Efforts should be made to increase the understanding that NGOs and extension workers have of disease and treatment and to provide them with reliable information for the farmer. Farmers should be encouraged to seek information from these reliable sources.

- Obtaining an accurate picture of what is happening in these systems, in terms of production and losses, is very difficult from the data collected, and there are many ambiguities. The CARE GOLDA Project is encouraging farmers to record costs of inputs and production, and may lead to a better picture.

- There is a problem with farmers' expectations of production; with few exceptions, farmers did not achieve what they had expected. Farmers generally overestimate production, as they base their expectations on stocking rates, disregarding management problems, mortality and carrying capacity. Also, in the year surveyed, severe floods and poor post-flood gher management may have caused a wider than usual gap between expectation and actual harvest. Looking at only one year of production may not be adequate to determine trends; however, a better understanding of what farmers can realistically expect from these systems may help them make better decisions regarding investment. Typically, farmers should expect production of between 250 and 450 kg/ha; however, as can be seen from Table 4, the average expectation was 831 kg/ha and the maximum expectation was 1,536 kg/ha.

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POTENTIAL ADVERSE SOCIO-ECONOMIC AND BIOLOGICAL IMPACTS OF AQUATIC ANIMAL PATHOGENS DUE TO HATCHERY-BASED ENHANCEMENT OF INLAND OPEN-WATER SYSTEMS, AND POSSIBILITIES FOR THEIR MINIMISATION

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ABSTRACT

The introduction of exotic fishes into natural waters, and the culture and stocking of both introduced and indigenous species to enhance production from freshwater artesianal fisheries has often produced significant socio-economic benefits to small-scale rural fishing communities. These include increased availability of freshwater fish as a source of dietary protein for the rural poor, and an increased and more stable income for small-scale fishermen, fish sellers etc., their immediate families, and rural communities at large. However, to avoid unanticipated adverse effects on local communities and aquatic ecosystems, such programmes for improvement of existing fisheries must be well designed, taking into consideration not only social aspects (e.g., local preferences and traditions with regard to fish consumption), but also potential impacts related to the biology (predation, spawning habits, competition with native species etc.), genetics (possibility of hybridisation with native species, possible over-exploitation of less abundant native species with increased fishing activity), and the disease status of the enhanced species. The introduction of exotic pathogens along with introduced aquatic animals has too often resulted in severe socio-economic and/or ecological impacts. In most cases, such impacts can be avoided, if fisheries managers follow internationally accepted procedures (e.g., the protocols of the International Council for the Exploration of the Sea, ICES) when importing exotic fish. Enhancement of artesianal fisheries by stocking of hatchery-reared fry of native or well established and widespread introduced fishes (such as the Chinese and major carps in Bangladesh), poses much less threat with regard to pathogen spread. If broodstock are obtained locally, all pathogens will already be present in the country and most will probably already be widely distributed in natural waters. However, good hatchery management practices, including rigorous screening of broodstock for pathogens and routine disease diagnostics and treatment of fry and fingerlings will do much to reduce the possibility of stocking unhealthy seed (with resulting poor survival and/or production) and the potential for spread of disease into new areas.

INTRODUCTION

In this short discussion paper, we address, in a broad context, the potential socio-economic and biological risks associated with the introduction of exotic species for various purposes, among them inland-water fisheries enhancement and stocking in large water bodies and floodplains, and look at options to minimise these hazards. We will look at a few hard lessons learned from past experience, and then briefly examine the risks and benefits of hatchery-based enhancement and stocking programmes. We will also try to address these issues within the context of inland fisheries enhancement in Bangladesh.

INTERNATIONAL MOVEMENT OF AQUATIC ANIMALS

The use of exotic aquatic species to increase food production and income has been an established practice since the middle of the Nineteenth Century. However, the practice dates back much further, to the ancient Romans and medieval European monks, who transported common carp, *Cyprinus carpio*, and perch, *Perca fluviatilis*, around Europe and the Roman Empire; and to the Greeks, who transplanted oysters around the Greek Islands during the Golden Age of Greece. Advances in controlling the spawning of salmonids, primarily rainbow trout, *Oncorhynchus mykiss*, in the mid-1800s led to increased exportation of these fish to other areas (Welcomme 1988). Recent advances in trade and transport have made large-scale movements of many different species over great distances possible.

Controversy over the use of exotic species stems from the many highly publicised and spectacular successes and failures. For example, Chile has become the world's second leading producer of farmed salmonids because of the introduction of coho salmon (*O. kisutch*), Atlantic salmon (*Salmo salar*) and rainbow trout. The Chilean salmonid culture industry provides foreign exchange and employment for thousands of people in areas where there are few other opportunities for development. In contrast, the introduction of the golden apple snail (*Ampullaria canaliculata*) to the Philippines to increase rural aquaculture production has lead to the infestation of 15% of the Philippine rice fields, with losses in some areas as high as 75%. Perhaps the most famous controversy is the introduction the Nile perch (*Lates nilotcus*) into Lake Victoria. As a result of this introduction, a primarily artesianal fishery turned into a multi-million dollar industrial fishery and processing operation. Tremendous income was generated, but the socio-economic system of the community surrounding the lake changed, and there have been estimates that perhaps hundreds of enzootic species of fish have been lost to predation by the Nile perch.

Statistics on the introduction of inland aquatic species provided by the Food and Agriculture Organization of the United Nations (FAO) (see Table 1) show that aquaculture development has been the primary reason cited for most introductions, accounting for almost 40% of all cases. Other important reasons cited for the introduction of exotic species include development of capture and sport fisheries, accidental introductions (escapes), ornamental fish culture, research, control programmes for insects and aquatic plants, use as bait etc.

Table 1. Reasons for introduction of exotic species.[1]

Reason	%
Aquaculture	38.7
Fisheries	8.7
Angling/sport	7.9
Accidental	7.5
Ornamental	7.3
Unknown	15.4
Other (research, control, bait, etc.)	14.5

[1]Source: FAO's Database of Introduced Aquatic Species (DIAS) (www.fao.org/fi/statist/fisoft/dias/mainpage.htm).

Welcomme (1988) listed 1,354 international movements of 237 species of inland fishes. Of the 237 species, the three most widely introduced were common carp, Nile tilapia (*Oreochromis niloticus*) and rainbow trout. These three and others, such as black bass (*Micropterus* spp.), mosquitofish (*Gambusia affinis*), and grass carp (*Ctenopharyngodon idellus*), now occur on every continent except Antarctica as the result of human-assisted movement (see Table 2).

Table 2. Most often introduced fishes.[1]

Species	No. of Records
Common carp	124
Rainbow trout	99
Mozambique tilapia	92
Grass carp	91
Nile tilapia	80
Silver carp	79
Mosquitofish	67
Largemouth black bass	64
Bighead carp	55
Goldfish	54

[1] Source: FAO's Database of Introduced Aquatic Species (DIAS) (www.fao.org/fi/statist/fisoft/dias/mainpage.htm).

FAO statistics also show that there has been an exponential increase in the number of introductions since 1940 (Table 3), and that this trend has continued during the past 20 years. This increasing trend towards the international movement of live aquatic animals has been made possible by advances in transportation that allow rapid shipment of live fish and shellfish throughout the world, and to a large extent, is directly related to the global development of the aquaculture industry and the concomitant demand in many countries for new species for culture.

Table 3. Statistics by year of introduction.[1]

Year	% Total Records
Before 1800	1.5
1800-1899	4.3
1900-1939	10.0
1940-1979	35.5
1980-date	19.2
Unknown	26.6

[1] Source: FAO's Database of Introduced Aquatic Species (DIAS) (www.fao.org/fi/statist/fisoft/dias/mainpage.htm).

THE PROBLEM OF PATHOGEN INTRODUCTIONS

It has become increasingly clear that many of the human-assisted movements of aquatic animals into new areas have also been responsible for the introduction, establishment and spread of pathogens and parasites into new geographic areas. Hoffman (1970) and Bauer and Hoffman (1976) summarised the state of knowledge on the transfers of fish parasites along with host movements through human activities. Although Hoffman (1970) was able to document movement and establishment on new continents of at least 48 species of parasite (5 Protozoa, 31 Monogenea, 3 Nematoda, 5 Digenea, 1 Acanthocephala and 3 Copepoda), it is clear, given the number of host species that have been moved, that the actual number must be much higher. For example, Arthur (1995) noted that 50% (9 of 18) of the parasites known from Nile tilapia in the Philippines were probably introduced into the country along with the introduction of this fish for aquaculture and stocking in natural waters. Given that the number of transfers and introductions has increased significantly with the increased ease of air travel and the recent explosive growth of the aquaculture industry, and that movements of other types of pathogens (e.g., viruses, bacteria, fungi) have not been considered, the pathogens that have been moved and are now established in new localities must number in the thousands. In general, fisheries managers must be faulted for not giving pathogens adequate consideration when contemplating introductions and transfers of aquatic animals. In many cases this has led to serious pathogens becoming established in new areas and hosts. Once established in natural waters, such pathogens are usually impossible to eradicate. With proper planning, the introduction of many these disease agents could have been avoided.

There are a number of international codes of practice and guidelines which, if followed by fisheries management, would do much to reduce the risk of introducing pathogens into new areas along with the movements of their hosts. The Office International des Épizooties (OIE) has developed recommendations and protocols for the prevention of the international spread of diseases of aquatic organisms as part of its *International Aquatic Animal Health Code* (OIE 2000), which deals with the health surveillance of animals for domestic and international trade. Recommendations for policies dealing with the introduction of aquatic species and guidelines for their implementation, including methods to minimise the possibility of disease transfers, have also been developed by the International Council for the Exploration of the Sea (ICES) for marine introductions (ICES 1995). More regionally oriented guidelines are provided by the Great Lakes Fish Disease Control Committee of the Great Lakes Fishery Commission (Meyer *et al.* 1983) and the

North American Commission of the North Atlantic Salmon Conservation Organisation (Porter 1992), among others. Regionally, there have been a number of initiatives (see Arthur 1996), the most recent being the FAO/NACA (Network of Aquaculture Centres in Asia-Pacific) *"Asia Regional Technical Guidelines on Health Management for the Responsible Movement of Live Aquatic Animals and the Beijing Consensus and Implementation Strategy"* (see FAO/NACA 2000).

Despite these various codes, protocols, and guidelines, fish and shellfish continue to be introduced into new areas with little consideration of potential disease consequences. There exists an enormous number of documented cases where parasites and diseases have been spread to new regions due to human activity (for examples, see the summaries by Hoffman 1970, Bauer and Hoffman 1976, Bauer 1991, Williams and Sindermann 1992, Humphrey 1995, and Arthur 1995). Most well-documented cases involve international movements - diseases introduced along with exotic fishes, and the subsequent spread of these exotic species and their pathogens within national borders. Because transfers (movements of aquatic animals to areas within their areas of historical distribution) are generally less controversial, they appear to be less often documented, and the possible concurrent movement of pathogens and parasites less well investigated. Never-the-less, there are equally valid concerns regarding transfers of aquatic animals. One of these is the potential for introducing new diseases and/or new strains of established pathogens that may be specific to the host species being transferred. Because of this specificity, these pathogens or strains may increase the chance of a disease incursion that will severely impact existing wild and cultured populations of the species.

Some Examples of Introduced Pathogens

Introductions and transfers of aquatic animals have often occurred with little apparent repercussions due to exotic disease introduction (although, this may be due, to a large extent, to lack of any detailed pre- or post-introduction studies). However, there are many examples where ill-considered introductions of fish and shellfish have resulted in the spread of exotic pathogens that have caused unexpected and far ranging adverse impacts on host populations and commercial and sport fisheries, with accompanying severe socio-economic impacts on human populations. The following section presents three examples involving finfish, one of historical interest, and two of recent occurrence that continue to have major effects on inland capture and sport fisheries.

A monogenean destroys a valuable commercial fishery

The first scientifically documented case of the devastating effects exotic pathogens can have on a previously unexposed fish population was apparently reported by Dogiel and Lutta (1937). In an investigation into mass mortalities of spiny sturgeon (*Acipenser nudiventris*) in the Aral Sea, these authors found that the gills this extremely valuable fish were severely infected by a large, blood-feeding monogenean, *Nitzschia sturionis*. This monogenean was unknown in the Aral Sea prior to 1936; however, in 1934 spawners of the Caspian stellate sturgeon (*A. stellatus*) were transferred by fisheries managers from the Caspian Sea into the Aral Sea without inspection by fish disease specialists. As all Caspian sturgeon were known to be suitable hosts for *N. sturionis*, it was clear that these mortalities were due to the introduction of this parasite into a new water body where it was able to infect and severely damage populations of a previously unexposed host species.

As a result of this study, Dogiel and Lutta (1937) made the following recommendations, which are still valid, but often unheeded today:

1. "When introducing new objects which are useful for the fishing industry, it is necessary to hinder the spread of harmful organisms. Further transfers and adaptations in order to make our basins richer in new valuable fish species must be carried out under the control of specialists in fish diseases."

2. "Transfers from infested basins are to be prohibited pending full cessation of liquidation of the epizootic. Thus, the further transfer of spiny sturgeon from the Aral Sea to other basins must be prohibited."

Whirling disease – an introduced parasite impacts a trophy sport fishery

The story of the spread of *Myxobolus cerebralis*, the causative agent of whirling disease in rainbow and cutthroat trout, into the rivers of the western United States provides evidence of the serious impacts exotic diseases can have on natural fisheries. *Myxobolus cerebralis* is a myxozoan parasite first found in North America in 1956 in Pennsylvania (Bergersen and Anderson 1997), and is believed to have been imported into the United States along with shipments of infected European trout (see Hoffman 1963). The parasite infects, but causes no apparent disease, in brown trout (*Salmo trutta*), however, rainbow trout are highly susceptible (Hoffman 1970). Small trout are severely affected, the pathogen infecting and eroding cartilage and weakening the skeletal structure. By destroying the auditory capsule, equilibrium is affected, producing the characteristic clinical sign of whirling.

Myxobolus cerebralis has gradually spread westward, and was first detected west of the Mississippi River in 1965 in both California and Nevada (Bergersen and Anderson 1997). It is now distributed in 21 states having self-sustaining trout populations. Until the 1990s, whirling disease was considered a manageable problem affecting rainbow trout in hatcheries. However, it has recently become established in natural waters of the Rocky Mountain states (Colorado, Wyoming, Utah, Montana, Idaho, New Mexico) where it is causing heavy mortalities in several trophy sportfishing rivers. An example is its impact on the rainbow trout population in the Madison River, Montana.

The Madison River is one of the best known sportfishing rivers in western North America and is a Mecca for fly fishing enthusiasts from around the world. Although the rainbow trout populations in the Madison first began a noticeable decline in 1991, it was only in December 1995, when brown trout and rainbow trout collected in the upper river were found to be positive with spores of *M. cerebralis*, that the cause of this decline became known. This discovery was the first known finding of this parasite in Montana, and culminated a four-year search for factors which could explain the large population decline in wild rainbow trout in this important sport fishing river. As a result of declines in annual recruitment due to *M. cerebralis* infections, the adult population of rainbow trout experienced steady decline such that by 1994, the total number of two-year-old and older trout in the river had decreased nearly 90%. Prior to the introduction of whirling disease (pre-1991), wild populations of rainbow trout one-year-old and older averaged about 3,800 per mile, with yearling trout comprising about 58% of this number. Numbers of yearling rainbow trout ranged between 1,172-2,602 per mile and averaged 2,198 per mile. During the immediate eight years post-whirling disease introduction, the average number of yearling rainbow trout was 507, a decline of 77%. As a result of this decimation of the juvenile trout population, the number of two-year old and older trout showed an even more dramatic decline (89%), the average number being slightly less than 500/mile of river (Vincent and Byorth 1999). An example of the impact of whirling disease on one section of the river is shown in Table 4.

Table 4. Example of the impact of whirling disease on Madison River rainbow trout.[1]

	No. of Yearling Trout/Mile	No. of Trout 2 Years and Older/Mile
Pre-whirling disease	2200	1600
Post-whirling disease	500	500
% Decline	77%	69%

[1]Data for Pine Butte Section; source: Montana Whirling Disease Task Force, 1999 (www.whirlingdisease.org).

Epizootic ulcerative syndrome

The history of epizootic ulcerative syndrome (EUS) in South and Southeast Asia is well known to all fish health workers in the region, as this condition has been the major cause of losses of freshwater fishes for more than two decades (see Lilley *et al*. 1992, Roberts *et al*. 1994, Das 1997).

SOCIO-ECONOMIC IMPACTS

The socio-economic impacts of exotic aquatic animal diseases have been severe, and many instances involving freshwater fishes and brackishwater prawns are documented in other papers contained in this volume. An example of the impacts exotic diseases can have on rural communities is provided by EUS.

Among the diseases affecting freshwater aquaculture and capture fisheries in developing countries of Asia, EUS has had by far the most serious socio-economic impacts. These include direct economic losses to small-scale fishermen and aquaculturists due to high mortalities of wild and cultured fish, and indirect losses due to collapsed markets for fish, resulting in loss of employment opportunities to fish sellers, transporters, processors and those involved in selling supplies and equipment used by all these sectors.

Examples of the effects of this disease on local economies, and its severe impacts on rural fishing communities are provided for Bangladesh by Barua (1994) and for India by Das (1994). EUS was first confirmed in Bangladesh in 1988, before which such large-scale fish mortalities had never been seen in the country. The disease first appeared in irrigation canals in the Chandpur District, about 200 km from the Myanmar border, and may have occurred in water bodies in districts bordering Myanmar the previous year. The disease then spread in all directions, affecting the entire eastern and central parts of the country within nine months, then spreading northward during the flooding of September 1988. The first outbreak, which lasted 13 months, was followed annually by less severe outbreaks during October to March. EUS caused severe socio-economic impacts, including a sharp drop in the price of fish, as consumers avoided eating fish. As in other countries, this was based on unfounded fears that consuming EUS-affected fish would affect human health, causing illnesses ranging from skin lesions to death. The nature of the disease was irresponsibly reported by some sectors of the media, resulting in fear and confusion among the rural population. The result was a drop in demand and supply of fish by some 64.5%, with prices falling 50-75% in badly affected districts. Total economic losses due to EUS were estimated at $US3.38 million during the first outbreak and some $2.24 million during the second occurrence.

By May 1988, the disease had spread into the northeastern states of India (Das 1994), and by 1990 outbreaks had occurred throughout much of the country. As in Bangladesh, sectors dependent upon capture and culture of fish were severely affected. A study conducted in five districts of Kerala showed that EUS had completely disrupted the inland fish market. The economic situation of small-scale fishermen and fish vendors, many of them women, was particularly affected, farther marginalising this segment of the rural poor and forcing many to seek employment in the most impoverished sectors such as agricultural labourers, head-load and quarry workers etc. with little success. The disease also affected small-scale aquaculturists. In five districts of West Bengal, for example, 73% of aquaculture operations were adversely affected. Aquaculturists suffered direct losses due to mortalities in the ponds. Some 42% suffered losses of 31-40% of their stock, while another 25% had losses of between 21 and 30%. Additional indirect losses were also felt due to severely affected markets.

Similar scenarios have been played out in many of the developing countries in South and South East Asia (see Lilley *et al.* 1992, Roberts *et al.* 1994). Total losses due to EUS in the region are impossible to calculate with any degree of accuracy, however, estimates for only four countries (Thailand, Bangladesh, Sri Lanka and Nepal) for limited periods up to 1990 total more than $US15 million (see Lilley *et al.* 1992) (Table 5). A substantially larger estimate for Thailand is given by Chinabut (1994), who suggested that Thai losses due to EUS may exceed $US100 million.

Table 5. Some estimates of economic losses due to EUS.

Country	Loss (US$)
Thailand, Bangladesh, Sri Lanka, and Nepal (before 1990)	>15 million
Thailand	100 million
India : 1st Outbreak	3.38 million
2nd Outbreak	2.24 million

EFFECTS OF EXOTIC PATHOGENS ON BIODIVERSITY

It is only recently that the potential effects of pathogens on aquatic biodiversity have begun to be investigated. However, it is becoming increasingly clear, from both a theoretical and field perspective, that pathogens may determine aquatic community structure and regulate host abundance (see, for example, Marcogliese and Cone 1997, Marcogliese and Price 1997). Some of the effects of parasites (and of other pathogens) on their hosts, which may affect community structure and host abundance, include altered energetic demands, altered behaviour, increased mortality, reduced fecundity, altered nutritional status, reduced growth, modified interspecific competition, enhanced susceptibility to predation, altered mate choice and sex ratio (see Marcogliese and Cone 1997). It would thus seem logical that introduction of exotic fish and shellfish pathogens into new ecosystems may have far-reaching, if unpredictable, impacts on aquatic biodiversity.

The unanticipated results of transfer of stellate sturgeon infected with *Nitzschia sturionis* from the Caspian into the Aral Sea was the devastation of the local population of spiny sturgeon in the Aral Sea, which was depleted for more than two decades (see Bauer and Hoffman 1976). Another parasite, the monogenean *Gyrodactylus salaris*, believed to have been introduced from Sweden to Norway about 1975 as a result of movements of Atlantic salmon for stock enhancement, has been responsible for the complete destruction of more than 30 populations of Norwegian Atlantic salmon (Heggberget *et al.* 1993).

Because of its high pathogenicity to wild rainbow trout, whirling disease can pose a threat to genetic diversity by severely effecting local populations or strains. For example, Walker and Nehring (1995) provided the first account of a wild rainbow trout population in Colorado so severely affected by whirling disease that its continued existence as a self-sustaining fishery was seriously in doubt. Because certain strains of rainbow trout may have innate resistance to whirling disease, it is possible that genetic diversity could be reduced by the selective mortality of non-resistant populations. Also, the identification and use of resistant strains of trout as an enhancement strategy by fisheries managers might also, as a by-product, contribute to the reduction or extinction of non-resistant strains. Any such reduction in genetic diversity could lead to increased genetic homogeneity, reducing the ability of a species to respond to challenges posed by subsequent new pathogens.

Although more than 100 species of fish have been affected by EUS (see Lilley *et al.* 1992, Chinabut and Roberts 1999), some species are much more affected by the disease. Populations of snakeheads (*Channa striata*, and to a lesser extent other *Channa* spp.) are reported to be most severely impacted, such that during the outbreak of EUS that occurred in 1988 in Bangladesh, investigators were unable to find any healthy snakeheads in affected waters (Roberts *et al.* 1989). Other species considered to be highly affected by EUS include air-breathing fishes such as *Fluta alba*, *Trichogaster pectoralis*, *Mastacembelus armatus*, *Anabas testudineus*, *Clarias batrachus*, *Heteropneustes fossilis*, and the major carps (*Catla catla, Cirrhinus cirrhosus and Labeo rohita*). Although it seems likely that outbreaks of EUS have changed the population structure and perhaps, species composition of many water bodies in South and Southeast Asia, detailed quantitative studies have not been conducted. However, observations made my many workers suggest the effects on some species, such as striped snakehead, have been dramatic. For example, Barua (1994) noted that following the outbreaks of EUS in Bangladesh in 1988 and 1989 snakehead populations were so severely decreased that few fish were seen in local markets during this period.

Data given by Das (1994) comparing landings at the Jorhat Fish Assembly Centre in Assam for species of EUS-affected fish from the capture fishery in the Brahmaputra River system before (1987-88) and during the initial (1988-91) three years in which outbreaks occurred in India show declines for highly susceptible species of as much as 98% (Table 6). Species most severely affected included *Channa punctata, C. striata, Nandus nandus*, *Puntius* spp., *Amblypharyngodon mola*, *Labeo rohita*, *L. bata* and *C. cirrhosus.* Such data indicate that the fish population structure in this major river system was severely altered by the introduction of EUS.

Table 6. Impact of EUS on local abundance of highly susceptible species.[1]

Species	Decline in Landings (%)
Channa punctata	85-94
C. striata	82-88
Nandus nandus	82-97
Puntius spp.	64-90
Amblypharyngodon mola	37-71
Labeo rohita	49-63
L. bata	54-87
Cirrhinus cirrhosus	28-66

[1]Data from Das (1994).

HATCHERY ENHANCEMENT – PROBLEMS AND SOLUTIONS

The use of hatcheries to provide fry and fingerlings for stocking into natural waters and man-made ponds offers many potential benefits to rural communities. These include increased fish production, increased protein availability, increased and/or stable incomes for fishermen, fish sellers etc., and mitigation of losses caused by development due to dams, embankments for flood control, road ways, agriculture etc.

The use of hatcheries, as opposed to other means of stock enhancement (protection of habitat etc) has been the subject of much discussion (see, for example, LaPatra *et al.* 1999, Hilborn 1999, Waples 1999). Concerns include genetic issues (e.g., loss of intra-species variability, impacts on biodiversity through increased fishing pressure on less common species), ecological issues (e.g., effects due to habitat destruction, competition and predation) and diseases issues (introduction and/or spread of exotic pathogens). While there remain concerns related to genetic issues (i.e., "domestication" of wild stocks) that may be inherent in hatchery-based enhancement, issues surrounding possible pathogen introductions can, for the most part, be addressed by the careful use of existing protocols to insure that fish being introduced are free of potential pathogens.

The Bangladesh Situation

With regard to Bangladesh, many of the concerns related to introduced pathogens and to proposals for enhancement of native fish stocks expressed above may not come fully into play. Because Bangladesh shares major waterways with the neighbouring countries of India, Nepal and China, it is impossible to prevent the spread of diseases into the country from neighbouring countries by natural means (e.g., by movements of fish hosts or by water currents). Bangladesh is also subject to annual flooding, which permits almost unrestricted host movements throughout the country through interconnected waterways. As a result, most parasites and pathogens, once present in Bangladeshi waters, are likely to obtain widespread distribution by natural means. Also, this absence of natural boundaries probably leads to relative genetic homogeneity (i.e., an absence of races or stocks) of fish in these flood plain systems.

The proposed stocking of native species (major carps) using locally obtained broodstock should not pose major threats with regards to the spread of pathogens, as any pathogens infecting the offspring will be species which are already enzootic in the area. Finally, in a country suffering such severe pressures from population growth and for which flood control and water utilisation (dyking and damming) is a high priority for development, it may be impossible to retain pristine natural ecosystems. In such cases, hatchery-based enhancement may be the only practical way to increase or maintain food fish production.

Minimising Disease Concerns in Hatchery-based Enhancement

The following actions can be taken to minimise disease concerns in hatchery-based enhancement projects:

- Stock indigenous species or introduced species that are widely distributed and well established in local waters (avoiding the introduction of exotics, which may involve unacceptably high risk of introducing new diseases). Exotics or natives with limited or disjunct distributions often involve higher disease risks, while use of native or previously introduced species already having continuous distributions within the country will often intail lower risks

- Be intimately familiar with the disease profile of the species to be stocked, including a comprehensive study of the world literature (i.e, conduct a risk assessment!)

- Exercise proper sanitary measures during hatchery production, including:
  - comprehensive inspection and testing of broodstock (obtain broodstock from a certified source, if possible);
  - sound hatchery design to restrict entry of pathogens from outside sources; and
  - routine diagnostics and testing of fry and fingerlings

As previously highlighted, the inland fisheries of Bangladesh have recently been severely affected by epizootic ulcerative syndrome, a disease believed to be exotic to the country. There is no evidence to suggest that EUS has been disseminated in Bangladesh by stocking of hatchery-raised fry and fingerlings, or that hatchery enhancement would lead to increased outbreaks of this disease. In Bangladesh, there is ample possibility for disease dissemination by natural means, and, in fact, EUS already occurs widely throughout the country in many fish species.

CONCLUSIONS

Until recently, concern around the introduction and transfer of aquatic animal pathogens has centred mainly on their potential impacts on aquaculture. However, as shown by the devastating losses of wild rainbow trout in the western United States due to *Myxobolus cerebralis*, and of Atlantic salmon in Norway due to *Gyrodactylus salaris*, the potential for damage to capture and sport fisheries is at least as significant as that posed to culture operations. The following are some major points we believe should be taken into consideration when contemplating stock enhancement programmes in the developing countries of Asia:

- Introduction of a new (exotic) species should be considered as a completely separate issue within the context of enhancement. Appropriate protocols (e.g., ICES 1995) should be followed if introductions are to take place.

- In considering the possible disease impacts resulting from enhancement, it is important to differentiate between the use of introduced, exotic and native species.

- The socio-economic costs of inadvertently introducing a serious pathogen may far exceed the costs of rigorous measures to prevent pathogen introduction.

- The impacts of exotic pathogens cannot be predicted *a priori*. Species that are well tolerated by their normal hosts may be highly pathogenic to previously unexposed species.

- For inland water enhancement, there is a need for permanency in hatchery development. This permits establishment of quality broodstock and production avenues of known disease status and can eventually lead to reliable guarantees of freedom from specific pathogens.

- Fisheries managers and development agencies must take disease concerns more seriously than has been done in the past. If introduction or enhancement is worth doing, then it's worth the time, effort and money to adequately address disease concerns both before and after production.

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SOCIAL, ECONOMIC AND BIODIVERSITY IMPACTS OF EPIZOOTIC ULCERATIVE SYNDROME (EUS)

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ABSTRACT

Few surveys have been conducted that accurately assess the impacts of epizootic ulcerative syndrome (EUS) on fish populations and associated fishing communities. A review of past information on the disease is hampered by the fact that a pathology-based diagnosis of EUS was not used in most studies prior to 1994, and many accounts of ulcerative fish diseases in Asia may be unrelated. Data from the Bangladesh Flood Action Plan 17 (FAP17) Project, from October 1992 to March 1994, showed that 26% of 34,451 freshwater fish examined had lesions of some sort. A recent cross-sectional survey in Bangladesh revealed that 80% of 471 fish with lesions sampled from 84 sites were diagnosed as EUS-positive. This indicates that studies of EUS in Bangladesh that just examined fish with lesions were not grossly overestimating the prevalence of the disease.

Outbreaks of EUS have subsided in many areas, but new occurrences are being reported in previously unaffected areas and in newly developed farming and fisheries management systems. There is recent evidence that EUS does not always occur in seasonal outbreaks or always cause high mortalities, but may be prevalent at low levels throughout the year. It may, therefore, have an effect on productivity that cannot be measured in terms of mortalities alone. Communities that are heavily dependent on local fisheries have been affected by outbreaks of EUS. Social impacts may extend beyond persons directly affected by fish losses. Estimates of direct economic losses due to EUS-caused mortalities in several affected countries are given, and further estimates are calculated from recent survey data; however, losses due to lowered productivity may be of greater significance. Reduced aquaculture and fisheries production can be demonstrated during times of serious EUS outbreaks, although it cannot be positively determined that EUS was the factor that caused the decline. Anecdotal evidence suggests that during times of severe outbreaks highly susceptible species may be difficult to locate. The long-term effects on aquatic ecology have not been investigated.

INTRODUCTION

There is a great deal of anecdotal information on outbreaks of epizootic ulcerative syndrome (EUS) and extrapolated data on EUS-related losses, but relatively little survey data that provide actual randomised counts of mortalities or of fish with lesions. Even fewer studies have defined the lesions caused by EUS and confirmed the diagnosis in each case, or in a proportion of cases. Scientists at the Aquatic Animal Health Research Institute (AAHRI) in Bangkok, Thailand, the only diagnostic reference laboratory for EUS approved by the Office International des Épizooties (OIE), define an EUS case as: a fish with necrotising granulomatous dermatitis and myositis associated with hyphae of *Aphanomyces invadans*. This is a slightly modified definition of that given in Roberts *et al.* (1994), and requires processing of histological preparations with haematoxylin and eosin (H&E) and Grocott's stain in order to make a positive diagnosis (OIE 2000).

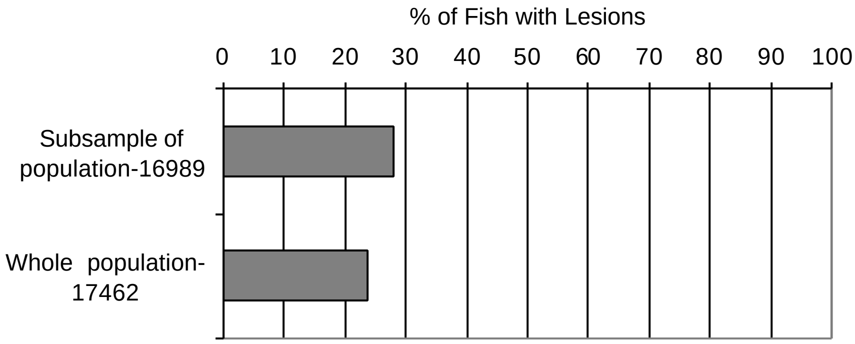
The severity of EUS outbreaks has subsided in many areas, but there remain occurrences of lesions on fish that do not fit with the conventional view of EUS, as they are not associated with large-scale fish kills. Nonetheless, a cross-sectional survey in Bangladesh conducted during the winter of 1998-99 revealed that 80% of 471 fish with clinical lesions, sampled from 84 sites, were diagnosed as EUS-positive (Khan and Lilley 2001). This indicates that EUS is still the largest cause of lesions on freshwater fish in Bangladesh, and that studies that just examined fish with lesions were not grossly overestimating the prevalence of the disease.

A review of some previous EUS surveys in Bangladesh is given here, indicating whether a diagnosis fitting with that given above was provided. These surveys give information on the social, economic and biodiversity impacts of EUS at that time.

EUS PREVALENCE SURVEYS IN BANGLADESH

The Bangladesh Flood Action Plan 17 Fisheries Studies and Pilot Project (FAP17 1995) accumulated data on the occurrence of lesions on about 35,000 wild freshwater fish. Summary of this data (Figs. 1-5 and Table 1) demonstrates a surprisingly high prevalence of lesions on these fish. More than half of the fish examined comprised the whole population of fish in the water body, which eliminates the danger of selecting sub-samples of less healthy fish (Fig. 1). Whole population samples had only a slightly lower percentage of lesions (24%) than population sub-samples (28%).

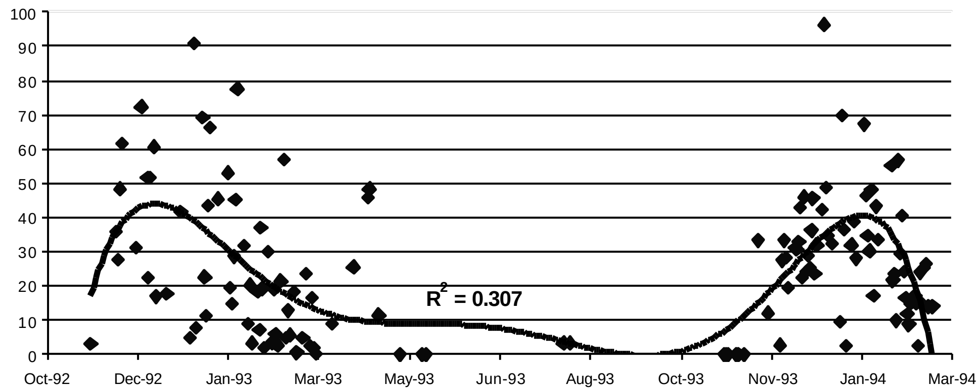
Figure 1. Percentages of fish with lesions grouped by sample type (sample size follows sample type).



The higher occurrence of lesions in winter (Fig. 2), and on species that are generally considered to be most EUS-susceptible (Table 1), provides further evidence that the lesions are predominantly the result of EUS infections. The prevalence data on individual species (Table 1) equate well with unpublished data collected by M.H.

Khan and co-workers on species affected during the 1998-99 winter period. The latter study confirmed which species were EUS affected.

Figure 2. Percentages of fish with lesions from October 1992 to March 1994 (only samples with more than 25 fish are plotted).



The FAP17 database includes comments on the severity of the infections in each sample. These were coded from X (mild) to XXXXX (severe lesion), and the average severity is given in Table 1. Again, the most affected species were those recorded as highly susceptible to EUS (e.g., *Puntius* spp., *Channa* spp. and *Mastacembelus* spp.). It is interesting to note any differences in susceptibility within genera for fish that are being considered as candidate species for aquaculture development. For example, *Puntius terio* is listed as one of the worst affected species, whereas no lesions were recorded on any *P. phutuio* sampled.

Some regional differences in the occurrence of lesions are given in Figure 3, although these cannot be accounted for by flooding or the other risk factors considered. Variations in lesion occurrence between habitat (Fig. 4) support findings by Khan and Lilley (2001) that EUS is less likely to occur in actively flowing waters.

Figure 3. Percentages of fish with lesions grouped by region (sample size follows region).

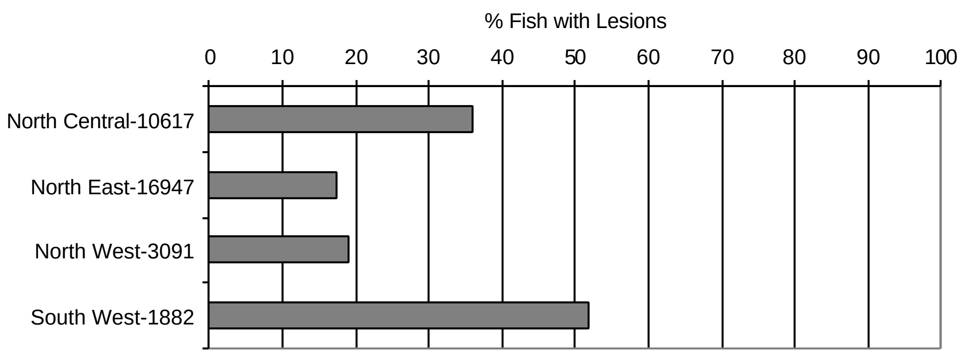
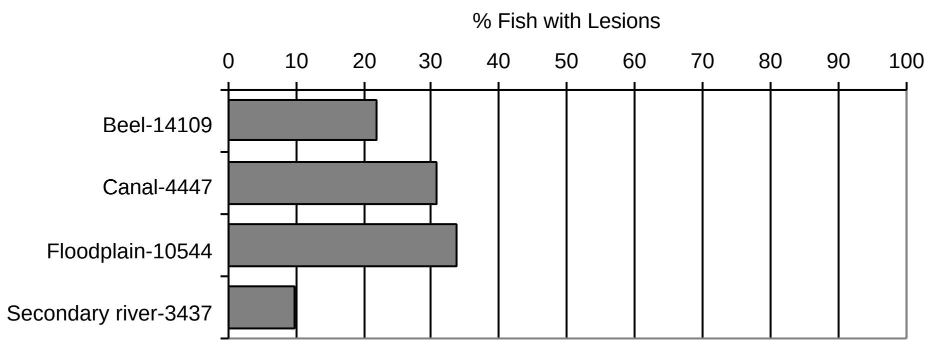


Table 1. Prevalence of lesions on 34,612 wild fish in Bangladesh (calculated from unpublished FAP17 survey data 1992-94, arranged in order of % with lesions).

Species	No. Examined	% Affected	Severity Index
Ailia coila	18	66.7	X
Channa striata	315	65.1	XXXX
Mastacembelus armatus	187	55.6	XXXX
Mystus vittatus	2603	53.9	XXX
Anabas testudineus	130	52.3	XXX
Puntius sarana	6	50.0	*
Wallagu attu	17	47.1	XX
Ailia punctata	11	45.5	X
Rhinomugil corsula	27	44.4	XXXX
Mystus tengara	796	44.1	XXX
Nandus nandus	154	40.9	XXXX
Cirrhinus ariza	5	40.0	* [1]
Puntius chola	712	38.8	XXX
Puntius terio	50	34.0	XXXXX
Puntius sophore	12368	33.4	XXX
Colisa lalia	12	33.3	XXX
Puntius ticto	122	31.1	XXX
Channa punctata	1614	30.7	XXX
Macrognathus aculeatus	231	26.4	XXX
Mystus cavasius	631	23.5	XX
Gangra viridescens	312	23.1	XXX
Channa marulius	123	21.1	XXX
Ompok pabda	15	20.0	XXX
Clarias batrachus	20	20.0	X
Puntius conchonius	986	19.5	XXX
Colisa fasciatus	829	19.3	XX
Salmostoma bacaila	47	19.1	X
Notopterus notopterus	43	18.6	XXX
Hyporhampus quoyi	6	16.7	*
Tetraodon cutcutia	49	16.3	XX
Xenentodon cancila	170	15.9	XX
Pseudeutropius atherinoides	28	14.3	XXX
Trichogaster chuna	170	13.5	XX
Mystus bleekeri	678	13.3	XXX
Chela cachius	8	12.5	*
Lepidocephalichthys guntea	723	10.1	XX
Osteobrama cotio cotio	183	9.3	XXX
Parambassis baculis	1886	8.5	XX
Heteropneustes fossilis	652	7.5%	XX
Macrognathus pancalus	1562	7.5	XX
Acanthocobitis botia	70	5.7	XX
Rasbora daniconius	190	5.3	X
Glossogobius giurus	1337	4.1	XX
Gudusia chapra	252	4.0	XX
Amblypharyngodon mola	244	3.7	XXX
Esomus danricus	57	3.5	*
Chanda nama	779	3.3	XX
Sperata seenghala	300	3.0	X
Salmostoma phulo	541	3.0	XX
Trichogaster labiosus	35	2.9	*
Parambassis ranga	873	2.6	X
Badis badis	41	2.4	*
Corica soborna	221	0.5	*
Puntius gelius	460	0.4	*
Rama chandramara	5	0.0	
Gagata cenia	7	0.0	
Sicamugil cascasia	9	0.0	
Botia dario	10	0.0	
Danio devario	13	0.0	
Pseudapocryptes elongatus	13	0.0	
Brachygobius nunus	15	0.0	
Labeo boga	18	0.0	
Johnius coitor	23	0.0	
Chaca chaca	26	0.0	
Ichthyocampus carce	36	0.0	
Somileptes gongota	44	0.0	
Neoeucirrhichthys maydelli	48	0.0	
Pellona ditchela	85	0.0	
Puntius phutunio	361	0.0	
Total/Average %	34612	17.5	

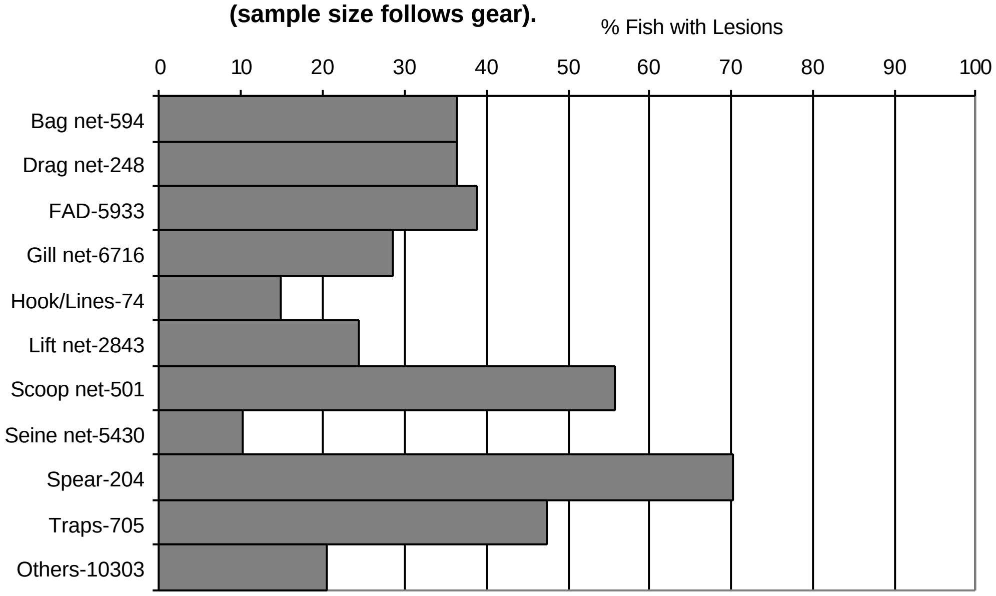
[1] Asterisk indicates that too few infected samples (≤3) were examined to calculate severity.

Figure 4. Percentages of fish with lesions grouped by habitat (sample size follows habitat)



As with the whole- versus sub-sample analysis (Fig. 1), the fish that were collected using less selective fishing methods (e.g., seine net) had a lower prevalence of lesions than fish collected using methods that were likely to select for weaker fish (e.g., spear, scoop net) (Fig. 5).

Figure 5. Percentages of fish with lesions grouped by fishing gear (sample size follows gear).



FAD = fish aggregation device.

A study of the prevalence of EUS in three floodplain areas was undertaken by Subasinghe and Hossain (1997) using a histological diagnosis of the disease (see Box 1). They showed that prevalence was generally lower in artificially stocked fish sampled from natural waters than in wild fish. It is unlikely that fry reared in hatcheries within Bangladesh pose a significant EUS risk to wild fish, as there are few accounts of EUS in carp hatcheries, and EUS has now been shown to be endemic in natural waterways throughout most of Bangladesh (Khan and Lilley 2001). It is the wild fish themselves that are considered risk factors for EUS. Khan and Lilley (2001) also showed that sites that were artificially stocked showed no significant association with occurrence of EUS.

Box 1. EUS surveys of wild fish in Bangladesh.[1]

- 26% of 34,451 fish examined had lesions, October 1992-March 1994 (FAP17 data).
- 0-23% of stocked fish and 2-37% of wild fish were affected by EUS in three floodplains, Decmber 1992-March 1993 (Subasinghe and Hossain 1997)[2].
- 0-9% of stocked fish and 0-11% of wild fish were affected, December 1993-March 1994 (Subasinghe and Hossain 1997)[2].
- 16% of 6,433 wild fish had lesions, November 1998-March 1999 (Khan and Lilley 2001)[2].

[1] All studies used random or whole-populations samples.

[2] A description of the pathology is also given.

There has been a decreasing occurrence of EUS in both wild (Box 1) and farmed fish (Box 2) in Bangladesh over the last 10 years. The reduced severity of outbreaks has been even more evident. EUS-affected ponds netted during initial outbreaks commonly revealed that certain fish species were 100% infected, with high rates of mortality (Barua *et al.* 1991, Ahmed and Rab 1995). These susceptible species now usually show lower rates of infection, and lesions often heal as temperatures rise

Box 2. EUS surveys of farmed fish in Bangladesh.[1]

- 68% of 200 ponds in Chandpur District in March–April 1988 were affected, often severely (Hossain *et al.* 1992).
- 50% of 234 carp ponds suffered EUS-type outbreak in 1991-92 (Ahmed and Rab 1995).
- 13% of 96 extensive and 7% of 522 intensive/semi-intensive carp farmers reported EUS in 1992-95 (ADB/NACA 1995).
- 16% of 6,401 farmed fish had lesions in November 1998–March 1999 (Khan and Lilley 2001)[2].

[1] All studies used random or whole-populations samples.
[2] A description of the pathology is also given.

(M.H. Khan and co-workers. unpubl. data). An ADB/NACA (1995) questionnaire survey of carp farmers in Bangladesh showed that 17% of extensive farmers and 53% of intensive and semi-intensive farmers reported resolution of the EUS problem from 1992-95 (see Tables 2 and 3). Similarly, Hossain (1998) reported that 85% of Thana Fisheries Officers (TFOs) indicated that the general aquatic animal disease situation improved from 1994-96, and that 91% of the TFOs indicated an improvement from 1996-98.

Table 2. Losses in semi-intensive and intensive carp farms reporting EUS from 1992-95 (source: ADB/NACA 1995, M.J. Phillips pers. comm).[1]

	% of All Farms Reporting EUS	% of Farms Reporting Disease that Consider It to be EUS	% of Farms Reporting Resolution of EUS Problem, 1992-94	National Loss Due to Disease (US$'000)	National Loss Due to EUS (US$'000)
Bangladesh	7	29	53	4,087	1,185
Cambodia	1	9	50	2	0.18
China	0	0	-	17,171	-
Hong Kong	0	0	-	89	-
India	7	37	77	7,035	2,603
Malaysia	0	0	-	1	-
Nepal	37	95	70	120	114
Pakistan	0	0	-	6	-
Thailand	0	0	-	49	-
Viet Nam	0	0	-	172	-
Average	5	17	63	2,873	976

[1]Does not include losses from diseases categorised as “unknown” or fungal diseases, and does not include cage culture.

Table 3. Losses in extensive carp farms reporting EUS from 1992-95 (source: ADB/NACA 1995, M.J. Phillips pers. comm).[1]

	% of All Farms Reporting EUS	% of Farms Reporting Disease that Consider It to be EUS	% of Farms Reporting Resolution of EUS Problem, 1992-94	National Loss Due to Disease (US$'000)	National Loss Due to EUS (US$'000)
Bangladesh	13	42	17	1,348	566
China	0	0	-	67,201	-
Hong Kong	0	0	-	-	-
India	7	29	50	5,684	1,648
Malaysia	0	0	-	-	-
Nepal	18	100	35	14	14
Pakistan	0	0	-	21	-
Philippines	0	0	-	-	-
Thailand	0	0	-	-	-
Viet Nam	0	0	-	292	-
Average	4	17	34	12,427	743

[1]Does not include losses from diseases categorised as “unknown” or fungal diseases, and does not include cage culture.

PRESENT STATUS OF EUS

Although EUS outbreaks have subsided in Bangladesh and other areas, new occurrences are being reported in previously unaffected areas, and in newly developed farming systems and fisheries management systems. A summary of recent outbreaks is given in Box 3.

The recent outbreaks show that EUS is not always strictly seasonal, or always causes high mortalities, but may be prevalent at a low level throughout the year. It may, therefore, have an effect on productivity that cannot be measured in terms of mortalities alone.

This year, several occurrences of EUS in juvenile giant gourami and climbing perch in Thailand have been confirmed at AAHRI. These have occurred at times outside the usual "EUS season."

EUS in Australia remains an important issue in estuarine wild fish and in cultured silver perch (*Bidyanus bidyanus*) in New South Wales, Queensland and the Northern Territory. The disease has occurred almost all year round and at

Box 3. Recent outbreaks of EUS.

- Widespread, low-severity occurrences in Bangladesh (1998-2000) (Khan and Lilley 2001).
- Snakehead and cultured carp in Punjab (1996) and Sindh (1998), Pakistan (S. Chinabut pers. comm.).
- High losses in community ponds in Tripura, India (S.N. Chakraborty pers. comm.).
- Cultured giant gourami, climbing perch and snakeheads, Thailand (1999) (S. Chinabut pers. comm.).
- Cultured silver perch, Australia (1998-99) (R.B. Callinan. pers. comm.).
- Wild fish in Luzon (1996) and Mindanao (1998-99), Philippines (J. Albaladejo unpubl. data).
- Wild and cultured snakeheads from Cambodia (L. Sophat pers. comm., Anon. 2000).
- Wild snakeheads and cultured carp from Terai and midhill regions in Nepal (1999) (S. Dahal pers. comm.)
- Wild and cultured snakehead in Vietnam (2000) (Phan Thi Van. pers. comm.)

prevalences of 20-90% in farmed silver perch (R.B. Callinan, unpubl. data).

In 1998, EUS occurred for the first time in the Philippine island of Mindanao (J. Albadladejo unpubl. data) Earlier, in January 1996, there was up to 30% prevalence in EUS-susceptible fish from both Laguna Lake and Mangabol Swamp in central Luzon.

SOCIAL IMPACTS

Communities that are heavily dependent on local fish catches have been most affected by outbreaks of EUS. For example, 10,650 fishing families are dependant on fisheries production from Batticaloa Lagoon in eastern Sri Lanka, and any fluctuations in catch levels have a severe socio-economic impact on the local community (P. Vinobaba, S.T. George and N. Kandasamy unpubl. data). Disease outbreaks have occurred in the lagoon in 1989, 1993 and 1994, and Vinobaba and Vinobaba (1999, and unpubl. data) clearly demonstrated EUS mycotic granulomas in samples of a number of lagoon fish species. P. Vinobaba and colleagues (unpubl. data) suggest that flooding and agricultural run-off may be risk factors for disease. They believe that there is an urgent need to protect and develop fisheries resources in Batticaloa District, which has 168,300 ha of inland waterways, and should be capable of sustaining the local communities.

Similarly, Laguna Lake and Mangabol Swamp in Luzon, Philippines support capture fisheries and pond and cage aquaculture. Some 75,000 people depend on fish from these areas as a source of food and income. EUS first occurred in Laguna Lake in 1985, and by 1992, the disease was considered the most important factor determining the size of the fish harvest. In 1989, over 50% of the harvest of susceptible fish was lost due to EUS; and in 1990, over 40% was lost (R.B. Callinan unpubl. data).

In Kerala State, India, Kurup (1992) reported that between the first appearance of EUS in August 1991, and by April 1992, the disease had caused serious loss of income to 25,000 full-time and 7,000 part-time fisherfolk.

Bhaumik *et al.* (1991) surveyed the effects of EUS on fish producers, traders and consumers in West Bengal (see Box 4). Virtually all of the farmers interviewed (97%) were allocated as having "marginal" or "small" farms. Of the EUS-affected farms, 48% were low-input traditional farms, compared to 35% that were described as "semi-scientific" and 16% as "scientific" farms.

The effect of EUS on traders and consumers was skewed towards poorer rural communities. A higher percentage of people from rural areas (53%) preferred the more susceptible snakehead and "miscellaneous fish species" compared with 18% of urban

Box 4. Summary of the study by Bhaumik *et al.* (1991).

- 73% of the 500 farms surveyed were affected by EUS.
- 71% of affected farms suffered losses of 20-40%.
- 78% of affected farms reported losses between Rs 1-10,000 (US$22-220).
- 96% of urban dwellers ate fish often before the EUS outbreak and 52% after the outbreak.
- 59% of rural people ate fish often before the EUS outbreak and 47% after the outbreak.
- 35% of rural people were prepared to eat diseased fish, but no urban dweller interviewed would do so.
- 77% of fish traders had decreased sales during the outbreak.
- 89% would not trade in diseased fish due to resistance from consumers.

dwellers. Fewer rural people were able to eat fish often, but after an EUS outbreak, demand for fish was not much reduced in rural areas, largely because prices were reduced (Box 4). Similarly, despite high consumer resistance to diseased fish, they were more likely to be bought in rural areas. Das and Das (1993) reported that women fish vendors suffered particular hardship after EUS outbreaks and often had to seek alternative employment.

In contrast to the above situations, other communities that do not rely heavily on susceptible fish have not been badly affected by EUS outbreaks. For instance, snakehead and other wild fishes in Punjab, Pakistan are not widely fished for local consumption. Of the freshwater fishes that are eaten in Pakistan, the preferred species are usually EUS-resistant common and Chinese carps.

The social impacts of EUS may extend beyond persons directly affected by fish losses. For example, one of the main constraints to aquaculture development in Nepal is an ongoing fear of disease, largely a result of previous EUS outbreaks. People are reluctant to start aquaculture activities due to the perceived high risk of disease and a lack of knowledge of how to deal with fish disease (Callinan *et al.* 1999). Conversely, Little *et al.* (1996) noted that in Thailand, the decimation of wild fish stocks, particularly snakehead, due to EUS in the early 1980s, was a major stimulus to the culture of herbivorous fish.

In Thailand, a questionnaire survey of snakehead farms is being undertaken to determine the present impacts of the disease. Mortalities in intensive snakehead culture accounted for most of the recorded economic losses due to EUS in Thailand in the 1980s. It is suspected that losses are currently not high, but one early reply stated that the farmer had given up the business due to disease problems in 1994, when significant EUS outbreaks occurred.

With regard to control of diseases in rural aquaculture, managing the risk of disease is usually a cheaper and more effective means of control than treatment. Gopal-Rao *et al.* (1992) pointed out that in Andhra Pradesh, an average of 10% of the production cost is spent on disease treatment. They called for an integrated approach to fish health by combining management techniques with chemotherapy.

ECONOMIC IMPACTS

Published estimates of direct economic losses due to EUS mortalities in several affected countries are listed by Lilley *et al.* (1998). Further estimates of economic loss during early outbreaks in Bangladesh are given by Hossain (1993), who reported that the 1988 EUS epizootic caused an average loss in each district of Taka (Tk) 405,960 (US$8,300); and by Collis (1993), who recorded the loss of 18 mt of fish at Tk 430,000 (US$8,800) from 240 ponds in six thanas between 1991-93. More recent estimates of the economic loss to carp culture in the region are given in a revised edition of the ADB/NACA (1995) data and are listed in Tables 2 and 3. Projecting future losses, the most conservative estimate of the cost of fish losses due to EUS in Australia, the Philippines and Indonesia until the year 2027 has been calculated at US$63 million (ACIAR 1998).

Freshwater aquaculture in Asia is generally not a major foreign exchange earner, and production is mainly for local or domestic consumption. Therefore, the more significant impacts of EUS on local micro-economies are probably not reflected within economic loss data.

As EUS lesions in most affected areas do not appear to be causing mortalities on the scale of previous outbreaks, it may also be the case that economic loss due to lower productivity is of greater significance than direct mortalities. A survey in Andhra Pradesh in the early 1990s combined the effects of disease-induced growth loss with mortality, in an estimated annual loss due to disease of 40 million Indian rupees (US$860,000) (Gopal-Rao *et al.* 1992).

There are further concerns for the future, as several countries in the region attempt to diversify the species used for aquaculture to include fishes known to be susceptible to EUS. For example, snakehead culture is being developed in southern India, and the associated dangers of EUS should be considered during this process (Callinan *et al.* 1999).

BIODIVERSITY IMPACTS

The idea that a pathogenic fungus can have significant biodiversity impacts on aquatic animals is not unique to the case of EUS. A very similar species of fungus, *Aphanomyces astaci*, devastated European crayfish populations at the end of the last century and, when it hit Scandinavia in the early part of this century, Sweden was transformed from the world's largest crayfish exporter to the world's largest crayfish importer (Swahn 1994). More recently, a chytridiomycete fungus has caused massive population declines and possible extinctions of amphibians. It is considered to be the single greatest cause of amphibian declines in the western hemisphere and Australia (Munkacsi 1999).

Outbreaks of ulcerative mycosis (UM) in the 1980s had a significant impact on the productivity of the estuarine fisheries of the eastern United States (Noga *et al.* 1988). Recent evidence indicates that the invasive *Aphanomyces* involved in those outbreaks may be *A. invadans*, the EUS fungal pathogen (Blazer *et al.* 1999).

Reductions in aquaculture and fisheries production can be demonstrated during times of serious EUS outbreaks. For example, within the past decade, India showed an increase in aquaculture production in every year other than 1990. Subasinghe (1997) speculated that this might be due to EUS losses in that year.

Data provided by Das (1994) on wild fish landings from the Brahmaputra River show massive declines in EUS-susceptible species at the time of first EUS outbreaks in that water system. Landings of *Channa striata* decreased by 88%, from 22 mt in 1987-88 to 3 mt in 1988-99, and remained at a similar level until 1991. Catches of *Channa punctata* declined by 85%, from 30 mt to 5 mt over the same period, and further declined to 3 mt by 1991. Data on one species that is not generally considered susceptible (*Gudusia chapra*) are given, and this showed an 880% rise in landings, from 0.1 mt to 0.9 mt over the period 1987 to 1989.

Similarly, scientists in Kerala are convinced that populations of susceptible fish have declined as a result of the EUS outbreaks, although no data were given (Callinan *et al.* 1999). However, it cannot be positively determined that EUS was the major factor that caused these declines in overall fish production.

Anecdotal evidence suggests that during times of severe outbreaks some susceptible species disappeared from fish markets altogether. In Bangladesh, *Channa* spp., *Nandus* spp. and *Mastacembelus* spp. were said to be difficult to locate in 1988-89, but Table 1 indicates that by 1992-94, reasonable numbers were being caught. *Puntius sophore*, a highly susceptible fish, appears to have been present in large numbers throughout the outbreaks.

CONCLUSIONS

- Randomisation and a pathology-based case diagnosis are essential for disease prevalence studies, and should be employed in studies monitoring EUS prevalence.
- There has been decreased severity and prevalence, but continued widespread occurrence, of EUS in Bangladesh and many other affected areas.
- EUS has continued to affect new areas and new systems.
- In Asia, EUS generally has more significant impacts in extensive, low-input systems and wild fisheries, than in controlled intensive fish culture.
- In South and Southeast Asia, rural traders and consumers are more affected than urban/suburban communities.
- Fear of disease is an important constraint to aquaculture development in some areas.
- Managing risk of disease losses from EUS is usually a cheaper and more effective means of control than treatment.
- EUS has probably affected the diversity of species in certain areas, but the long-term effect of this is unknown.

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HEALTH MANAGEMENT ISSUES IN FRESHWATER FISH HATCHERIES, NURSERIES AND FRY DISTRIBUTION, WITH EMPHASIS ON EXPERIENCES IN VIETNAM AND BANGLADESH

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ABSTRACT

An understanding of the status of fish seed production and marketing in various countries in Asia informs any analysis of health management issues. Rapid development of the sector by small entrepreneurs over the last few decades, and its concentration at certain favourable locations, may have either positive or negative impacts on the health status of fish seed. Key factors likely to affect health status are identified for hatcheries, nurseries and traders. Decentralised seed production approaches have most potential for minimising health management problems.

BACKGROUND

Freshwater fish seed supply in Asia is largely based on networks of small entrepreneurs that produce and deliver seed to farmers for stocking in ponds and ricefields. Most food-fish culture in the region remains semi-intensive, and farmers consider health issues to be relatively unimportant. In contrast, seed production is typically intensive, and health management of both brood and seed fish can be critical. Understanding people and their motivations within these networks is important if these health issues are to be tackled.

Sustainable rural aquaculture requires timely delivered, high-quality seed; the performance of food fish is related to both the quality of seed and their management post-stocking. Most seed used by smallholders is produced and delivered by the private sector, conservatively more than 90% in countries such as Bangladesh and Vietnam. Increasingly, as the quantity and availability of fish seed have improved, the quality has been questioned. Factors affecting the health status of fish seed available to farmers are complex and relate to both the knowledge of the various "actors" in seed networks and the broader environment, both physical and economic.

In areas where it developed in response to local demand, traditional aquaculture was based on wild seed. Current centres of seed production are often former sites of wild seed nursing and distribution. Typically, they are close to large rivers, from which hatchlings and fry were harvested, and to railways and, increasingly, roads that have facilitated their distribution. More recently, as the importance of seed availability in promoting aquaculture has become better appreciated, these centres have become nodes of demonstration and extension.

The modern hatchery sector in both Vietnam and Bangladesh is less than 30 years old, but is characterised by increasing levels of competition, declining prices and increasing diversification and specialisation. While an increased choice of species for rural farmers is beneficial, these production trends can negatively affect the quality of seed.

NETWORKS

The delivery of fish seed to farmers is preceded by their production and transfer through a network of "actors" responsible for different stages and processes. Fish, both brood and seed, are moved around using a variety of methods including motor vehicles e.g., trucks and motorcycles, and human power (bicycles and on-foot). Earthen ponds remain the main type of production unit, but tanks, usually brick or concrete, and cages, especially fine-mesh hapas, are important in the production and marketing of fish seed.

The human element of networks includes producers, final customers and traders of various types. The inputs required for producing fish seed are specialised and, where production is well established and concentrated, a range of service providers usually develops. These include people specialising in supplying hormones, especially pituitary glands, chemicals, feeds, cloth and small items of equipment. Harvest and transportation of seed and broodfish often also becomes a speciality, partly because of the necessary skills and equipment required. Enterprise "clusters" are typical for both hatchling and nursed-seed production, such as in Jessore and Bogra in Bangladesh; Gong Nam in Nong Khai Province, Thailand; and Hai Hung Province in Vietnam. In Bangladesh and Vietnam, separate, specialised producers carry out production of hatchlings and nursed fry. These may occur in distinct and separate locations, as different resources are required.

Broodfish are typically both held by the hatchery operator and purchased as required, depending on the species, size of hatchery and demand. The open nature of broodfish supply generally results in frequent transfers and mixing of different batches of fish, with consequences for genetic quality and the transfer of pathogens.

A major issue is the determination of whether underlying cause and level of losses in fish seed, which occur at each stage of production and delivery within networks, have any impact on their subsequent performance as food fish after purchase and stocking. In practical terms, poor management post-stocking could obscure real variation in fish seed quality.

MANAGING THE ENVIRONMENT – PATHOGEN-FISH BALANCE

The major components of management and environment that impact on health outcomes for fish include water quality, nutrition and the degree and quality of handling. The nature of fish-seed supply networks predisposes fish to disease. Handling of both brood and seed fish typically occurs frequently and in environments prone to change and extremes. This increases stress on fish and the likelihood of infection and disease. Moreover, declining profit margins encourage practices that increase seed output for a given level of resources (space, water, feed, labour) that exacerbate these problems. These trends towards more intensive practices, if not accompanied by improved management, may further affect the pathogen-fish balance, increasing the prevalence of disease.

SEED PRODUCTION

Hatcheries

Management of broodstock has critical impacts on the health status and subsequent performance of seed. A trend towards commercial hatcheries outsourcing broodfish has consequences for both genetic quality and the movement of pathogens. Broodfish management of this type entails little risk of inbreeding occurring provided that the genetic variation of initial stocks is sufficiently high.

Husbandry of broodstock, particularly during maturation of the gonads, is also likely to affect seed quality. Transportation and immediate induced ovulation of female *Clarias macrocephalus* have been shown to reduce the quality of hatchlings when compared to seed from broodfish maintained and matured in the hatchery (Ingthamjitr 1997). A trend in northern Vietnam, and elsewhere in the region, towards increasing carp broodstock density, for economic reasons, prior to induced spawning could also negatively affect seed quality (RIA 1/AIT 1999). Other factors identified by hatchery operators that might affect seed quality include increased frequency of spawning and out-of-season production, both of which may increase stress on broodfish and/or result in production of seed from immature gametes.

Induced spawning techniques themselves have also been associated with variable quality seed. Food-fish farmers in northern Vietnam believe that seed produced using pituitary glands are stronger than seed produced using LH-RH analogues and dopamine antagonists and are prepared to pay more for the pituitary glands. A recent field trial indicated that different hormone types can impact on the numbers and quality of seed produced (Pham *et al.* 1999). Handling stress associated with stripping gametes is known to reduce survival of broodfish, and natural spawning, where possible, is often preferred for this reason.

Collection and incubation of seed can result in high losses through poor design and management. Mixed batches of seed produced from multiple and small-batch spawners, such as tilapia and gourami, increase problems of cross infection by pathogens and competition/cannibalism between fish of different age classes.

Poor design of spawning and incubation systems, such as catfish (*Clarias*} egg collecting trays that do not allow efficient separation of hatchlings from eggs, and tilapia incubators that mechanically traumatise eggs, result in poor survival. Secondary fungal infections that follow primary bacterial disease or direct injuryrelated mortality are common in such systems. Effects on the quality of surviving seed have, however, not been quantified.

Maintaining good water quality throughout the spawning and incubation cycle is critical if hatcheries are to reduce losses due to pathogens, however, water shortages and costs have forced hatcheries throughout the region to innovate. Carp hatcheries in Bangladesh have increased the efficiency of hatchling production/volume of water by using antiseptics during incubation. This is partly because reduced profit margins over the last decade have stimulated operators to use more surface water rather than ground water, which is costlier to pump. In Bangladesh and Vietnam, where use of surface water is the norm, hatcheries use floating aquatic macrophytes to moderate water temperatures and reduce the level of suspended solids in hatchery water.

Nurseries

Production of carp fry and fingerlings in earthen ponds is the standard system throughout Asia. The key design features, in terms of enhancing survival and quality of the seed produced, are the availability of water and the ability to drain such ponds. Ponds that can be cost-effectively drained, rapidly and completely, will encourage sound management that maintains water quality and natural feed levels and prevents accumulation of predators and pathogens. Close proximity of large numbers of nursery operations or “clusters,” as with any aquaculture system, can result in greater likelihood of pathogen transfer and poor water quality.

TRADING

The trading of fish seed, as with other perishable commodities, imposes high risks on those involved. Minimum holding times benefit the individuals and organisations involved, and experience is quickly developed to "make the sale," rather than prevent deterioration in condition of the product *per se*. Often, especially as customers become more knowledgeable, these factors can become interdependent. In practice, itinerant vendors are the main suppliers of seed in the region, and farmers may have little experience in selecting high quality seed. The level of choice (i.e., the number of vendors that visit during any given season) varies dramatically, however, even within the same region.

There are many practical difficulties in maintaining fish seed in good condition. High ambient temperatures, long marketing chains and basic physical facilities are important constraints. Traders selling fish seed from fixed outlets at the same location have many advantages in maintaining fish-seed quality, as electricity and clean water may be accessed more easily.

Closed transportation, based on polythene bags inflated with oxygen, can improve quality, but will also impose limitations. Generally, motorised vehicles are required, and the amounts that can be transported are reduced; this increases the costs of seed transportation compared to open systems using aeration/oxygenation.

Marketing Fish Seed - Small Business Enterprises

The production and marketing of fish seed is increasingly characterised by concentrations of operations clustered closely together. Although this is typical of specialised small businesses in Asia, the phenomenon can have both positive and negative impacts on the quality of such a perishable commodity as fish seed.

Close proximity of sales outlets can allow knowledgeable customers to select for quality and price, increasing pressure on vendors to maintain quality. It can also encourage better information exchange and rapid dissemination of improved techniques and practice. Clusters of enterprises are also characterised by specialisation in knowledge and activity that can enhance consistency and quality of fish seed. These include specialists in pituitary gland extraction and preservation, harvesting of earthen ponds, management of incubation, selection and inducement of breeding fish etc. The availability of materials and equipment (e.g., pumps, nets and chemicals) that are otherwise scarce or expensive is also typically improved.

Fish-seed health can also be negatively affected in clusters of nursing operations through reduction in local water quality caused by pond effluents. Nursery ponds have shorter production cycles and are typically emptied and refilled more often than foodfish-producing units. The greater competition among neighbouring nursery operations can also lead to reduced profitability and investment, especially in terms of pond preparation and feeding. Perhaps most importantly, clusters of nursing enterprises inevitably result in long-distance marketing of fry and concomitant risks of transport stress and damage.

Local Production and Marketing of Fish Seed

The high fecundity of most cultured fish species means that even extensive seed production may suffice to meet local needs, especially when demand is highly seasonal. Temporary environments, such as ricefields and simple hapas suspended in water bodies can be used to produce large fish seed for the beginning of the main culture season. Such an approach has advantages in terms of low entry costs for poor farmers to move to seed production, and important consequences for quality, since seed needs to be distributed only over short distances. The likelihood of transport-induced stress and trauma is highly related to distance and duration of transportation. Pest and pathogen build-up and the need to use chemotherapeutants are also less likely with such seasonal, extensive practices. Local production of tilapias and small carps that are easy to breed has proved particularly successful. The potential constraints to basing fish seed supply on small, isolated breeding populations should be understood and counteracted. Development agents, whether government, non-government or commercial, could have important roles in overcoming such constraints. Knowledge of the issues and action by farmer-producers themselves as individuals or groups may ultimately be more important, however.

Promotion of decentralised seed supply runs counter to the specialisation and centralisation of seed production occurring in both Vietnam and Bangladesh. Indeed, the economies of scale, specialised knowledge and overall relative advantage of such clusters of seed production have been a major force for promotion of aquaculture in both countries. Promoting, within seed supply networks, appropriate technologies and methods for local people, can improve availability and quality of fish seed and improve the livelihoods of seed-producing farmers and their customers.

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ISSUES IN CARP HATCHERIES AND NURSERIES IN BANGLADESH, WITH SPECIAL REFERENCE TO HEALTH MANAGEMENT

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ABSTRACT

The results of a case study carried out in 180 hatcheries and nurseries in northeastern and southwestern Bangladesh over a 30-day period during August–September 1999 are presented. The objective of the survey was to study different aspects of management issues in small-scale carp hatcheries and nurseries, with special reference to their health management. Three Indian major carps (rohu, catla and mrigal) and three exotic carps (silver, grass and common carp) were the dominant fish species cultured in most hatcheries and nurseries. The average production for spawn in hatcheries was 844 kg/ha, while in nurseries the production depended on the size of fry, the average production being 1.722 million/ha, 1.339 million/ha and 0.837 million/ha, respectively, for early fry, fry and fingerlings. Average survival of spawn, fry and fingerlings in hatcheries and nurseries was reasonably high, varying between 74-82%. The study indicated that the major source of spawn for nurseries was hatcheries, while hatchery broodstock were mostly collected from the farmers' grow-out ponds. In general, hatcheries were more profitable than nurseries. Profitability of nursery operations appeared to be vulnerable, due the high variability in market price of fry and fingerlings. Hatcheries and nurseries provided full-time employment to the farmers. The average contribution of aquaculture to the household income of hatchery and nursery owners varied between 79.3% (nursery owners) and 95.1% (hatchery owners). Although hatchery and nursery operations were often family activities, they also generated employment for hired labour.

The major management problems faced by hatcheries and nurseries were due to disease, drought and flooding. Diseases were less prevalent in hatcheries than in nurseries. The major diseases reported in nurseries were white spot, tail and fin rot, epizootic ulcerative syndrome (EUS), sudden spawn mortality, gill rot, dropsy and malnutrition, while the major diseases reported in hatcheries were sudden spawn mortality and fish lice. The economic loss due to disease was about 7.6% of the profit. Gill rot caused highest economic loss to affected farms, followed by sudden spawn mortality, fish lice, EUS and malnutrition. The results of this case study indicate that disease is an important issue in hatcheries and nurseries, although direct economic losses are not significant at this stage and hatchery and nursery operations are both profitable enterprises.

INTRODUCTION

Fisheries and Aquaculture in Bangladesh

The contribution of fisheries to the gross domestic product of Bangladesh is 5.3% (M.R. Hasan unpubl. data). It is estimated that fisheries and its related activities support more than 7.0% of the country's population. The fisheries sector contributes about 6.0% of the export earnings, ranking third after jute products and leather. Fish account for about 6.0% of the *per capita* protein intake and contribute about 60.0% of the animal protein consumed throughout the country. The fisheries sector provides income for an estimated 1.5 million full-time and 11 million part-time fishers.

The inland-water resources of Bangladesh can be divided into the open inland waters, including rivers, streams, canals, estuaries, natural depressions (beels and haors)[1], Kaptai Lake and seasonal flooded lands; and the closed waters, including the ponds and tanks, baors[1] and brackishwater shrimp farms. During 1996-97, 1.31 million mt of fish were produced; of which about 1.0 million mt were obtained from the inland waters, contributing about 79% of the total fish production.

The open-water capture fishery contributed about 58% of the total inland production, and the remaining 42% came from closed-water culture fishery. The production from culture fisheries has been increasing since 1983-84, and its annual growth rate over previous years has varied between 4 and 20%. The contribution of culture fisheries to inland fish production was 16% in 1983-84, which had increased to 33% by 1996-97. During the period 1983-84 to 1989-90, the average rate of decrease from capture fisheries was 1.7%/yr, although a trend of increasing fish production has been registered since 1991-92, probably due to the large-scale, open-water stocking programme initiated by the Government of Bangladesh.

The projected target for fish production during 2001-2002 is 2.08 million mt, and it is anticipated that this goal can only be achieved through intensification of aquaculture and probably, through enhanced fisheries from floodplains. Both the intensification of aquaculture and enhancement of fisheries through open-water stocking will, however, require a sustainable supply of large-sized quality fish fry and fingerlings.

Status of Carp Hatcheries and Nurseries

Prior to 1990, most carp-seed production was derived from the collection of natural spawn from rivers. This situation was altered beginning in 1990, when a large number of hatcheries were established in different parts of the country. A comparison of spawn production from riverine sources and from hatcheries from 1988 to 1998 is presented in Table 1 and Figure 1. It is estimated that over 500 hatcheries have been established, and that they presently contribute about 97.6% of the total spawn production (Chowdhury 1999) (Tables 1 and 2). Of the total hatchery-produced spawn, 94.6% is contributed by private hatcheries and about 3.0% comes from public-sector hatcheries (Banik 1999) (Table 2). Therefore, the

[1]Beels are floodplain lakes, which may hold water permanently or dry up during the winter season; haors are depressions in floodplains located between two or more rivers, which function as internal drainage basins; while baors are oxbow lakes.

private hatcheries appear to play an ever-increasing role in fish production of Bangladesh.

Table 1. Comparative status of spawn production from riverine sources and hatcheries in Bangladesh from 1988-98 (source: Chowdhury 1999).

Year	Riverine Spawn (kg)	% of Total	Spawn Produced from Hatcheries (kg)	% of Total	Total Production (kg)
1988	12,533	68.8	5,697	31.2	18,230
1989	12,235	73.9	4,315	26.1	16,550
1990	5,128	28.3	13,014	71.7	18,142
1991	6,855	23.6	22,170	76.4	29,025
1992	9,342	22.0	33,072	78.0	42,414
1993	4,913	10.2	43,047	89.8	47,960
1994	5,871	10.7	49,000	89.3	54,671
1995	9,144	11.3	72,000	88.7	81,144
1996	2,399	2.0	116,212	98.0	118,611
1997	2,824	2.4	117,500	97.6	120,324
1998	2,885	2.4	118,100	97.6	120,982

Figure 1. Comparative status of carp seed production from riverine sources and hatcheries from 1988 to 1998.

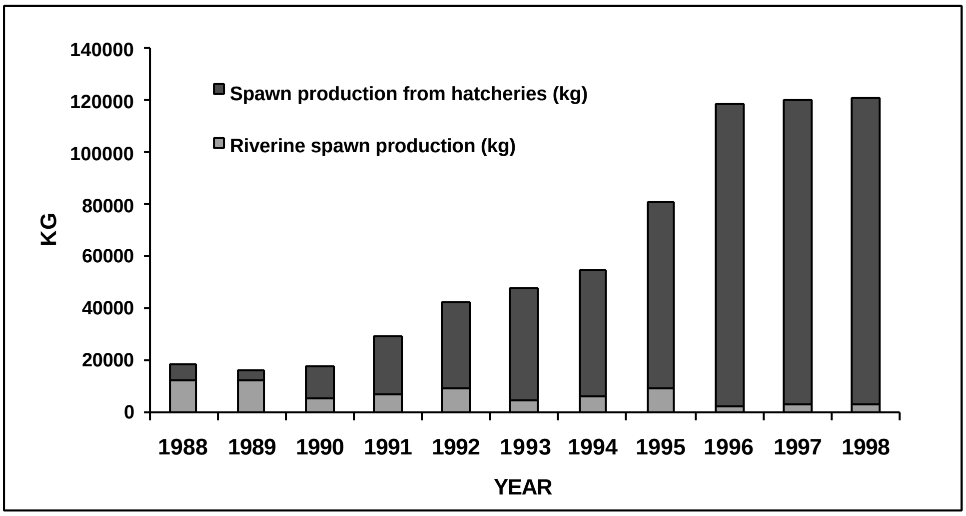


Table 2. Status of spawn production from riverine sources and hatcheries in Bangladesh during 1998 (source: Banik 1999).

Source of Spawn	Production (kg)	% of Total
Riverine spawn fishery	2,885	2.4
Hatcheries		
Government hatcheries/fish-seed multiplication farms	3,600	3.0
Bangladesh Fisheries Research Institute	100	0.1
Private hatcheries	114,400	94.6
Sub-total	118,100	97.6
Total	120,985	100.0

A carp hatchery is generally considered as a facility for producing carp fry and fingerlings suitable for stocking in grow-out ponds. The carp hatchery, therefore, incorporates broodstock ponds, a hatchery (indoor facilities for fish spawning and egg incubation) and nursery ponds for raising spawn to fry, and rearing ponds to rear fry to fingerlings. Although many hatcheries have combined hatchery and nursery operations, others only produce spawn that is sold to the nurseries for production of fry and fingerlings. Fry and fingerlings are subsequently sold from the combined hatchery/nursery or from the nursery to the pond owners, either directly or via fry traders.

In recent years, a large number of nurseries have been established in different parts of the country, due to the growing demand of large-sized fry and fingerlings for stocking in grow-out ponds or in open waters. It is estimated that about 3 billion carp fry and fingerlings are produced in the country, whereas the projected demand of carp fry and fingerlings for aquaculture, culture-based fisheries and floodplain stocking is about 4.25 billion (Chowdhury 1999).

Aquaculture in Bangladesh is mostly carp-based; with Indian major carps (rohu, *Labeo rohita*; catla, *Catla catla*; and mrigal, *Cirrhinus cirrhosus*) and exotic carps (common carp, *Cyprinus carpio*; silver carp, *Hypophthalmichthys molitrix;* and grass carp *Ctenopharyngodon idellus*) being the main species cultured. The three Indian major carps and three exotic carps are also the main species so used in culture-based fisheries in oxbow lakes (Hasan *et al.* 1999) and in enhanced fisheries in floodplains through open-water stocking (Ali and Islam 1998).

Diseases in Carp Hatcheries and Nurseries

Disease is one of the major constraints to intensification of aquaculture, and may eventually become a limiting factor to the economic success of the industry. In improved farming systems, nursery operators have a tendency to overstock fish, which ultimately causes disease. High stocking densities of fry and fingerlings during nursery operation generally increases stress, and subsequently, fish become more susceptible to infectious disease (Snieszko 1974). Fry and fingerlings are more susceptible to pathogens than are older fish because of their immature immune systems.

Parasitic diseases in nurseries are one of the most important factors limiting the growth and survival of fry and fingerlings. Gill myxoboliasis, caused by *Myxobolus* and *Henneguya,* has caused heavy losses in Indian major carps, mainly *Catla catla*, in Bangladesh. Hussain *et al.* (1994) reported that 61% of carp fry in nurseries of the greater Mymensingh District were infected with ectoparasites. The highest mortalities of carp fingerlings were due to the infection by *Trichodina*, *Myxobolus* and *Dactylogyrus*. Chandra *et al.* (1996) reported high prevalence of myxosporeans in juvenile Indian major carps (*L. rohita* and *C. cirrhosus*) in nursery ponds of Mymensingh. They reported severe gill infections caused by five species of the genus *Myxobolus*. Heavy mortalities of carp associated gill myxoboliasis have raised concern among Bangladeshi fish farmers (Chandra *et al.* 1996).

In Bangladesh, fry are also affected by gas bubble disease (Ahmed 1997), a result of water that is supersaturated with dissolved gases (N_2 and O_2). In hatcheries, the most serious diseases of eggs are caused by fungi (*Saprolegnia* and *Achlya*) (Ahmed 1997). Fry are also highly susceptible to microbial diseases.

Considering the important role of hatcheries and nurseries in providing a sustainable supply of quality fish seed for increased aquaculture and enhanced fisheries, a survey was initiated to study different aspects of management issues in small-scale carp hatcheries and nurseries, with special reference to health management.

MATERIALS AND METHODS

Data Collection

This paper presents the results of a case study carried out in some selected hatcheries and nurseries in the northeastern (Mymensingh) and southwestern (Jessore) regions of Bangladesh. These two regions were selected because the concentration of hatcheries and nurseries in these districts is much higher than in other regions of Bangladesh. The study was carried out over a period of 30 days during August-September 1999 using a structured questionnaire. The draft questionnaire was prepared by the Network of Aquaculture Centres in Asia-Pacific (NACA) Secretariat. Prior to the actual survey, the draft questionnaire was field tested by the authors in few selected hatcheries and nurseries at Jessore and Mymensingh, and necessary modifications were made based on the feedback received.

The questionnaire was divided into two sections. The first section had six parts: general description, description of operation, revenue, cost of production, household information and problems occurring. The second section focused on specific disease problems, their economic impact and management interventions used to control disease. This section was used only when the farmers reported disease problems in their hatcheries or nurseries. The first section contained 74 questions, while the second section contained 29 questions. Except for requests for some qualitative information, all questions were multiple choice.

Altogether, 180 hatcheries and nurseries were surveyed (Table 3). Only private hatcheries and nurseries were surveyed; government hatcheries and nurseries were excluded from the study in consideration of the fact that 94.6% of the total spawn is produced by the private sector (Table 2). Data were collected by the enumerators directly from the hatchery/nursery owners using the questionnaire. Three enumerators were employed for Mymensingh region and two for Jessore region. The types of farm surveyed included hatcheries, nurseries and combined hatcheries and nurseries. Data were analysed from 174 of the 180 farms surveyed (six farms were omitted because information obtained from them was incomplete). A detailed breakdown of the types and numbers of farms analysed is given in Table 3. The information collected during the case study covers the period of one year from January-December 1998. Prior to the field-testing, background information on the number, location and distribution of hatcheries and nurseries was collected.

Limitations

Enumerators tried to collect data as accurately as possible. However, in many cases, the farmers did not answer directly when they were requested to provide quantitative information and numerical figures for the revenues earned and the cost of production. For example, some farmers were unable to provide numerical figures for their total sales proceeds. In these cases, enumerators calculated the total sales proceeds from the quantity of fry and fingerlings marketed and the average sales price. Therefore, as these data were often derived from other related information and figures, in some instances, they may not be entirely accurate. Data were collected from the areas with the largest number of hatcheries and nurseries within both the Jessore and Mymensingh regions. Data collection is, therefore, somewhat biased and may not necessarily reflect the whole country. Nevertheless, the survey results should provide a precise picture of the status of carp hatcheries and nurseries, and reflect the relevant health management issues, as the farms were randomly selected from areas where the concentration of hatcheries and nurseries was highest.

Table 3. Type and number of farms analysed during the case study.

Region	Type of Farm	Number
Jessore	Hatchery	19
	Nursery	53
	Combined hatchery & nursery	12
	Total	84
Mymensingh	Hatchery	10
	Nursery	64
	Combined hatchery & nursery	16
	Total	90
Overall	Total hatchery	29
	Total nursery	117
	Total combined hatchery & nursery	28
	Total number of farms analysed	174

RESULTS AND DISCUSSION

Altogether, data from 174 farms (90 from Mymensingh and 84 from Jessore) were analysed. Indian major carps (rohu, mrigal and catla), common carp, and Chinese carps (silver and grass carp) were the dominant species cultured in most of the farms at both Mymensingh and Jessore. The other Indian major carp (orange-fin labeo, *Morulius calbasu*) was cultured in 13 and 55 farms in the Jessore and Mymensingh regions, respectively. Apart from the Indian major and exotic carps, Java barb (*Barbodes gonionotus*) was the other dominant fish species cultured at the farms of Jessore (n=73; 86.9%) and Mymensingh (n=81; 89.0%). Kuria labeo (*Labeo gonius*), a minor cyprinid, was cultured in 47 farms at Mymensingh (51.6%). Other species cultured included sutchi catfish (*Pangasius hypophthalmus*), African catfish (*Clarias gariepinus*), black carp (*Mylopharyngodon piceus*), reba (*Cirrhinus ariza*), clown knifefish (*Chitala chitala*), bighead carp (*Aristichthys nobilis*), various carp hybrids and Nile tilapia (*Oreochromis niloticus*).

Description of Operation

In Bangladesh, most intensive hatchery and nursery activities take place during June-December, although nursery activities often extend up to February. Generally, during or after February, farmers begin their pond preparation to start the new cycle of breeding and rearing. On average, the duration of the hatching cycle in hatcheries at both Mymensingh and Jessore was about five days and the number of cycles per year (June-December) was about 30. The hatchery cycle generally starts from the day when the broodstock are brought to the hatchery from the brood pond until the larvae absorb the yolk sac and the fry are transferred to the rearing pond or cement cistern from the hatching jar.

Nursery rearing of carp fry and fingerlings is generally carried out in three stages: a) early fry raising (spawn-early fry), b) fry raising (early fry-fry), and c) fingerling raising (fry-fingerling). The duration of the nursery cycle varies depending on the stage of rearing. The raising of early fry is, however, more common in Jessore, and the nurseries of Mymensingh generally do not produce early fry. The duration of the early fry-raising cycle varies between six to eight days, that of fry raising varies between 20-30 days, and that of fingerling raising between 90-100 days. On average, the total number of nursery cycles per year was 8-12. During early fry raising, spawn are raised up to 0.5-1.0 cm size; during fry raising, the fry are grown from 1.0 to 3.0 cm; while size ranges in fingerling raising vary widely between 3-15 cm.

Most hatchery and nursery owners in both the Mymensingh and Jessore regions had their own broodstock and nursery ponds. Many of the nursery owners also lease ponds from villagers. The study did not reveal any major difference in the number of ponds owned by the hatchery and nursery owners in these two regions. On average, the hatcheries had eight ponds with a total pond area of 2.06 ha, and the nurseries had, on average, seven ponds with a total pond area of 1.88 ha. Combined hatcheries and nurseries were larger, with an average of 10.5 ponds and an area of 6.74 ha.

Nevertheless, there was a large variation in total area between different hatcheries and nurseries. The maximum nursing pond area was 17.8 ha, and the minimum was only 0.06 ha. Forty-two percent of the nurseries sampled had a pond area of less than 1 ha. For hatcheries, the average area of ponds was 2.23 ha, with a minimum of 0.13 ha and a maximum of 9.93 ha. Forty-five percent of hatcheries had an area of less than 1 ha. For the combined hatcheries and nurseries, the average size was greater, with an average pond area of 6.74 ha. The maximum farm size was 43.71 ha, and the minimum was 0.82 ha.

The nursery owners were interviewed about their most likely sources of spawn and the hatchery owners about the sources of their broodstock. The source of spawn for nurseries was mainly from hatcheries (72.6 %); followed by wild caught (e.g., river - 13.7%), own grown (12.6%) and other farmers (0.5%) (Table 4). Similarly, the source of broodstock for the hatcheries was mainly from other farmers' ponds (41.3%), followed by own grown (16.3%), wild caught (16.3%), traders (11.5%), government and private hatcheries and other sources.

Table 4. Sources of spawn in the nursery and of broodstock in the hatchery as reported in the case study.

Nursery			Hatchery		
Source of Spawn	**Number**	**Percentage**	**Source of Broodstock**	**Number**	**Percentage**
Hatchery	127	72.6	Other farmers	43	41.3
Wild caught (i.e., river)	24	13.7	Own grown	17	16.3
Own grown	22	12.6	Wild caught (i.e., river)	17	16.3
Other farmer	1	0.5	Trader	12	11.5
Trader	1	0.5	Government hatcheries	6	5.8
			Other private hatcheries	3	2.9
			Other sources	6	5.8

In Bangladesh, the production of spawn is generally measured by weight, while the production of fry and fingerlings is measured by number. The average production from hatcheries and nurseries based on pond area was as follows: spawn 844 kg/ha, early fry 1.722 million/ha, fry 1.339 million/ha and fingerlings 0.837 million /ha.

Survival rates of spawn, early fry, fry and fingerlings in carp hatcheries and nurseries are given in Table 5. The average survival rates were higher for spawn (82%) and in fingerlings (81%) than for early fry and fry. The minimum survival for spawn, early fry and fry was 50%, and the maximum survival was 90-95%. There was more variation in the fry to fingerling stages, where survival varied between 20-97%.

Table 5. Survival rates (%) of spawn, fry and fingerlings in hatcheries and nurseries.

Category	**Percentage Survival**			
	Average	**Maximum**	**Minimum**	**Standard Deviation**
Spawn	82	95	50	11.2
Spawn – early fry	77	90	50	11.7
Early fry – fry	74	95	50	14.0
Fry – fingerling	81	97	20	17.0

Economics of Hatchery and Nursery Production

Fish spawn is generally sold by weight (kg), while fry and fingerlings are sold by number (thousands) in both Jessore and Mymensingh. Average prices for spawn, fry and fingerlings are shown in Table 6. Although there were variations in the price for different fish species, the information on average price was collected ignoring this species-wise variation. The average price of carp spawn was Taka 1154/kg, with the maximal and minimal price being Taka 1700/kg and Taka 750/kg. The average prices for early fry, fry and fingerlings were Taka 21, 112 and 1147 per 1000 individuals, respectively. There appears to be large variation in the minimum and maximum price of fry and fingerlings (Table 6). The minimum price of 1000 fry was Taka 40 and the maximum price was Taka 1000. Similarly, the maximum and minimum prices of 1000 fingerlings were Taka 3000 and 50. This shows that the market prices of fry and fingerlings were very much dependent on demand, and that the market demands are highly variable.

Table 6. Average price of spawn, fry and fingerlings in hatcheries and nurseries.

Category	Price (Taka[1])			
	Average	Maximum	Minimum	Standard Deviation
Spawn (Taka/kg)	1154	1700	750	204
Early fry (Taka/1000)	21	50	10	8
Fry (Taka/1000)	112	1000	40	95
Fingerlings (Taka/1000)	1147	3000	50	734

[1]1 US $ = 49 Taka.

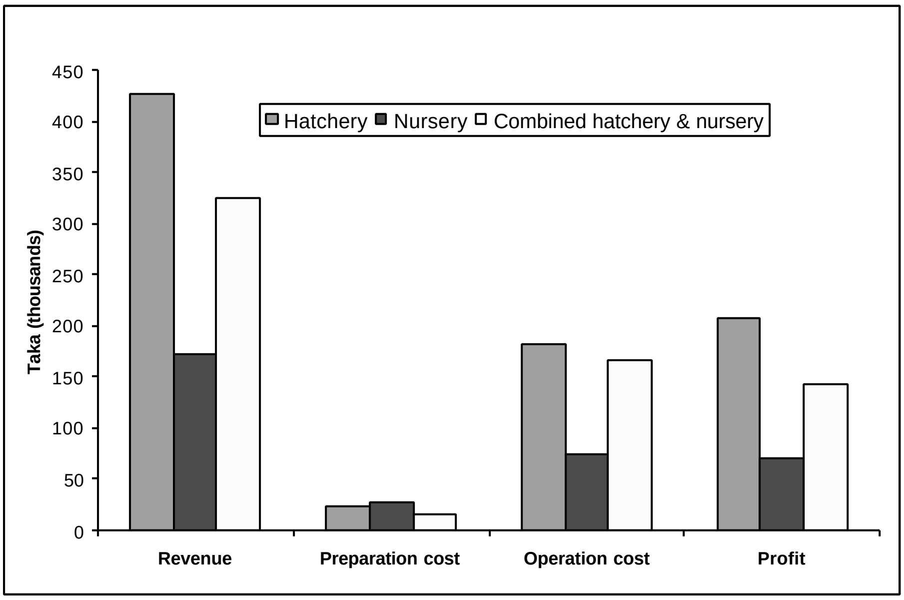
Average revenue, cost and profit with their standard deviations are shown in Table 7. The costs are highly variable, as is evident from their large standard deviations. In general, costs of operation are higher than preparation costs for all the three production systems studied. Although operational cost was lower for nurseries than for hatcheries and combined hatcheries/nurseries, the revenue earned and profit were also lower for nurseries than for the other two systems (Fig. 2). The average profit per ha water area was Taka 206,300 for hatcheries, while that for combined hatcheries & nurseries was Taka 142,300). The high variability in the market price of fry and fingerlings (Table 6) probably reflects the large fluctuation observed in the revenues earned by the nurseries. The average revenues for nurseries were Taka 172,200/ha.

Table 7. Revenue, cost and profit in hatcheries and nurseries.

Category	Taka (thousands/ha)			
	Revenue	Preparation Cost	Operation Cost	Profit
Hatchery	427.5 (±304.0)[1]	24.3 (±27.6)	182.2 (±366.2)	206.3 (±187.6)
Nursery	172.2 (±796.7)	26.7 (±28.9)	74.5 (±204.2)	71.0 (±45.8)
Combined hatchery & nursery	325.1 (±442.8)	15.4 (±13.5)	167.4 (±679.1)	142.3 (±177.4)
Average	237.4 (±241.8)	24.6 (±27.1)	106.9 (±394.0)	104.6 (±120.7)

[1]Values in parentheses are ± standard deviation of mean.

Figure 2. Revenue, cost and profit in hatcheries and nurseries.



Household Information

The average per caput income was highest in combined hatcheries/nurseries (Taka 78,746), followed by hatcheries (Taka 69,332) and nurseries (18,482) (Table 8). Although the average per caput income is reasonably high, especially for hatcheries and combined hatcheries/nurseries, the income is highly variable. The average contribution of aquaculture to household income is reasonably high, contributing from 79.3% (nursery) to 95.1% (hatchery). The contribution is, however, highly variable, especially for nursery and combined hatchery/nursery systems (see Table 8). The average number of persons in each household for the three systems varied from 7.5 to 10.

Table 8. Household income, percentage contribution of aquaculture in household income, and number of persons for different farm systems.

System	*Per Caput* Income (Taka)				% Contribution from Aquaculture			No. of Persons
	Ave[1]	Max	Min	SD	Ave	Max	Min	
Hatchery	69,332	646,919	2,273	134,980	95.1	100	49.3	9
Nursery	18,482	128,929	980	15,488	79.3	100	8.2	10
Combined	78,746	441,176	9,300	98,027	83.5	100	15.0	7.5
Average	36,165	646,919	980	72,299	80.9	100	8.2	8

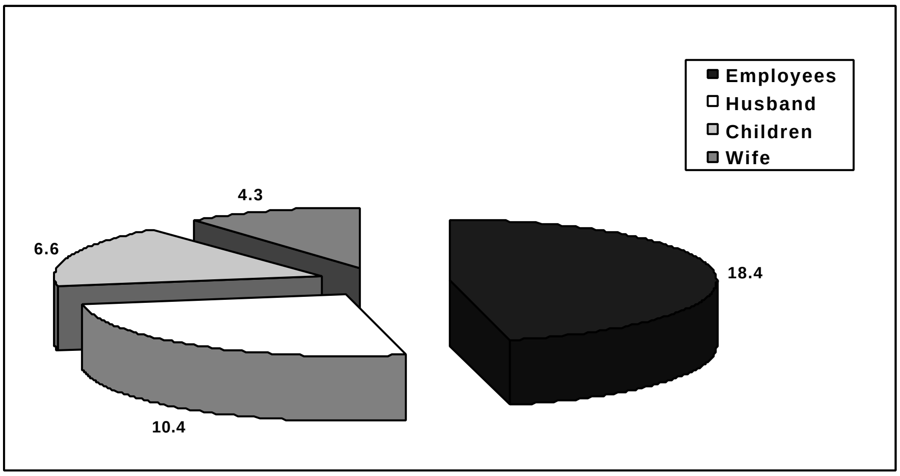
[1]Ave=average, Max=maximum, Min=minimum, SD=standard deviation.

Apart from aquaculture, other economic activities of the farmers included paddy cultivation (most common), followed, in order of importance, by livestock raising, vegetable growing and fruit gardening. On average, the involvement of farmers in aquaculture was 9.7 yr. When farmers were asked to rank the reason for taking up aquaculture activities, 79.3% (138 of 174) responded that the cash income was the main reason, followed by employment (20.7%; 36 of 174). Few farmers ranked food, hobby or status as the main reason for their aquaculture activities.

The study also revealed that most of the hatchery and nursery owners are highly dedicated to their farming activities, as 170 out of 174 farmers (97.7%) responded that they spent most of their time in aquaculture as compared to other activities such as paddy cultivation, other crops, livestock raising etc. Farmers often share their farming activities with their wives and children (Fig. 3). Study of the breakdown of time spent by the family members of hatchery and nursery owners shows that the husband spent about 10.4 hr, followed by the children (6.6 hr) and wife (4.3 hr). However, hatchery and nursery activities may be comparable to a small-scale, rural agro-based industry, rather than with small-scale rural aquaculture. The use of hired labour is quite high (average 18.4 hr/day) in hatcheries and nurseries (Fig. 3). This shows that hatcheries and nurseries are generating some form of employment in rural areas.

When the farmers were interviewed about the sources or the agencies from which they learned about aquaculture, the majority responded that they learned the techniques from other farmers (28.6%) and neighbours (24.5%), followed by government training courses (21%). About a fifth of the farmers (19.7%) responded that they were self-taught. Government training courses appeared to have a much better extension effect in comparison to non-governmental agency (NGO) training courses (2.1%).

Figure 3. Breakdown of time (hr) spent by family members of hatchery and nursery owners.



Problems Faced by Farmers

Sound health management practice is a key to success in any hatchery or nursery operation. In both the study areas, hatchery and nursery operators mentioned several problems they encountered in their operations. When ranking problems, 51 farmers (29.3%) mentioned the occurrence of disease as their major problem, while 48 (27.6%) ranked shortage of water was their major problem (Table 9). Other problems faced by the farmers were flooding, theft and extremes of temperature (too hot or too cold). In addition, some of the farmers mentioned lack of finance, frequent hartals (general strikes) and bad road communication as their major problems. Altogether, 118 (67.8%) and 133 (76.4%) of the farmers mentioned disease and shortage of water, respectively, as one of their problems (Table 9).

Table 9. Ranking of problems faced by hatchery and nursery operators.

Problem	Rank 1		Total Responses	
	Number	Percentage	Number	Percentage
Disease	51	29.3	118	67.8
Shortage of water	48	27.6	133	76.4
Flooding	24	13.8	65	37.4
Theft	4	2.3	35	20.1
Too hot	2	1.1	66	37.9
Too cold	0	0	7	4.0

Disease Problems

When ranking their problems, 118 farmers (67.8%) mentioned that they encountered diseases in their farms (Table 9). However, when specifically asked, 69% of the farmers said that they considered disease to be an important issue in hatcheries and nurseries. Disease was reported to be a more of a problem in the hatcheries and nurseries of the Mymensingh area, than in those of the Jessore area. The percentage of farmers reporting disease was 67%, 83% and 90% in hatcheries, nurseries and combined hatcheries/nurseries, respectively, in the Mymensingh area, while in the Jessore, area it was 61%, 54% and 0%, respectively. When the three production systems are compared, slightly more nurseries (72.9%) reported disease as one of their problems than did hatcheries (62.1%) or combined hatcheries/nurseries (66.7%).

The diseases reported were white spot (16.7%), tail and fin rot (16.3%), epizootic ulcerative syndrome (EUS) (12.9%), sudden spawn mortality (12.2%), fish lice (10.9%), gill rot (6.1%), dropsy (6.1%), malnutrition (5.4%), air gulping (4.1%), deformed larvae (1.7%) and others (7.5%) when the occurrence of disease in both study areas was combined (Fig. 4). As reported by several authors (e.g., Ahmed 1987, Hussain *et al.* 1994, Chandra *et al.* 1996), the diseases are caused primarily by parasites, fungi, bacteria and nutritional deficiency. However, in contrast to earlier reports, gas bubble disease of fry and fungal infection of carp eggs were not reported to be major problems in the hatcheries and nurseries covered in this survey. The occurrence of the most common diseases in the Jessore and Mymensingh regions is shown in Figure 5. Except for fish lice and white spot, the other diseases (e.g., tail/fin rot, gill rot and dropsy) were recorded in more farms in Mymensingh than in Jessore.

Figure 4. Occurrence of diseases (%) in carp hatcheries and nurseries.

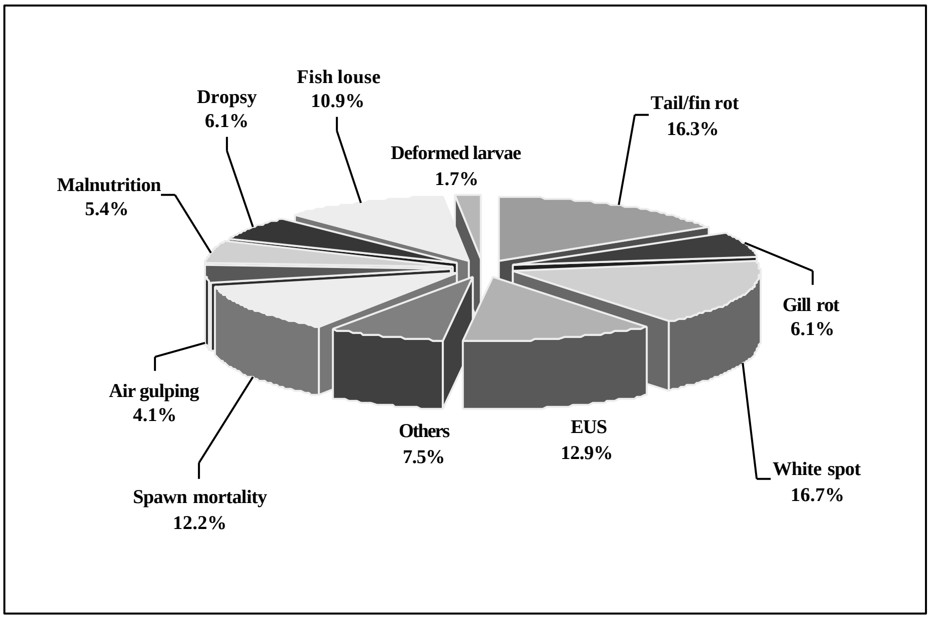
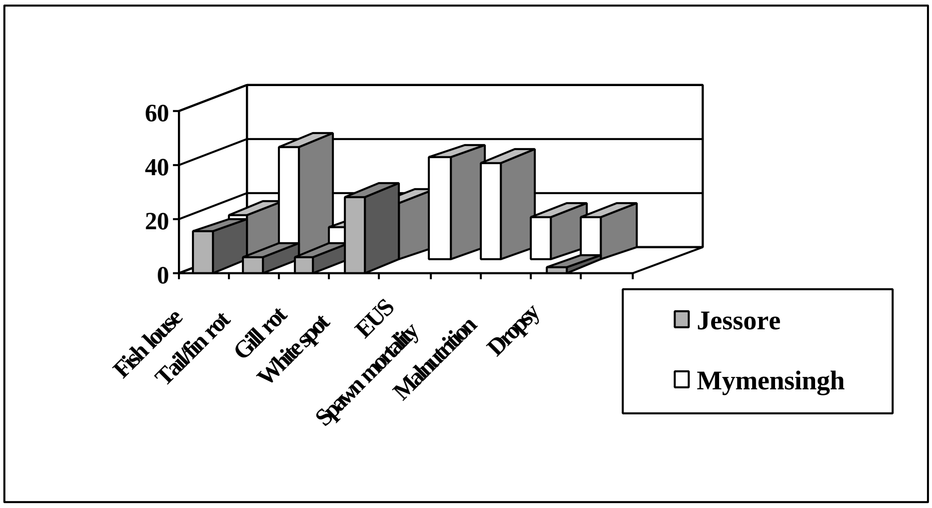


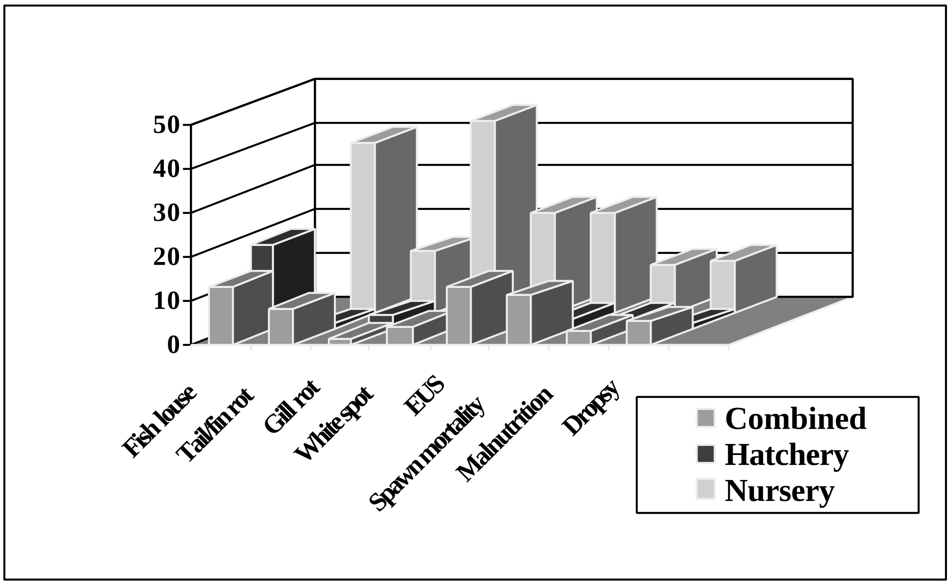
Figure 5. Disease problems (number of farms) by region.



In Mymensingh, 40% of the farms (36 of 90 farms) reported sudden large-scale mortality of spawn. The reason for this sudden spawn mortality was unknown. Some of the farmers thought that a sudden sharp rise of water temperature in hatcheries and nurseries might be the cause. However, many of the farmers observed that sudden spawn mortality and the occurrence of deformed larvae are more common for spawn produced late in the breeding season. Hatchery owners often produce spawn three to four times using the same broodstock. Presumably, this practice deteriorates the larval quality and eventually results in deformed larvae and sudden mortality. Hussain and Mazid (1997) and A.S. Sardar (pers. comm.) reported reduced growth rate, physical deformities, diseases and high mortality in hatchery-produced carp seed, and they identified improper broodstock management, unconscious negative selection of broodstock, unplanned hybridisation and inbreeding as the probable reasons behind this reduced performance. EUS, sudden spawn mortality and malnutrition were not reported in Jessore. As commercial hatchery and nursery activities started much earlier there than at Mymensingh, this difference may be due to better experience in farm management by the farmers of Jessore.

When the occurrence of the most common diseases was compared by system (e.g., hatchery, nursery and combined hatchery/nursery system) (Fig. 6), there are, in general, more problems reported in nurseries, followed by combined hatcheries/nurseries and then hatcheries alone. An exception was recorded with fish lice (argulosis), which is slightly more prevalent in hatcheries. In both the hatcheries and nurseries in both the study areas, diseases occurred more frequently during the hot season (April-May), followed by the rainy season (June-July) and then the winter (December-January).

Figure. 6. Disease problems (number of farms) by system.



Farmer Response to Disease Problems

One hundred and sixty-six of 174 farmers responded that they had faced disease outbreaks in their farms. When asked if they had ever attempted to treat their fish during an outbreak of disease, nearly all farmers (97.0%, 161 of 166 responses) replied that they had used some form of treatment. Most of the farmers of both the study areas attempted preventive and curative treatment measures, and only a negligible percentage of farmers (1.2%) harvested and marketed their products. A few farmers (1.8%) did nothing during disease outbreaks in hatcheries and nurseries.

Farmers in both study areas used different treatments such as chemicals and antibiotics, water exchange and manipulation of feeding and fertilisation. Use of chemicals ranked highest (98.1%, n=158), followed by stopping of fertilisation (31.7%, n=51) and feeding (28.6%, n=46), water exchange (27.3%, n=44) and use of antibiotics (15.5%, n=25). Insecticides and pesticides are often used for chemical treatment e.g., sumithion and malathion are commonly used to treat against fish lice on broodstock. Fifteen percent of the farmers had complete recovery from diseases as a result of treatment, whereas 31% had usually had recovery, 59%

sometimes had recovery, and 4% never had recovery. Farmers engaged in hatchery and nursery businesses appeared to be well informed about their problems, in comparison to farmers engaged in other aquaculture activities. Most of the farmers have a good understanding of the diseases problems, and apparently, most (87.7%, n=142) have the ability to recognise some of the diseases, while 16 farmers (9.9%) reported that they were able recognise most of the diseases.

Impact of Disease Problems

The impact of disease in hatcheries and nurseries was measured by fish mortality, economic loss, and also, if the farmers had changed their attitude due disease problems. In most facilities (66%), diseases caused partial loss of fry and fingerlings; only 7% of hatcheries and nurseries reported total loss of their stock, while 27% of the farmers reported no loss due to disease. For individual disease outbreaks, farmers reported varying losses. In hatchery and nursery operations, the following average mortalities were reported: malnutrition (55%), air gulping (43%), dropsy (42%), EUS (39%), sudden spawn mortality (38%), gill rot (34%), tail & fin rot (34%), argulosis (23%) and white spot (21%).

Ninety-one percent of the farmers (n=149) reported reduced fish price at the market and a subsequent reduction in household income as an impact of disease. A certain number of farmers (64 of 149) reported that an increase in debt resulted from disease outbreak, although this appears not to be a major impact of disease. Although disease was one of the major problems in hatcheries and nurseries, most farmers expressed their desire to continue aquaculture. There was no evidence of any change of attitude to aquaculture, and no farmers stopped aquaculture or changed species.

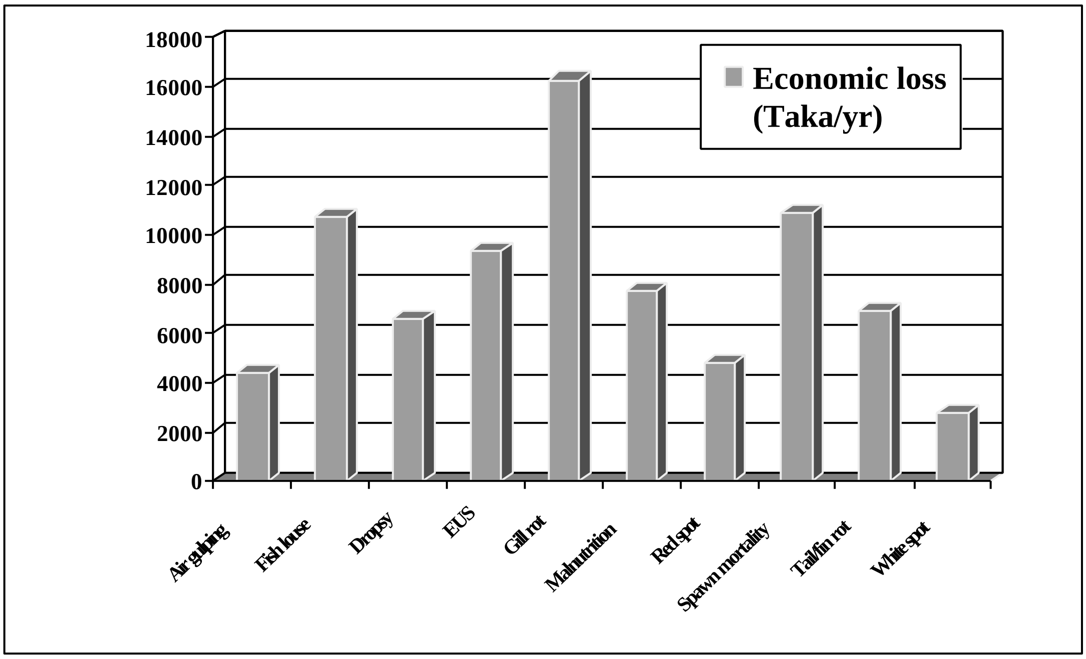
The economic losses reported by the farmers due to disease are presented in Figure 7. Gill rot caused highest losses, followed by sudden spawn mortality, fish lice, EUS and malnutrition. Other diseases causing considerable economic losses were tail/fin rot, dropsy, red spot, air gulping and white spot.

The average economic loss from diseases on those farms reporting disease was Taka 8062/ha/yr. However, the extrapolated loss for all 174 farmers included in the study was Taka 6275/ha/yr. The reported cost of treatment in hatcheries and nurseries was Taka 1669/ha/yr. The average profit was Taka 104,575/ha, and the loss due to disease was approximately 7.6% of the profit.

Sources of Disease Information

A majority of the farmers (57.7%, 75 of 130) contacted a government extension officer for help, guidance and suggestions when their hatcheries or nurseries had a disease outbreak. Farmers also contacted other hatchery owners (52.3%, n=68), other farmers (44.6%, n=58) and drug and chemical salesmen (11.5%, n=15). Apparently, the government extension officers provided the most useful information (42.3%, n=55) followed by other hatchery owners (27.6%, n=36), other farmers (16.9%, n=22) and drug and chemical salesmen (6.2%, n=8).

Figure 7. Reported economic loss of the farmers due to different fish diseases for affected farms.



SUMMARY

- Three Indian major carps (rohu, catla and mrigal) and three exotic carps (silver, grass and common carp) are the dominant fish species cultured in most hatcheries and nurseries. The other dominant fish species cultured are orange-fin labeo, Java barb and Kuria labeo.

- Hatcheries continue to be the major source of spawn for the nurseries, while hatchery broodstock are mostly collected from the farmers' grow-out ponds.

- Average survival of spawn, fry and fingerlings in hatcheries and nurseries is high, varying between 74-82%.

- In general, hatcheries are more profitable than nurseries. The high variability in market price of fry and fingerlings tends to make nursery operations more vulnerable in terms of profitability.

- Hatcheries and nurseries provide full-time employment to the farmers. The average contribution of aquaculture to the household income of hatchery and nursery owners varies between 79.3% (nursery owners) and 95.1% (hatchery owners).

- In general, rich farmers, own hatcheries, while nurseries are owned by small- to medium-scale farmers.

- Although hatchery and nursery operations are often family activities with labour shared by the husband, children and wife, they also generate employment for hired labour. The average use of hired labour in hatcheries and nurseries is about 18 hr/day.

- In comparison to other small-scale, rural activities, access of hatchery and nursery owners to government extension services is reasonably good.

- Disease, drought and flooding are the major management problems in hatcheries and nurseries. Diseases are less prevalent in hatcheries than in nurseries.

- The major diseases reported in nurseries are white spot, tail and fin rot, EUS, sudden spawn mortality, gill rot, dropsy and malnutrition, while the major diseases reported in hatcheries are sudden spawn mortality and argulosis.

- The prevalence of disease is less in Jessore than in Mymensingh. This regional difference may be due to the farmers of Jessore having more experience in farm management than their counterparts at Mymensingh.

- The economic loss due to disease is about 7.6% of the profit. Gill rot causes highest economic loss to affected farms, followed by sudden spawn mortality, fish lice, EUS and malnutrition.

CONCLUSIONS AND MAJOR ISSUES

- Disease is an important issue in nurseries, although direct economic losses are not significant at this stage.

- In spite of a certain amount of loss due to disease, hatchery and nursery operations are both profitable enterprises.

- Although it cannot be quantified from the present data, hatchery and nursery operations generate employment for certain groups of labourers.

- In comparison to other aquaculture sectors, hatchery and nursery operators are generally aware of their problems and appear to have better access to government extension services.

- Nursery operations appear to be vulnerable, in terms of profitability, due the high variability in market price of fry and fingerlings.

- Hatchery owners often produce spawn three to four times by using the same broodstock. This practice appears to cause deterioration in larval quality.

- Inbreeding is quite common in most of the hatcheries, and hatchery owners do not exchange broodstock among themselves to maintain genetic diversity.

- Indiscriminate use of insecticides and pesticides as treatment measures may, in the long run, pose environmental hazards.

ACKNOWLEDGEMENTS

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THE IMPACTS OF RED SPOT DISEASE ON SMALL-SCALE AQUACULTURE IN NORTHERN VIETNAM

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ABSTRACT

Small-scale aquaculture plays an important role in livelihoods in rural areas of Vietnam. The main cultured species are Chinese carps (*Ctenopharyngodon idellus*, *Hypophthalmichthys molitrix* and *Aristichthys nobilis*), Indian major carps (*Labeo rohita* and *Cirrhinus cirrhosus*), common carp (*Cyprinus carpio*) and tilapia (*Tilapia* spp.). A disease, the causative agent of which has not yet been identified, but known in Vietnam as "red spot disease" (RDS) because of the presenting signs, which are similar to those of epizootic ulcerative syndrome, is causing significant economic loss. This disease is the major constraint to improving output from freshwater aquaculture in Vietnam.

The objective of this study was to provide an overview of RDS in Vietnam and the socio-economic impacts on small-scale fish farming in the north of Vietnam. A total of 145 farmers in Thai Nguyen and Bac Ninh provinces, representing highland and lowland aquaculture systems, were interviewed using a questionnaire provided by the Network of Aquaculture Centres in Asia Pacific (NACA), and the Epi-Info[2] software program was used to analyse the data. Findings from the study confirmed that grass carp is the most susceptible species to RSD and, out of 81.4% farmers who had disease problems during the growing cycle, 83.1% had this disease problem. The disease has a severe negative socio-economic impact in both lowland and highland small-scale aquaculture systems in the north of Vietnam. It appears to have a seasonal pattern, occurring mainly in March-April and October-November. The findings also showed that government extension officers have been working very closely with fish farmers to assist in controlling this disease. However, farmers have very limited knowledge of disease prevention and control In order to improve this situation, there is a pressing need for more training in basic disease recognition and fish health management for both farmers and extension officers. Research to identify the aetiology of RDS, investigate its epidemiology and find methods for prevention and control is also required. If successful, the experience would serve as a useful model on which to build improved aquatic animal health management in small-scale aquaculture systems in Vietnam.

[2]EpiInfo is a specialised program for epidemiological analysis and is distributed free by the Centres for Disease Control, Atlanta, Georgia, USA. A copy can be obtained from their website at http://www.cdc.gov.

INTRODUCTION

Freshwater aquaculture production in Vietnam has increased from 111,157 mt in 1988 to 369,000 mt in 1997 (FAO 1999), an increase in tonnage of more than 330% in a decade. Freshwater aquaculture is dominated by small-scale systems, such as household integrated farming systems (VAC system), rice-fish, cage culture in rivers and reservoirs and culture-based enhancement reservoir fisheries. The main freshwater cultured species are Chinese and Indian major carps and tilapia. Production from freshwater aquaculture is mainly used for local, domestic consumption.

A disease, the causative agent of which has not yet been identified, known in Vietnam as “red spot disease” (RSD), is the major constraint to improving the output from freshwater aquaculture. It causes significant economic loss and presents signs similar to those of epizootic ulcerative syndrome (EUS).

In this paper, the history of RSD in Vietnam is described and the findings obtained from a questionnaire survey to evaluate the impact of the disease on small-scale aquaculture systems in two northern provinces are presented.

HISTORY OF RED SPOT DISEASE IN VIETNAM

RSD was first reported in grass carp (*Ctenopharyngodon idellus*), common carp (*Cyprinus carpio*) and (*Hypothalmichthys molithrix*) in 1962 in Ninh Binh Province (Ha 1995). Since then, it has spread to almost all northern provinces of Vietnam. The disease is characterised by the presence of one or more red, circular lesions on the body of affected fish. In 1973 and 1976, RSD outbreaks were also reported in catfish in the Cuu Long River Delta (Bui *et al.* 1992), in 1981 in Nghe An Province, and in 1982 in Da Nang and Hoang Lien Son Province (Ha 1992). From 1983 to 1984, RSD was reported to have infected grass carp, bighead carp (*Aristichthys noblis*), common carp and snakehead fish in the Cuu Long River Delta. In 1986-1994, RSD was widespread in cage-cultured grass carp. In 1994-1998, RSD was reported to be prevalent in pond culture.

SOCIAL AND ECONOMIC IMPACTS OF RSD

Little information is available on the impact of RSD between 1962 and 1982. During the outbreak of 1983 in the Cuu Long River Delta, mortalities amounted to 20-30% of the total fish production from cage culture. In Tuyen Quang Province, between 1986-1987, an RSD outbreak forced the farmers to stop growing grass carp in all of the 339 cages. In early 1993, due to an overabundance of labour, farmers again started cage culture of grass carp. An outbreak of RSD occurred again and affected 357 of 390 cages. This time, mortalities were low and farmers maintained fish production, although levels were not as high as expected. In 1994, the disease re-occurred, causing 70-80% mortality and reducing the number of cages in use to 100. During 1993-1994, the disease appeared to have a seasonal pattern, occurring mainly during the wet season from May to August (Ha 1995). In 1992, RSD affected 42 of 43 grass carp cages in Hoa Binh Province, causing a 100% loss. In the Da River in 1988, 80 of 100 cages were affected by RSD, also causing severe losses (Bui *et al.* 1992).

In the Hanoi region, cage culture has developed substantially since early 1993, with 619 grass carp cages in the Red, Duong, Nhue and North Hung Hai rivers. From October 1993 to 1994, 105 cages in the Red River were affected by RSD, causing high mortalities. Thirty cages in the Duong River were also affected, and there were several infected cages in the North Hung Hai and Nhue rivers. Due to this disease, the number of cages in the Hanoi region was reduced to 238 by the end of 1994, and in 1996, the number of cages in use was insignificant (Truong *et al.* 1996). The disease affected not only cage culture, but also pond culture. In Coloa, Dong Anh District, the disease caused a significant loss in broodstock farms. Around Gialam Airport, the disease resulted in losses of nearly 100% in seed production in 1995 (Bui *et al.* 1998).

In what was then known as Ha Bac Province, now divided into Bac Ninh and Bac Giang provinces, the first outbreak occurred in 1988-1989 in broodstock, causing a drop of 30-40% in seed production. Since then, the disease has occurred annually. In Mao Dien District, known as the "cradle" of seed production in the lowland region in the north of Vietnam, almost all fish farmers have changed to other activities due to severe losses caused by RSD (Bui Quang Te, pers. comm.).

In the centre of Vietnam, including Nghe An and Thanh Hoa provinces, RSD has been reported to cause losses of 30-40%.

RSD has caused heavy mortality in grass carp in Thai Nguyen Province, with the highest mortality (90% to 100%) being in Phu Binh District. In general, during the period of 1995-1997, in the north of Vietnam, 80% of the 5,000 or so cages and 80-90% of ponds were affected by RSD, resulting in severe losses estimated at more than US$500,000 (RIA 1 1998).

SURVEY METHODS

Survey Area and Samples

The survey took place in two provinces during August 1999: Thai Nguyen and Bac Ninh, representing both highland and lowland aquaculture systems. These provinces were once part of Bac Thai and Ha Bac provinces, respectively, but have since been separated.

Bac Ninh is a lowland province with a population of 920,460 people, 797,854 of whom are engaged in agriculture (including aquaculture). Bac Ninh has a long experience in aquaculture, such as seed production, nursery, grow-out and fry trading (Nguyen 1998). Bac Ninh has five districts and one town, all of which have aquaculture activities. Two of the districts and the town are considered to have a higher standard of living than the rest. Gia Luong and Que Vo districts were randomly selected as representing districts of higher and lower standards of living, respectively (ranking by Agricultural Extension Officer).

Thai Nguyen is a highland province where 390,000 of a population of 1,019,299 are engaged in agricultural activities. Five of nine districts/towns are considered to have a lower standard of living than the other four. Thai Nguyen town and Dai Tu District were randomly selected as representing higher and lower standards of living, respectively.

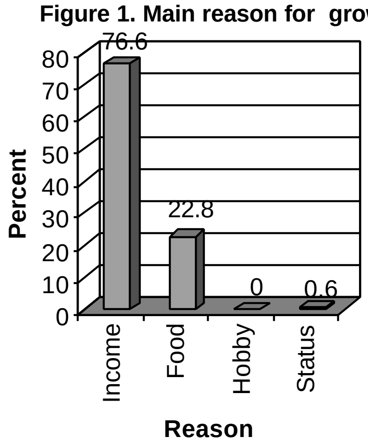
A total of 145 farms in seven villages located in DaoVien, Phuong Mao (Que Vo District) Trung Chinh, Phu Luong (Gia Luong District) Tan Thai, Tan Lap (Dai Tu District) and Thinh Dan (Thai Nguyen town) were visited. Data were collected from farmers using a questionnaire provided by the Network of Aquaculture Centres in Asia-Pacific (NACA). The questionnaire was divided into two sections. The first section contained six parts (General, Description of Operation, Revenue, Cost of Production, Household Information and Problems Occurring), while the second section focused on specific disease problems.

Data Analysis

"EpiInfo," a data management and analysis programme, was used to analyse the data.

Other sources of data, taken from reports of the local extension centre and extension staff and from talks with farmers, have also been used in compiling the results of the survey.

Figure 1. Main reason for growing fish.



Case Study Approach

The survey covered only pond aquaculture systems. Farmers are involved in growing or nursing fish, but some also practice a combination of these two activities.

Poverty ranking, based on family income, was carried out by extension officers. There was only a very slight difference between groups with low and high standard of living; this is because most freshwater, small-scale farmers in northern Vietnam are poor.

Survey Limitations

Not all the questions were completed, as some farmers were not able to provide reliable answers, especially for those questions where numerical answers were required.

In addition, some interviews were attempted at a time when the national football team was playing, and this was broadcast on television. Consequently, some farmers refused to be interviewed, or did not concentrate on the interview. In some cases, this problem was overcome, either by waiting until the football match was finished or by arranging to visit at another time. This pointed out the importance arranging interviews at times that suited the farmers.

RESULTS

Description of Small-scale Aquaculture Systems

All respondents had pond culture systems, and the main culture species were grass carp, common carp, silver carp, mrigal and rohu (*Labio rohita*). Grass carp is the most popular cultured species because of the low investment cost and also, because family labour can be used. Cash income was considered the main reason for growing fish by 76.6% of farmers. Food consumption by the family was considered the main reason for growing fish by 22.8% of farmers surveyed, while only 0.6% of farmers were growing fish because of status. None of the farmers was growing fish as a hobby (Fig. 1).

In general, growing rice and livestock were the main activities supporting the farmers; however, other activities such as growing vegetables and fruit also provided income. The farmers in Dai Tu District of Thai Nguyen Province were able, due to geographic differences, to pursue another activity, tea growing, which was a significant source of income for the family. Most of the farmers did grow-out of fish, while some of them also nursed fish for fry production. Nursing requires a lot of labour to take care of the fish, and therefore, larger families carried out this activity.

HEALTH PROBLEMS

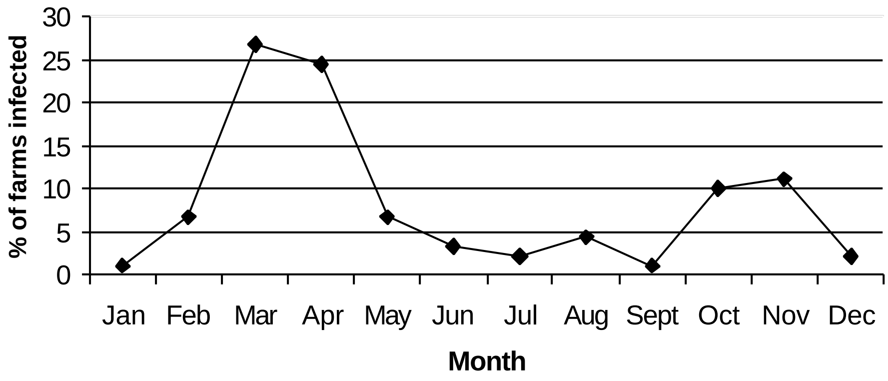
The most important issues affecting farmers were disease (65.8% of the farmers surveyed mentioned disease as the most important problem), insufficient water (15%), theft (8.6%), and flooding (5.7%). Other responses (predation, water temperature too hot or too cold, unidentifed) made up the remaining 4.9%. It has to be noted that most of the farmers do not have a water inlet and outlet canal, they, therefore, depend on rain or ground water supply. More than 8% of farmers considered theft the most important constraint; these farmers will have to invest either money or time in prevention (e.g., by building a fence).

Disease affected 81.4% of farms surveyed. Of these, 83.1% reported that their fish had been affected by RSD, 11.9% by unknown diseases, 4.2% by parasitic diseases and 0.8% by fungal diseases. Insecticides may have caused the unknown diseases that were reported, since they were reported to occur just after rain. This is especially likely in Thai Nguyen Province, a mountain province with fishponds located in the valley and where tea is grown on the sides of the mountain. Farmers very often apply insecticides to the tea bushes and, when it rains, the insecticides are washed into the ponds, causing the death of the fish. These unknown diseases could also be caused by parasites.

The signs of RSD disease are haemorrhage, red spots on the body, scale loss, swollen vent and darkened skin. Grass carp were the species most frequently reported to be affected by RSD, although in some farms mrigal and rohu were also infected. In those two species, no red spots were seen on the body of the fish, but they tended to have dark skin. The size of fish affected by RSD varied.

From the survey, RSD appeared to have a seasonal pattern, occurring mainly in March-April and October-November (Fig. 2).

Figure 2. Time of occurrence of red spot disease.



EMBED

Of the farmers interviewed, 60.4% said that they could choose the fry they purchased. Of the farmers interviewed, 92.7% said that they had access to healthy fry and only 7.3% said that they received unhealthy fry. Farmers check fry by visual examination, making a judgement about their health based on personal understanding of the movement and colour of the fry.

Poor water quality was considered by 84.5% of farmers as the cause of RSD. Other suggestions were bad food (5.6%), too little water (2.8%) and cold water (7%). All farmers thought that cold water contributed to the occurrence of the disease, probably because their fish were affected by RSD during October-November. Due to shortage of water and capital, (water exchange is expensive, using rented water pumps with additional cost for gasoline), very few farmers cleaned their ponds after every crop, even when the previous batch of fish had a disease problem. Only in Tan Thai Village (Dai Tu District) could farmers readily change water between crops, as it is located near a reservoir with a canal that provides easy access.

SOCIAL AND ECONOMIC IMPACTS OF RSD

Of the farmers interviewed, 88.3% considered that their crop did not perform as well as expected, 3.5% considered it did as well as expected and 7.7% did not know. Only one farmer considered that the farm performed better than expected. The reason he gave was that he was able to sell by-catch fish caught when harvesting. Normally by-catch fish can be harvested from every pond, however, there are not usually saleable.

In farms where RSD occurred, it caused an average loss of 45.2% of production (range of 5-100%, SD=24.2). The total in 1998 for the 58 farmers who answered the question was 71,170,000 VND (US$5,120). Average percentage contribution from aquaculture to the total household income was 38.4% (SD=18.7), which excluded fish consumed by the family (on average each family consisted of five persons).

For those farmers facing disease problems, there was a decrease in the market price of fish leading to a reduction in household income. However, 95.4% of farmers considered that disease did not cause an increased household debt, even though they were poor, as they had not borrowed any money from the government.

It was very clear that RSD caused losses that affected the household income. Despite this, farmers still tended to continue with aquaculture activities because they still considered that aquaculture was profitable (see Table 1). In this situation, “profitable” means some income from selling fish, some fish for food or additional income from family labour. Very few farmers changed to growing rice in fish ponds, since farmers perceived this as a short-term alternative crop, with aquaculture remaining as their main goal for ponds. Farmers considered that rotation between rice and aquaculture was an innovative idea, and by changing crops, they hoped that pathogens remaining in the pond soil would be destroyed. Insecticide or herbicide residues were not considered as a possible cause of problems in aquaculture. There are few other choices for farmers, and they are not able to leave their ponds empty. A number of farmers reported that, if they did not have a good yield in the present year, they would change to rice growing the following year. This was because they saw that people who grew rice in the ponds were sure of good rice production. However, they again stressed that ponds were better for fish growing, and they would continue to grow fish in their ponds, with rice as a crop in alternate years.

Table 1. Changing attitude to aquaculture caused by disease.

Question: Did the disease change your attitude to fish farming?	**Yes (%)**	**No (%)**	**No Idea (%)**
Resistance to continuing aquaculture	24.8	49.0	26.2
Stopped aquaculture	2.1	73.1	24.8
Changed species farmed	15.9	57.9	26.2
Reduced importance of fish on the farm	18.6	52.4	29.0
Stopped promoting fish farming	11.7	51.0	37.2

Changing fish species was not popular among small-scale farmers because, as discussed above, grass carp do not require a big investment and require minimum labour, such as that provided by children after school. While taking care of the buffalo, grass can be cut for the fish; therefore, grass carp is still the main species for their pond. Some farmers tend to change the ratio of fish species grown; for example, some farmers have increased the proportion of tilapia in the ponds. However, at the moment, sex-reversed tilapia culture is not popular among small-scale farmers in the north of Vietnam.

A general picture of aquaculture in rural northern Vietnam is shown in Table 2.

Another issue for farmers was the use of antibiotics to treat RSD. Among the farmers using antibiotics, 85.7% eat sick fish. There is, therefore, a risk in these communities of consumption of fish containing antibiotic residues that may lead to development of antibiotic resistance in human bacterial pathogens.

Table 2. General picture of aquaculture in rural northern Vietnam.

Question	Agree (%)	Do Not Agree (%)	No Idea (%)
Aquaculture is a risky venture	25.5	59.3	15.2
Aquaculture is profitable	95.9	1.4	2.8
Aquaculture has high status	22.8	55.9	21.8
Aquaculture is only profitable for large-scale farmers	18.6	55.9	25.5
Disease is an important issue	84.8	10.3	4.8
Disease doesn't occur in small-scale	3.4	76.6	20.0

At the beginning of the survey, according to government extension information, farmers were classified into two standards of living. However, while carrying out the survey, the authors saw that there was no significant difference in terms of standard of living between the two groups; essentially all the farmers covered by the study were poor.

MANAGEMENT INTERVENTIONS

Most farmers used some kind of treatment for RSD, some of which are shown in Table 3.

Antibiotics and lime were the most popular treatments applied when fish were affected by RSD. However, effectiveness was not high, as most farmers reported that treatment was rarely or never successful. Of the farmers surveyed, 4.9% applied more fertiliser when their pond was affected by RSD; such advice (though never successful) came from other farmers. This indicates that farmers need more training in culture techniques and pond management. Apart from using Neem and banana leaves that can be obtained from local gardens, the average cost of treatment was 132,414 VND (US$101).

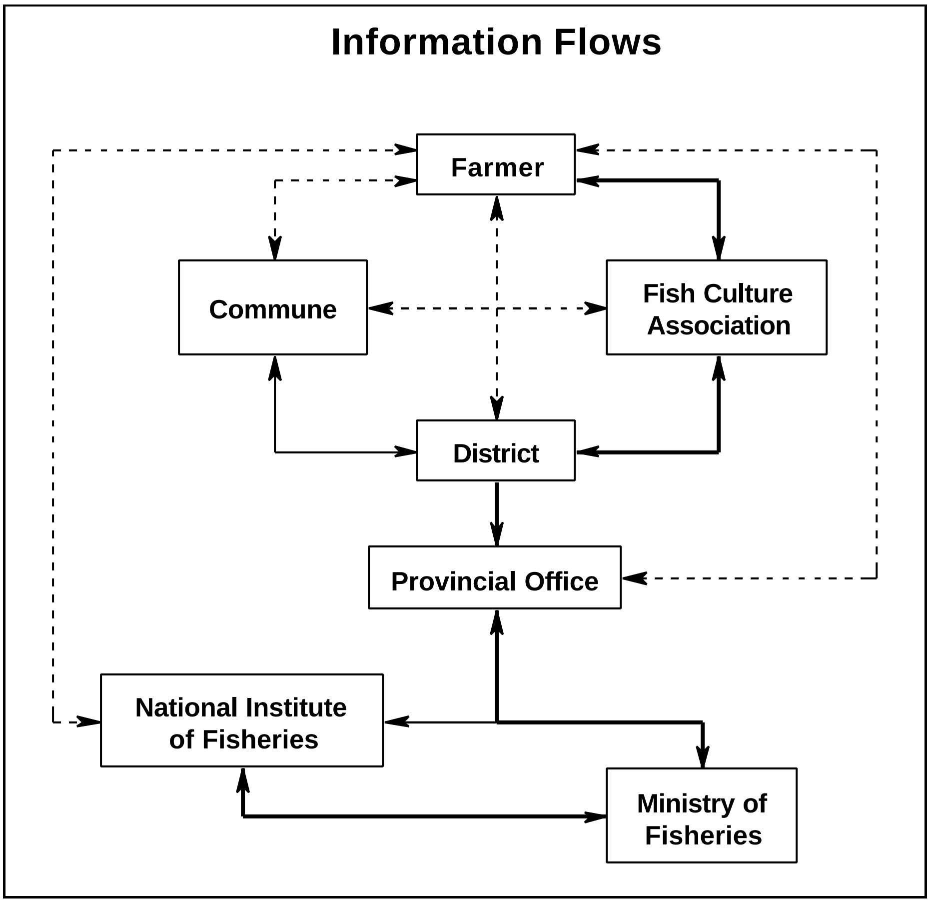
The findings also show that government extension officers work closely with fish farmers to assist in controlling this disease, as 63.2% of farmers asked for help from government extension staff, while 33.7% sought help from other farmers. Farmers often establish aquaculture groups with a nominated leader, so that they can help each other with problems, as well as share experience.

Table 3. Percentage of farmers using different treatments.

Treatment		Effectiveness			From Whom It Was Learned	
	(%)	Never (%)	Sometimes (%)	Usually (%)	Source	(%)
Banana leaf	2	50	0	50	Other farmers	100
Changing water	2	0	100	0	Gov. ext. officer	50
					Other farmers	50
Antibiotics	39.2	40	55	5	Gov. ext. officer	57.1
					Other farmers	33.3
					Drug salesperson	9.5
Herbal medicine	14.7	40	53.3	6.7	Gov. ext. officer	73.3
					Other farmers	20.0
					Drug salesperson	6.7
Lime	32.4	36.4	63.6	0	Gov. ext. officer	63.6
					Other farmers	36.4
Neem	4.9	0	100	0	Gov. ext. officer	60.0
					Other farmers	40.0
Applying fertiliser	4.9	100	0	0	Other farmers	100

INSTITUTIONAL ANALYSIS

There are four institutes under the Ministry of Fisheries. Each has a disease unit responsible for a particular region in Vietnam. All the institutes have the capability to carry out routine microbiology, parasitology and histopathology for research and diagnosis. Farmers can contact the institutes directly and submit samples for diagnosis, or ask for a field visit from institute staff. Disease diagnostic units only operate at the national level, while provincial and district-level operations focus on extension activities. The disease reporting system in Vietnam is shown in the diagram below.



Extension staff, especially those at the district level, require more training in diagnosis, treatment and prevention of specific fish diseases in order to improve their skills in fish health management. At the moment, there are not many fish extension staff working at the provincial and district levels. Most are from Agriculture Extension, as most inland provinces do not have Department of Fisheries offices. Therefore, with the limited human resources available, farmers who lead aquaculture groups should also be involved in extension activities and will, therefore, require training. As they are located near other farmers, exchange of information will be easier than through government extension staff.

CONCLUSIONS AND RECOMMENDATIONS

RSD is the main disease causing severe losses in small-scale fish farming systems in northern Vietnam and is affecting cultured grass carp. This disease has a major impact on the livelihoods of small-scale farmers.

Farmers were keen to learn and to exchange information with other people. However, they have very limited knowledge of culture techniques, pond management and disease prevention and control. Although very few farmers measured water quality parameters, most of them considered the cause of RSD to be poor water quality.

Improving water quality management is recommended in order to reduce the impact of disease outbreaks. In some circumstances, changing the ratio of the species cultured (i.e., increasing the numbers for species less susceptible or resistant to RSD) may reduce the impact of RSD on fish production. More care should be taken during those seasons when disease outbreaks are more likely to occur (March-April and October-November). At the moment, no treatment is available for RSD, although emergency harvest is recommended in certain cases.

There is a pressing need for more training in basic disease recognition and fish health management for farmers and extension officers. Research is also required to identify the pathogen(s) that cause RSD, investigate its epidemiology and find methods for prevention and control. If successful, the experience would serve as a useful model on which to build improved aquatic animal health management in small-scale aquaculture systems in Vietnam.

Present institutional capacity and human resources in aquatic animal health need to be strengthened, not only in research, but also in extension activities, as disease prevention is the most important issue. Each time government officers visit farmers or collect samples, they should service the needs of farmers by giving sound extension advice. During the present survey, most farmers took the opportunity to ask questions, not only relating to fish diseases, but also about culture techniques and management.

A national workshop on RSD would be of great benefit. Such a workshop would provide the opportunity for all fish disease staff in Vietnam to participate and develop a uniform approach to dealing with the problem. Such a workshop should include invited fish disease specialists from other countries, in order that a greater range of ideas on the possible causal agent can be considered. In this workshop, fish disease staff would be able to exchange information, present hypotheses on RSD and develop future research plans. A case definition for RSD should also be developed, as other diseases are sometimes mistakenly called RSD by farmers and extension staff.

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SOCIAL AND ECONOMIC IMPACTS AND MANAGEMENT OF SHRIMP DISEASE AMONG SMALL-SCALE FARMERS IN THAILAND AND VIETNAM

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ABSTRACT

Shrimp farming in Thailand is dominated by small-scale farms, which make up around 80% of the total number. Whilst shrimp aquaculture has contributed to income generation among coastal communities, disease outbreaks have caused significant economic losses to farmers and the country in recent years. Outbreaks of white spot syndrome virus (WSSV) and yellowhead virus (YHV), as well as bacterial diseases which struck later in 1997, led to the overall shrimp production of Thailand being reduced by 30% (from 210,000 to 150,000 mt). These diseases had a serious impact on all farmers, especially small-scale farmers whose main income was derived from shrimp farming. Moreover, at least 60% of small-scale farmers are thought to have become indebted to banks due to production lost as a result of shrimp disease. This paper discusses some of the impacts of disease outbreaks on small-scale farmers and reviews the strategies adopted by farmers to manage risks associated with shrimp disease.

The shrimp farming situation in Vietnam is very different from that in Thailand, as shrimp farming is mainly low input and extensive. Shrimp farming also provides an important source of income in some coastal areas and has potential to contribute to poverty alleviation among coastal communities. A project supported by the Australian Centre for International Agricultural Research (ACIAR) looked at the impacts and management of shrimp disease problems among extensive farms in Ca Mau Province of the Mekong Delta, as part of a project for improving the social and economic returns to farmers from “mixed shrimp-mangrove” farming systems. The households in the project area were primarily dependent on aquaculture and capture fishery as the main source of family income, the majority being dependent primarily on shrimp aquaculture. The average household income in 1996 was 12.08 million Dong/household/yr, equivalent to around US$1,000 at 1998 exchange rates), or 2.4 million Dong/person/yr (US$170/caput/yr). Poverty thresholds as quoted by the United Nations Development Programme (UNDP) in 1995 were around 1.1 million Dong/person/yr. An estimated 40% of households were below this threshold, showing a significant poverty problem in the area. Shrimp culture provides an opportunity to improve

incomes and contributes to poverty alleviation, although effective management to reduce risks associated with disease outbreaks is required. Disease outbreaks severely affected shrimp yields in the Mekong Delta area from 1996, leading to negative social and economic impacts on farm households, including reduced incomes and increased debt. In 1997, mass mortalities occurred four times (in January, June, July and October), and were associated with high prevalence of WSSV and adverse environmental conditions associated with poor water and soil quality. The disease problem was also compounded by the low educational level of most farmers, farmer inexperience with aquaculture, and lack of access to technical advice and to capital to invest in farm improvements and risk-reduction measures. The implementation of technical recommendations for reducing disease risk is closely interlinked with educational, institutional, social and economic conditions. In particular, better educational opportunities, more flexible and accessible credit arrangements, and greater access to regular technical support are key factors in determining the willingness and capacity of farmers to implement farm-level risk management strategies. In view of the lack of technical support in the area, much closer co-operation among farmers, building on existing farm groups, is also important to promote effective self-help and extension of support.

BACKGROUND

This paper gives information on the social and economic impacts of disease on small-scale shrimp farms in two contrasting environments; the first in Thailand, which is the world's major shrimp-producing country; and the second in Vietnam, where shrimp farming is mainly low input and extensive. The case in Vietnam is particularly relevant to the topic of this consultation, as it deals with the social and economic impacts of disease on a poverty-focussed project in the Mekong Delta and the development of management strategies which are appropriate to the farmers' social circumstances and farming system.

SOCIAL AND ECONOMIC IMPACTS OF SHRIMP DISEASE IN THAILAND

Thailand, as the world largest shrimp producer since 1992, has faced many disease problems, as well as other management-related problems. Shrimp diseases are most serious, since they can cause losses from low (chronic) levels up to acute (100%) mortalities. The production of Thai shrimp, which was increasing every year, reached its highest level in 1994, when 250,000 mt were produced. Due to disease and management problems, production started to decline, first to 225,000 mt in 1995 and then to 205,000 mt in 1996. The major pathogens affecting the Thai shrimp industry are white spot syndrome virus (WSSV), yellowhead virus (YHV) and bacterial diseases (vibriosis). In 1997, another 30% decline in production occurred, only 150,000 mt of shrimp being produced in that year.

WSSV is the major cause of mortality in Thai shrimp farming. Many attempts have been made to understand this problem and many recommendations aimed at preventing disease outbreaks have been made. This concerted effort by farmers and supporting institutions has resulted in an increased production to 230,000 mt in 1998. Farm management strategies have been developed depending largely on farming conditions, as indicated below.

Economic Impacts of Disease

White spot disease, caused by WSSV, has now been reported from most Asian countries. It has also been reported as "red body," systemic ectodermal and mesodermal baculovirus (SEMBV) and PJ-RV. The infection will be referred to here as “white spot disease,” since the presence of white spots on the carapace is the most noticeable of the clinical features.

When outbreaks first appeared, they were all associated with extremely severe production and economic losses, and the virus appeared to be highly pathogenic. If shrimp were exposed to enough of the virus, they would die, regardless of the environmental conditions. Losses due to WSSV alone were estimated at US$600 million in Thailand in 1997, and at over US$2 billion throughout Asia in the same year (Flegel 1998). Now, however, infections appear to cause severe losses only if the shrimp are also suffering from poor environmental conditions in the ponds. It is still not clear if this change has been due to an alteration in the virus, the host or to other factors, including the implementation of better management practices by the farmers. The direct economic impact of the virus appears to have decreased.

Other estimates of economic losses due to shrimp disease in Thailand include an estimated US$30.6 million from yellowhead disease in 1992 (Nash *et al.* 1995), and US$650 million from all shrimp disease outbreaks in 1994 (Flegel *et al.* 1995). Flegel (1998) pointed out that YHV and WSSV are currently the most serious diseases threatening the shrimp farming industry in Thailand. Together, these two pathogens may be responsible for the drop in shrimp production in Thailand from 250,000 mt in 1994 to 220,000 mt in 1995. At approximately US$8/kg, this represented a shortfall of $240 million. However, this small difference in production is not a true reflection of the full impact of these diseases. At that time, Thai production was rising at approximately 20,000 to 30,000 mt per year, and production for 1996 had been expected to rise correspondingly. The diseases were thus estimated to have caused the loss of 70,000 mt of shrimp (around 40% of total production) in 1996 (Alday-Sanz and Flegel 1997). At a rough estimate of $US3-5 per kg profit, this represents between $US210 and $US350 million in lost revenues. Also, these figures do not include losses in related businesses such as feed production, processing plants and feed raw material producers, and the income lost by labourers.

Socio-economics and Impacts on Small-scale Farmers

The socio-economics of small-scale farmers have been studied, although the impacts of disease at the household level in Thailand are surprisingly less well understood. Some information on the cost-profit of Thai shrimp farming along the Gulf of Thailand was determined from a survey of 104 farms in Nakhon Sri Thammarat and Songkhla provinces (Nipanpong and Sidthimunk 1998). The survey split the farms into six groups depending on their area. The first three groups were small farms (less than 1.6 ha) and represented almost 90% of the total number of farms surveyed. There are a number of important features that have implications for disease control and management of shrimp aquaculture:

- These farms were arranged into three groups: (1) farms smaller than 0.5 ha (32%), (2) farms between 0.5-0.8 ha (35%) and (3) farms between 0.8-1.6 ha (33%).

- The cost-profit analysis for each group revealed that the least profit (0.6 US$/kg) (38.5 Baht = 1 US$) was obtained by the smallest farms (equivalent to US$725/farm/crop at this time).

- Sixty percent of the farmers in the group with the smallest-sized farms had one to five years experience, whereas over 50% of the farmers from the group with the largest-sized farms had more than five years experience. This indicates that farmers with smaller farms were just moving into this business and had limited experience with shrimp culture.

- More than 50% of the total number of farmers sampled learned from, and followed the technology used by, their neighbours. Most farm owners were between 41-50 years old and had a low level of education.

- The major source of income for 65% of the farmers came from shrimp culture.

- The average mortality of shrimp reported in this survey was between 46-54%, and was mainly due to disease and management problems.

- During the survey period, farmers still achieved profits, since serious outbreaks of disease started in 1996 and 1997.

The reduction of total production by 30% that occurred in 1997 was estimated to have a value equivalent to US$600 million, a figure which excludes losses in related businesses such as feed production, processing plants, and feed raw material production, and in labour. When the same losses were applied to the smallest farm group, a 30% production loss was equivalent to a loss of around US$1,000/pond/crop. As 65% of the farmers were reliant on shrimp as their main source of income, it is not surprising that disease was reported to have serious impacts on households involved in shrimp culture. This aspect needs to be better understood, and some further information is given in the paper by Adis Israngkura contained in this volume.

Management of White Spot Disease

One of the many problems associated with the management of viral diseases is that there is increasing evidence that clinical signs similar to those seen in white spot disease may occur in shrimp that are not infected with WSSV. It would appear that if the virus is present in a population, a rapid rise in mortalities is associated with environmental deterioration. Most dead shrimp will either have no clinical signs or will have the clinical signs typically associated with the viral infection i.e., white spots. If the environment does not deteriorate, it is unlikely that mass mortalities will occur. In some cases, chronic low-level mortalities are seen with the shrimp showing signs of external fouling, vibriosis or other conditions. Some of these animals may also show white spots, but if the mortalities are low, the virus may not be present. These findings emphasise the difficulty of correctly diagnosing viral diseases based solely on gross clinical signs, and the importance of environmental management as a means of controlling economic losses due to disease.

Although a great deal of information is still lacking regarding these very serious viral conditions, some general recommendations for their control have been developed. Prevention has to be based on not only maintaining a healthy environment, but also on keeping the virus out of the system. For white spot disease, the most common route of infection is through entrance with infected postlarvae (PL). However, in some cases the virus enters the population with the incoming water or via wild crustaceans. Outbreaks due to WSSV can be prevented by eliminating potential vectors and screening intake water. However, serious outbreaks can still occur in ponds stocked with infected PL. Using the polymerase chain reaction (PCR) to screen for infected PL is one way to reduce this risk (Flegel *et al.* 1997, Kasornchandra *et al.* 1997). The technique is now used in many countries with varying results. PCR is very sensitive and can, therefore, detect small numbers of the virus in individual animals. However, the technique is not as effective where populations are large and only a small number of individuals are infected. This might explain why outbreaks still occur in ponds with PL certified as PCR-negative.

Since outbreaks of white spot disease often stem from infected PL, elimination of such animals from the population before stocking can reduce the likelihood of disease. Formalin, at a concentration of 150 ppm, can be used to treat PL for 30 minutes. After treatment, weak and unhealthy individuals should be separated from actively swimming shrimp and discarded. This technique successfully reduces the number of infected PL stocked into ponds (Limsuwan 1997). However, if the prevalence of infection is high, this technique may not be practical, especially when climatic conditions fluctuate.

It is important to keep predators and competitors out of the pond. Initially, the pond should be filled and the water treated with calcium hypochlorite at 15 to 20 ppm active chlorine. After the pond is filled, water exchange should be reduced to a minimum for at least the first month after stocking. Water should only be exchanged when it is necessary, not as a routine procedure. It is also important to ensure that the incoming water is free from animals and has not been contaminated by wastes from other farms. A reservoir is essential for treatment of incoming water.

The main aim of low water exchange is to minimise contact with poor quality or contaminated water from outside the farm. Partial recirculation is the system of low water exchange most commonly used in Asia. When water cannot be pumped into the farm, effluent from the production ponds is first allowed to settle and may be treated before being mixed with the water reserve. The reserve water is pumped from the external water supply when conditions are suitable, or from an inlet reservoir. In most partial recirculation systems, harvest effluents are not introduced to the mixing reservoir, but are normally passed through a settlement system before discharge (Chanratchakool *et al.* 1998).

Although, infections can spread between ponds on a single farm, when more than one pond is affected with white spot disease it is usually due to a common source of infected PL. None-the-less, unless it is absolutely unavoidable, equipment should not be used in more than one pond. If equipment is to be moved between ponds, it must be first thoroughly cleaned and disinfected.

If an infection does get into the population and an emergency harvest is not appropriate, it has been suggested that removing the affected shrimp may limit the spread of the infection within the pond. The affected shrimp will usually be seen at the surface of the pond, especially in the morning and evening.

Moving shrimp between countries, or between distinct areas within a country, should be avoided, wherever possible. Moving stocks of shrimp not only carries the risk of introducing disease to farms, but may also have adverse effects on local populations of wild shrimp.

If a new infection occurs, it is important that it not be allowed to spread to neighbouring farms. Dead shrimp should be removed from the pond and disposed of in a manner that does not contaminate the water supply. They can either be buried with quick lime, or they can be burned. The water from the affected pond should not be discharged from the farm. Once the infection is detected in the shrimp, it may be possible to conduct an emergency harvest. The water from an emergency harvest should be retained in a settling pond and treated with calcium hypochlorite (at least 20 ppm active chlorine). In some cases, it may not be worth conducting an emergency harvest, for example, if the shrimp are too small or if most have already died. In such cases, the water should be treated in the pond prior to discharge. Every effort should be made to avoid the water from the affected pond coming into contact with the inlet water of the affected farm or of any neighbouring farms.

Early detection of the problem is extremely important. The shrimp should be examined regularly for signs of disease, especially if there is an increased risk of infection.

Management Recommendations for Small-scale Farms

Small, newly developed shrimp farms are owned by rice or fish farmers who follow management techniques learned from neighbouring farmers. Their farms consist of one to three ponds, and more than 80% of them take their water directly from the source, without using a storage reservoir. Poor-quality water supply is one of the major problems leading to management difficulties and diseases causing severe losses. Some farmers have returned to rice or fish farming. However, as the income generated from rice or fish is relatively low and is inconsistent, large families still need to generate incomes from other agriculture-based activities. Integrated farming has shown a good potential for farmers living in coastal areas. Dividing the land into three or four parts consisting of a shrimp pond, a fish pond (which serves as a source of water for the shrimp pond), a rice paddy or a cash crop (such as vegetables), and an area for raising poultry is recommended. One or two shrimp-production cycles per year generate the major income for the family, whereas fish, rice, poultry and cash-crop production provide extra income and food for direct consumption.

Institutional Analysis

Since income generation from shrimp production has become a focus for poverty alleviation for poor farmers in coastal areas, information and technology transfer are required in order to ensure success. Extension material and technical support in various forms are being developed and transferred though both the government and private sectors.

Disease control and management in Thailand is not the responsibility of a single governmental body. Many institutes have been involved in the successful development of the shrimp-farming industry during the past 12 years. Governmental agencies, such as the Department of Fisheries, the universities, various research institutes and the private sector have jointly set up a good network to study the causes, preventive methods and treatments for diseases, as well the development of good management practices for shrimp farming. This information and recommendations are being transferred to the end-users by various means, such as seminars, workshops and training courses that are jointly organised by the government and private sectors, and via scientific publications and articles produced by various institutions and widely circulated among the interested parties. There are also government and private laboratories that provide services for disease diagnosis in difference areas, which all farmers can easily access.

When management recommendation are made, they can easily reach the end-users through the many institutions set up in Thailand. However, their successful application depends largely on the farmer's decision. In order to assist the farmers, more well-trained and experienced local staff are still greatly needed, since the shrimp culturing area in Thailand is quite large. Establishing a disease reporting system is one effective strategy to obtain information from the field, and can be used to pass recommendations back to the farmer quite effectively.

SHRIMP DISEASE AND A POVERTY-FOCUSSED SHRIMP AQUACULTURE DEVELOPMENT PROJECT IN THE MEKONG DELTA, VIETNAM

The Mekong Delta is Vietnam’s most important shrimp-producing area, with nearly 200,000 ha of ponds. In the southern tip of the delta, the Government of Vietnam is undertaking a mangrove reforestation programme, and mixed brackishwater farming systems - mangrove and aquaculture - are practised. The propose of the mixed farming system is to provide wood through mangrove reforestation and food and income to people involved in mangrove planting through brackishwater aquaculture. Until recently, this brackishwater aquaculture was solely shrimp aquaculture, but the systems have recently become more diversified. The people living in the area are poor, and an estimated 40% are living below the “official” government and United Nations Development Programme (UNDP) poverty thresholds. The reforestation and aquaculture-development activities in the southern part of the delta, therefore, have a strong poverty alleviation focus.

As part of a project to improve the economic returns and management of these mixed-farming systems, the Australian Centre for Agricultural Research (ACIAR) has supported a research project in Ca Mau Province. Two enterprises, Tam Giang III and SFFE 184, in the Ngoc Hien District of what is now Ca Mau Province were selected as the main foci for research activities, in consultation with national, provincial and enterprise officials. The enterprises are designated by provincial authorities as State Fisheries-Forestry Enterprises (SFFEs).

Description of the Mixed Farming Systems

Two main fisheries-forestry farming systems presently operate in Ngoc Hien District are:

- ***Traditional capture fisheries-mangrove forestry farming system.*** In this system, being carried out in Kien Vang Enterprise, mangrove forest occupies more than 80% of the enterprise area. Here, forest management aims to produce a final yield of 200 m^3 wood/ha when harvested at year 20. Fisheries products come from capture fisheries only; pond culture is not practised.

- ***Fisheries-forestry farming system.*** In this system, practised in the Tam Giang III and SFFE 184 Enterprises, farm households are officially assigned 5-10 ha of land on which they must carry out both shrimp culture and forestry. Two different farming models are practised in Tam Giang III, (i) separate pond (20-30% of farm) and forest (70-80% of farm) areas; and (ii) combined shrimp farming-mangrove forestry on the same area of land. Shrimp culture is carried out in canals or channels dug in the forest. The area for shrimp farming (canals, channels and levees) is restricted to 20-30% of the total farm area. Both the separate and combined models are used in Tam Giang III, but most farms in SFFE 184 use the combined model.

Description of Farm Households

Household surveys carried out in 1996 revealed information on household incomes, and demonstrated the overwhelming importance of aquaculture and aquatic products to people living in the enterprises. The average reported household income was 12.08 million Dong/household/yr (equivalent to around US$870 at 1999 exchange rates), or 2.4 million Dong/person/yr (US$172/yr). Poverty thresholds are around 1.1 million Dong/person/yr. It was estimated that 80 (39.4%) of the surveyed households were below this threshold, indicating a significant poverty problem in the enterprises.

Traditional farmers or those making limited investment in their ponds reported lower incomes than did extensive farmers, although the survey suggested that farm households that had made investment had significantly more debt, as a result of borrowing funds to purchase seed and undertaking some pond improvements. Table 1 shows the relative contribution of the different activities to family income (data from both enterprises are combined).

Table 1. Sources of household income in two forestry-fishery enterprises (n=194).

Source of Household Income	% Contribution to Household Income
Business/employee	6.6
Crab/fish catching (including juvenile crabs)	20.9
Shrimp/crab/fish aquaculture	46.3
Sale of aquatic products (source not specified)	14.8
Agriculture (livestock, rice)	7.1
Mangrove propagule collection/wood selling	1.1
Other	3.2

The survey noted differences in income patterns between the different farming systems. Farmers reported that they can obtain higher production from models with stocking, but will suffer a greater loss if they lose the crop. In other words, households can generate greater income by undertaking shrimp stocking and pond improvements, but they are also exposed to a higher risk of crop losses because of shrimp disease outbreaks.

Aquaculture Problems and Constraints

Farmers reported several aquaculture problems, which were explored by questionnaire and during the local participatory workshops. Information on the technical and nontechnical problems faced by farmers is shown in Table 2.

Environmentally related problems, including water and soil-related problems, were faced by a significant proportion of farmers. These included problems that were perceived as being due to water pollution, turbidity and water acidity. The water quality problems were similar between farm types. The major problems included shallow ponds, acidic soils, and poor productivity caused by high turbidity. Other aquaculture-related problems reported by farmers included lack of credit, lack of experience and a perceived lack of technology.

Table 2. Percentage (%) of farmers reporting various aquaculture problems (n=194).

	SFFE 184		TG III		Combined	
	Separate	**Mixed**	**Separate**	**Mixed**	**Separate**	**Mixed**
Water/soil problems	60	64	63	65	62	64
Shrimp disease	93	100	96	95	95	98
Seed problems	0	5	3	3	2	6
Poaching	0	8	3	10	2	9
Lack of credit	7	33	46	23	39	29
Lack of experience	7	15	27	10	24	13
Lack of technology	7	20	41	33	35	24

Shrimp Health Problems

Disease was clearly a major problem, with nearly all farmers (95% of separate farms and 98% of mixed farms) reporting outbreaks causing financial losses. Farmers found it difficult to assess the causes, and none reported any success in solving the problem during 1996.

During participatory workshops, farmers clearly recognised shrimp monoculture as being more risky than polyculture. They considered diversification of aquaculture through stocking fish and crabs to be less risky. Farmers also reported that all farms stocked with hatchery-raised postlarvae were affected by disease. However, farmers were unable to identify for certain whether mortality was caused by disease or by other factors, as they had little experience in distinguishing between different diseases. No aquaculture extension was available at the time to provide advice on shrimp disease control.

Shrimp farms based on natural recruitment apparently did not experience such severe problems, but yields were reported to be low. This suggests that recruitment was poor at the time of the disease and raises a number of questions regarding the impact of disease on wild stocks that need to be addressed by research.

Economic Impact of Shrimp Disease

Shrimp disease has become a serious problem in the Mekong Delta of Vietnam, and these very extensive farms were no exception. Whilst it is difficult to estimate the overall economic losses, the figures from the survey reported here extrapolate to an estimate that US$27 to 28 million was lost throughout the delta in 1994. World Bank (WB) estimates are on the order of US$50 million for the same period.

Financial losses from the survey were reported as $732 per affected separate farm and $1,249 per affected mixed farm, figures that indicate the financially serious nature of the problem. These figures, whilst difficult to verify, are close to the annual income of many households. The disease clearly had a major affect on farm profitability, with many farms falling into debt at this time.

The social impacts of shrimp disease were severe in the enterprises, and included problems with increased debt. This situation was made worse by a lack of alternative income. However, food was available from the brackishwater areas. These problems affected the potential of shrimp culture to contribute to poverty alleviation.

Shrimp Disease Investigations

The shrimp disease problems were subsequently diagnosed as being due to viral disease and water quality problems associated with the onset of the rainy season. Disease surveys conducted in 1997 and 1998 revealed that WSSV was simultaneously present in wild shrimp seed and *Acetes* spp. during January, April and May. Monodon baculovirus (MBV) was present in wild seed all year round, and was detected more often in the separate farming system than in the mixed farming system. WSSV was present in most samples of harvested shrimp, particularly those collected in the rainy season and in the middle of the dry season. MBV was present in harvested shrimp all year round, with greater prevalence in the rainy season. Mass mortalities occurred four times during the one-year sampling period, in January, June, July and October. These were associated with the presence of WSSV at high prevalence and intensity, and also with poor environmental conditions associated with the onset of the rainy season.

The most important conclusion to be drawn from the results of the disease survey was that risk was significantly higher around the peak of the wet season in July and August, and again in the months October, November and December, the middle of the dry season. These peaks in disease occurrence correspond to the two extremes in the water quality regime. In the peak months of the wet season, low pH and rapid changes in salinity are likely to stress shrimp and predispose them to disease, while in the middle of the dry season, above average water temperatures may predispose the animals to disease. These extremes of water quality partly result from the poor design of ponds, most of which are too shallow and do not have adequate water volume to minimise fluctuations in water quality.

Farmer Responses to Shrimp Disease Problems

Generally, the technical support for farmers is very poor. Farmers received some technical training in mangrove forestry, but there was very limited technical support for aquaculture. In dealing with the various problems faced by farmers, extension support is important. The survey questionnaire explored the extent to which farmers had received technical assistance and their sources of technical information. Only 7% of farmers had received a visit from an extension officer with experience in aquaculture, in contrast to mangrove extension, which was available through each of the Enterprises. The most important source of information on aquaculture was other farmers. Farmers are grouped together in local area groups under the management structure of the Enterprise, which could provide an efficient means of information exchange. Although these groups are currently more involved in forest protection, the opportunity for using them as a means of extending aquaculture advice needs to be examined.

Farmers reported that they had limited opportunities to receive aquaculture advice. The Enterprise has no resident aquaculture extension officer, and funds for extension by provincial fisheries/aquaculture staff appear to be very limited. Advanced farmers were reported to have good co-operation with other farmers and often exchange experience, even though there is no official association. Advanced farmers also can provide advice to poorer farmers. Exchange of ideas among farmers was an important source of advice.

When disease occurred, the farmers could only attempt limited actions, mainly emergency harvest. For many, the only option was to take no action.

Development of Management Interventions

Based on the results of the shrimp health survey and associated work on environmental conditions in the mixed farming systems, a series of management strategies were tried and their effectiveness evaluated. As mortalities were related to water quality, improvement in pond design, considered in more detail elsewhere, is a key first step to minimising the risk of mortality from disease. The following recommendations were developed:

- Improving pond design, particularly to improve water depth and settlement of water. As this approach requires investment, it has to be incremental.

- Nursing of postlarvae. As the return from the stocked shrimp was very low, nursing was recommended to improve survival and allow farmers to check the quality of seed before stocking.

- Postlarval quality checks. Long-term improvements in seed quality are essential.

- Stocking/harvesting at lower risk periods. For example, stocking during the dry period and avoiding the higher risk, cooler winter period and rainy season.

- Diversifying away from shrimp into other income-generating practices to reduce the risk associated with shrimp culture due to poor and unreliable seed recruitment. Viable options to be explored include agricultural cash crops and alternative aquaculture species. Mud crab culture and fish culture are being tried.

It is also necessary to consider the institutional support needed to implement the technical recommendations. The following issues are receiving attention:

- Improved technical co-operation and support for self-help among farmers, and co-operation among farmer groups, including development and testing of extension materials.

- Credit access and particularly, accessing arrangements for the poorer farmers.

- Development of a surveillance/response system to respond more quickly to problems.

- Other institutional arrangements, such as insurance for crop failures, also need to be addressed.

Other policy and institutional issues which have an important bearing on the provision of improved health management in these mixed farming systems include:

- Improving the security of land tenure for farmers. This is necessary to permit longer land leases or provide options for farmers to acquire ownership of land and make longer-term investments in land development.

- Providing on-going and effective training to upgrade the skills of extension officers.

- Devising institutional arrangements to manage risk associated with poor people who have limited assets; joint credit schemes, joint insurance policies etc need to be considered.

The current ACIAR project is assessing current management intervention strategies and their success in minimising aquatic animal health problems. It will help identify potential future intervention strategies.

Lessons Learned from the Vietnam Project

In the southern tip of the Mekong Delta, there are many poor people involved in aquaculture and mangrove forestry. Shrimp disease has become a constraint, even in extensive shrimp culture. Experience has shown, however, that the management of risk is important, and that several options exist to reduce risk to farmers and their households. This approach relies very much on understanding and management of the whole system. Health problems cannot be seen separately, but should be seen as part of the system. This requires a whole-system approach to health management, integrating health management concerns within the whole approach to aquaculture development, including consideration of institutional issues. There is a need to understand the farmers' situation and institutional support structure, as well as the technical issues faced in managing health risks in small-scale shrimp aquaculture. Thinking of pathogens alone, without considering the broad development framework, will not work.

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SOCIAL AND ECONOMIC IMPACTS OF SHRIMP DISEASE AMONG SMALL-SCALE, COASTAL FARMERS AND COMMUNITIES IN BANGLADESH

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ABSTRACT

Outbreaks of viral disease causing mass mortalities of tiger shrimp, *Penaeus monodon*, have occurred in Bangladesh since 1995 and have resulted in a dramatic decline in shrimp yields. Many small-scale farmers have fallen into serious economic difficulty after incurring losses from white spot syndrome virus (WSSV). The coastal communities are greatly concerned about the virus, which has been crippling shrimp farming and the economy. Participatory Rural Appraisal (PRA) has been used in three affected areas to collect qualitative information, particularly on people's perception of the impacts of shrimp disease. This paper discusses the findings of PRA in terms of people's realisation of the extent of diseases, the causes of loss, and the impacts on livelihood.

INTRODUCTION

The sustainability of shrimp farming has become a major concern among small-scale, coastal farmers in Bangladesh, as the sector has experienced widespread disease problems for four or five consecutive years. In Bangladesh, diseases like black spot, soft shell, external fouling and broken appendages occurred only infrequently and were not though to have significant impacts on shrimp production. However, in April 1994, an outbreak of disease of cultured black tiger shrimp (*Penaeus monodon*) occurred in semi-intensive farms in Cox's Bazar, southeastern Bangladesh, where it caused losses of 50-60%. Later, the disease occurred in southwestern Bangladesh, where it severely affected small-scale farms practising low stocking density, resulting in great economic loss.

Production and export of shrimp play a dominant role in the economy of Bangladesh; the shrimp sector is the third largest earner of foreign currency. Black tiger shrimp are being cultured in about 115,000 ha of brackishwater farms under extensive (90%), improved extensive (9%) and semi-intensive (1%) methods. Of these farms, 70% are small-scale and are mostly situated in the southwestern region. The production from extensive farms varies from 150-250 kg/ha.

Throughout the 1980s, the shrimp sector grew dramatically in response to global demand. Bangladesh produces 4.2% of the global shrimp production (Rosenberry

1996). However, over the past two years, the exportation of shrimp has declined, due mainly to disease outbreaks. In 1994-95, Bangladesh earned 1,045.64 crore Taka (US$205 million) by exporting 26,277 mt of frozen shrimp, while in 1997-98, Bangladesh exported only 18,630 mt and earned 1181.48 crore Taka (US$231.5 million).

The Expansion of Shrimp Culture

At the end of the 1960s, production of food grains in some polder[1] areas became impossible due to stagnation of water, and people began to raise fish as an alternative. The primary species cultured were barramundi (*Lates calcarifer*), gold-spot mullet (*Mugil parsia*) and mystus (*Mystus* sp.). In the 1970s, the demand for, and price of, shrimp increased in the world market, and their culture became popular and profitable. Other polder areas that were not affected by stagnation also began shrimp culture in place of rice culture. Paikgacha, Dumuria, Batiaghata, Dacope, Rampal and other brackishwater areas came under shrimp culture, in addition to rice culture, and the process expanded rapidly in brackishwater areas as this subsidiary crop became increasingly popular. In the 1980s, the price of shrimp rose gradually, and as a result, expansion of shrimp culture accelerated. Influential persons and outside investors gained control of vast shrimp cultivation areas.

Socio-economic Circumstances

Earlier, people of the area depended mostly upon the cultivation of food grains. Influence and status were achieved through the possession of land and crops. However, shrimp cultivation soon produced another moneyed class; influence and social power gradually transferred to others, and the basic social hierarchy broke down. This initially created a hazardous situation in the rural areas, as the inhabitants became hostages to the whims of these people. Gradually, however, the small landowners organised. They protested against the newcomers and began individual and co-operative shrimp culture for their economic emancipation. Initially, shrimp farmers made enough profit so that farming expanded greatly within three years. In 1994, the area under shrimp cultivation reached more than 100,000/ha. Thus, co-operative and small-scale shrimp farming became very popular and profitable within a short period

Shrimp has replaced rice as the main crop; as traditional shrimp farming is easier and more profitable than rice growing. Poor womenfolk earn a considerable amount of money from fry collection, weeding out, de-heading and other related activities. Young folk with no opportunity to enter farming directly, buy small amounts of shrimp from the farms and sell them to the nearest market, providing themselve with good earnings. As well as the activities mentioned previously, there is also land preparation, fertilisation, contract-based shrimp collection etc. These seasonal activities play an important role in poverty alleviation for local landless people.

Now, the backyard of every homestead has been turned into a shallow pond where shrimp are grown. Whereas previously, many small-scale farmers had to starve through half of the year, they now have plenty of money to buy food and provisions. Even the landless in the shrimp farming areas have bank accounts and deposit money every month. The mobility of shrimp farmers has increased significantly, and

[1]A polder is an area encircled with an embankment to prevent the intrusion of salt water where shrimp and paddy culture are practised.

shrimp farming has brought substantial changes to the livelihood status of the coastal communities in Bangladesh.

Shrimp Culture System

Aquaculture, especially shrimp culture, in the southern part of the greater Khulna area differs due to various factors, such as salinity, availability of fry and local geologic conditions. There are several types of system used in three areas:

Satkhira-Shyamnagar. Farmers in this coastal area, adjacent to the Sundarbans, are able to culture shrimp year round. The salinity is stable all year long, and fry are also available. Most farmers, therefore, get four harvests. Farmers in this area follow a more methodological approach than do those in other areas. They prepare the farm with lime, use both organic and chemical fertilisers, and even use medicines available in the market. They also try to test the water and soil, and are eager to have the assistance of the government. Their first crop is started in the first week of February and harvested in May, depending on growth. They begin to stock fry for the second time in the first week of April, and then harvest again in July. They start to stock the third crop in June and harvest in September, while the fourth crop is stocked in the first week of August and harvested in November. December and January are used for preparing the farm; they dry the ponds, plough the land, scatter lime and apply manure.

Khulna-Paikgacha. Paikgacha is an area with diverse patterns of shrimp farming. Both big farms and small farms are located here. Farmers generally grow both shrimp and rice on the same land; large farm owners lease the land for shrimp farming. In this area, the main harvest is made in June to July. However, many farmers try to have a pre-harvest and a post-harvest along with the main harvest. Farmers start to stock before the onset of winter, and the fry are conditioned to tolerate the cold. This crop will be harvested in February/March, which assists the farmers, as they obtain a good market price and have money available during what is normally a hard period. The main stocking begins in February and continues until June, depending on the availability of fry and money. The farmers like to practice staggered stocking in order to have a staggered harvest, and it continues from May to September. The last stocking is considered as a post-main harvest. Most of the farmers aim to complete harvest in August in order to leave the land for rice cultivation.

Khulna-Dacope. Farmers in this area mostly culture shrimp on a small-scale or co-operative basis. Encroaching farmers are very few; therefore, social amity and solidarity still exist. However, water management is not carried out on an equitable basis.

Bagerhat-Rampal. In this area, there is a different type of shrimp culture. None of the land is under control of polders, therefore, farmers have to prevent flooding at high tide by building strong embankments. The harvesting system is almost the same as that followed in Dacope.

*Cox's Bazar***.** In southeastern Bangladesh, shrimp farming is a post-independence phenomenon that started off in salt beds. From December to April, crude salt is produced by evaporation, while shrimp and fish are farmed on the same land from May to November.

METHODS

The information presented in this paper was generated by a qualitative survey using Participatory Rural Appraisal (PRA), a qualitative tool for in-depth assessment of people's perceptions. Discussions were also held with some key informants engaged in the production of shrimp.

PRA was conducted in three areas affected by shrimp disease. The areas included Polder-31 at Tildanga, Dacope Thana, Khulna District, where the Union Parisad Chairman, members and local elite participated. This area has suffered little shrimp disease, and here shrimp and rice are cultured at regular intervals. One session was conducted in this area, and two group discussions were also held with shrimp growers at Batbunia and Chalna. Another area chosen for PRA was in Polder 5 at Burigoalinee Union campus of Shymnagar Thana, in Sathkhira District. At least 20 shrimp producers gathered for free and frank discussions on the issues. The area has a maximum of four crops a year and suffered mass mortalities of shrimp over the past few years. Focus-group discussions were also held in Polder 16 at Kapilmuni, in Paikgacha Thana, Khulna District, where individual discussions were also held to ascertain the impact of disease.

RESULTS

PRA sessions, including focus-group discussions, were conducted on a number of issues relating to the impact of shrimp disease. The findings are summarised below:

Shrimp Disease

White-spot disease made its first appearance in southwestern Bangladesh in 1995**.** It had a high impact through 1996 and 1997, and then seemed to disappear. In 1998**,** there was no report of the disease. In 1997, after release into the farm, the fry were severely affected by the virus; however, the situation has since improved, and farmers reported a good harvest in 1999**.** Bacterial disease was noticed in some of the farms in Shyamnagar.

The diseased shrimp displayed the classic signs - red or bluish coloration and white spots under the shell. This virus affected 80% of ghers[2] in all the polders. Dead shrimp were sometimes found on the bottom. In two to three days, mortalities reached 50-70%, and the remaining shrimp did not grow well. As a consequence, farmers harvested small-sized shrimp. Farmers also became nervous when neighbouring farms were hit with white spot, and they harvested early. Moreover, in 1998, soft-shell, swollen and cramped muscle necrosis and broken appendages appeared in cultured shrimp, problems that were attributed to different bacterial diseases.

[2]Ghers are modified rice fields with high, broad peripheral dikes, and are found throughout southwestern Bangladesh in areas that are seasonally or perennially inundated. A trench dug inside the dikes retains water in the dry season, while the dike protects the gher from flooding during the summer.

Causes of Shrimp Disease

Environmental and management factors relating to seasonal fluctuations in brackish water apparently influence the onset of white-spot disease. The major causes identified from the sessions were:

Poor water management

Three types of sluice gates exist: those constructed by the Bangladesh Water Development Board (BWDB), those individually constructed and those constructed by the Third Fisheries Project (TFP). Reports of virus in the individually owned and gated farms and in farms at the periphery were less. However, many farmers are located far from these gates and do not have systematic arrangements for flushing and drainage of water in the shrimp ghers. These farmers are totally dependent on the individual gate owners and need to pay them higher rent for the use of water. Although there are some sluice gates owned by the authorities, these are not serving the purpose of managing the overall water supply and drainage in the gher.

Small ghers often experience waterlogging[3], mainly because of under development of infrastructure. The waterlogging causes variations in the level of salinity, oxygen and natural feed. Moreover, excessive temperature increases the salinity of the stagnant water, which may produce poisonous gases such as ammonia and hydrogen sulphide and cause deterioration of the gher environment.

Lack of awareness about shrimp farming technology

Shrimp farming is a highly technical activity and very sensitive to the environment. Repeated outbreaks of viral disease in most farms have made this sector more vulnerable. Most farmers are conscious of the requirements for environmentally friendly shrimp farming; often, however, they do not fully follow these requirements, mainly because of the temptation to earn short-term profit. Most farmers adopt a "wait and see" strategy and prefer to exchange knowledge among themselves. If one farm does well from applying new knowledge, others will adopt it. Farmers are not well informed about the quality of soil and water and will apply lime and fertiliser without testing the soil. They are also not careful about using the correct stocking density. Farmers can understand when their ghers are attacked by disease, but they do not know how to deal with this problem. All this leads to adverse changes in the gher ecosystem. Decomposing faeces and other organic matter accumulate on the gher bottom, and with rising temperature, cause oxygen depletion and increases in toxic material (NH_3, NO_2, H_2S etc.).

Imported fry

In 1994, fry were very few in local rivers, and the price increased significantly. Many small farmers failed to stock fry in time, and some stocked fry imported from Thailand. These were brought into the country without checks on their health status and without quarantine. It is generally believed that white spot syndrome virus (WSSV) was carried by these fry. Since then, many farmers have lost their harvest to this disease. In 1995, 1996 and 1997, white-spot disease spread in

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[3]Accumulation of stagnant water due to rain or flooding that is not possible to drain and does not dry out naturally.

epidemic proportions. Some farms were affected, while adjacent farms were not. The reason for this is not known, and remedies for the disease are yet to be discovered.

Intensification of Diseases

Farmers of Shyamnagar said that many of them had lost their harvest and they were very confused. The fry grew to a certain stage (50-70/kg) and then disappeared. Other species, such as crabs and fish, were also affected and disappeared within a week. The farmers tried many ways to overcome this situation, but once a farm was affected no harvest was possible. Some farmers who had earlier achieved one or two harvests could manage, while others who had been affected since the first crop had serious problems. The impact was so serious that many of them considered changing the species cultured. Reasons for losses, other than viral infection, that were identified included lack of growth, long legs, soft-shell and tail and gill rot. The occurrence of viral infection was less in Paickgacha than in Shyamnagar and was almost nil in Dacope and Rampal. The reason is assumed to be high salinity; where the salinity is less, viral infection is also less. Poor water management has increased the problem. The main constraints to production in the Paickgacha region include the high price of fry and the immaturity of shrimp. Farmers stocked both local and hatchery-raised fry, but some encountered problems of slow growth; a few had viral infections or leg lengthening. The farmers of Dacope had the problem of low growth rate; there were no reports of viral infection.

Lack of Capital

Losses due to the problems mentioned previously are harmful to the small-scale farmers and to all concerned. People carrying out this activity are not inclined to save money; they only save one term's investments and depend on the harvest. If this fails, the farmer is left with no alternative but to borrow at a high interest rate from the local moneylenders, or to get a loan from the bank, which is very difficult. Some farmers sell household belongings and invest once again, in an attempt to recover their losses. In addition to these problems, the market price of shrimp is not steady. When the harvest is at its peak, the price in the market generally falls, and farmers do not get an adequate return. Case studies of the problems disease has caused to two small-scale farmers are given in Boxes 1 and 2.

Remedial Measures Undertaken by Affected Farmers

Some farmers affected by the virus tried to overcome the problem with the help of the local Fisheries Extension Service; however, most preferred to follow the measures taken by their neighbouring farmers. Also, extension services were not always available when required. Some traders are now selling various chemicals to promote shrimp growth, and to treat bacterial infections and other problems; however, the effectiveness these compounds is not always known.

Box 1. Case study 1 – shrimp virus and Mr. Mistry.

Jatindranath Mistry, a rich farmer of Burigoalinee Village in Shyamnagar Thana, began shrimp culture when influenced by other local farmers. He had 4 ha of land, inherited from his father, near his homestead with a water supply from the sluice of the BWDB embankment. Mr. Mistry made a good earning in the early years of cultivation, and followed the traditional methods, as many others do. Being an educated and elite person, he often took advantage of advice and extension services from the local Thana Fisheries Office. He is not a saving-minded man and saved only the expenditure value of one crop.

In 1999, he started stocking his pond in the first week of February. He had applied lime, urea, TSP and cow dung during pond preparation and dried the farm and ploughed with a power tiller. Despite this, his stock became infected with white spot syndrome virus, and he lost all the shrimp. He stocked again in the first week of April, but the result was the same. During this period, he obtained a bank loan and began a third stocking; however, he again got no harvest due to viral infection. Mistry then borrowed some money locally and invested again; however, he once again had viral disease problems.

His sorrows now know no bounds. When he began aquaculture, he had his own land and did not need to borrow money for stocking. Now, the two loans hang upon him, and he has no money left to attempt further stocking. He is completely stunned and thinking that he may lease out the farm. He says that viral infection has ruined his family in all respects.

Box 2. Case study 2 - Mr. Parmal Zoarder's disaster.

During 1988, Sudhir Zoarder and his son Parimal started a shrimp farm on 5.6 ha of land belonging to them. In 1995, the farm was divided into four portions. Sudhir Zoarder got a farm of 2.5 ha, which was under two landowners. In 1996, it was again compartmentalised into two sections. Sudhir now had a farm of 1.6 ha, and handed over its management to his son Parimal. He had capital of about 200,000 Taka (US$3,900), earned earlier from shrimp fry and shrimp trading. In early February 1996, he stocked 13,000 fry at Taka 2,200 (US$43) and got a good return. In early April, he stocked 10,000 fry; however, these fry did not grow well, and thus, his return was poor, although he managed to recover his capital. He stocked again during early June, but the harvest was totally affected by viral disease. In early August, he stocked again, and again lost the entire crop to virus.

In 1997, Parimal prepared the farm and the nursery with lime, organic fertiliser, cow dung, urea and TSP. He ploughed the land with a power tiller and stocked fry costing 2000 Taka/1000 PL (US$40). All four harvests were virus free, and he had a good profit. In 1998, he stocked fry from India. He got a harvest in April; however, WSSV affected the next crops.

In 1999, during pond preparation, he applied lime, fertilisers etc., as usual, but he applied a little more TSP. Virus infected the first and second crops. Before the third crop, he dried the ponds, applied only lime, and stocked fry from Cox's Bazar; however, virus also affected the harvest. He again prepared the land and stocked, but the virus infected the shrimp again. He is now puzzled, has debts and no way left to survive. He is frustrated in every aspect, and he finds life hazardous and colourless.

Other Disease-related Issues

The following are some other impacts and issues resulting from disease outbreaks:

- The price of land in the coastal area where shrimp is farmed became constant due to the negative impact of disease. At the beginning of shrimp culture, land cost 10,000 Taka/bigha[4] (US$1,470/ha; 1US $ = 50.66 Taka). The price then jumped to 30,000-40,000 Taka/bigha (US$4,410-5,880/ha) and has since remained stationary. People from outside have lost interest in entering this sector.

- Outside leaseholders refused to pay lease money to landowners. Many closed up business and left the area without paying the remaining lease money; this generated chaos.

- Lease money demanded by landowners remained constant or, in some cases, was reduced in comparison to previous years.
- On 24 January 1998, the Government of Bangladesh (GOB) imposed a ban on the importation of shrimp fry. Since then, there has been a great scarcity of fry, and farmers have had to pay very high prices, 3,000-4,000 Taka/1000 PL (US$59-78/1,000 PL), whereas previously the price had been 300-1,000 Taka/1,000 PL (US$5.8-19.6/1,000 PL). Due to this, most of the ghers in the southwest region remained vacant until May. Moreover, the small farmers' shortage of capital multiplied the problems. As a result, fry collectors have suffered reduced income.
- The ban on the importation of fishery products into European Union (EU) markets from Bangladesh imposed in 1997-1998, and the fall in price of 30-40% in the international market, accelerated the economic disaster in this sector.

RECOMMENDATIONS

Participants in the PRA sessions put forward the following suggestions:

- **Credit management**. Shrimp culture is a sector demanding high investment; however, the present bank credit arrangements are time consuming and rigid. A more flexible, timely and accessible approach to disbursement of credit to farmers is required.

- **Insurance**. All other sectors have insurance facilities. They have the right and ability to insure their factories, trading centres and even their products; however, this is not available to shrimp farmers. This is an area of high investment without insurance facility; steps should be taken to bring this into line with other industries.

- **Extension activities.** Extension facilities need to be within the farmers' reach. An informed extension service and a routine reporting system should be in place. Co-ordination of experts, extension workers, investment agencies and farmers is urgently required.

[4] 1 bigha = 33 decimal = 0.13 ha.

- **Network building.** A co-operative network to address shrimp diseases should be further developed that includes research, field investigation, information exchange and preventative measures.

- **Farm management**. A management strategy, adopted at the conception of the shrimp farm, should include pond preparation, the use of fine screens at inlets, maintenance of standard stocking densities and implementation of a water management system. In the case of imported postlarvae, proper checking should be carried out before importation is allowed.

- **Crop diversification.** Shrimp cultivation should be stopped occasionally to allow ponds to recover. Crop diversification should be encouraged.

- **Alternative income-generation activities.** Provisions should be made for small-scale shrimp farmers to explore, and engage in, alternative activities.

CONCLUSIONS

Small-scale shrimp farmers in the coastal area are presently in a poor state. The flow of capital between the shrimp farmers and related activities is reduced. Measures need to be taken to assist shrimp farmers; otherwise this potentially valuable sector will disappear from this area.

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A CASE STUDY OF ISOPOD INFESTATION IN TILAPIA CAGE CULTURE IN THAILAND

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ABSTRACT

Tilapia is one of the most economically important species of cultured fish and is more resistant to disease than are many other species. However, when raised in intensive culture systems, tilapia suffer from increased parasitic and other infectious disease problems. Recently, cage culture of red tilapia (*Oreochromis niloticus*) in small reservoirs and sandpits throughout Thailand has increased, with the normal culture period being four months. A severe isopod infestation of tilapia in these cage-culture systems in central Thailand was recorded between June 1998 and January 1999. The mortality rate was 50-100% within 2-7 d after initial infestation. Trichlorfon at a concentration of 0.5-0.75 ppm for 24 hr is being recommended for pond treatment. However, chemical treatment for cage culture is not practical. Therefore, biological control may be the method of choice for prevention. Since the immature form of the isopod is planktonic, stocking more plankton-feeding species or cleaner-fish into the reservoir is recommended. Economic losses due to isopod infestation based on 50-100% mortalities was estimated at between US$234-468/cage.

BACKGROUND

Tilapia is one of the most economically important species of cultured fish and is more resistant to disease are than many other fish species. However, intensive culture systems increase parasitic and other infectious disease problems. Recently, cage culture of red tilapia in small reservoirs and sandpits throughout Thailand has increased; the normal culture period is four months.

THE EPIZOOTIC

Salespersons for a feed company, who work closely with the farmers, reported a severe isopod infestation of tilapia in cage culture in central Thailand to the diagnostic laboratory at the Aquatic Animal Health Research Institute (AAHRI). The infestation occurred between June 1998 and January 1999. The number of cages in this area was 200-300, with a size of 3 x 3 x 2 m. The fish were stocked at a size of 50 gm at the rate of 1,000-1,250 fish/cage. Mortality was 50-100% within 2-7 d after infestation.

THE PATHOGEN

The parasitic isopod, *Alitropus typus* (Fig. 1), is a common crustacean parasite of fish in Southeast Asia which feeds by sucking blood. After feeding on the fish, they drop off the host and stay in the substratum while digesting their meal. After the digestive process is finished, they will again attack the fish. Under aquarium conditions, 15-20 of these isopods can kill a 2-3 inch tilapia within 5-6 hr. Peak infection by this parasite is in the rainy season.

EM

Figure 1. *Alitropus typus*. Total length is about 0.7 cm.

RECOMMENDATIONS

Trichlorfon (Dipterex) at a concentration of 0.5-0.75 ppm for 24 hr is recommended for pond treatment; however, chemical treatment for cage culture is not practical. Therefore, biological control may be the method of choice for prevention. Since the immature form of the isopod is planktonic, stocking more plankton-feeding species or cleaner-fish into the reservoir is recommended.

ECONOMIC IMPACT

Production of tilapia is 400-450 kg/cage after four months of culture. The wholesale price is US$/1-1.2 kg. Therefore, the economic loss due to isopod infestation based on 50-100% mortality is US$234-468/cage.

THE IMPACT OF DISEASE ON SMALL-SCALE COASTAL CAGE-FISH CULTURE IN THAILAND

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ABSTRACT

The socio-economic impact of disease in small-scale coastal finfish aquaculture in the east and south of Thailand was assessed during July-September 1999 using a questionnaire. A total of 136 fish farmers were interviewed. The species cultured in the survey area are barramundi (*Lates calcarifer*) and grouper (*Epinephelus* spp.). The farms surveyed included 102 seabass farms and 34 grouper farms. The farms are located in four provinces: Satun, Pattani, Chanthaburi and Songkhla. Of the farms surveyed, 119 were cage-culture farms, while only four farms were pond-culture systems; five farms were solely hatcheries, while six farms combined hatchery and pond-culture systems. Two of the seabass farms carried out all of the above culture systems. There were more seabass farms than grouper farms, as seabass seed is more readily available from traders and private hatcheries. Grouper seed supply from hatcheries has been inconsistent due to disease losses. The survey indicates that the majority of the problems in grow-out grouper cage culture and seabass cage culture are due to seasonal variations and disease.

INTRODUCTION

Coastal aquaculture is receiving more attention in fisheries development in Thailand because of the decline in marine capture fisheries. Coastal finfish production has been gradually increasing, and production in 1996 was 4,800 mt (Fisheries Statistics of Thailand 1996). Coastal aquaculture is mostly concentrated in the south and the east coasts. The two fishes most commonly cultured are barramundi, *Lates calcarifer* (usually referred to as seabass in Thailand), and grouper, *Epinephelus* spp. The cage-culture system for these two species is similar; however, the market price for grouper (US$10-20/kg) is about five to seven times more than that for seabass (US$2-3/kg). Because of the higher market price, fish farmers tend to culture grouper rather than seabass. Unfortunately, neither the government nor private hatcheries has consistently produced large amounts of grouper seed, and most is presently collected from the wild. However, seabass seed can be produced by hatcheries and is available almost all year. Therefore, small operators, who cannot afford grouper seed, are still farming seabass. Apart from seed supply and problems of market price, disease may be a concern among farmers. In this paper, the impact of disease on small-scale operations is investigated.

MATERIALS AND METHODS

A coastal aquaculture survey was conducted in four provinces, Chantaburi, Pattani, Satun and Songkhla. A total of 136 questionnaires were completed for this study, of which 107 were obtained from Songkhla Province. Coastal aquaculture in Thailand is mainly cage-culture systems located in brackish water.

RESULTS

General Practice of Thai Coastal Fish Farmers

Seabass is the dominant species cultured (75%), while grouper accounts for the remainder (25%). Over 88% of farms practice cage culture, with 9% practising pond culture. Of the cage-culture farms, 50% were small, ranging in cage surface area from 5 to 100 m^2. About 62% of the cage fish farmers owned 1-5 cages. Four seabass hatcheries were covered by this survey. Seventy percent of the fish farms bought fry from traders, and 15% of the farms collected seed from the wild.

Socio-economic Circumstances of Farmers

Of the farmers interviewed, 118 said that production had generally been as good as expected. Average survival rates for cage fish culture were ~60-70%. Farmers seemed to find mortalities of 30-40% per crop acceptable. The total revenue as expressed by the farmers varied from US$25 to $2000/yr. The cost of fish production, ranked from high cost to low cost, came mainly from feed, cage preparation and chemicals. Aquaculture was found to be an important occupation, as over 75% of the farmers spent more than 50% of their time in aquaculture. The main reason given for culturing fish was for income; a secondary reason was for household consumption.

Time Spent on Different Activities

The husband spends more time working in the fish farm, feeding or harvesting the fish, than the wife and children. However, the wife plays an important role in marketing the fish and buying the fry.

Where Farmers Learn to Raise Fish

Farmers coming into aquaculture normally learn how to grow fish themselves (28%) or obtain the knowledge from their friends (27%); other farmers learn from government officers (21%) or neighbouring farmers (22%).

Problems

Cage-culture information was mainly obtained from Songkhla Province, where cage culture is located in the river and the lake, which both open to the sea. The first-ranked problem was low water level in the culture area during the hot season. The second-ranked problem was flooding during the wet season, while disease problems were ranked third.

Coastal finfish cage culture was considered a risky venture by 130 of the 132 farmers interviewed. Surprisingly, 123 of the 132 farmers still considered cage culture to be profitable. However, 81 of 132 farmers said that the profits were not large. 120 of 132 farmers did not believe that large-scale fish farming would bring them large profits. Most of the farmers (128 of 132 farmers) said that disease was an important issue.

Disease Status

Most of the farmers interviewed had good contacts with the Aquatic Animal Disease Unit in the National Institute of Coastal Aquaculture (NICA). Around 55% of the farmers could identify diseases. Results indicate that bacteria, parasites, viruses, and red spots on the body of the fish were the main problems (from high frequency to low frequency) in seabass and grouper culture. However, about 45% of the fish farmers could not identify diseases.

Disease usually occurred within 10-30 days after stocking the fish in the cage. Eighty of 124 farmers indicated that disease problems mainly occurred during the rainy season, while 35 of 124 farmers said that the problem occurred during the hot season. When disease occurred, 99 of 119 farmers reported losses of between 30-50%. The value of lost production varied as shown in Table 1. Over 50% of fish farmers preferred to use drugs or antibiotics to treat their fish. The cost of treatment varied between US$5 - over $500/yr; however, 87% of fish farmers spent around US$5-100/yr. Fifty-nine of 121 fish farmers said that treatments were “usually” effective, while 61 of 121 said that treatments were “sometimes” effective.

Table 1. Value of fish products lost due to disease.

Value of Loss (US$)	Number of Farms Reporting	Percentage of Farms
0-500	18	15.0
501-1000	17	14.2
1001-1500	9	7.5
1501-2000	17	14.2
2001-2500	9	7.5
2501-3000	6	5.0
3001-4000	16	13.3
4001-5000	12	10.0
>5000	15	12.5
Total	120	100

DISCUSSION

Most of the finfish cage culture in Thailand is comprised of small farms, with farmers usually owning 1-5 cages. Even though farmers felt that cage culture did not make a lot of profit, they would still continue with aquaculture. In small farms, the farmers spent some of their time culturing fish and some on agricultural or fishing activities. Cage culture is located in the shallow water near their homes and is easily polluted by drainage water from the villages or towns. This pollution can have a greater effect on fish health during the hot and wet seasons. Apart from these seasonal variations, disease is also a cause of mortalities. The findings suggest that extension and research programmes are required to improve finfish cage culture in Thailand. It is likely that the 30-40% mortality per crop encountered in finfish cage culture could be reduced following research into the disease problems.

Two different viruses, an iridovirus (Danayadol *et al.* 1994; Kasornchandra and Khongpradit 1997) and a nodavirus (Danayadol *et al.* 1995) have been identified as pathogens and capable of causing high mortality. These viruses have been identified in seabass and grouper culture from a wide geographical area, including Southeast Asia, Japan and the Mediterranean. Co-operation among affected countries would assist in controlling these diseases and preventing their spread.

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IMPACTS OF DISEASE ON SMALL-SCALE GROUPER CULTURE IN THE PHILIPPINES

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ABSTRACT

A farm-level participatory survey of the impacts of disease in small-scale grouper (*Epinephelus* spp.) culture in the Philippines was conducted from July to September 1999. A total of 72 fish farmers and one co-operative with a membership of 65 families engaged in small-scale fish production from Cavite and Capiz provinces in Luzon and the Visayas Islands, respectively, were interviewed. Grouper culture is carried out in pens and cages along coastal bays and adjoining tributaries. It contributes significantly to local livelihoods, particularly of those carrying out small-scale fishing activities as the main source of income. It requires low capital investment (as little as US$250, 1 US$=39 Pesos) with potentially high returns. Being an export commodity, live grouper commands a good market price of US$7-11/kg, similar to the price of shrimp. Grouper seed, from natural sources, are either purchased from traders or caught by the farmers themselves. The culture period ranges from 6-12 months, depending on the size of fry or fingerlings at stocking.

Fish farmers recognise health problems as a significant constraint to grouper culture. Unidentified diseases exhibiting a range of clinical signs such as ulceration, fin rot, tail rot, scale loss, white spots, haemorrhages and cataract; leech parasitism; or a combination of these abnormalities were found to cause high mortalities, especially among fry. Proliferation of grouper and milkfish pens and cages, oyster and mussel farming, unstable climatic conditions and run-off following heavy rains contributed to the deterioration of the quality of the aquatic environment, which is believed to be associated with the problems reported. For beginners, the lack of proper husbandry knowledge intensified existing problems. An inadequate supply of fry was another important constraint identified by farmers.

Farmers experiencing large losses due to disease temporarily cease operations and resume production when they acquire sufficient capital. Other species, such as snapper (*Lutjanus* sp.), seabass (*Lates calcarifer*), and milkfish (*Chanos chanos*), are also cultured in the majority of farms; however, they are not considered good alternative species. Although these species are quite resistant to the diseases affecting grouper, they have a low market value. Even though disease poses a high risk to grouper culture, farmers are not discouraged from continuing this activity, as they believe that the high market price of grouper will contribute to the advancement of their household status.

INTRODUCTION

In 1998, aquaculture production in the Philippines was 954,000 mt, valued at 26.2 billion Philippines pesos (PHP) (US$671.79 million) and contributing 34.2% to the total fisheries production. There are about 258,480 Filipinos engaged in aquaculture activities, about 26% of the total number of people employed in the entire fishery sector (aquaculture, municipal and commerical fisheries activities) (Philippine Fisheries Profile 1998). In 1997, total fish production from marine fish cages, pens and brackishwater ponds was 199,349 mt valued at PHP 2,176,481,300 (US$55.8 million) (BAS 1997).

Grouper (*Epinephelus* spp.) is the most popular marine finfish species cultured because it adapts easily to different culture conditions (pond, cage and pen) and has a high growth rate. Grouper, particularly live, commands a high market price in both local and foreign markets, especially among Chinese communities. The average price per kilo is about US$7-11, which is almost the same as the price of shrimp. In 1997, total grouper production in ponds, cages and pens was 496 mt, valued at PHP 184,388,000 (US$4.7 million) (BAS 1997).

The industry depends on seasonal wild-caught seed. The orange-spotted grouper (*Epinephelus coioides*) and the Malabar grouper (*E. malabaricus*) are the two commonly cultured species, the former being the most commonly cultured. The culture period ranges from six to twelve months, depending on the size of fry and fingerlings at stocking. Market size is about 0.4-1 kg, and trash fish is commonly used for feeding.

The majority of grouper cage and pen operators are smallholders for whom the primary source of income is fishing. They mostly reside in coastal areas and have no stable daily income. Culturing grouper can reduce poverty and improve their livelihood, as it requires low capital investment and has potential for high returns.

There are several reports of disease and health-related problems affecting grouper (Baliao *et al.* 1998, Leong 1994, Chong and Chao 1986). Significant mortalities of grouper are also experienced in the Philippines. Laboratory examinations based on diagnostic cases received, as well as on samples collected for the research project on grouper health undertaken by the Philippine Bureau of Fisheries and Aquatic Resources (BFAR), showed consistent isolation of *Vibrio* spp. in the affected fish and the presence monogenetic trematodes on the gills.

This survey was conducted to determine the impacts of health problems in small-scale grouper culture in the Philippines. Its specific objectives were: 1) to determine the current understanding of small-scale grouper farmers of the concepts of fish disease, aquatic animal health and health management; 2) to assess the socio-economic impacts of diseases and other health-related problems on the livelihoods of small-scale grouper farmers; and 3) to identify health management strategies used in small-scale grouper culture systems.

METHODS

A farm-level survey was conducted from July to September 1999 using a semi-structured questionnaire developed by the Network of Aquaculture Centres in Asia-Pacific (NACA). It consisted of two parts. The first part contained questions on: a) general account of the farm; b) description of operation; c) revenue; d) cost of production; e) household activities; f) general disease problems, recognition of diseases and related losses, action taken and received, and social perception of the effect of problems. The second part related to specific diseases that had been encountered.

A total of 72 fishfarmers and one co-operative (with 65 member families) engaging in small-scale fish production in the provinces of Cavite and Capiz were visited and interviewed. The areas visited were: Cavite City, Cavite (n=29); Cagay, Roxas City, Capiz (n=3 + 1 c-ooperative); Barra, Roxas City, Capiz (n=12); and, Basiao, Ivisan (n= 28). The information gathered was collated and tallied manually and data are presented as percentages.

RESULTS

Description of Grouper Culture Operation

Small-scale grouper culture uses cage and pen systems. They are located along coastal bays and adjoining tributaries. The usual size of cage is 3x3x3 m, whereas, with pens, there is no standard size. Of the farmers interviewed, 18.0% started grouper farming between 1980-1990. There was a significant increase to 81.9% between 1991-1995. The culture cycle runs from 6-12 months, depending on the size of fry and fingerlings at stocking. Market size ranges from 0.4-1 kg, with a market value (live) of US$7-11/kg. Seed from natural sources is either purchased from traders or caught by the farmers themselves, and ranges in price from US$0.12-1.53/fish.

Aside from grouper, fish farmers also catch and raise other marine fish species such as snapper, *Lutjanus* spp. (45.8%); seabass, *Lates calcarifer* (16.7%); milkfish, *Chanos chanos* (6.9%) and others (e.g., siganids and porgy). Trash fish are also used as feed.

Household Status

The majority of the fish farmers interviewed earn much less than the Philippine minimum wage of US$129.00/month (Table 1). Most farmers (70.8%) rely on fishing activities to support their families, while others are involved in labouring and small business (e.g., mini store, livestock) activities. Farmers culture grouper as a source of income (100%). Some considered other cultured species for food (30.6%). Fish culture makes a significant contribution to their income (Table 2). The operating costs vary depending on the number and size of cages and pens. Some farmers started grouper culture with a capital investment of less than US$100.00 (Table 3).

Table 1. Annual household income of surveyed grouper farmers in 1998.[1]

Income (US$)	Operators (N)
350-500	5
600-900	20
1000-1400	20
1500-2000	11
>2000	12
No comment	4

[1]Minimum wage=US$129/month.

Fish culture is usually managed by the husband (96.6%) or wife (1.4%); some (11.1%) use hired labourers. Feeding, cleaning of cages or pens and fry purchasing are performed by the husbands. Two to five hours per day are usually spent on the farm; however, some farmers may spend more than ten hours, staying overnight to protect their stocks from theft. Wives provide assistance during harvest and in marketing the fish. Farmers learned to raise fish by themselves (76.4%) or from other fish farmers, neighbours and friends (16.7%). Only a few (6.9%) learned to raise fish from governmental and non-governmental organisations.

Table 2. Contribution of aquaculture to household income.

Percent Contribution	Operators (N)
20-30	13
31-50	25
51-70	21
71-90	8
100	5

Table 3. Operating cost during the last culture period.

Cost of Operation (US$)	Operators (N)
< 100	5
100-250	30
260-500	15
600-750	8
760-1000	5
> 1000	9

Disease Problems

The farmers experience several diseases and considered the first two months of the culture period to be critical. Common problems encountered by farmers are summarised in Table 4, and discussed below:

White spots, eroded caudal fin, fin and tail rot

This problem is common during the first two months of the culture period and mortalities may reach 70%. Farmers use freshwater (rainwater) bath as a treatment. A very few farmers also use betadyne and formalin. Treatment is not always successful.

Leech infestation

Leeches are prevalent between the months of February and September in both the nursery and grow-out stages. Higher prevalences are observed in farms with no regular cleaning of net cages. Affected fish at all stages show pale discoloration, weakness and inappetence. Leech infestation may result in 100% mortality within a short period of time. The problem is managed by the manual removal of leeches and the cleaning of net cages. For treatment, jackfruit peel, hung in the water along the sides of net cages is used. Farmers believe that the strong odour of jackfruit peel dislodges and eliminates the leeches.

Table 4. Summary of health problems encountered in grouper farming.

Health Problems	Occurrence (%)	Stage Affected	Seasonality	Mortality Rate (%)	Treatment
White spots, scale loss, fin & tail rot	38.9	Nursery	1-2 months after stocking	30-70 (may reach 100)	Freshwater bath, betadyne, formalin
Leech infestation	15.3	Nursery and Grow-out	February-September	30 (may reach 100% in small sizes)	Jackfruit peel, manual removal
Ulcerations, red spot with fin & tail rot	31.9	Grow-out	No specific period	10-35	Freshwater bath, guava leaf extract, madre cacao leaf extract, betadyne, formalin
Exophthalmia, cataract	6.9	Grow-out	No specific period	<5	None
Ruptured gallbladder	5.6	Grow-out	January-February	<5 (affected fish do not survive)	None
Mortalities without gross lesions	26.4	Nursery & grow-out	No specific period	May reach 100%	None

Ulceration, red spots with tail and fin rot

This problem is common during the grow-out stage. The condition is chronic and mortalities may range from 10-35%. There is no seasonal pattern to its occurrence. A freshwater (rainwater) bath is commonly used to treat the fish. Application of betadyne and formalin is also commonly used. Some fish with early signs of the disease may respond to treatment. Some farmers have tried guava and madre cacao leaf extracts without success.

Exophthalmia, cataract

This disease is observed at grow-out stage; however, it is not considered as a serious problem. Mortalities related to this condition are less than 5%. No treatment is being applied.

Ruptured gallbladder

The problem is acute and the fish do not show any external lesions. Sudden mortalities are observed, and farmers assume that the affected fish did not survive because the gall bladder is ruptured. This problem is experienced during January to February; no treatment is applied.

Mortalities without gross lesions

Nursery and grow-out stages are both affected with this problem. This is an acute condition and mortalities may reach 100%.

Others

A few farmers are affected by flooding. Strong water currents and flash floods can destroy the net cages and allow fish to escape. Farmers also anticipate thefts, and dogs are used to guard the farm. The owner or hired labourer may also stay on the farm during the night.

When farmers experience disease problems, a very few (8.3%) contact fry traders and local government for assistance. Most (91%) of the respondents did not contact the government because of the perception that small-scale farmers are not given particular attention. Information on fish health is mainly provided by other farmers who are usually neighbours and friends.

Survival rates (%) are presented in Table 5.

Table 5. Survival rate of grouper during the last culture operation

Survival (%)	Operators (N)
0	4
5-20	8
21-40	24
41-60	25
61-80	9
>80	2

Causes of Disease Problems

Several factors are believed to contribute to the disease problems encountered by fish farmers. These include (a) unstable conditions brought about by sudden changes in weather, such as heavy rain after a long dry season; (b) run-off of domestic and industrial waste following heavy rain; (c) deteriorating water quality due to increased aquaculture activities, such as grouper and milkfish pen and cage culture, and oyster and mussel farming; (d) lack of technical knowledge relating to proper husbandry and health management, particularly for beginners; and (e) lack of desire among farmers to contact appropriate governmental agencies.

Socio-economic Impacts of Health and Disease Problems

Disease problems significantly affect the livelihoods of the fish farmers. The majority (75%) of farmers experienced reduction in income, while some (19.4%) increased their debt, particularly those who borrowed to invest in aquaculture. Culture operations were also prolonged because of the time needed for the affected fish to recover from disease.

Although disease problems are recognised as significant constraints to grouper culture, 87.5% of respondents did not change their attitude towards grouper farming. A small percentage, particularly those that experienced large losses, temporarily stopped culturing grouper (9.7%), while some changed culture species (2.8%). Farmers usually resumed operations once they had acquired sufficient capital. Other fish species cultured by the majority of the farms surveyed were not considered as good alternatives. Although these species seemed to be resistant to the disease problems affecting grouper, they have a lower market value.

Although disease poses a high risk to grouper culture, fish farmers are not discouraged and continue operating because they believe that it is still very profitable. They are optimistic that this activity will contribute greatly to the enhancement of their household status.

CONCLUSIONS

Grouper culture is a promising industry, particularly for small-scale fish farmers. It has huge potential to make a significant contribution to the household income of these farming communities, and the farmers are very keen to further develop it. To make the industry sustainable, the following strategies are strongly recommended:

- *Development of policies for the regulation of aquaculture activities and strict enforcement of associated laws.* In the areas surveyed, there were no designated sites for aquaculture and no regulations stipulating the maximum permitted number of cages or pens for the culture of grouper and other fish species, nor any regulation of other aquaculture (e.g., oyster and mussel farming) activities. This unregulated establishment resulted in overcrowded conditions. The Philippines Fisheries Code of 1998 (RA 8550), Article III, Section 51, states that "fish pens, fish cages, fish traps and other structures for culture of fish and other fishery products shall be constructed and shall operate only within established zones duly designated by Local Government Units (LGUs) in consultation with the Fisheries Aquatic Resources Management Councils (FARMCs) concerned consistent with the national fisheries policies." If the provisions in this code could be duly implemented, it would significantly reduce the deterioration of the environment and the stress that results from crowded conditions.

- *Training on grouper culture, including proper husbandry and health management, is required*. Most farmers, particularly new entrants, have inadequate technical knowledge on proper fish culture, husbandry and health management. Training on these subjects will help them to understand the concept and principles of sustainable fish farming. Through training, they will be equipped with sufficient scientific knowledge to realise the consequences of improper fish culture, husbandry and health management and the impact on productivity and the aquatic environment.

- *Strengthening of technical assistance and extension services to farmers is required*. There should be strong linkages between the government extension workers and the small-scale fish farmers. This should be enhanced through regular farm visits and consultation. Monitoring of the health status of grouper farms should be carried out regularly. Extension workers should be more active and ensure that they respond to the needs of the farmers. They should be encouraged to report problems immediately in order to ensure appropriate technical services and guidance.

- *Research on significant disease problems and formulation of preventative and control strategies is required*. Research should be problem solving and focused on the needs at the farm level. The farmers should participate in developing research plans. Short-term studies should provide immediate practical application of results to address significant issues.

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RISKS TO SMALL-SCALE CAGE FARMERS IN BANGLADESH, WITH EMPHASIS ON FISH HEALTH EXPERIENCES OF THE CARE-CAGES PROJECT

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ABSTRACT

The CARE-CAGES Project (Cage Aquaculture for Greater Economic Security) was initiated in September 1995, began cage-aquaculture activities in 1996, and is now working with approximately 4,200 households, through 45 partner non-governmental organisations (NGOs). The only pathogens that have been observed in caged fish are the parasitic isopod *Alitropus typus* (Milne-Edwards, 1840), and epizootic ulcerative syndrome (EUS). EUS effects mostly Java barb (*Barbodes gonionotus*) during the winter season, resulting in chronic low-level mortalities. Although found sporadically in other sites, *A. typus* only significantly effects cage-farming operations in one river in the Jessore region. It is suspected that the large amount of aquatic vegetation present in this river is a pre-requisite for large parasite numbers. This parasite makes cage culture impossible due to 100% fish mortalities in late spring. When the monsoon begins, parasite numbers reduce, and with lower numbers, there is milder damage and no mortalities. Other pathogens may be present, however, due to lack of appropriate resources, these have not been observed. Fish health concerns for CARE-CAGES largely relate to providing quality fingerlings and feeds, good site selection and cage management. A breakdown of mortalities for the CARE–CAGES project for 1998 and 1999 is provided, and key issues relating to fish health highlighted. Total losses of stocked fish were reduced from 36% in 1998 to 22% in 1999. All categories (stocking mortalities, mortalities during culture, escapees, poaching and other) were reduced, and this is due principally to greater farmer experience in this new culture system.

INTRODUCTION

Cage culture has a limited history in Bangladesh. CARE-CAGES (Cage Aquaculture for Greater Economic Security) is the first project in Bangladesh to focus exclusively on cage aquaculture. Established in September 1995, the project has attempted to develop a range of systems that offer resource-poor farmers an opportunity for successful cage culture, within their social, economic and institutional environment. The project is due to finish in March 2001 and, as shown in Table 1, has expanded each year since start-up and is working with approximately 4,200 households in 2000. The CAGES Project is currently delivering its outputs to farmers through 45 small-partner non-governmental organisations (NGOs) in seven districts: Barisal, Comilla, Jessore, Dhaka, Natore, Sylhet and the Chittagong Hill Tracts.

Table 1. Expansion of the CARE-CAGES Project, showing numbers of households and cages operated by these households.

	1996	1997	1998	1999	2000
Number of households	10	308	632	1987	4,200
Number of cages	30	520	959	2698	5,500

There has been a trend in the project to move towards smaller (1 m^3) floating cages (Kabir and Huque 2000). It has been found that ease of management and the lower investment required with these smaller cages are the key reasons for changing from larger 8 m^3 cages. A full review of cage types used in the project is provided by Kabir and Huque (2000).

It has become clear over the past few years that some species thrive in cages better than others. The major carps for example, though popular with the people and capable of obtaining a high market price, do not generally grow well in cages. Species farmed by CAGES beneficiaries in 1998 are shown in Table 2.

Table 2. Species farmed by cage farmers in the CARE–CAGES Project in 1998.

Common Name	Latin Name	Percentage of Species
Tilapia	*Oreochromis* spp.	39
Java barb	*Barbodes gonionotus*	34
Grass carp	*Ctenopharyngodon idellus*	10
Sutchi catfish	*Pangasius hypophthalmus*	6
Silver carp	*Hypophthalmichthys molitrix*	2
Others		9

Species cultured in 1999 were similar to those cultured in 1998, with tilapia remaining the most popular species. In 1999, however, less grass carp were farmed, due to poor results relating to under-feeding by farmers. Percentages for sutchi catfish and freshwater prawn (*Macrobrachium* spp.) have increased from 1998, with farmers encouraged by their high survival and good market price. In 1999, due to high returns, rapid return on investment, and less risk for these resource-poor groups, some farmers changed from table-fish production to nursery operations in fine-mesh hapas (McAndrew *et al.* 2000).

PATHOGENS

Only two pathogens have been identified that cause disease and economic loss to farmers. It is, however, accepted that there may be more that are presently unrecorded, due to difficulties of implementing a detailed fish health-monitoring system for these widely dispersed, poor farmer groups. The two pathogens are the parasitic isopod *Alitropus typus* (Milne-Edwards, 1840) and epizootic ulcerative syndrome (EUS).

Epizootic Ulcerative Syndrome

EUS almost exclusively affects *Barbodes gonionotus*, although *Pangasius* spp. may also be affected. It is estimated that around 3% of all *Barbodes* cages are affected (CAGES regional Technical Officers' estimation). The disease occurs between November and January, when water temperatures fall. Farmers are well aware of the disease, and recognise the sluggish movement of fish and reduced appetite that are often the first clinical signs of infection. No treatment is recommended, as it has been advised that interventions may increase stress levels and result in higher losses. Farmers remove any diseased fish immediately, which are usually consumed by the household, although it is reported that approximately half the market price can be obtained for infected fish at the local market. Farmers are also advised to harvest all fish in an infected cage soon after the first fish are seen to be diseased, as experience has shown that few fish recover from the disease over the winter period.

Parasitic Isopod

In the Nabagonga River in the Jessore region, there are large numbers of *Alitropus typus*. Although reported by CAGES Technical Officers in other rivers in Bangladesh, the parasite numbers in these rivers do not appear to pose a serious threat to fish health. It is hypothesised that the reason for such large numbers in this particular river is the large amount of aquatic vegetation present. Farmers with cages on the river reported that fish culture was impossible during early spring, as the high numbers of parasites led to all fish being attacked by large numbers of the isopods, resulting in anaemia and death within 24 hr. Local fishermen also reported that, when the monsoons arrived, the parasite disappeared.

Investigation of the biology of the isopod; its impact on cage farmers, local fisher groups and other water users; and development of appropriate alleviation strategies for farmers were carried out in 1999 (Bulcock 1999). This work was financed through the DFID-funded Research Project “Improved Management of Small-scale Cage Aquaculture in Asia,” the Bangladesh component of which is supporting the CARE–CAGES project.

FISH HEALTH AND RISKS TO CAGE OPERATORS

Fish loss is inevitable in cage culture. In this report losses to the farmer are split into five different categories. These are:

- stocking mortalities - when fish die within five days of stocking;
- culture mortalities - when fish die after five days of stocking but before harvest;
- escapees - all fish that are lost accidentally throughout the culture period;
- poaching/vandalism - all fish lost due to deliberate human theft or damage; and
- other - any other losses not covered above.

There were a total of 1,072,426 fingerlings stocked in cages in 1999. Of these, 22% were not sold by beneficiaries at harvest. A breakdown of losses is shown in Table 3, and compared to 1998.

In all categories there are less losses in 1999 then in 1998. The main reason for this is greater experience of the farmers and NGOs in cage culture, and the improved information and training that was provided by CAGES staff based on their previous experience. This overall reduction may be also be due to the increased numbers of 1 m^3 cages, which have previously been shown to have lower mortalities during production (CARE unpubl. data). A particularly large fall was seen in escapees, which is due to better cage management, as well as improved site selection.

Table 3. Reasons for fish loss in cages in 1999 compared with 1998.

	1999	1998
Stocking mortalities (%)	9	12
Culture mortalities (%)	7	9
Escapees (%)	4	11
Poaching (%)	1	2
Other (%)	1	2
Total lost (%)	22	36

Of the losses detailed in Table 3, only some of the stocking and culture mortalities could be due to preventable fish health problems. Stocking mortalities are often beyond the control of the farmer, with poor quality and badly transported seed the major problem, although poor management practices when handling and acclimatising the fry may also result in severe losses. Escapees are a result of poor management and, in some cases, inappropriate site selection, while poaching and theft are a result of social problems and inadequate security.

Although farmers have not identified disease to be a major constraint to cage-culture operations, good fish health is essential for adequate growth and survival, which is necessary if adequate income is to be obtained from the cage operation. In the case of Bangladesh, as elsewhere, health of caged fish depends on seed transportation and quality, adequate nutrition, appropriate site selection and good management practices. Each of these will be summarised, with examples of experiences from the Bangladesh CARE-CAGES Project.

Seed Quality

Transportation and stocking

Mortalities due to poor transportation and stocking have been the most common cause of losses in the CAGES Project each year since inception, although each year the number of mortalities has declined. The project encourages farmers to buy from reputable fry traders and to obtain fry from as close to the farm as possible. It has been found that tilapia suffer especially high mortalities, perhaps due to their dorsal spines physically damaging other fingerlings, or to the lack of knowledge concerning transport of this relatively new aquaculture species in Bangladesh.

As would be expected, there is a strong relationship between transportation time for fingerlings and stocking mortalities. The CAGES Project is attempting to overcome these problems with hapa breeding of tilapia, over wintering of fry and the development of local linkages between cage farmers and reputable seed suppliers (hatcheries, nurseries and fry traders).

In addition to a supply of fry that are healthy at the time of arrival, adequate preparations for stocking of the cage are also essential. Fingerlings that are being placed in a cage are stressed, both by the change in water chemistry (water in the cage compared to water in the fry-carrying container) and by being placed in a cage. It is important that fingerlings are acclimatised slowly to the water in the cage to reduce stress. Fingerlings that have never been enclosed by a net may be panicked by the experience and attempt to escape through the netting. It is obvious that netting must be sufficiently small to prevent fry escaping or being trapped or "gilled." Such trapping of the fry is frequently observed, especially with less-experienced farmers. Where resources allow, the acclimation of fingerlings in a fine-mesh hapa is recommended.

Nets must be conditioned by placing them in the water for up to a week before the introduction of fry. This allows periphyton to become established on the net, reducing the chance of physical damage to fingerlings when they are first placed in the new environment of a cage.

Stocking mortalities, although still high, have been falling every year, and with greater farmer experience, availability of early quality fingerlings from hapa breeding and over-wintering, and local linkages with seed suppliers, it is expected that these will be reduced further in 2000.

Genetic quality of seed

The seed obtained must be capable of reasonable growth, and this is not the case with all seed currently used by the CAGES-Project beneficiaries. Common carp (*Cyprinus carpio*) have consistently shown very poor growth, or even sometimes weight loss in cages (CARE unpubl. data) and are no longer recommended by CAGES staff as a suitable culture species. Problems also exist with some strains of local tilapia, with early maturation and poor growth being found by some farmers. This may be the result of hybridisation of *Oreochromis mossambicus* with the stocked *O. niloticus*, resulting in a reduction in growth potential of the resultant fry. In other locations, trials have shown that some strains of local tilapia have similar growth to GIFT tilapia (Genetically Improved Farm Tilapia), recently imported into Bangladesh (CARE unpubl. data). The GIFT strain has the advantage, however, of consistently good growth potential, while local strains vary widely in their growth potential.

Farmers invariably prefer wild seed to hatchery-produced seed, reporting that wild seed is hardier and also has the obvious advantage of being free of charge in certain locations. However, wild fingerlings must be carefully collected, handled and transported to cages. Careful handling of fry and careful stocking are also essential for hatchery-produced fingerlings. In the Barisal region, the success or failure of climbing perch (*Anabas testudineus*) was largely determined by the amount of care taken during seed collection (CARE unpubl. data).

Size and timing of seed

For successful cage culture, farmers require large fingerlings early in the season in order to maximise the growing season, and hence, increase returns. In the CAGES Project, several strategies are being tested to achieve this aim. Hapa breeding of tilapia is being attempted by most of the 44 NGOs involved in the project. Success in 1999 was mixed, but with better planning, it is expected that hapa breeding and nursing will provide a locally available source of high-quality seed for cage operators in 2000. Hapa over-wintering of several species was undertaken in 1998/99 with good results. Over-wintered fingerlings produce a seasonal "growth spurt" in spring, with superior results to same-season fry (CARE unpubl. data). Most of the project's 44 NGOs are attempting over-wintering in the 1999/2000 winter season, and so far, results appear encouraging, with few mortalities observed.

Fish Nutrition

Inadequate feeding is the major reason for poor growth of fish amongst project beneficiaries (CARE unpubl. data). Except in the case of certain species in eutrophic ponds, caged fish require supplementary feeds. Especially with inexperienced farmers, the amount of feed provided to fish has often been insufficient to allow reasonable growth. Lack of feed is the major reason for inadequate growth of grass carp, resulting in poor returns and a reduction in the number of farmers culturing this species in 1999.

Poor growth and poor fish health also result from poor quality of feed. A complete pelleted diet is neither available nor affordable for CAGES beneficiaries; feeds, therefore, vary greatly in quality. Farmers are often reluctant to spend relatively large amounts of money on fish protein, which results in nutritional problems; this is especially true of high-valued piscivorous fish. Fisher groups attempted to culture several of these species (*Channa marulius*, *C. striata* and *Wallago attu*), however, all ended in failure (CARE unpubl. data). CAGES staff hypothesised that these fisher groups would be able to supply “trash fish” to these fish, however, as every fish caught has a market value, fishers were reluctant to feed them to the caged fish. This resulted in inadequate fish nutrition, poor fish health, poor growth and subsequent failure of the cage operation.

Fish are usually fed a “ball-form” feed, the composition of which varies according to the species under culture and the local resources available. The feed usually contains, rice bran, oil cake and fishmeal, and often, many other ingredients (e.g., kitchen wastes, flour, rice water, snails, mussels). Farmers have also obtained good results by including cheap “opportunistic” ingredients, such as broken bread and damaged biscuits fed to tilapia, banana leaves and trunks fed to grass carp, and viscera from dead cows fed to sutchi catfish. The key is to obtain low-priced feeds that satisfy the nutritional requirements of the species being cultured. For the more herbivorous species, culturing in green water helps reduce the effects of inadequate nutrition in supplemental feeds.

Site Selection

Good site selection is essential for the success of any cage-culture operation. Poor site selection greatly increases the risk to the cage-culture operation. A complicating factor in Bangladesh is that water levels vary substantially during the season. This results in most cages being moved during the production cycle. Therefore, cage operators often have to select two sites, one for during the monsoon and one for when water levels are lower.

Some areas of Bangladesh (Sylhet, Barisal) are prone to flash floods. During this time, water currents and turbidity are high, which results in problems with feeding, physical damage to cages, and possible gill damage to fish from suspended solids.

Feed loss has been significantly reduced by the use of fine-mesh panels on the bottom of the cage and 10 cm up the sides from the bottom of the cage. This mesh is now used in all project areas, provided turbidity is not a major problem. In areas with high turbidity, the fine mesh becomes clogged, reducing water flow and placing structural stress on the cage (Kabir and Huque 2000).

In one site at Barisal, a bamboo barrier was constructed around the cage to protect it from physical damage and to produce a microclimate of calmer water that is more conducive to fish growth. Although the cage of sutchi catfish survived the flash floods, it was not economically successful.

Poor site selection usually results in economic loss, with fish unable to thrive. In areas prone to flash floods, rivers and canals are not recommended for cage culture. Ponds are more suitable, as they are not subjected to the same conditions, and only in severe flooding are they subjected to currents. However, not all potential cage farmers have access to ponds, as many beneficiaries do not own any land. This means that poorer groups, who are less able to risk investing in cage culture, are placed in a higher risk category due to inferior site availability. This is a constraint to entry of poorer groups in some areas.

Jute retting is also practised in many areas of Bangladesh, especially in the Jessore and Dhaka regions. After harvesting in August, jute is placed in water bodies until the flesh of the plant has been removed by bacterial decomposition. As a result, a black, anaerobic sludge forms. This process results in water quality deterioration, making fish culture impossible in waters in which jute retting is carried out. Unfortunately, jute farmers seldom give warning of their activities, and many cages have suffered 100% mortality as a result of such practices.

Site selection is critical to the participation of woman in cage culture (Brugere *et al.* 2000). In Bangladesh, it is difficult for women to move a long distance from their homesteads, both for reasons of security and in order for them to carry out their many other tasks. If a woman is responsible for feeding the fish (which they often are), cages must be located close to the homestead, or fish will not be adequately maintained. This is a major issue when the project is attempting to involve women in the activity.

The distance from the homestead is also critical in reducing poaching, which is a major cause of fish loss (Table 2). Remote cages are at much greater risk from poaching than those close to the home. Many farmer groups have formed cage clusters, making it possible to have a guard on the cages every night, with each farmer carrying out the duty in turn.

Management Practices

Early failure of the project's beneficiaries was due, in part, to the rapid move to the new practice of cage culture from the more traditional and better-understood pond aquaculture system. Cage culture differs from pond-based culture in that management must be pro-active. There are activities that must be carried out at regular intervals in order to obtain any outputs from the cage (e.g., cage construction, stocking, feeding, net cleaning, net checking, removing mortalities). Many of these are complex activities that have to be learned and understood by beneficiaries.

Although all beneficiaries were trained in all the practices necessary for successful cage culture, they still lacked experience. Beneficiaries in their second and third year are continuing to improve their management practices, and to fine-tune their production system for local conditions. This is leading to improved health, growth and economic returns from the system. Some of the key management practices include:

Net cleaning

Maintaining clean nets is essential for good water exchange. Brushing of nets is usually required once a week, and care must be taken not to injure fish or damage the netting, especially the easily damaged fine-mesh (hapa) netting. Rubbing the netting together with the hands is the most effective method of cleaning hapas. Some fish, especially *Morulius calbasu* and tilapia, actively clean periphyton from the net walls, maintaining good water exchange without the need for net cleaning. This provides supplemental feed for the fish, although nets are only cleaned effectively if there is also a relatively high density (usually a stocked pond) of fish around the cage.

Removal of mortalities

Dead and dying fish must be removed as soon as possible to prevent the spread of disease, and also, to prevent nets being cut by crabs. In many areas in which the project is working, most escapees are the result of holes cut by crabs that are attracted to the dead fish at the bottom of the cages. In areas where crab cutting of nets is a serious problem, inverted funnels are placed on all cage legs to prevent crabs reaching the netting. This has been found to be highly effective in reducing the problem (D. Griffiths pers. comm.).

Re-location of cages

Moving cages during the monsoon is a difficult and high-risk activity. This is one of the reasons why most beneficiaries have changed to smaller, floating cages with a rigid frame, which are much easier to move.

Examination of fish

Fish are best examined during twice-daily feeding, where cage operators can observe their approximate number and general health. Beneficiaries are advised to avoid completely removing fish from the water. This often occurs when visitors come to the cages and the farmer wishes to show off his/her fish. Fish deaths, or more commonly reduced feeding (and hence growth), occur after such events.

SUMMARY

At present, fish diseases are not a major problem for farmers in the CAGES project, but fish health issues do affect the success of many cage operators. Good fish health is essential for adequate fish growth and the economic viability of the fish cage. With the relatively low density of cages present in water bodies of Bangladesh at present, diseases are rarely noted by farmers or CARE extension staff as a constraint to successful cage culture; however, with expansion in the number and density of cages, it is possible that fish diseases may become a constraint on the system in the future. This will be continually monitored by extension workers, along with all other aspects of farmers' constraints and opportunities. Fish health in cage aquaculture in Bangladesh is, at this time, determined by appropriate fish seed quality, cage-site selection, fish nutrition and cage management.

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TAM GIANG LAGOON
AQUATIC SYSTEMS HEALTH ASSESSMENT

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ABSTRACT

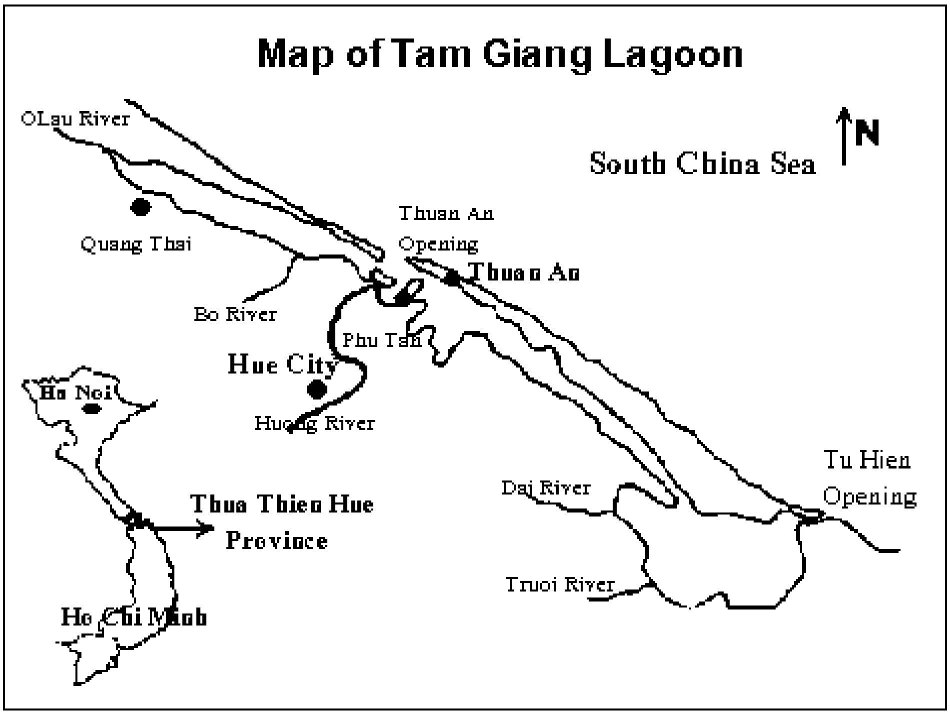
Tam Giang Lagoon, one of the largest lagoons in Asia, has an area of 22,000 ha and stretches for more than 60 km. Current aquaculture methods are mainly fish ponds, net enclosures and cage systems. Ponds are more commonly used for extensive, improved-extensive and semi-intensive types of culture, and in 1998, covered an area of about 1,980 ha. Aquaculture is being developed in the lagoon to overcome the depletion of natural aquatic resources and to satisfy the demand of the increasing population for aquatic products. The local government considers it an alternative measure to improve lagoon-dwellers' income and a means of reducing random exploitation of the lagoon's resources. As a consequence of the increased exploitation, environmental conditions have deteriorated. Some water quality parameters have exceeded their permissible limits. Diseases have been reported in four major cultured species (i.e., seaweed (*Gracilaria* sp.), shrimp, crab and fish) with high risk and frequency. Two disease epidemics broke out in 1995 and 1998, causing great losses to aquaculturists. The diseases resulted in an enhancement of the role played by the Aquatic Animal Hygiene Inspection and Veterinary Office of the Department of Fisheries in developing new mechanisms and strategies for the management of aquatic animal health in the lagoon. This paper also presents a proposal for a "Tam Giang Lagoon Aquatic Systems Health Assessment," which is based on research results from the International Development Research Centre of Canada (IDRC)-sponsored project "Management of Biological Resources in Tam Giang Lagoon," as well as on input provided by specialists from the Network of Aquaculture Centres in Asia-Pacific (NACA).

INTRODUCTION

Tam Giang Lagoon (see Figure 1), which runs along the coast of Thua Thien Hue Province, Vietnam, has an area of 22,000 ha and a length of more than 60 km. On its eastern side, the lagoon is separated from the sea by sandy dunes with two openings, Thuan An and Tu Hien. On the western side of the lagoon are rice fields and river estuaries. The area is unique in terms of landscape and biological resources. Communities settled there to exploit the lagoon's biological resources and farm on the sandy land at its edge.

Because of increasing population pressure and a decrease in aquatic resources, government officials consider aquaculture as an alternative means of improving villagers' income and reducing exploitation pressure on the lagoon. As a result, aquaculture has recently developed so rapidly that it is having a strong impact on attempts to promote a sustainable aquaculture production system in the lagoon area.

Figure 1. Map of Tam Giang Lagoon.



FACTORS AFFECTING AQUACULTURE DEVELOPMENT

Tam Giang Lagoon mixes with the sea through the two openings on the eastern side. The lagoon also receives water from many rivers, such as the Huong, Bo, Dai, O Lau and Truoi. Thanks to this unique topography, the lagoon has a mixture of fresh and salt water that makes the changes in its salinity both seasonally and spatially regular. This creates a typically brackishwater environment with valuable resources and a high potential for aquaculture.

The average depth of the lagoon is 2 m, although along its length there runs a channel 3 to 4 m deep. Thuan An Estuary is deepest, at more than 7 m. Therefore, the salinity and characteristics are favourable for the construction of aquaculture ponds and net enclosures in most parts of the lagoon.

AQUACULTURE DEVELOPMENT

The first aquaculture activities in Tam Giang Lagoon began with seaweed cultivation in 1977. Shrimp culture began in the early 1990s, and from 1990 to 1993, the area of shrimp ponds increased from 42 to 437 ha. Meanwhile, the area under seaweed cultivation increased from 226 to 357 ha. The total aquaculture area in the lagoon reached 1,000 ha in 1995 (Phap 1996).

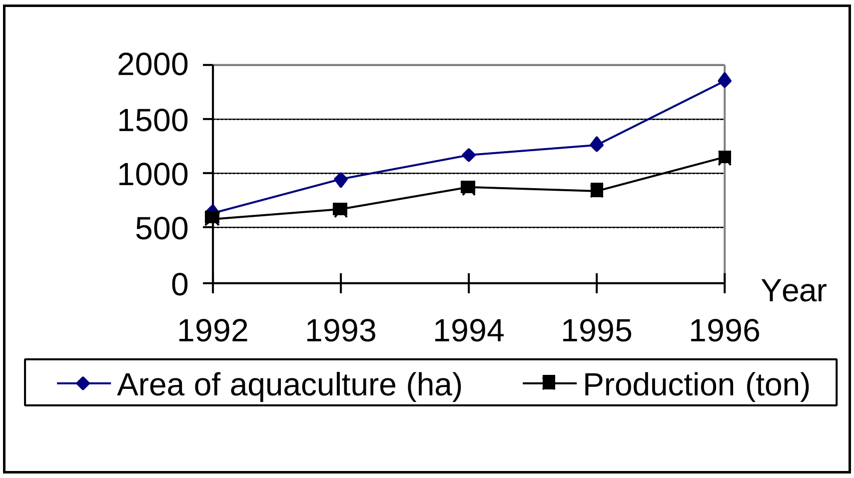
Present aquaculture methods involve mainly ponds, net enclosures and cages. Ponds are more common for the following systems: extensive, improved-extensive and semi-intensive. The area of production and the aquaculture patterns in the lagoon in 1996 are presented in Table 1 and Figure 2 (Phap 1996).

Table 1. Types of aquaculture and areas covered in Tam Giang Lagoon.

Type of Aquaculture	Area (ha)
Semi-intensive pond culture	8.8
Improved-extensive pond culture	824
Extensive pond culture	100
Net enclosures	138
Floating cages	120 cages

During the 1998 culture season, the area of net enclosure in Phu Tan Commune alone (where most of the aquaculture activity is concentrated) was 413.5 ha. Although this does not present a full picture of the aquaculture boom in the lagoon, it does reflect the significant rate of increase.

Figure 2. Aquaculture production in Tam Giang Lagoon, 1992-96.



Aquaculture is regarded as a pilot scheme investigating the economic potential for fisheries development in Thua Thien Hue. The Department of Fisheries in Thua Thien Hue promotes semi-intensive culture in which villagers include aquaculture as part of their livelihood portfolio and state-run companies supply seed and technical support. This is the official strategy for aquaculture development in Thua Thien Hue Province (Phap 1996).

In the past five years, basic aquaculture techniques, acquired from training courses held at the Fishery Extension Centre, Phu Tan, have enabled the lagoon fishers to experiment and learn from other experienced aquaculturists. Step by step, they are developing their own aquaculture practices that are characterised by low stocking density and polyculture. Polyculture seems to be more sustainable than monoculture, as it reduces the risk of losing the whole crop due to disease. Common polyculture patterns include: shrimp (*Penaeus monodon*)/crab (*Scylla serrata*)/ fish (*Siganus guttatus*)/seaweed (*Gracilaria tenuistipitata*); shrimp/ seaweed and shrimp/crab/fish. Grouper and grass carp (*Ctenopharyngodon idellus*) are cultured in cages.

This flexible approach is more appropriate to the environmental conditions of the Tam Giang ecosystem and to the management and investment capacities of local people. This runs counter to previous aquaculture development (semi-intensive and monoculture) that was applied by state-run companies. Low intensity polyculture has resulted in increased economic benefits, because investments for seed and feed are low, no improved techniques are required, product quality is good and the price obtained for the product is higher than in high-density culture.

Meanwhile, aquaculture companies that relied on more intensive cultivation methods have had to abandon their ponds or rent them to fisherfolk; these companies are no longer involved in aquaculture development in Tam Giang Lagoon. However, aquaculture production in the lagoon is still regarded as unstable, and further research is required to address the associated problems.

THE LIFE OF AQUACULTURE COMMUNITIES

Approximately 220,000 people in 38,000 households, or about 20% of the population of the province, live directly around the lagoon. The population is increasing at a rate of 3.1% per year. Families in villages around the edge of the lagoon that depend on agriculture as their main livelihood activity have the lowest income in their community, while families who have adopted aquaculture have higher incomes (Newkirk 1995).

Before 1970, the total fish catch in the lagoon was about 3,600 mt/yr; however, since 1980, production has been around 2,000 mt/yr. The number of persons engaged in fishing has increased rapidly, from 66,000 in 1980 to 90,000 in 1993. The amount of fishing gear used has also increased; 13 types of fishing gear are in use, including fishing corrals, fixed lift nets and bottom nets, all in high density. Electro-fishing gear is also becoming commonplace.

High fishing intensity has resulted in the depletion of the lagoon's resources and increased the difficulties of fisherfolk. To improve the situation, aquaculture has been accepted by the fisherfolk and is considered by local government as an alternative source of income, as well as contributing to reducing degradation of the lagoon’s aquatic resources. Aquaculture brings greater income, which helps improve the life of the fisherfolk. For example, in Phu Tan Commune, changes have resulted in an improvement of infrastructure, and most families now have brick houses with modern conveniences. Community health care and education are also improving; the number of malnourished children is decreasing and over 80% of the children attend school.

Nevertheless, aquaculture demands a high initial investment, and a high risk of disease outbreaks may result in losses. Therefore, the poor fisherfolk, who are mostly migratory fishers, cannot get involved, while their natural fishing grounds are becoming more confined This widens the gap between the more wealthy, the mobile fishers and the poor in these communities.

EMERGING DISEASE PROBLEMS

The Aquatic Animal Health Situation

Aquaculture in Tam Giang Lagoon is generally regarded as a risky venture associated with high mortalities from disease. Diseases are common in the lagoon, and all four groups of cultured species (seaweed, shrimp, crab and fish) have been affected.

In 1985 "colourless" disease appeared in *Gracilaria*. The local fishers call it "white canopy" disease, the tips of the fronds becoming white and the thallus perishing. Meanwhile, some fish species living in the *Gracilaria* ponds, such as mullets and rabbitfish, suffered from ulcers.

From 1993 to 1994, shrimp diseases began spreading. Initially, the disease affected only limited areas; then, in 1995 and 1997, diseases reached epidemic proportions.

Recently, at the Quang Thai Commune, a research site of the Tam Giang Project, 26 households were supported with capital from the project to develop grasscarp cage culture; however, after. months of rearing the fish, 80% of the cages suffered 100% mortality from "red spot" disease. So far, 16 diseases of aquatic animals have been recorded in Tam Giang Lagoon (Table 3).
In the Hue area, there are eight hatcheries for shrimp fry production (one state-run, seven private) and 28 nursing units. The average number of postlarvae (PL15) produced each year is about 20 million, meeting half of the local demand.

The common diseases in fry are luminescent disease, carapace deformation, red spot and external fouling. Interventions applied by fisherfolk to reduce the impact of disease on affected animals consist of changing the water to improve water quality and providing enough food to help the animals overcome the disease. Some fry producers have used antibiotics and chemicals for treatment of disease (Table 4).

Aquatic animal diseases have been recognised since 1994. They tend to spread over a large area of the lagoon in March, April, July and August of each year. There are no official statistics on the economic impact of disease; however, data from the Department of Fisheries suggest that the impact has been severe. For example, during the 1995 shrimp disease epidemic, 300 million fry and 900 million grow-out animals died. This resulted in huge capital losses for the farmers, and many have been unable to repay their bank loans. A survey showed that one household lost all its capital when it invested 38 million Vietnamese Dong (VND) (1 US$= 14,000 VND) after stocking 20,000 PL15 in a 5,000 m^2 pond in 1998. Due to disease, another household received only 15 million VND in returns after investing 52 million in a 3,000 m^2 pond (Anon. 1999).

Aquatic Animal Health Management

The Aquatic Animal Health Inspection Office (AAHIO), Department of Fisheries, has responsibility for managing the health of cultured species in the whole lagoon. The staff of the AAHIO consists of five people, one of whom is responsible for carrying out laboratory work. The other staff conduct monthly field visits to inspect the health of cultured animals, to provide the fisherfolk with guidance to improve pond conditions before stocking, and to teach them the basic indicators used to identify healthy fry. The AAHIO keeps in regular touch with the fisherfolk to assess aquaculture activities and to collect samples of diseased animals.

Fry production is strictly controlled by the AAHIO. All production units require health certificates and production licenses. The AAHIO also organises training courses to teach the fisherfolk how to protect their cultured animals from becoming infected (Anon. 1999).

Table 3. Common diseases of aquatic animals and plants in Tam Giang Lagoon (source: fisherfolk and staff of the Aquatic Animal Health Inspection Office; Anh and Thanh 1998).

Disease	Time of Year When Disease Occurs	Species Affected[1]	Clinical Signs
Muscle necrosis	March-April, July-August	Shrimp	White body, soft flesh
Body cramp	March-April, July-August	Shrimp	Contracted abdomen & tail
Black spot	March-April, July-August	Shrimp	Black spots on shell, bad smell
Black gill	March-April, July-August	Shrimp	Black gills, bad smell
Red gill	March-April, July-August	Shrimp	Red swollen gills, weakness
White spot	March-April, July-August	Shrimp	White spots on shell
Softened shell	March-April, July-August	Shrimp	Lack of movement, soft shell
Yellow head	March-April, July-August	Shrimp	Lack of movement, yellowish head & abdomen
Blind eye	March-April, July-August	Shrimp	Blindness, loss of eyes
External fouling	March-April, July-August	Shrimp	Immobile legs covered with microalgae &/or protozoans
Carapace deformation	March-April, July-August	Shrimp	Carapace open, bent upward, weakness
Leg & tail rot	March-April, July-August	Shrimp	Gradual decay of legs & tail
Swollen gill	March-April	Crab	Swollen gills, weakness
Red shell	March-April	Crab	Reddish shell, weakness
Red spot	March-April	Fish	Red spots on skin
White canopy	March & April	*Gracilaria*	Discoloured tips of fronds

[1]Shrimp = *Penaeus monodon*, crab = *Scylla serrata*, fish = grass carp.

Table 4. Antibiotics and chemicals used in treatment of fry diseases (source: producers).

Disease	Treatment
Carapace deformation	Treflan
Red spot	Tetracycline
Luminescence	Tetracycline
Organism adhesiveness	Formalin

In the event of an epidemic, the AAHIO must report the situation and the resulting losses to the Provincial Peoples Committee (PPC). Based on this report, the chairman of the PPC provides advice and recommends solutions to manage the problem, and provides support to producers who suffer great losses. For example, in the epidemics of 1995 and 1997, the banks extended repayment deadlines and granted low-interest loans (Anon. 1999).

Research on aquatic animal diseases is a new area for the University of Hue and the AAHIO. Initial research conducted by the Department of Biology (Hue University of Sciences) and the Department of Fishery (Hue Agriculture and Forestry) concentrated only on diseases caused by protozoan parasites and fungi, such as *Fusarium* spp. and *Lagenidium* spp.

Even though a co-operative programme is in place between the Department of Fisheries and Hue University to study aquatic animal diseases, there are still no effective measures for controlling diseases in aquaculture. Therefore, the office has adopted the following animal health management (Anon. 1999):

- Clean the rearing ponds before stocking fry and maintain the cleanliness of the water to minimise diseases.

- Carry out health checks of the fry before stocking in the ponds.

- Conduct inspections of the production process and conduct farmer-based participatory training to help farmers recognise diseases and devise management strategies.

- Recommend that the PPC set up insurance funds aimed at supporting culture units or fisherfolk suffering serious hardship.

One of the objectives of the Tam Giang Project is to develop methods of sustainable aquaculture production by addressing technological, organisational and regulatory issues (Newkirk 1995). From 1998 to 1999, the IDRC-supported Tam Giang Project undertook two research activities, implemented at Phu Tan Commune, related to improvement of the culture pond water of the lagoon: (i) trials on raising monosex *Tilapia* in polluted ponds, and (ii) a study of preliminary impacts of improved-extensive culture on the natural environment of the pond. Initial results show that:

- In the pond with improved-extensive farming, parameters such as pH, dissolved oxygen and biological oxygen demand all exceeded levels that could result in stress-associated mortalities.

- The environment of organically polluted ponds is remarkably improved after tilapia are stocked, and it is then possible for shrimp to be reared in the system. Using this method for cleaning the pond environment, some aquaculturists achieved a shrimp harvest in 1999 valued at around 30 million VND/pond (Hong 1999).

These results uphold the local aquaculturists' perception of the importance of maintaining adequate water quality to help reduce losses from diseases that are exacerbated by stress.

APPROACH TO AQUATIC ANIMAL HEALTH ASSESSMENT IN TAM GIANG LAGOON

Tam Giang Lagoon has a close relationship with the sea and the land. Its biological and physical characteristics have created a unique brackishwater ecosystem with a diverse range of resources, supporting a large population around the lagoon.

With rapid development, the whole area over 2 m in depth will soon become an aquaculture area, and this will increase the income of the local people, contributing to poverty alleviation in lagoon fishing communities. However, three main constraints have been identified: lack of capital, lack of good fry and occurrence of disease. The latter is considered to be the biggest constraint, for which there is still no solution. In order to solve this problem, the "Tam Giang Lagoon Aquatic System Health Assessment Project" has been proposed. The specific objectives of the project are:

- To identify the current problems in the Tam Giang Lagoon and assess their social and economic impacts.
- To determine strategies to reduce identified impacts.

To identify and assess current problems, the aquaculture production systems in two different areas of the lagoon will be investigated, as well as the range of people involved in using these systems for their livelihoods. The areas are: Phu Tan, where aquaculture is well developed, and Quang Thai, where the people are poorer and aquaculture is a recent introduction. The species cultured, number of households involved and disease problems encountered are shown in Table 5.

Table 5. Aquaculture systems practised in Phu Tan and Quang Thai areas of Tam Giang Lagoon.

System	Species	Area	Disease Situation
Net enclosure: polyculture	Shrimp, fish, crab	Phu Tan: 274 households	
		Quang Thai: 34 households	
Pond culture		Phu Tan: 4 groups	
Monoculture	Shrimp	Quang Thai: 3 ponds	
Polyculture	Freshwater & marine fish, crabs		Disease present in fish
Cage culture	Grouper	Quang Thai: 26 households	Disease present
Rice-fish		Quang Thai: 1 household	
Hatcheries	Shrimp Freshwater fish	Phu Tan: 7 (1 government and 6 private)	Disease present

This comparative analysis between people and locations, where aquaculture is in different stages of development, will enable lessons from areas with more experienced farmers to be applied in new locations.

METHODS

Survey team

The survey will be undertaken by a research team from the Tam Giang Project:

- 7 people from the project
  - Provincial Department of Fisheries (2)
  - Science University
  - Agriculture University
- 4 people (2 from each commune-Phu Tan and Quang Thai).

The survey will use a participatory approach:

1. Participatory
   group discussions.
   farmer interviews.

2. Questionnaires
   Prompt or list of key points.
   Train farmers to fill in the key points.
   Semi-structured questionnaires.

3. Observation

Based on key informant interviews, if the farmers find a disease problem, then researchers will visit the site, observe the situation and carry out field-environmental and laboratory investigations.

Preliminary key points to be addressed include:

- What are the problems?
- What are the social and economic impacts of these problems?
- What do they do about the problem?

Institutional analysis

An institutional analysis will be carried out to determine the different institutions involved and their current and possible future roles in aquatic animal health management, as well as the training needs at the different levels (village, commune, district and province). Extension capabilities and the support available to farmers will also be evaluated. The roles and inputs of suppliers of seed and bankers as possible sources of management intervention will also be defined.

Expected outcome and follow up

The outcome from this work is expected to include:

- An assessment of current aquatic animal health problems and their social and economic impacts. Particular attention will be given to the potential impact of aquaculture on poverty alleviation.
- An institutional analysis and needs assessment will allow the roles of different "actors" to be identified and areas for strengthening, from farmer to provincial government level, to be identified. A training-needs analysis, based on a clear

understanding of current and future farmer problems, will also help to identify training needs and how these might be fulfilled.

- Capacity building, institutional arrangements, training needs and other interventions will be identified.

- A project proposal to put health in the perspective of system management will be developed.

Overall, the activity will contribute to the sustainable management of aquaculture resources in the lagoon for the livelihood of the people involved.

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A SURVEY OF THE SOCIO-ECONOMIC IMPACT OF AQUATIC ANIMAL DISEASE ON SMALL-SCALE AQUACULTURE PRODUCTION AND RESERVOIR/CAPTURE FISHERIES IN SOUTHERN LAO PDR

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ABSTRACT

An aquatic animal health assessment was conducted in August 1999 as part of a framework to develop an aquatic animal health programme in southern Lao PDR. The objectives of the survey were to use a participatory farm/household/community survey to assess the socio-economic impact of aquatic animal disease and production-related problems on six different small-scale aquaculture practices (i.e., fish pond, rice-fish culture, nursery, community pond, state and private hatchery, and capture fishing in reservoirs and natural waters) in southern Lao and to train livestock and fisheries officers from four provinces in aquatic animal health assessment.

A disease exhibiting signs consistent with epizootic ulcerative syndrome (EUS) was recognised by most farmers in most production systems. The other problems recognised were red discoloured patches; deaths with no clinical signs; parasitism by *Lernaea;* and problems related to technical capability, resource availability, the environment and predation. Losses due to disease and other problems were estimated to range from a low of 5% in a nursery system to a high of 79.4% in a state hatchery. Losses incurred by fishers practising capture fishing in natural waters and reservoirs were 49% and 74%, respectively. EUS-like lesions were reported by a large number of respondents from fish ponds and capture fisheries, as well as from two community ponds. The greatest losses occurred in state hatcheries (US$6,458/yr) followed by reservoirs (average of US$1,028/family/yr),

which partly reflects their higher potential production relative to the other systems. Among the various production systems surveyed, losses in state and private hatcheries appear to have the most significant impact, as any drop in production results in a decreased capacity to meet the demand for fry and broodstock for fish ponds, nurseries, hatcheries, and rice-fish ponds, as well as availability of fry for stocking in reservoirs and natural waters. Little social impact was reported for most production systems; however, disease in fish production facilities often meant that more time had to be spent catching fish, greater competition in capture fisheries, and more time spent obtaining and preparing alternative food sources.

An institutional and training needs assessment carried out in conjunction with the survey found that district staff play a central role in aquatic and terrestrial animal health, and that their dual responsibilities should be taken into account when training is planned. Increased efficiencies can be achieved by integrating the activities of the veterinary and fisheries divisions in the areas of surveillance, information systems and diagnostic laboratories. District staff should be seen as generalists, and receive training that will help them in the range of their duties, while having access to a network of provincial and national specialists in different fields. The results and recommendations of this survey, including the institutional and training needs assessment conducted independently by a consultant (Dr. A.Cameron), will form the basis for the formulation of a strategy for aquatic animal health management in southern Lao.

INTRODUCTION

A Network of Aquaculture Centres in Asia-Pacific (NACA)/South East Asia Aquatic Disease Control Project (SEAADCP)/Aquatic Animal Health Research Institute (AAHRI) mission to southern Lao in June 1999 discussed possible co-operation with the Regional Development Committee (RDC) on aquatic animal health management in southern Lao, including a survey of fish health in small-scale aquaculture systems and the development of local capacity for aquatic animal health management. This was followed by a three-day appraisal and preliminary survey of hatcheries and fishpond facilities in Savannakhet and Khammouanne provinces in mid-July to assist in identifying specific issues and planning of the survey.

METHODS

Objectives

The objectives of the survey were to (i) assess the social and economic impacts of aquatic animal diseases on small-scale aquaculture practices in southern Lao; (ii) identify aquatic animal health training needs for the two provinces; and (iii) identify institutional requirements for aquatic animal health.

Survey Methods

The survey was conducted between 2-13 August 1999 by a team of national livestock and fisheries officers from Savannakhet, Khammouanne, Champassack and Vientiane provinces and international participants from SEAADCP, AAHRI, NACA and AusVet. Prior to the survey, a workshop held on 2-3 August (a) provided orientation for participants on the objectives and scope of the survey, (b) defined the team composition and job roles, (c) determined the areas and production systems to be covered, (d) developed the guidelines and approach and (e) discussed methods for analysing and reporting the results of the survey.

The 15 surveyors were divided into four groups, and the survey was conducted through farm/village visits, key informant interviews and group discussions. A set of questions and key points were identified, discussed and developed, and these ultimately served as prompts to guide the field surveyors. The aim was to obtain qualitative and, where possible, quantitative information on farmers' perceptions, attitudes, opinions and experiences with regard to aquatic animal health and other production-related issues affecting small-scale fish production and capture fisheries in southern Lao. The survey focused on key information that was likely to be available within the production systems being examined. The section below lists the main questions and key points that were addressed in this survey.

What problems exist? (List and rank health and production problems related to aquatic animal production). Key points:

Outputs

- Death
- Visible lesions
- Poor production

Inputs

- Inadequate feed
- Inadequate fry
- Poor quality fingerlings
- Inadequate water
- Poor quality water

Describe the problem

- Species affected
- Age/size of fish
- Number affected
- Time of year
- Management changes associated with the problem
- Description of lesions

What is the effect of these problems? Key points:

Economic impact (quantify)

- Income/benefits foregone
  - Decrease in number of fish used for food
  - Decrease in size of fish used for food
  - Decrease in number or quality for sale, and decrease in income from fish
- Expenses incurred

- Increased financial/material/labour inputs due to problems (e.g., treatments, alternative food sources)

Social impacts

- Changes in attitudes to aquaculture (e.g., will stop doing it, move to a lower-risk system, discourage others from starting etc.)
- Changes in work patterns due to problems (consider different gender roles and ages)
- Cultural use of fish (e.g., celebrations, entertainment)
- Role of fish in increasing social status
- Stigma associated with fish disease or low production

What do you do about these problems? Key points:

- From whom do you get help; where do you get advice?
- What treatment do you use?
- What other action do you take?

Survey Area

The survey focused on two provinces in southern Lao, Savannakhet and Khammouane, covering four districts, namely: Champhone, Outoumphone and Pinh districts in the Province of Savannakhet, and Thakhek District in Khammouane Province (Fig. 1).

Survey Sample

The target group for the survey was small-scale fish farmers and rural fishermen involved in the following production systems:

- Fish ponds
- Rice-fish ponds
- Hatcheries (government and private)
- Community fish ponds
- Nurseries
- Reservoir fisheries
- Capture fisheries

The local staff made estimates of the total number of families or enterprises in the target areas that fall into each of the above categories. A number of villages and enterprises were then selected to ensure that each of the production systems was represented in the sample, as shown in Table 1. The sample was, therefore, a non-random, purposive sample.

Figure 1. Map of Lao PDR showing the areas covered by the survey.

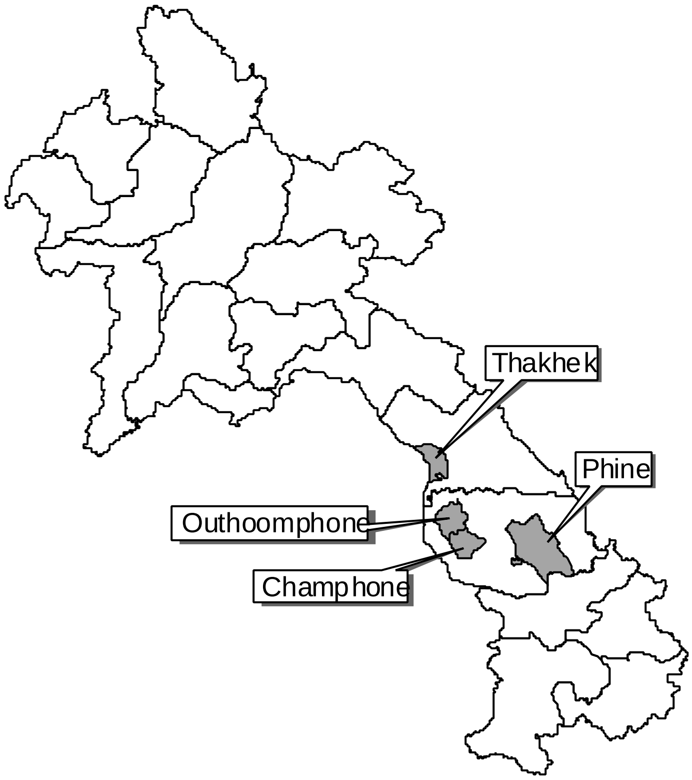

Table 1. Production systems covered in the survey, with estimates of the total number of families/enterprises in the target areas.

Production System	Group 1 Champhone	Group 2 Outoumphone	Group 3 Pinh	Group 4 Thakhek	Total
Fish ponds	11	16	7	13	47
Rice-fish	11	0	1	0	12
Community ponds	1 (117 families)			1 (87 families)	2 (204 families)
State hatchery				1	1
Private hatcheries					6
Reservoirs	16		5		21
Nursery	1				1
Capture fishery	0	10	10	15	35

Data were collected by a combination of small-group and key-informant interviews using a semi-structured approach. The three main questions were asked in turn, and after each main question, a discussion took place to explore, refine and characterise the information being sought. All analysis and reporting was done in the Lao and English languages in parallel.

RESULTS AND DISCUSSION

General Description of Farming Systems

Fish pond production

The size of fish ponds included in this survey ranged from 500 to 10,000 m^2, with water depth of around 80 cm to 2.5-3.0 m. The ponds are mainly rainfed. The culture period starts from April-May, and the harvest season begins in September-October; however, farmers usually begin to take fish for consumption three months after stocking and progressively thereafter until the end of the dry season. The cycle starts again at the beginning of the rainy season.

Stocking density depends largely on availability of fry in the area, and may range between <1-5/m^2. The system involves minimal inputs, with little use of liming. Production, therefore, depends largely on the natural productivity of the ponds. Selling of fish directly to the market is not common. The usual practice is for customers who want fish to come directly to the farm. The farmer either sells the fish or organises the catching and/or preparation of food, depending on the requirements of the customer. Fish are also exchanged for labour during rice harvest, or for other agricultural products, such as vegetables. Aside from providing food for the family and an additional source of income, fish are used during weddings, funerals, festivals and other community celebrations.

Most of the farmers interviewed were involved in pond aquaculture as a secondary source of income, the main source of income being agriculture. However, there are indications that more farmers, particularly those who already have ponds, are intending to take up aquaculture on a full-time basis, as they perceive it to be more profitable, less laborious and requiring minimal inputs. There are a good number of potential fish farmers who are constrained by a lack of land, or in some cases, by a lack of funds, for pond construction.

Rice-fish production

The average area used for rice-fish production is about 0.3 ha. The average stocking density using tilapia, common carp and Java barb (3-5 cm length) is about 2,465, or approximately one fish per m^2. There is only one production cycle per year, with a duration of eight months, starting at the beginning of June, about one week after rice planting. The pond is fed with rice bran at the rate of 3-5% of fish body weight, and manure (cattle dung) at the rate of 0.5-1.0 kg/m^2/yr. Normal production is about 112 kg, equivalent to 372 kg/ha. Some fish are consumed, and the rest (market size of four fish per kilogram) are sold to the market at the current price of 10,000 Kip/kg (1 US$= 9,600 Kip).

State hatchery production

One state hatchery in Khammouane Province was included in this survey. The hatchery relies on water fed by gravity into square concrete tanks, usually from a stream or reservoir. The water supply is largely insufficient.

The species of broodstock most commonly used for fry production are common carp, silver carp and bighead carp, mrigal, rohu, Java barb, catfish and tilapia.

The state hatchery employs induced spawning techniques using lutenising hormone/releasing hormone (LHRH) analogue in combination with domperidone maleate. Chemical hormones, now widely available from Thailand (“suprefact,” “motilium”), Vietnam and China, are now commonly used instead of fish pituitaries to induce spawning.

Total fry production from the beginning of 1999 to the time of the survey was 785,000 fry, an increase of about 50% from the 1998 production of 400,000. Current demand for fry in Khammouane Province stands at two to three million fry.

The state hatchery conducted a training programme for farmers in 1996 through which 14 families were trained in nursery techniques using hapa nets. In 1997, 70 families were trained in pond-culture techniques. If funds were available, the station could produce more seed to meet local demand, and they could train more farmers.

Private hatchery production

Private hatcheries are also in operation, and six were visited during this survey. Farmers are using fewer species (e.g., common carp, tilapia, Java barb and mrigal) compared to state hatcheries; they also use hormone induction techniques.

Nursery production

Nursery production was pioneered by the Asian Institute of Technology (AIT) Outreach Project in Savannakhet Province. This involves taking fry from state hatcheries and nursing them for one month before sale.

Community pond production

Community ponds are organised by the people of the village according to a government policy of empowering local communities through developing livelihood projects that support social services (e.g., schools, latrines, community halls, health services, support for festivals, material contribution to weddings and funerals) that are beneficial to the whole village.

In Champhone District, with a population of 97,647, there are five community ponds located in Nong Hung, Dong Deng, Bann Pai Khong, Bann Buk Tong and Bann Ouie Say. These ponds range in size from 2 ha water area in Bann Buk Tong and Bann Ouie Say, involving 50-60 families, to 10 ha in Nong Hung, involving more than 100 families. In Khammouanne Province, there are three community ponds, one each in Thakhek, Seabang Fai and Hinboun districts, with a total of approximately 182 families involved. The description of the management and operation of community ponds given below is based on information collected in Nong Hung village in Champhone.

The community pond is managed by a village committee of three persons: the head of the village, an elder and a security person. The whole management is supported by six committees: (a) administration, (b) a controller or financial manager responsible for daily financial transactions, (c) a fishermen’s group involved in the technical operation, (d) an accountant, (e) a treasurer and (f) a cashier. Apart from these committees, several groups involving women, the elderly, junior citizens and security people are involved in specific tasks in the management of the community pond.

Community fishpond production is a secondary income and food source for the village, the main activity being rice and vegetable production. Every family participating in the operation of the pond gets an equal share of fish, and a certain percentage of profit earned is used for community projects.

In Nong Hung village, a community pond was started in 1998 and now involves 117 families. The money earned from fish production is being used to support a school in the village and to repair the water outlet. Ten kilograms of fish are provided to the community during a festival, and 5 kg for every wedding and funeral in a family.

Fish production from the community-managed pond has raised the general standard of living of the villagers and was regarded as more profitable and less laborious as compared to agriculture and livestock production. Aside from the additional income generated and the contribution to food availability for the family, it was regarded as generally good for society.

Reservoir fisheries

Man-made reservoirs, mainly for hydroelectric power or irrigation, are also used for fish production in southern Lao. In Champhone District alone, there are four reservoirs: Soui Reservoir, Nhot Houi Bac, Thong Bac and Oui Chiao.

The Soui Reservoir in Bann Don Ngeng, for instance, started as a small stream. In 1985, the Department of Irrigation constructed a reservoir for agricultural purposes. In 1992, the DLF in Savannakhet stocked several fish species, such as common, silver and bighead carps, rohu, mrigal and tilapia. The reservoir now stretches to about 5,046 ha of water area with more than 30 villages and four sub-districts surrounding it. About 100 families are catching fish daily from this reservoir.

Aside from stocked species, snakehead, catfish, gourami and "corica"[1] are among the wild species present in the reservoir. "Corica," the mature size of which is about 4-5 cm, are collected and sold in both fresh and fermented form. Women are primarily involved in collection, and the maximum catch is about 10 kg/day, valued at 5,000 Kip/kg (1 US$=9,600 Kip). The peak season for collection is between November and December.

Capture fisheries

Capture fishing involves catching fish in streams, lakes and other water bodies. In Thakhek District, for instance, a 150 m^2 dam was built near the Nong Tour Stream. The stream that feeds the dam has a water area of 200,000 m^2. There are some seven villages surrounding the stream and dam area. Many species of wild fish are caught, and about 200 fishermen are fishing daily as a secondary activity, as in reservoir fishing. The normal *per capita* daily catch is about 5 kg, of which, 1 kg is consumed and 4 kg are sold.

[1]"Corica" is a transliteration of a local common name. The scientific name of this species was unknown at the time of publication.

Aquatic Animal Health and Production-Related Constraints Affecting Small-scale Aquaculture and Fisheries Production

In a previous survey (LAO/97/007) conducted by FAO which covered five provinces including Savannakhet, several causes of fish mortality were identified (see Box 1). The survey reported that farmers frequently mentioned mortality, and ulceration and wild fish mortality, particularly in snakehead and catfish, consistent with EUS, which occurs annually during the transition between the cool and hot seasons. Mortalities of cultured major carps and Java barb in fish ponds in 1998 were reported in Sayaboury and Oudomxay provinces, northern Lao. The survey concluded that the impact of fish disease on aquaculture and fisheries in rural populations is presently unquantified.

About 20 different disease and production-related problems were identified during the current survey. They are ranked below (Table 2) according to the number of farmers, families or enterprises who reported each problem.

Box 1. Reported fish mortality from survey of LAO/97/007 target provinces.[1]

Cause of mortality (number of respondents)
Unspecified mortality (40)
Unspecified disease (29)
Ulcerated bodies (14)
Red spots (5)
Spots (4)
Red scales (1)
Predation (2)
Mortality at stocking (2)
Water too hot (2)
Low oxygen (3)
Insufficient water (2)

No disease reported (296)

Total repondents (373)

[1]Source: LAO/97/007 unpubl. data.

The different fish disease and production-related problems listed in Table 2 are similar to some of the problems identified by the Lao/97/007survey. These problems can be classified into several broad categories, namely:

Disease with clinical manifestations, susceptible species and time of occurrence similar to that described for EUS

Disease with clinical signs similar to EUS (erosion/ulceration around the mouth, tail region and body surface) and occurring between November and March was found in fish ponds, community ponds and reservoir/capture fisheries, mostly affecting wild species like snakehead, catfish and eel. One farmer reported these signs in silver carp. The only species confirmed to be susceptible to EUS in Lao PDR is snakehead (Lilley *et al.* 1998), but the results of the survey based on farmer interview seem to indicate that other species are also affected by this disease. The first reported occurrences of EUS in fish ponds and community-pond systems were in November-December 1997 in Savannakhet Province and in 1994-1995 in Khammouane Province. Farmers reported that this disease occurred among wild populations in reservoirs and natural water bodies as early as 1978-79 in Khammouane Province, and that it was first observed in 1991-92 in Savannakhet Province. Farmers report continuing losses up to the present.

Parasitism by Lernaea

Infections by the parasitic copepod *Lernaea* were reported in fish ponds, rice-fish culture and state hatcheries. Mortalities are common when infections are heavy or when small fish are involved. *Lernaea* may predispose fish to other infections such as EUS, and render them unmarketable due to associated lesions.

Unspecified disease

An unspecified disease characterised by red patches with intact skin affected mainly Java barb and occasionally native barb, silver carp and snakehead. These clinical signs could be the result of physical handling, or could be caused by any one of a number of diseases, including EUS. The signs are reported to occur year round and are seen in both live and dead fish.

Mortalities showing no apparent signs

Mortalities of cultured Java barb, common carp, bighead carp and mrigal, and of wild catfish, snakehead and eel were reported during the dry season in fish ponds, reservoirs and natural waters. They may be associated with poor water quality due to the low water level during these periods.

Predation and theft

Predation by snakes, fish and crabs was a major problem reported in fish ponds and rice-fish ponds. The state hatchery also reported predation by insects. Fish-pond operators reported problems related to theft.

Problems associated with resource availability

Problems related to the availability of necessary resources were reported in varying degrees by fish-pond and state and private hatchery operators. They included inadequate supply of fry, lack of food, lack of water, difficulty in water management, not enough nursery ponds, not enough hapa nets and lack of oxygen cylinders.

Problems associated with technical capability

These included lack of technical knowledge or experience, use of fry that were too small, and overstocking (reported mainly by fish-pond operators); poor selection of broodstock, low hatching rates and damaged eggs (reported by private hatcheries); and poor genetics (reported by the state hatchery).

Overstocking results from the farmers' desire to purchase as many fry as they can afford and to stock them in their ponds without consideration of the required material and management inputs (feeding, fertilisation etc.) and the resulting technical problems, such as poor water quality and disease. The intention is to stock more in order to get more at harvest, and this situation deprives other farmers of their share of fry available in the market.

Table 2. Ranking disease and production-related problems and number of respondents reporting for each production system.

Disease and Production-related Problems	Total Number of Respondents (Families, Community Ponds, Enterprise)	Production System[1]							
		A	B	C	D	E	F	G	H
Death–no signs	67 families	21					21		25
Red erosion (EUS-like)	59 families, 2 community ponds (204 families)	3		2			21		35
Predation by snakes, fish & crabs	58 families, 1 state hatchery	47	11		1				
Overstocking	37 families	37							
Not enough food	36 families	36							
Lack of experience, technical knowledge	31families	31							
Red spots with skin intact	21 families						21		
Fry too small	20 families	20							
Weeds & polluted water	16 families						16		
Flood	15 families	15							
Theft	8 families	8							
Lack of oxygen cylinders	6 families					5		1	
Lack of nursery pond	6 families					6			
Low hatching rate	6 families					6			
Damaged eggs	6 families					6			
Poor selection of broodstock	6 families					6			
Red patches	5 families	3	2						
Lernaea infection	4 families, 1 state hatchery	3	1		1				
Death-white spot	5 families					5			
Not enough water	4 families	4							
Not enough hapa nets	3 private hatcheries					2		1	
Difficulty in water management	2 private hatcheries					2			
Inadequate distribution of water	1 state hatchery				1				
Predation by insects	1 state hatchery				1				
Poor genetics	1 state hatchery				1				
Erosion of dikes	1 state hatchery				1				

[1]A=pond culture, B=rice-fish culture, C=community pond, D=state hatchery, E=private hatchery, F=reservoir, E=nursery, G=capture fisheries.

Natural problems

This category includes flooding of fish ponds, erosion of dikes in the state hatchery, and weed and pollution problems in reservoirs.

ASSESSMENT OF SOCIAL AND ECONOMIC IMPACTS OF AQUATIC ANIMAL HEALTH PROBLEMS

Social Impacts

Of the seven production systems covered in this survey, diseases and production-related problems were reported to have no social impact on rice-fish, community-pond, private-hatchery and nursery systems. On the other hand, the social impacts brought about by disease and production-related problems in pond culture, the state hatchery and reservoir/capture fisheries are indicated in Box 2. These include the time required to find other food, as well as the costs involved, an increase in the price of fish and theft from ponds. A state hatchery in Khammouanne Province experiencing disease and other problems is unable to provide the required seed to the farmers, and this has resulted in decreased aquaculture activity and a decrease in general fish consumption. For reservoir and natural fishing, disease resulted in a greater amount of time being spent catching fish, greater competition among fishermen, and theft due to lack of food. In all systems, families were generally concerned about consumption of diseased fish.

Box 2. Social impacts of disease and other production-related problems.

Pond culture
- need to find other food
- time taken getting other food
- cost of other food
- price of fish increases
- theft due to lack of food

State hatchery
- decreased use of aquaculture
- decreased consumption of fish
- not enough fish seed to provide to farmers

Reservoir/capture fishery
- decrease in number of fish
- longer time to catch fish
- greater competition for catching fish
- theft due to lack of food

Economic Impact

To give an indication of the value of production losses caused by diseases and other production-related problems, an estimate of production losses was calculated from data on expected production, actual or realised harvest, and market price at the time the fish were sold, excluding the other inputs to the system. For reservoir and capture fisheries, losses were computed based on daily catch during normal fishing conditions and catches during disease events. This was then converted into an annual (number of fishing days in disease events/yr) and family basis. All figures are presented as average production loss for each production system on a family/yr basis (see Table 3).

Table 3. Estimated production losses (1999 production cycle) due to disease and other production-related problems in small-scale aquaculture and fisheries in southern Lao.

Production System	Average Production Losses	Average Value of Losses per Family/Yr		No. of Families
		Kip[1]	US$	
Pond culture	25.8%	425,000	44.30	47
Rice-fish	55.0%	1,128,181	117.51	11
Community pond	9.0%	60,170.94	6.26	117
State hatchery	79.4%	62,000,000	6,458.30	1
Private hatchery	64.7%	4,750,000	494.79	6
Nursery	5.0%	120,000	12.50	1
Reservoir	73.8%	9,878,000 (100 fishing days)	1,028.90	16
Capture fishery	49.0%	2,571,400 (100 fishing days)	267.85	35

[1]1 US$=9, 600 Kip.

Production losses were estimated from a low of 5.0% in nursery systems to a high of 79.4% experienced by the state hatchery. Losses from hatchery production (both state and private) range between 64.7 and 79.4%, primarily due to factors such as limited technical capability, unavailability of materials and equipment for broodstock management and fry production, and in some cases, parasitism by *Lernaea* and predation by insects, snakes, crabs or fish. EUS-like lesions were reported by a large percentage of respondents (59 families) and by the two community fish ponds (117 families surveyed). The community pond in Khammouane (87 families), reported EUS-like lesions on fish, but not in significant numbers. Losses incurred by capture fishing in reservoirs and natural waters were estimated at 73.8 and 49.0%, respectively. This is due to several reasons, among which are overfishing without restocking, use of inappropriately sized nets, water pollution and disease. Disease problems include a disease similar in appearance to EUS, red spot and mortalities with no apparent signs. In both fish ponds and rice-fish production systems, where losses were reported to be 25.8 and 55.0%, respectively, the most common problem was predation by snakes, crabs and fish. Other problems were related to lack of technical experience, limited resources, disease (*Lernaea* infection), flooding and theft. Mortalities without clinical signs also represented a significant part of the production loss.

Among the different production systems surveyed, losses in hatchery systems (both state and private) appear to have the most significant impact, as any drop in production results in a chain reaction in the other production systems; reduced capacity to meet the demand for fry (see Table 4) and broodstock for fish pond, nursery, and rice-fish production systems, and non-availability of fry to stock in reservoirs and natural waters.

Table 4. Estimated fish fry production and demand in three provinces of southern Lao (1996).[1]

Province	Fry Production			Demand (1996)	Expected Demand (1999)[2]
	State Hatchery	Private Enterprise	Total		
Savannakhet	720,000	455,000	1,175,000	5,700,000	10,000,000
Khammouane	150,000	25,000	175,000	570,000	3,000,000
Champassack	500,000	66,000	566,000	3,800,000	2,500,000

[1]Source: estimates provided by participants.
[2]Estimates gathered from the survey.

Actions Taken

Actions taken by farmers when confronted by disease and problems related to technical management include generic approaches not specific to any particular problem. In the case of fish-pond operators, use of herbal medicine, liming, draining and drying of ponds, and in some cases, changes in feeding and fertilisation are carried out. For community ponds, villagers try to regulate the fishing gear being used and may resort to changing species. The state hatchery uses several different approaches when dealing with specific problems. These include pre-treating the pond with gasoline in the case of predation, salt treatment and liming in the case of *Lernaea* infection, and removal of fish affected with white discoloration and sloughed scales. The more general approaches included increasing the number of broodstock, changing hatching equipment, increasing the number of ponds and improving management.

Farmers involved in rice-fish systems and private hatcheries are generally not taking any particular action in relation to specific problems, while those involved in capture fishing remove affected/dead fish and report occurrences to government stations.

The government, on the other hand, tries to provide training and technical support (seed supply, equipment), and advises farmers to stop movement of fish and consumption of affected species.

ANALYSIS OF INSTITUTIONAL STRUCTURES FOR AQUATIC ANIMAL HEALTH MANAGEMENT IN SOUTHERN LAO

An analysis was undertaken of all institutions involved in aquatic animal health in southern Lao, including an examination of institutions working in livestock and animal health that may, in the future, be able to co-operate with aquaculture activities.

The main findings of the analysis are:

- District staff play a key role in the delivery of aquatic animal services (extension, promotion of new enterprises, problem solving, disease investigation). These staff have a wide range of other responsibilities relating to livestock production and health. Planning for development of these staff should take into account their breadth of responsibility, and aim to produce competent generalists rather than specialists in specific project activities.

- Significant opportunities exist to gain synergistic benefit from co-operation between the different divisions of the Department of Livestock and Fisheries (DLF) in key areas, specifically laboratory systems, surveillance and information management. It is proposed that DLF establish a policy framework to encourage cross-divisional co-operation in these areas.

- A network of diagnostic laboratories with capabilities in aquatic animal health should be established in co-operation with the European Union Livestock Extension Project, the National Veterinary Diagnostic Laboratory in Vientiane, and the Aquatic Animal Health Research Institute (AAHRI) in Bangkok. Staff from existing veterinary laboratories currently being upgraded under the EU project (in Vientiane, Luang Prabang and Champassack) should receive basic training and follow-up in-country support, along with staff from the laboratory in Savannakhet. AAHRI should provide support in the establishment of the Savannakhet laboratory, using equipment already provided.

- Integrated surveillance systems should be established for aquatic animals and livestock, using active and passive surveillance techniques established during previous and current livestock health projects of the Australian Centre for International Agricultural Research (ACIAR).

- An integrated information system should be established to meet the needs of the DLF, based on existing systems and utilising the district-level record keeping systems developed under the Regional Development Committee (RDC).

- The RDC should endeavour to continue to develop a truly national institution, through developing the capabilities of provincial-level staff outside Savannakhet. It should endeavour to develop closer and more formal communication links with central agencies to facilitate extension of systems developed in the south to other parts of the country, and to avoid the risk of duplication of effort.
- NACA should work towards the development of a regional (multi-country) project, involving (at least) Lao PDR and other Mekong countries, focusing on the development of aquatic animal surveillance systems, but incorporating extensive district staff training, information system development and laboratory support, integrating livestock and fisheries activities.

TRAINING NEEDS ANALYSIS TO SUPPORT THE DEVELOPMENT OF AN AQUATIC ANIMAL HEALTH MANAGEMENT PROGRAM FOR SOUTHERN LAO

An analysis of training under various projects over the past few years was undertaken, and the needs of different staff assessed. The conclusions of the analysis are that:

- Training of district staff should take into account their generalist role within DLF. Training should, therefore, be targeted at providing skills that are generally applicable across their areas of responsibility, as well as basic technical skills in specific areas.

- An on-going programme of development of networks of specialist staff at the provincial and national levels should be undertaken in association with specific project activities. These staff are required to support the generalist field staff.

- Recommendations for areas of specific specialist training for selected provincial and national staff (some of which is already being undertaken in some areas) include: aquatic animal laboratory techniques; information management, analysis and reporting; active surveillance techniques for livestock and aquaculture; continued development of skills in aquatic animal production systems; language skills and training skills

- Potential areas of training for district staff (already being undertaken in some areas) should include participatory techniques; training/extension skills; communication skills (Lao and English); problem investigation (livestock and aquatic animals); disease/problem reporting; laboratory specimen collection and submission; and specific technical skills for local systems (basic livestock skills (e.g., restraint, examination, vaccination), basic aquatic animal skills, basic livestock production techniques (for extension) and basic aquaculture techniques (for extension)).

- Training should be undertaken by those staff who will act as information resources in the future, in order to encourage the development of networks.

CONCLUSIONS

Even though aquaculture and fisheries in southern Lao are still in their infancies, there is a clear indication from this survey that production-related problems and aquatic animal diseases can play a substantial role in determining overall productivity, and that they are affecting potential development. The major issues identified during the survey include:

Diseases and problems

- A disease showing signs consistent with EUS is recognised by most farmers in most production systems surveyed.

- Other disease signs recognised were patches of red discoloration, deaths with no clinical signs, and parasitism by *Lernaea*.

- Other problems identified were related to technical capability, resource availability and natural problems, and predation.

Socio-economic impacts of disease and other problems

- The greatest economic or production losses are occurring in state hatcheries, followed by reservoirs. This reflects their higher potential production relative to the other systems, combined with high losses due to disease and production-related problems.

- Most production systems reported little social impact, but disease in fish production often meant that more time was spent catching fish or seeking and preparing alternative sources, and in a few cases, resulted in theft due to unavailability of food.

Actions taken by farmers

- Farmers operating fish ponds take generic approaches when confronted with disease and production-related problems. These include use of herbal medicine, liming, draining of ponds, and sometimes, feeding and fertilisation.

- The state hatchery uses several different approaches when dealing with specific problems e.g., pre-treating the pond with gasoline in the case of predation, and salt treatment and liming in the case of *Lernaea* infection.

- Farmers carrying out rice-fish culture and operating private hatcheries generally do not take any particular action in response to problems, while those engaged in capture fishing report occurrences to government stations.

The findings and recommendations of this survey, including the institutional and training needs assessment, will assist in the formulation of a strategy for aquatic animal health management in southern Lao.

RECOMMENDATIONS

This section, based on the final-day workshop, presents the recommendations agreed upon by the participants that are directed at the major issues and problems identified during the survey.

It was recognised that, as a matter of priority, the disease and production-related problems identified during the survey should be addressed in the following order:

1. Problems associated with technical capability
2. Disease with clinical manifestations similar to EUS
3. Problems associated with resource availability
4. Predation problems: snake, fish, crab, insect and human (theft)
5. Deaths/mortalities with no apparent sign
6. *Lernaea* infection
7. Unspecified disease showing red patches

The following specific activities were identified as necessary to support a programme that will establish systems for improved productivity and enhanced capability of both government staff and farmers to address problems:

- Farmer education on pond management and disease prevention.

- Training of staff and provision of facilities for health management and disease diagnosis.

- Setting up of committees to manage reservoir and community ponds and to address the following:

  - Developing rules and regulations

  - Implementation

  - Producing seed for stocking purposes

  - Issuing permits for fishing

    - Managing water supplies for fisheries
    - Organising workshops or training for villagers to sustain productivity
- Increasing efficiency of government staff to assist farmers (e.g., fish-culture techniques)
- Establishing demonstration farms in villages
- Farmer education on cost-effective management strategies (e.g., feeding, fertilisation)
- Improving capability of state hatcheries (technical training) and resources (provision of equipment and funds) to increase production
- Developing private hatcheries in villages through training
- Developing and providing technical manuals and extension materials
- Providing loans from government and private banks
- Restructuring tax conditions to promote local production and allow importation of necessary items

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A REVIEW OF THE ECONOMIC IMPACTS OF AQUATIC ANIMAL DISEASE

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ABSTRACT

Quantifying the economic costs of aquatic animal disease is important in determining the optimal investment in aquatic disease control. This study develops three approaches in studying the economic impact of aquatic animal disease: (i) measuring the economic costs of aquatic animal disease at the farm level and (ii) at the national level, and (iii) via the farmer's investment decision in disease control. At the farm level, the conceptual model illustrates that measuring the economic loss of aquatic animal disease by using the output forgone (volume of dead animals) times the market price will lead to an overestimation of the economic loss. The correct concept of economic loss to the farmers is to measure the difference between the profit when the animal is fully grown and the actual profit received when some (or all) the animals died. The empirical results show that the economic costs of aquatic disease at the farm level decrease with time, as expected. Farmers who are able to keep their aquatic animals alive longer will experience a smaller economic loss compared to farmers whose animals die at an earlier stage of the cropping period. This result contradicts the belief that if disease strikes when the animals are fully grown, then the economic loss will be large. At the national level, the Sri Lankan secondary data for 1995-97 reveal that shrimp processing and exporting companies are able to guard themselves from economic loss better than the farmers. As a nation suffers economic loss due to an aquatic animal disease, shrimp processing and exporting companies take a smaller share of the national economic loss as compared to that of the the farmers. Based on the farmer's investment decision model, it was found that Thai farmers invest rather optimally (i.e, in a profit-maximising manner) with regard to disease control investment in shrimp farming.

BACKGROUND

Aquaculture is important to the international economies in many ways. To many producing countries, it is an important income earner for local farmers and upstream-downstream industries. Often, it also contributes to the country's export earning and generates employment in rural areas. In the case of Thailand, fishery production contributed 2.73% to GDP in 1998 (Office of the National Economic and Social Development Board 1999), and in 1999, fishery exports earned US$1,877 million in foreign exchange (Bank of Thailand 2000), resulting in it being classified among the country's major export items.

The volume and value of international trade derived from aquaculture products have risen steadily from US$35.8 billion in 1990 to $47 billion in 1994 (FAO 1996).

While the major importers of cultured fish and shellfish are developed countries such as the members of the European Union (EU), Japan and the United States, the major exporters are mainly developing countries. FAO (1996) reports that this trade represents a significant source of foreign exchange earnings for many developing countries. Between 1985-94, the net receipts from foreign exchange in developing countries increased from US$5.1 billion to $16 billion.

Despite the important role aquaculture has played in determining economic well being, the success and sustainability of the sector evolve around the issue of disease management. Often, the success or failure of aquaculture enterprises rests on how effectively the producers and researchers are able to manage aquatic diseases. Records show that success in managing disease results in high profits for producers and increased benefits for consumers.

Table 1 shows some estimates of the magnitude of losses resulting from shrimp disease. During the first half of the 1990s, it is reported that the losses due to disease totalled about 541 mt and were valued at around US$3,019 million (based on a price of US$5/kg). In interpreting the numbers reported in Table 1, it is essential that one adopt a correct method of calculating these economic losses. If these values are calculated using an incorrect concept of economic loss, then the values report will be misleading, either too large or too small. If the miscalculated numbers are then used by the concerned agencies as a benchmark for allocating investment funds for aquatic disease control, this can lead to an over-investment or under-investment in disease control.

Table 1. Some estimated losses due to shrimp disease (source: unpublished World Bank report prepared by C.G. Lundin in 1998).

Country (Year)	Estimated Loss (mt)	Loss as Percentage of Expected Output (%)	Value of Production Loss (US$ Million, 1994)
Thailand (1994)	130	58	650
Philippines (1989)	57	96	285
Ecuador (1992)	34	27	170
Indonesia (1991)	50	34	250
China (1992)	180	84	900
Taiwan (1987)	100	72	500
Mexico (1994)	1	8	5
USA (1993)	12	NA[1]	60
India (1994)	25	36	125
Vietnam (1994)	10	20	50
Bangladesh (1994)	5	14	25
Total	**541**	**74**	**3,019**

[1]NA = not available.

Economic losses associated with aquatic animal disease also have international implications. As aquaculture products are traded internationally, diseases can lead to two types of economic losses. Firstly, internationally traded products can be subject to disease and/or quarantine control. Failure to comply with the quarantine standards imposed by an importing country can result in a total ban on importation. This will lead to economic losses deriving from a decline in export earnings, and also, losses derived from a decline in consumer welfare in importing countries. Secondly, infected products derived from aquaculture can transmit diseases to other countries, resulting in production and consumption losses in the recipient countries.

Aquatic animal disease management is crucial to aquaculture, and thus, investment in disease control is vital to success and sustainability. Investments in aquatic animal disease control can take place at the international, regional, national and farm levels. Just as aquatic animal diseases are costly to the economy, so is investment in aquatic disease control. The question that challenges policy makers is whether the saving to be realised from reducing economic losses due to aquatic diseases is worth the investment in disease control. For this reason, it is important that the economic losses resulting from aquatic animal disease are correctly evaluated, so that investment funds for disease control can be allocated in an optimal manner. An over-estimation of economic loss due to aquatic animal disease can lead to an over-investment in disease control efforts, while an under-estimation can lead to an under-investment. In other words, too little investment funding for disease control is considered as sub-optimal as too much.

Another concern in aquatic disease management is the hypothesis that the farmers may not invest sufficiently in disease management. Subsequently, this insufficient investment on the part of the farmers may result in an economic loss. This study will examine whether the farmers are investing optimally with regards to disease control. In this study, a farmer profit maximising model is developed to examine the net economic benefit of the farmers' aquatic disease control strategies. This model will help explain the farmers' investment behaviour in disease management and will indicate the extent to which the farmers are optimising their disease control investment.

The aim of this study is: 1) to develop a systematic assessment of the economic losses due to aquatic diseases; and 2) to construct a profit maximising model to examine the farmers' investment behaviour in aquatic disease control strategy. Such analyses will be useful for international and regional organisations, national governments and the private sector when calculating the economic loss from aquatic animal disease and for understanding the farmers' investment behaviour in disease control.

SHRIMP DISEASES

Disease problems are serious in many areas where more intensive farms have been operating. Diseases are commonly caused by viruses, bacteria, fungi, protozoa and toxins (Patmasiriwat *et al.* 1996). Bacterial and viral infections are among the most common diseases encountered in shrimp farms, and are usually associated with poor management or environmental conditions. In the past few years, viruses have been the most significant cause of serious losses in Thai shrimp production (Chanratchakool 1999). Among the viral diseases, yellowhead disease and white spot disease are most common. Other serious diseases include vibriosis caused by *Vibrio harveyi*.

Yellowhead Disease

Yellowhead disease (YHD), caused by yellowhead virus (YHV), is one of the most serious diseases affecting cultured shrimp. This disease was first reported on the east coast of the Gulf of Thailand in 1990, although the causative agent was not identified until years later (Alday-Sanz and Flegel 1997). Widespread epizootics have led to significant economic losses in Thailand and other Asian countries. Infected shrimp will die within three to five days (Panasont and Viwatchaisert 1996). Its name comes from the gross signs of the disease, which include a light yellow coloration of the dorsal cephalothorax due to the underlying yellowish and often swollen hepatopancreas showing through the translucent carapace in moribund shrimp (Alday-Sanz and Flegel 1997).

Outbreaks of this disease appear to be triggered by environmental factors, such as sub-optimal or unstable water condition and deteriorated pond bottom (Chanratchakool 1994). YHD infects several penaeid species, including those from the western hemisphere. This virus also infects planktonic shrimp species that are common residents of shrimp ponds, and these thus become viral carriers (Alday-Sanz and Flegel 1997).

There are currently no chemical treatments effective against this virus. However, on-farm sanitation should be regarded as a priority, and stocking densities should be kept within manageable limits in order to maintain a healthy, stress-free environment for the shrimp (Briggs 1993).

White Spot Disease

White spot disease, caused by white spot syndrome virus (WSSV), has caused the most severe production losses in Thailand since 1993, and is widespread throughout culture areas along the Gulf of Thailand and the Andaman Sea (Chanratchakool 1994). This virus is able to enter culture ponds through many vectors, such as various crustaceans, including shrimp postlarvae and wild shrimp entering the ponds during water exchange. Birds, land animals and workers are also possible vectors (Chanratchakool 1999). White spot disease can also be transmitted from adjacent affected ponds with poorly managed water exchange (Limsuwan 1997).

Affected shrimp show reddish to pinkish-red discoloration of the body, which is often accompanied by white patches on the inside surface of the carapace. Mortality can reach 100% within seven to ten days (Kasornchandra *et al.* 1995).

Currently, there is no effective drug or chemical to control the virus. Therefore, prevention is often recommended. Since shrimp farmers have reduced the amount of water exchange by adopting closed or semi-closed systems and have implemented proper pond management, the severity of infection has been reduced (Limsuwan 1997). However, WSSV still has the ability to cause problems in shrimp culture through out the country, due to its presence in postlarvae (Limsuwan 1997).

Bacterial Disease

Vibrio harveyi is an important pathogen causing mortalities in shrimp hatcheries and farms. The disease usually occurs one month after stocking of postlarvae in the pond. Mortalities usually range from 5-80% within a few days (Kasornchandra *et al.* 1995). Good pond and hatchery management can help to avoid contamination and minimise the risk of disease. Water exchange management is recommended, because it can maintain the right concentration of phytoplankton in the pond. Treatment with oxytetracycline and other antibiotics has also been widely used for controlling the disease, however, their excessive use can lead to the development of drug-resistant populations of bacteria (Primavera 1993).

CURRENT INVESTMENT IN AQUATIC ANIMAL DISEASE CONTROL

Types of Disease Control Expenditures

Expenditures and investment in disease control take place at many levels: internationally, regionally, nationally and at the farm level.

International level

Shrimp disease problems have attracted much attention at the international level. In terms of health management, there have been vast efforts carried out in Ecuador, Taiwan Province of China, Thailand and the United States to promote sustainable shrimp farming through better management practices. Much of this effort has been directed towards improving health management by coming to terms with the ecology of aquaculture systems, namely, water exchange systems, farm densities, soil composition and intensity of farming practices.

C.G. Lundin, in an unpublished World Bank report prepared in 1998, indicated that, for medium-term solution of shrimp disease problems, investment in research should be on the order of US$31 million/yr for the first two years, $91 million/yr during years three to seven, and $90 million/yr during years eight to fifteen. Thus, a research effort totalling US$1,237 million is needed to help control disease problems. Table 2 provides a breakdown of this proposed research investment.

Table 2. Proposed annual funding requirements for shrimp disease research during the next 15 years (source: unpublished World Bank report prepared by C.G. Lundin in 1998).

Area of Research	Funding Required ($US Million/yr)		
	Year 1-2	Year 3-7	Year 8-15
Viruses	2	5	5
Bacteria	2	5	5
Rickettsia	0.5	0.5	1
Fungi	2	3	3
Protozoans	0.5	0.5	1
Nutrition, toxicology & environment	3	5	5
Health management	10	30	50
Culture technique improvement	10	50	30
International network on shrimp disease	1	1	1
Diagnostic technology development	2	2	1
Environmental control technology (probiotics)	3	3	3
Feed improvement	5	5	5
Totals	**31**	**91**	**90**

Regional level

In Asia, lack co-ordination has hindered progress in aquatic research. FAO/NACA (1997) reports that technical constraints include lack of technologies for nutrition and feed development, genetic improvement, breeding and seed production, health and environmental management, and integrated and intensive fish-farming systems. FAO/NACA (1997) recognised that the non-technological issues and constraints to effective aquatic research in Asia include weak interagency and institutional linkages, poor co-ordination among agencies, ineffective technology transfer and utilisation, ineffective information exchange, lack of skilled personnel, lack of understanding of impacts and implications of aquaculture development policies and plans, inadequate legislation and regulations specific to aquaculture, weak enforcement of regulations, low support for aquaculture in general and lack of support for aquaculture research.

Recent efforts in mobilising resources for research and development have resulted from the workshop held in Hawaii on diseases of cultured penaeid shrimp in Asia and United States. Also, some collaborative efforts have been made through the Asian Fisheries Society and the American Fisheries Society. The Network for Aquaculture Centres in Asia-Pacific (NACA) is a regional intergovernmental organisation promoting co-operation in research, information exchange and training and education in aquaculture development in Asia. NACA is actively involved in all aspects of aquaculture development, but in recent years has been giving particular attention to regional co-operation in aquatic animal disease control. The reason for such co-operation is that aquatic animal diseases are a common problem in Asia and can spread rapidly between countries through movement of live aquatic animals. Therefore, a common regional approach and technical co-operation have proved useful in assisting countries in solving such problems. Recently, in co-operation with the Food and Agriculture Organization of the United Nations (FAO), a regional agreement on a set of technical guidelines on health management for the responsible movement of live aquatic animals was reached among Asian governments. This represents an important step and a platform for development of common policy and actions for aquatic animal disease control in Asia (FAO/NACA 2000).

National level

Governments of developing countries faces limited budgets; hence, research efforts towards shrimp disease control in some countries are very low. The private sector of some developing countries has devoted funding to some applied research on improvement of feed quality, use of probiotics, and the search for natural products to enhance shrimp health. However, lack of sufficient knowledge has been a bottleneck for these efforts. An unpublished World Bank report claims that the private-sector spending on shrimp research in developing countries only accounts for 0.5% of a total production loss estimated at around US$3,000 million. One reason for the lack of financial support to developing aquatic research capacity is the difficulty associated with quantifying the economic returns from investment in research effort.

SYSTEM ANALYSIS AND MODELING

Thrustfield (1995) illustrates that animal disease affects economic well being in two ways: (1) disease leads to disease control expenditure (increase in production costs), and (2) disease decreases output and hence, consumption (loss in producer and consumer economic welfare). This study follows the concept of economic losses as suggested by Thrustfield (1995), but has made adaptations to fit phenomena specific to aquaculture, namely, diseased shrimp harvested before fully matured and revenue derived from the sale of dead or premature shrimp.

Disease outbreaks result in economic losses to the farmers in terms of income reduction. These losses can be divided into two components: reduction in revenue and increase in disease control costs. The reduction in income is measured as the difference between the income that the farmers actually receive after they experience a disease outbreak and the income they would have received if the animals were fully grown without disease. This income reduction includes reduction resulting from the sale of young (premature) or dead animals or the total loss when infected animals are too small and cannot be marketed. The cost of disease control is another component that reduces the profit a farmer would otherwise receive. This includes expenditure on disease prevention, such as lime and pond preparation costs, and additional disease-control costs when the farmer experiences a disease outbreak and more disease control inputs (e.g., chemicals) have to be used.

In addition to classifying these losses, it is sometimes essential when conducting the calculation to take into account the time dimension. For instance, a loss which takes place five days after stocking will be less detrimental to the farmer as compared to another case where the loss takes place at the 100th day after stocking and the animals are nearly full grown. To take into account the time dimension, the revenue and cost stream will be discounted by the interest rate at the beginning day of each crop, to derive what is called the “present value of economic losses."

Lastly, small occurrences of production losses due to disease outbreaks will have a different economic impact than production losses that occur at a large scale. This is because small occurrences of loss will have little impact on consumer welfare, while large losses will have a substantial impact. This type of consumer welfare loss is detected by observing the change in the market price of the product resulting from reduced production due to disease outbreak. When production losses are small, they will probably have no impact on the market price. On the other hand, if disease is widespread and results in a large volume of production loss, this may have an impact on market price (making the price increase). Therefore, valuation of production losses should also take into account the size of loss volume, as well as how it will affect the market price, and hence, consumer welfare.

Economic Losses Measured from Decline in Farmers’ Income

Measuring the total value of economic loss resulting from aquatic animal disease is a complex exercise, as it involves measuring the welfare loss on the part of both the consumers and the producers (farmers and upstream industries). Studying these losses in detail requires intense data analysis and modeling. However, a type of economic loss from aquatic animal disease can be more conveniently measured by examining the reduction in farmers’ income. A mistake that is often seen is when economic loss is calculated simply by measuring reduction in aquatic animal output (volume of dead animals) and multiplying it by the market price. This method of calculation tends both to over-estimate and under-estimate the true magnitude of economic loss for the following reasons. Firstly, measuring the economic loss as the quantity of dead animal times the market price only represents the loss of revenue to the farmer. But the economic well being of the farmers is not measured by revenue, but rather by the profit realised from each crop. Therefore, a more correct method to measure economic loss is to examine the profit foregone, not the reduction in revenue. Secondly, using the amount of dead animal times the market price is misleading in the situation where farmers can derive income from the sale of dead animals. Furthermore, there are situations where disease is detected and the farmers can harvest the animals prematurely. In this case, there may not be any animal reported as "dead," but an economic loss will have taken place. Thirdly, basing the economic loss on the reduction in farm revenue ignores the fact that aquatic animal disease also increases the cost of production, as the farmers have to spend money on disease control substances/inputs. Expenditures on disease control substances/inputs essentially constitute part of the reduction in the well-being of the farmers, and as it leads to a decline in farm profit, it should be counted as part of the economic loss.

For these reasons, this study shall develop an approach that can be used to accurately measure the economic loss due to aquatic animal disease on the part of the farmers. Figure 1 represents the economic loss when a disease occurs and the animals (either still alive or already dead) have to be harvested prematurely. R(t) represents the revenue function of the sale at different stages of cultivation. It is assumed that a particular animal will not be large enough for the market before 50 days of cultivation. After the 50th day, it will begin to capture some market value, as it can either be sold as dead or premature shrimp (not fully grown). The price and the size of shrimp will increase as the number of cultivation days increases, and hence R(t) is an increasing function of time, t. C(t) represents the costs of shrimp cultivation, which is also an increasing function of time, t.

Economic loss occurs when a disease causes the farmer to sell his product before it is fully grown. The economic loss in this case will be the difference between the profit the farmer would obtain if the animals were fully grown (cultivated for at least 120 days) and the profit (or losses) he actually obtains when the animals are sold (or discarded) prematurely. Equation 1 shows how this component of economic loss is calculated. Figure 1 shows that economic loss, EL(t), is the sum of the decrease in farmers' profit and disease control expenditure, DE(t). It is expected that the economic loss, EL(t), diminishes as the number of cultivation days increases.

Economic loss at t^{h} day

$$EL(t) = [Profit/rai \text{ at } 120^{th} \text{ day}] - [Profit/rai \text{ at } t^{h} \text{ day}] + DE(t) \qquad (1)$$

where t = Time when harvest or sale takes place.

DE(t) = Disease control expenditure at time t.

Figure 1 and the following examples show how the economic loss is calculated when disease occurs at different stages of cultivation.

Disease occurs at 120^{th} day:

$$\begin{aligned} \text{Economic Loss} &= (a-b) - (a-b) + DE(t) \\ &= 0 + DE(t) \\ &= DE(t) \end{aligned}$$

Disease occurs at 100^{th} day:

$$\begin{aligned} \text{Economic Loss} &= (a-b) - (c-d) + DE(t) \\ &= (a-e) + DE(t) \end{aligned}$$

Disease occurs at 80th day:

$$\text{Economic Loss} = (a-b) - (f-f) + DE(t)$$
$$= (a-b) + DE(t)$$

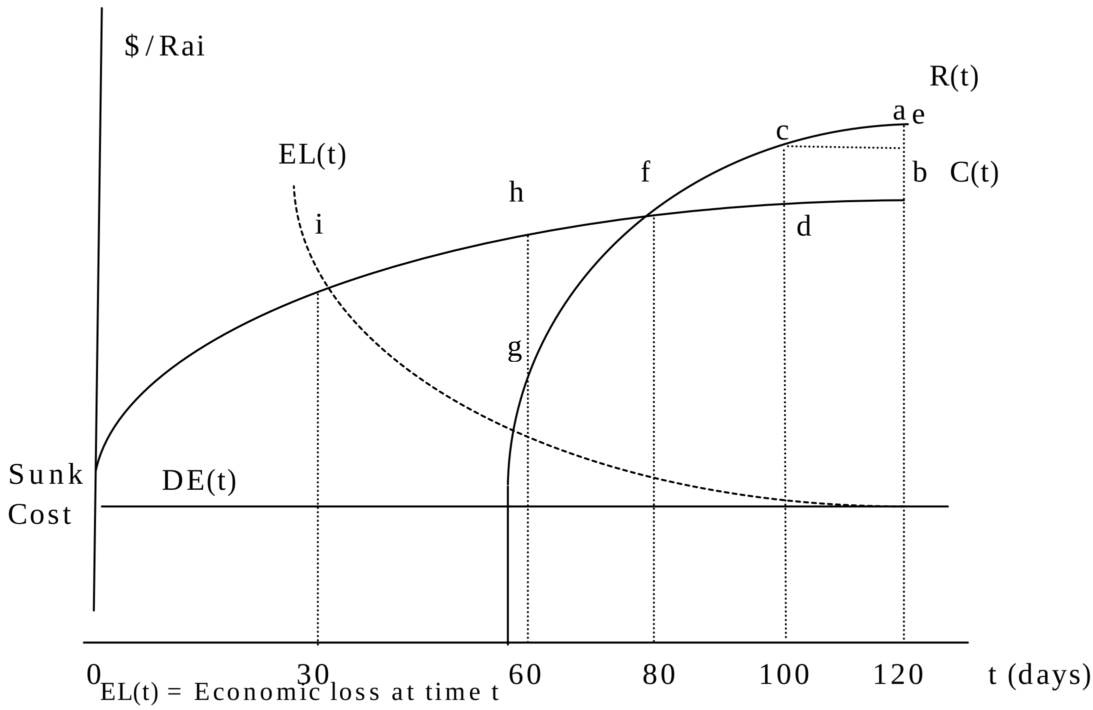
Disease occurs at 60th day:

$$\text{Economic Loss} = (a-b) - (g-h) + DE(t)$$
$$= (a-b) + (h-g) + DE(t)$$

Disease occurs at 30th day:

$$\text{Economic Loss} = (a-b) - (0-i) + DE(t)$$
$$= (a-b) + i + DE(t)$$

Figure 1. Economic loss from aquatic diseases as a function of time.



EL(t) = Economic loss at time t
R(t) = Total revenue at time t
C(t) = Total cost at time t
DE(t) = Total disease control expenditure at time t

Discounting Economic Value

When a disease takes place that may result in total death or premature harvest, the revenue and cost streams should be valued based on a particular point in time. This concept is known as economic discounting. For instance, a farmer who experiences a disease outbreak on day 80 and obtains a profit of $100 will be better off than another farmer who experiences a disease outbreak on day 110 and obtains a profit of $100. This is because the profit that occurs later in the process will cost more to the farmer due to interest foregone. Putting it differently, a farmer who suffers the loss sooner can reinvest sooner compared to another farmer who suffers the same magnitude of economic loss, but at the later stage of the cycle. When taking into consideration the discounting factor valued at a given interest rate, the economic loss function can be represented by equation (2).

Economic loss function

$$EL(t) = [(R(120)-C(120))/(1+r)^{120}] - [(R(t)-C(t))/(1+r)^{t}] + DE(t)/(1+r)^{t} \quad (2)$$

Market Price Effect

For small losses (marginal), the amount of dead shrimp will not affect the market price, hence $P = P^w$, where P^w is the world price of shrimp. The revenue of shrimp sale is:

$$R(td) = P^w Qh \quad (3)$$

As for large losses (non-marginal), the amount of shrimp losses will affect the market price, and hence P = f(Q, GDP; ...), which is the inverse demand function of shrimp. The revenue of shrimp becomes:

$$R(td) = P(Q, GDP; \ldots)Qh \quad (4)$$

Equations (3) or (4) will be used to calculate the revenue in equation (2), depending on the magnitude of disease outbreak and its impact on the market price.

Empirical Results

To illustrate the calculation of economic loss experienced by the farmers, this study uses the Thailand Development Research Institute survey[1] (TDRI 1996) to compute the revenue, R(t), as a function of time. The calculation of the farmer's economic loss will be based on equation (1) as shown above, and it will be assumed that the impact of the disease is small and hence, will not affect the market price of the aquatic animal. The discounting effect and the market price effect as discussed in equations (2) and (4) will not be included in the empirical analysis below. This revenue is measured on a per rai[2] basis. The cost of cultivation, C(t), is the cost per rai, and is also measured as a function of time. Table 3 shows the variables used in estimating the cost of disease faced by the farmers. These costs are divided into three categories: preparation cost, fixed cost and operation cost.

Table 4 shows summary data of the cost structure of the farms classified by number of cultivating days. Farms surveyed are classified into nine categories depending on the number of cultivating days. For each category, the average pond preparation costs, average fixed costs and average operating costs are calculated on a per rai basis. The results are as expected, in that both preparation costs and fixed costs do not vary with cultivating days. The only type of cost that varies with cultivating days is operating cost. For instance, farms that experience disease during the first 30 days of cultivation will only lose 61,270 Baht per rai in terms of

[1]The Thailand Development Research Initute (TDRI) conducted a shrimp farm survey in 1996. The survey collected farm-level data from 348 shrimp farmers in eight coastal provinces. The survey data include farmers' information regarding their shrimp output, factor of production, culturing system, costs, revenue and frequency of disease occurance.

[2]1 rai = 0.16 ha.

cost incurred. Farms which carry their stock longer, such as 90-119 days, and experience disease will lose as much as 117,621 Baht per rai in terms of costs incurred.

Table 3. List of variables of production cost.

Cost Component	Variable Name	Description
Pond preparation	STAY	Drying day
Cost	LIME	Quantity of lime
	CHLORI	Quantity of chlorine
	FERTI	Quantity of fertiliser
	QUAT	Quantity of chemical (excluding fertiliser)
	OTHER	Fixed cost
Fixed cost	LANDC	Land buying or rent
	LANDADJ	Land adjusted
	HOUSE	Building
	PIPE	Water pipe
	AIR	Aerator
	GENER	Generator
	BOAT	Boat
	CAR	Car
	OTH	Other
	Total	Total fixed cost
Operating cost	TLABOUR	Labour
	TFEED	Dry feed
	TWFEED	Wet feed
	TVITAM	Vitamin
	TSEED	Seed
	TLIMEO	Lime
	TFERTO	Fertiliser
	TCHLOO	Chlorine
	TTEAO	Teaseed cake
	TELECO	Electricity
	TOILO	Diesel oil
	TCLEANO	Sludge clean
	TMEDICO	Medicine
	TOTHERO	Other cost
	TVCO	Total variable cost

Table 4. Structure of production costs by culturing day (source: calculated by author and TDRI 1996 survey data).

Cultivating Days	No. of Cases	Mean Day	Ave. Prep. Costs	Ave. Fixed Costs	Ave. Operating Costs	Ave. Total Costs	Product Per Rai	Total Revenue
<30	2	<30	5,110	6,737	49,424	61,270	0	0
30-59	4	45	4,385	26,778	45,532	76,695	84	3,080
60-89	16	75	5,711	17,672	61,759	85,142	183	19,244
90-119	37	105	3,892	24,166	89,563	117,621	875	143,986
120-129	140	125	3,144	21,427	110,825	135,395	1,055	177,345
130-139	69	135	3,597	18,733	114,467	136,798	997	167,569
140-149	24	145	2,578	17,437	135,390	155,405	1,163	209,453
150-159	45	155	3,195	20,246	116,580	140,021	1,007	189,230
>160	11	>160	2,722	19,789	115,929	138,439	974	196,994

Table 5 corresponds to Table 4, but presents the costs of farms in percentage terms. Table 5 indicates that, on average, preparation costs will account for 3.9% of farm total costs, fixed costs will account for another 17.4%, and that most of the costs are operating costs of 78.7%. So the cost structure of an average shrimp farm surveyed shows that most of the production cost is in operating costs. As the number of cultivating days increases, the proportion of preparation costs to the total costs declines from 8.3% to 2.0%. This similar trend is also observed for the fixed costs.

Table 5. Structure of production costs by cultivating days (source: calculated by author and TDRI 1996 survey data).

Cultivating Days	No. of Cases	Mean Days	Preparation Cost (%)	Fixed Cost (%)	Operating Cost (%)	Total (%)
<30	2	<30	8.3	11.0	80.7	100
30-59	4	45	5.7	34.9	59.4	100
60-89	16	75	6.7	20.8	72.5	100
90-119	37	105	3.3	20.6	76.2	100
120-129	140	125	2.3	15.8	81.8	100
130-139	69	135	2.6	13.7	83.7	100
140-149	24	145	1.7	11.2	87.1	100
150-159	45	155	2.3	14.5	83.3	100
>160	11	>160	2.0	14.3	83.7	100
	Average		3.9	17.4	78.7	100

Table 6 shows the calculation of equation (1) (repeated below), that is, economic loss which occurs at t^{th} day is represented by:

$$EL(t) = [Profit/rai\ at\ 120^{th}\ day] - [Profit/rai\ at\ t^{th}\ day] + DE(t) \qquad (1)$$

In calculating the economic loss incurred by a shrimp farmer, it is assumed that the shrimp are fully grown at 120 cultivating days. Hence, the profit obtained at 120 cultivating days will be used as the bench mark for calculating economic losses of a farmer. In Table 6, farms are again classified into nine types according to the number of cultivating days. The total cost of an average farm, C(t), is simply the sum of average pond preparation costs, average fixed costs and average operating costs as shown in Table 5. The revenue stream, R(t), is calculated from the total revenue an average farmer in each category obtains. This revenue includes sales of farm products in all forms. For instance, R(t) includes sale of fully grown shrimp (for those belonging to categories 120 culturing days and more), and sale of premature and dead shrimp (for those belonging to categories 90-119 days and less). Based on this survey data, the bench-mark profit that an average farmer expects is the profit at 120 cultivating days, which is equal to 41,390 Baht/rai (177,345 Baht/rai minus 135,395 Baht/rai]. For the farmers who experience disease but still obtain some revenue, their economic loss will be the bench-mark profit of 41,390 minus the profit they actually obtain plus the cost of disease control, DE(t). Disease control costs, DE(t), are the costs that all farmers must face whether disease strikes or not, and hence, are included as a component of economic loss, EL(t) (see equation 1).

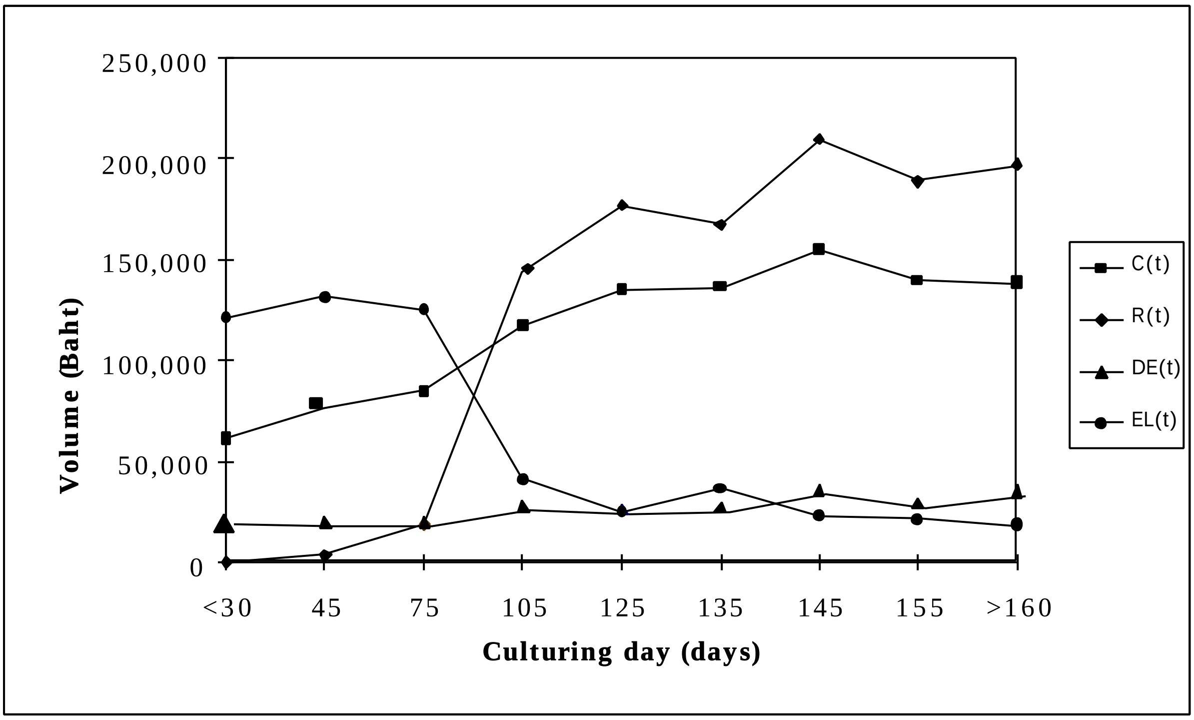
Table 6. Cost, revenue and economic loss of shrimp per area (unit: Baht/rai) (source: calculated by author and TDRI 1996 survey data).

Cultivating Days		C(t)[1]	R(t)	DE(t)	EL(t)
Range	**Mean**				
<30	<30	61,270	0	21,527	121,874
30-59	45	76,695	3,080	19,291	131,331
60-89	75	85,142	19,244	19,542	124,981
90-119	105	117,621	143,986	27,637	41,259
120-129	125	135,395	177,345	26,113	24,952
130-139	135	136,798	167,569	27,333	36,776
140-149	145	155,405	209,453	35,674	22,671
150-159	155	140,021	189,230	29,264	21,258
>160	>160	138,439	196,994	35,410	18,373

[1]C(t) = total cost at time t; R(t) = total revenue at time t; DE(t) = total disease control expenses at time t; EL (t) = economic loss at time t; t = cultivation day.

Figure 2 is based on calculations from data presented in Table 6. The cost of production, C(t), starts from 61,270 Baht/rai and is an increasing function, as expected. This means that an average farmer will face an initial start-up cost of 61,270 Baht/rai (Table 6). On the revenue side, an average farmer whose cultivating days is less than 30 days will not be able to market his product if disease occurs. However, after 30 days of cultivation, the size of shrimp will be large enough for market. An average farmer can obtain revenue from selling 30-day shrimp of only 3,080 Baht/rai (Table 6). As the number of cultivating days increases and the shrimp become larger, the revenue continues to increase. At around 90 days, an average farmer will break even, as the cost of production is about equal to the revenue, even though the shrimp are not fully grown. After 90 days of cultivation the farmers will begin to earn profit.

Figure 2. Analysis of economic losses per area of shrimp farming by culturing day.



Based on equation (1), the economic loss function is depicted by EL(t), which is decreasing as expected. This phenomenon leads to the following conclusions:

- Calculating the economic loss from aquatic animal disease based on the quantity of dead animal times the market price can overestimate the true economic loss realised by the farmers. This study demonstrates how a more accurate concept of economic loss on the part of the farmers can be measured by examining the change in the farmers' profits.

- From the TDRI survey, it is shown that the economic loss due to disease is a decreasing function of time. This means that the longer a farmer can keep his shrimp alive, the lower the economic loss will be. This phenomenon is probably contradictory to the belief that if disease strikes when the shrimp are fully grown, then the economic loss will be large.

ECONOMIC VALUE OF DISEASE CONTROL DEVICES

Numerous disease-control devices are currently employed by the farmers to help reduce disease risks. Such disease-control devices include, for instance, application of lime during pond preparation, and during stocking to help reduce acidity, application of fertilisers and medicines, and the use of aerators to increase oxygen levels in the pond. This section examines the farmers' behaviour towards disease control activities by calculating the returns to the use of disease control inputs or the value of marginal product (VMP) with respect to each disease control input. The benefits of calculating the value of marginal product of each disease control input are:

- To indicate how each disease control input affects the farmer's revenue and profitability.

- To inform aquacultural researchers which disease-control inputs are being over- or under-utilised by the farmers. This will provide a directional guideline for future extension work on application of disease control inputs.

For instance, the calculation of VMP for lime application during pond preparation may equal 2.50 Baht. This means that a kilogram of lime used generates an additional revenue of 2.50 Baht to the farmer. Suppose that a kilogram of lime costs the farmer 2.00 Baht; hence, every 2.00 Baht spent on lime during pond preparation increases the net benefit to the farmer by 0.50 Baht. This leads to two conclusions: 1) lime application during pond preparation is beneficial to the farmer, and 2) economically, the farmers did not overuse lime, that is, the return of 2.50 Baht is greater than the cost of lime, which is 2.00 Baht.

The following shows the formal derivation of the concept of VMP. Assume that a farmer selects input levels (feed, seed and disease control inputs) such that his/her profit is maximised.

$$P = P*Q(SX_i, SX_j, SX_k) - Sc_i*X_i - Sc_j*X_j - Sc_k*X_k \quad (5)$$

Where P *= farmer profit*
- P = *price of shrimp*
- Q = *quantity of shrimp sold*
- X_i = *quantity of primary inputs i (feed and seed)*
- X_j = *quantity of disease control input j*
- X_k = *quantity of fixed input k*
- c_i = *unit cost of primary input i*
- c_j = *unit cost of disease control input j*
- c_k = *unit cost of fixed input k*

Equation (5) shows that the farmers profit (Π) is obtained by revenue (P*Q) minus costs. The revenue component is composed of price (P) times quantity of output (Q), where Q is a function of all inputs used (X_i, X_j and X_k). The cost to a farmer is comprised of three components: costs of primary inputs, feed and seed (Σc_i*X_i), costs of disease control inputs (Σc_j*X_j) and costs of fixed inputs (Σc_k*X_k).

A rational farmer optimises his/her input used by choosing the level of variable inputs X_i and X_j until profit is maximised. As X_k are fixed inputs, they will not vary in the short run, and hence, will not enter the farmer's optimisation process in the short run. To maximise profit, partially differentiate the profit function with respect to X_i and X_j and set the first partial derivatives equal to zero.

$$¶P/¶X_i = P*MP_i(SX_i) - c_i \quad = 0$$
$$VMP_i = P*MP_i(SX_i)$$
$$VMP_i = c_i \quad (6)$$

$$¶P/¶X_j = P*MP_j(SX_j) - c_j \quad = 0$$
$$VMP_j = P*MP_j(SX_j)$$
$$VMP_j = c_j \quad (7)$$

Equations (6) and (7) are the first order conditions indicating that a farmer will maximise profit when the quantity of inputs is used at the level where VMP = unit cost of inputs, c.

However, due to the restriction in the definition of the Thai data set, many of the important inputs (X_i and X_j) are defined in value terms. For example, medicine application is given in expenditure, and not in quantity terms. For this reason, arguments in the production function will be redefined as expenditure on inputs used (c_i*X_i and c_j*X_j) instead of quantity of input used (X_i and X_j). Using expenditure instead of quantity should not affect the estimation of the production function or marginal product of inputs. Given that this study uses cross-sectional data where most farms are facing the same input prices (c_i and c_j), using expenditure of inputs instead of quantity of inputs simply means scaling the inputs to the same factor, that is, input prices (c_i and c_j).

For this reason, the production function $Q(\Sigma X_i, \Sigma X_j, \Sigma X_k)$ and the objective function of the farmer will be rewritten as equations (8) and (9), respectively.

$$P^*Q = f(Sc_i{}^*X_i,\ Sc_j{}^*X_j) \qquad (8)$$

$$P = P^*Q(Sc_i{}^*X_i,\ Sc_j{}^*X_j,\ Sc_k{}^*X_k) - Sc_i{}^*X_i - Sc_j{}^*X_j - Sc_k{}^*X_k \qquad (9)$$

Differentiating (9) with respect to input costs c_i*X_i and c_j*X_j obtains:

$$\P P / \P c_i{}^*X_i = P^*MP_i(Sc_i{}^*X_i) - 1 \qquad = 0$$

$$VMP_i = P^*MP_i(Sc_i{}^*X_i)$$

$$VMP_{cixi} = 1 \qquad (10)$$

$$\P P / \P c_j{}^*X_j = P^*MP_j(Sc_j{}^*X_j) - 1 \qquad = 0$$

$$VMP_j = P^*MP_j(Sc_j{}^*X_j)$$

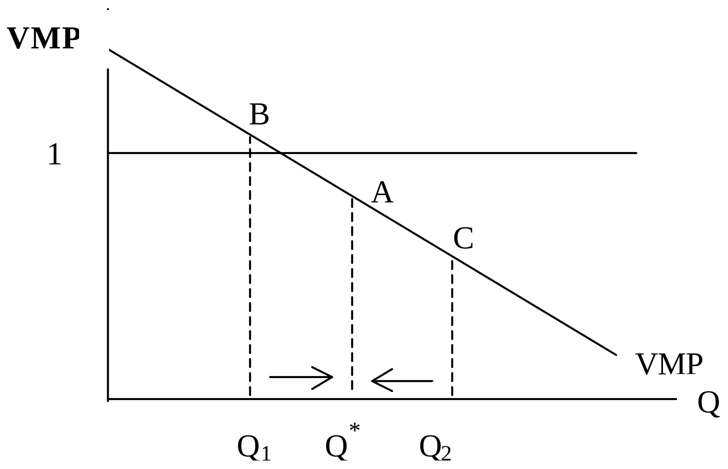
$$VMP_{cjxj} = 1 \qquad (11)$$

$$hence,\ VMP_{cixi} = VMP_{cjxj} = 1 \qquad (12)$$

Equation (12) indicates that a farmer’s use of inputs will be optimal (maximise profit) if the last Baht spent on each input yields equal returns, and these returns are equal to one.

Figure 3 shows the relationship between VMP and quantity of input. Point A, where VMP equals to 1 and quantity of input is Q*, is a point that the farmer’s use of input is optimal. Point B is a point where the quantity of input is decreased to Q1 and value of VMP is greater than 1. Thus, at this point, the use of input is not optimal. At point C, the quantity of input is increased to Q2 and the value of VMP is less than 1. Therefore, at this point, the use of input is not optimal. This indicates that the farmer will experience profit maximisation if VMP is equal to 1.

Figure 3. Relationship between VMP and quantity of input.



To examine if this phenomenon prevails in reality, this study tests the model using three different data sets: the Thai shrimp data collected by TDRI, the Bangladesh carp data set and the Indian carp data set.

To obtain equation (12), the study first estimates the revenue function (8), where farm revenue is a function of expenditure on each input. In this study, equation (8) will be specified linearly as shown in equation (13).

$$P*Q = a + Sb_i(c_i*X_i) + Sb_j(c_j*X_j) \qquad (13)$$

The first partial derivatives of equation (13) with respect to c_i*X_i and c_j*X_j represent the VMP_{cixi} and VMP_{cjxj}, respectively.

Thai Shrimp

Based on the TDRI survey, important disease control devices have been selected and are shown in Table 7. Table 8 shows the coefficient estimates of equation (13), the t-test of each variable. As expected, nearly all the disease control devices estimated have positive signs. This shows that all these disease control inputs are making positive contribution to farm revenue. However, due to limited observations and the fact that the estimation is carried out with cross-section data, only some coefficients are significant at the 95% level. Based on 95% significant level it is found that expenditure on dry feed (TFEEDO) and oil & electrical (TENERGY) have positive impact on the revenue of the farmer.

The resulting VMPcixi and VMPcjxj show the change in farm revenue from the last Baht spent on these disease control devices. For instance, the last Baht spent on dry feed increases the revenue of an average farmer by 0.4744 Baht. This, therefore, constitutes an economic loss of 0.5256 Baht. On the other hand, the last Baht spent on seed raises the revenue of an average farmer by 2.1040 Baht, hence, the economic value of seed is 1.1040 Baht.

Table 7. Variable description and property related to diseases (source: calculated by author and TDRI 1996 survey data)

Variable	Description	Property Related to Diseases	Mean (Baht/Rai)
TFEEDO	Value of dry feed	Main source of food supply, but too much application tends to increase disease risks	48,920
TSEEDO	Value of seed	High level of seed stock tends to increase stress & disease risks	11,350
TMEDO	Value of medicine used	Disease protection	2,997
TTEAO	Value of teaseed cake	Water treatment	347
TVITO	Value of vitamin	Disease control	3,424
TCHLO	Value of chemical	Water treatment & pH control	1,665
TLIMO	Value of lime	Water treatment	1,407
TENERGY	Value of oil & electricity	Adding oxygen to water	13,690
TCHLP	Value of chlorine	Pond preparation & disease prevention	1,573
TLIMEP	Value of lime	Pond preparation & disease prevention	559
TFERTIP	Value of fertiliser	Pond preparation & disease prevention	50
STAY	Number of pond drying days	Pond preparation & disease prevention	38

The results given in Table 8 show that out of the 12 disease-control inputs selected, as many as 11 have positive coefficients. This means that application of these 11 disease-control inputs contributes positively to farm revenue - the value of marginal product exceeds zero. However, when we consider the economic value of these disease-control inputs, the value of marginal product minus one, eight disease-control inputs have positive economic value. These disease-control inputs are seed, medicine, teaseed cake, vitamin, chlorine, lime, oil and electricity, and lime used during pond preparation. Although 11 inputs contributed positively to the farmers' revenue, economically, there are two inputs that the farmers have overused, and hence, their economic value is negative. They are dry feed (-0.5256) and chlorine during pond preparation (-0.1278). The results presented in Table 8 suggest the following:

- Out of 12 disease-control inputs, the coefficients, and hence, the economic value, for chlorine is highest at 4.3240 and 3.3240, respectively. This means that the last Baht spent on chlorine during cultivation generates revenue of 4.3240 and an economic value of 3.3240 Baht, or about three times the investment. This may imply that an average farmer ought to use more chlorine in his/her pond during cultivation, as those who do so tend to obtain higher returns to their farms.

- As for most of the other disease-control inputs (except fertiliser and chlorine used during pond preparation), their VMPs turn out to be very close to one another and are also close to one. These VMPs range between 0.2157 for vitamin to 1.6 for oil and electricity. This confirms that the Thai shrimp data largely conform to equation (12), which suggests that an average Thai farmer uses most disease-control inputs optimally.

Table 8. Estimated value of marginal product (VMP) with respect to each input for Thai shrimp (source: calculated by author and TDRI 1996 survey data).[1]

Variable	Description	VMP	T-test	Economic Value
TFEEDO	Dry feed	0.4744	3.634	-0.5256
TSEEDO	Seed	2.1040	1.687	1.1040
TMEDO	Medicine	2.1905	1.596	1.1905
TTEAO	Teaseed cake	1.3603	0.162	0.3603
TVITO	Vitamin	1.2157	1.743	0.2157
TCHLO	Chlorine	4.3240	1.666	3.3240
TLIMO	Lime	2.6667	1.640	1.6667
TENERGY	Oil & electricity	1.8742	3.120	0.8742
TCHLP	Chlorine in preparation	0.8722	0.374	-0.1278
TLIMEP	Lime in preparation	1.4185	0.245	0.4185
TFERTIP	Fertiliser in preparation	41.5140	1.746	-[1]
STAY	Number of pond drying days	-97.7438	-0.524	-[1]

[1]The values of VMP are unusually larger than expected (much greater than 1), hence, their economic values are not calculated here. See further discussion in the text.

- This result also suggests that Thai shrimp farmers have the ability to make rational decisions on farm inputs, particularly those related to disease control. The only exceptions which may indicate sub-optimal input use are in dry feed, where farmers should use less; fertiliser, where farmers should use more; and chlorine during pond preparation, where farmers should use less. As for all the other disease control inputs, the current amounts used by an average farmer are rather optimal.

- As for the two major shrimp-farm inputs, seed and dry feed, it is found that an average farmer tends to use the correct amount of seed (see discussion above), while dry feed is being over-used. The economic value of dry feed of -0.5256 means that the last Baht spent on dry feed results in an increase in revenue of 0.4744 Baht. As the cost of a Baht is one, the economic value of dry feed is calculated to be 0.5256 Baht. This suggests that an average farmer tends to use too much dry feed during cultivation. This could lead to water quality problems due to the accumulation of unconsumed feed in the pond. This can increase disease risks, reduce cultivation days, and hence, lower farm profitability. Based on these results, this study suggests that a reduction in dry feed per rai should help reduce disease risks and raise farmer profitability.

- The results also suggest that the average farmer has overused chlorine during pond preparation. The economic value of chlorine during pond preparation of -0.1278 means that the last Baht spent on chlorine results in a net loss of 0.1278 Baht. This suggests that a reduction in chlorine during pond preparation may help increase the farmers' profitability. Figure 3 can also describe what happened. The quantity of overused chlorine during pond preparation is represented by Q2 and the VMP value is less than 1 (0.8722). This indicates that the use of chlorine during pond preparation is not optimal. In order for the farmer to maximise his profit, he has to decrease the use of chlorine during pond preparation. Once the quantity reaches Q*, the value of VMP will be equal to 1, so that the use of this input will be optimal.

- As for the use of fertiliser during pond preparation, the estimated coefficient of 41.5140 is unusually large. This result is somewhat ambiguous and could have been caused by a number of factors. For instance, fertiliser is a heterogeneous input, with each farmer using different types and qualities, and hence, cross comparison may not be appropriate. Even for the same fertiliser, different application techniques could result in different levels of effectiveness and hence, lead to an unusually high coefficient. Lastly, as fertiliser is a minor input, during the questionnaire interview many farmers could not recall how much he/she had used and how much was paid for the fertiliser used.

- As for the number of drying days, the coefficient estimate represents the farmers' return from drying the pond one more day. The calculation shows that an average farmer loses 97.74 Baht for every additional drying day. This result, together with the negative net return from chlorine used during pond preparation, indicates that farmers may lack sufficient knowledge regarding pond preparation. This result suggests that aquatic research on pond preparation is needed to assist the Thai shrimp farmers.

In terms of future aquatic research, the results of this study lead to the following recommendations:

- The aquatic research community should disseminate more information on pond preparation, as the results show that the current level of drying days is sub-optimal.

- The aquatic research community should inform the farmers how to use dry feed properly during cultivation. The results also show that the farmers are using dry fertiliser sub-optimally. It is likely that the farmers are using too much dry feed during cultivation, which may have led to water quality problems, increased disease risks, reduced cultivating time, and hence, to a decline in farm profitability.

- Although most of the selected disease control devices are being used optimally by the farmers, these findings are limited to on-farm disease control behaviour by farmers. There is still a need for aquatic researchers to look into the long-term sustainability of shrimp farming by focusing on water exchange systems, appropriate land use and the dynamics of disease outbreaks over time. To make statistical inferences about these phenomena, time series data for shrimp farming are required.

Data collection on a continuous basis will be essential for future research. Annex I provides an example of a questionnaire format which may be adopted for long-term data collection. This data format will allow a researcher to trace the economic performance of shrimp farms with reference to disease outbreaks and ecological constraints.

Indian Carp

Equation (12) developed above is also tested using carp data from India. In addition to feed and seed (X_i), there are six disease control inputs (X_j) chosen from the survey data. The total number of observations included in this test is 560. Due to the difference in data format, some variables are measured in value (Rupee) and some are measured in quantity (kg). Coefficients of variables that are measured in Rupees will be interpreted as the value of output when an input used is increased by one Rupee (VMP_{cixi}). Equation (12) suggests that, at optimum, these coefficients should be equal to one. Coefficients of variables that are measured in quantity will be interpreted as value of output when an input used is increased by one kg (VMP_i). Equations (6) and (7) suggest that, at optimum, these VMP_i and VMP_j should equal their input prices c_i and c_j, respectively.

Table 9 shows that the important variables, feed and seed, are statistically significant and have positive sign, as expected. Their values are also close to one, as expected. This shows that the use of feed and seed by the Indian farmers is optimal, as equation (12) suggests. Disease-control inputs do not perform well. From six disease-control inputs selected, only three have positive signs as expected. The coefficient of fertiliser is positive and significant, and is close to one, as expected. This means that an increase in the farmers' expenditure on fertiliser will increase farm revenue. As for the other disease control inputs, the results are mixed. VCHEM is negative but its statistic is not significant. As for QLIME, QTEAS, QWATT and QFILL, which are measured in kg and not Rupee, their VMP will then be based on the value of applying an additional kilogram of input and not an additional Rupee in terms of expenditure. For this reason, their economic values cannot be calculated here. These four variables are, however, included in the model in the attempt to avoid model misspecification. It is believed that the reason that might explain the poor statistical performance of the disease-control inputs is the data availability. From the total of 1,004 observations, there are many observations that have missing data on harvested area, production, feed and seed. The number of observations available for the statistical analysis is only 560. Even within these 560 observations, there are some missing data for disease-control inputs. It is, therefore, difficult to judge whether these missing data on disease control inputs indicate that these inputs are not used, or that the results are due to survey error.

Table 9. Estimated value of marginal product with respect to each input for Indian carp (number of observations = 560) (source: estimated by author and NACA (1996) survey data).

Variable[1]	Unit	VMP	T-test	Economic Value
Constant	-	39983.90	20.927	-
VFEED	Rupee	1.0373	19.148	0.0373
VSEED	Rupee	1.4406	6.729	0.4406
VFERT	Rupee	1.2485	7.985	0.2485
VCHEM	Rupee	-0.1799	-0.221	-0.8201
QLIME	kg	-5.0715	-1.950	-
QTEAS	kg	-382.0497	-1.347	-
QWATT	kg	0.7781	2.192	-
QFILL	kg	0.1324	0.678	-

[1] VFEED = value of feed per area; VSEED = value of seed per area; VFERT = value of fertilizer per area; VCHEM = value of chemical per area (during cultivation); QLIME = amount of lime per area; QTEAS = amount of teaseed cake per area; QWATT = amount of chemical used for water treatment; QFILL = amount of chemical used during pond preparation.

Bangladesh Carp

From a total of 626 observations, only 74 observations were used in this statistical analysis. The remaining observations were deleted, due to the absence of important variables, such as harvested area, production, feed and seed. Variable definition for this Bangladesh case is the same as for the Indian case. The results of the estimated value of marginal products are reported in Table 10.

VFEED, VSEED, VFERT and VCHEM have positive signs as expected, although the t-scores on VFEED and VFERT are not statistically significant. Their VMP_{cixi} and VMP_{cjxj} vary from 1.5953, in the case of VFEED, to 17.2305, in the case of VCHEM. This outcome, together with the quality of data, suggests that the results presented in Table 10 may be unreliable and that more effort should be devoted to improving the quality of data collection.

Table 10. Estimated Value of Marginal Product with respect to each input for Bangladesh carp (number of observations = 74) (source: estimated by author and NACA (1996) survey data).

Variable[1]	Unit	VMP	T-test	Economic Value
Constant	-	8853.99	0.793	-
VFEED	Rupee	1.5953	1.257	0.257
VSEED	Rupee	3.8933	2.373	2.8933
VFERT	Rupee	6.2587	1.498	5.2587
VCHEM	Rupee	17.2305	3.057	16.2305
QLIME	kg	-02.4519	-2.781	-
QWATT	kg	-1.2460	-0.092	-
QFILL	kg	8.2888	2.274	-

[1]VFEED = value of feed per area; VSEED = value of seed per area; VFERT = value of fertilizer per area; VCHEM = value of chemical per area (during cultivation); QLIME is amount of lime per area; QTEAS = amount of teaseed cake per area; QWATT = amount of chemical used for water treatment; QFILL = amount of chemical used during pond preparation.

AREA STUDIES: SRI LANKA SHRIMP FARMING

Shrimp culture in Sri Lanka did not begin until the early 1980s. Having recognised the availability of coastal resources (unpolluted brackish water and unused coastal areas), the Government of Sri Lanka began stimulating private-sector involvement in shrimp culture through investment incentive packages, such as exemption from import taxes on machinery and income tax holiday. During the 1980s, shrimp farming expanded at a moderate rate, with a total of only 60 farms in operation covering an area of around 400 ha. Shrimp farming took off in the 1990s, the total number of farms growing to 960 by 1996. Out of the 960 farms in operation, as many as 589 were unauthorised. The total farm area in 1996 was 2,400 ha, of which 1600 ha were shrimp ponds (Siriwardena 1998).

Social and Economic Value of Shrimp in Sri Lanka

Shrimp culture benefits the Sri Lankan economy mainly through foreign exchange earnings. In addition, it contributes through linkages with downstream industries, employment generation and income distribution. Table 11 shows that the quantity of shrimp exported rose three-fold from 1992 to 1996. The total export volume in 1996 was 3,555 mt, of which about 90% was derived from cultured shrimp. In terms of export earnings, the total export value rose from 613 million Rupees in 1992 to 2,365 million Rupees in 1996. The expansion in shrimp aquaculture has exceeded that for other fishery products. This is seen from the increase in the contribution of shrimp export earning to the total fishery export, which rose from 42.3% in 1992 to 51.6% in 1996. Furthermore, shrimp culture also expanded at a faster rate as compared to the average growth rate of all other exports from Sri Lanka. The contribution of shrimp exports to the total export value rose from 0.6% in 1992 to 1.0% in 1996.

Table 11. Shrimp export data for Sri Lanka, 1992-1996.

Year	Quantity Export[1] (mt)	Value of Export[2] (Million Rs)	Percentage to Total Fishery Export Value	Percentage to Total Export Value
1992	1,246	613	42.3	0.6
1993	1,426	808	33.9	0.6
1994	2,301	1,650	45.1	1.0
1995	2,781	2,153	53.0	1.1
1996	3,555	2,365	51.6	1.0

[1] Source: Customs statistics.
[2] Source: Central Bank of Sri Lanka.

Major inputs into shrimp farming that have to be imported include feed, aerators, water pumps and electrical generators. Tables 12 and 13 show the value of these imports during 1992-96. In 1996, the value of feed imports into Sri Lanka for use in shrimp farming was 460.70 million Rupees. From 1992 to 1996, these feed imports totalled 1,352.92 million Rupees. This amount constitutes about 73% of the total value of material imported for shrimp farming. Other imported items account for the remaining 27% (see Table 13).

Table 12. Import of feed used in shrimp production in Sri Lanka, 1992-1996 (source: Siriwardena 1998).

Year	Quantity of Feed Import (mt)	Value of Feed Import (million Rs)
1992	2,018	121.11
1993	2,310	150.11
1994	3,728	261.00
1995	4,505	360.00
1996	5,760	460.70

Considering the total export value from the shrimp sector from 1992 to 1996 of 7,589 million Rupees (not taking into account economic discounting), together with the total import volume during the same period of 1,855 million Rupees, shrimp culture brought a net foreign exchange earning of 5,734 million Rupees into the country over this period.

Table 13. Import of feed and equipment used in shrimp farming from 1992-1996 (source: Siriwardena 1998).

Imports	Value (million Rs)	% Total Imports for Sector
Feed	1,352.92	72.9
Paddle wheel aerators	320.00	17.2
Pumps & generators	40.00	2.2
Other	142.00	7.6
Total	1,854.92	100.0

In addition, shrimp culture in Sri Lanka generates both direct and indirect employment. Siriwardena (1998) reports that direct employment in the shrimp sector is approximately 20,000 jobs. Another 20,000 indirect employment opportunities are also reported in supporting industries and part-time labour, such as work in construction of ponds and other infrastructure facilities on shrimp farms. The shrimp culture industry pays about 984 million Rupees in wages and salaries annually for direct employment. The total direct and indirect employment accounts for about 11% of the total employment in the fishery sector of Sri Lanka.

Having recognised that shrimp farming is an important foreign exchange earner, the Board of Investment (BOI) of Sri Lanka has granted a tax holiday package for licensed shrimp farms as a means to encourage exports. BOI privileges include: 1) a five-year full exemption on income tax, 2) a concessionaire tax period at 15% for another 15 years after full income tax exemption, 3) exemption from import duties on imported farm machinery, 4) exemption from turnover tax on sales, 5) exchange control exemption and 6) concessionaire tax for expatriates at 15% for five years. These privileges benefit mainly the large shrimp farms and shrimp processing factories with licenses. In 1998, there were about 65 licensed shrimp farms. Small farms without licenses were not entitled to these benefits.

Besides the direct economic impacts discussed above, the shrimp sector also generates social and environmental impacts on the community. The co-existence of large-scale and small-scale farms has led to conflicts in resource utilisation, such as access to land and to water from canals. During the last decade, suitable shrimp land was leased to large-scale or “licensed farmers,” while small-scale farmers were labelled as “intruders.” Conflicts often occur when both types of farmers’ extract and release water from the same water source, as this increases the likelihood of spreading disease. There are also conflicts between shrimp farmers and other farmers, as the salt water used in shrimp ponds may damage agricultural areas and grazing lands used for traditional animal husbandry. Hatcheries and farms which extend their water intake pipes into the sea to obtain sea water also create conflicts with coastal fisherman who operate their vessels in the area.

Clearing of mangroves for shrimp ponds has also had a great impact on local environments. For instance, reduction in nursery grounds for juvenile fish, loss of storm protection function, and loss of fuel wood supply have been outcomes of the expansion of shrimp ponds into mangrove areas. Lastly, many shrimp-farm owners extract groundwater to control the salinity level in their ponds. This practise could lead to reduced groundwater levels that could affect other water users in the vicinity.

Economic Assessment of the Sri Lanka Shrimp Sector at the National Level

Shrimp disease outbreaks took place in Sri Lanka during the second half of 1996. While some economic impacts were felt towards the end of 1996, most of the impacts were carried on to the 1997 crop. Table 14 shows the potential and actual shrimp outputs in Sri Lanka during 1995-97. Based on a postlarval capacity of 598 mt in 1995 and 849 mt in 1996 and 1997, the potential shrimp export volumes in 1995, and 1996 and 1997, were 2,781.00 and 3,948.28 mt, respectively. However, due to the disease outbreaks that occurred towards the second half of 1996, the actual shrimp export volumes in 1996 and 1997 were 3,155 and 1,228 mt, respectively. This translated into a production loss of 793.28 mt in 1996 and as much as 2,720.28 mt in 1997. Based on the average selling prices of shrimp exports in 1996 and 1997, this reduction led to a reduction in the value of exports of 594.64 million Rupees in 1996 and as much as 2,006.94 million Rupees in 1997.

Table 14. Shrimp production and exports for Sri Lanka, 1995-1999.

	1995	1996	1997
Total projects[1]	373	410	419
Total pond area (acre)[1]	4,452	4,698	4,814
Number of hatcheries[1]	32	49	49
Potential production capacity of postlarvae (mt)[1]	598	849	849
Potential value of postlarvae (million Rs)	448.5	636.8	636.8
Potential export volume (mt)	2,781.00	3,948.28	3,948.28
Potential export value (million Rs)	2,153.00	2,959.64	2912.98
Actual export volume (mt)[1]	2,781	3,155	1,228
Actual export value (million Rs)[1]	2,153	2,365	906
Average export price of shrimp products (Rs/kg)	774.18	749.60	737.78
Total loss in terms of export volume (mt)	0.00	793.28	2,720.28
Total loss in terms of export value (million Rs)	0.00	594.64	2,006.98

[1] Source: Ministry of Fisheries and Aquatic Resource Development (MOFARD).

Based on the total loss of 2,601.62 million Rupees, or US$43.36 million, Table 15 shows the breakdown of this economic loss by sector. The three sectors considered are the shrimp-processing sector, the shrimp-farming sector and the hatchery sector. The breakdown of the total economic loss in 1996 and 1997 is based on the price of shrimp sold at each stage. These are the price of postlarvae sold to shrimp farms, the price of fresh shrimp sold as inputs to shrimp processors, and the export price of processed shrimp. For instance, if a shrimp processor received, on average, US$12/kg of processed shrimp being exported, and the price paid for fresh shrimp from the farmers was US$9/kg, then processing adds US$3/kg to the value of shrimp. In other words, this US$3/kg represents the value added by the processing industry. This value added encompasses returns to the processing owners, wages of the workers, interest income and returns to capital, and the opportunity cost of land used during shrimp processing. As a result of disease outbreaks, this US$3/kg becomes an economic loss faced by all the stakeholders of the processing sector. A similar argument is used to calculate the breakdown for the shrimp-farming sector and the hatchery sector.

Table 15 shows that out of the total economic loss of 2006.98 million Rupees in 1997, about 25% were felt by the processing sector, 69% was absorbed by the farming sector and only 6% were shared by the hatchery sector. The farming sector absorbs most of the impact of disease outbreaks, as most of the value added by shrimp farming is located in this sector. A similar picture is also seen in 1996, when 33% of the impact was felt by the processing sector, 62% by the farming sector and the remaining 5% by the hatcheries.

Table 15. Economic loss of shrimp farming due to disease measured as reduction in exports (US$ 1 = Rs 60) (calculated by author based on Table 14).

Sector	Million Rs		Million US$	
	1996	**1997**	**1996**	**1997**
Loss in terms of reduction in total export value	594.64 (100%)	2006.98 (100%)	9.91 (100%)	33.45 (100%)
Loss shared by shrimp processing industry	197.50 (33%)	510.76 (25%)	3.30 (33%)	8.51 (25%)
Loss shared by shrimp farmers	366.76 (62%)	1,394.24 (69%)	6.11 (62%)	23.24 (69%)
Loss shared by shrimp hatcheries	29.74 (5%)	102.00 (6%)	0.50 (5%)	1.70 (6%)

In summary, the disease outbreak that took place in Sri Lanka in the second half of 1996 cost the country a total of about 2,601.62 million Rs (US$43.36 million) in terms of decline in export value. Due to the lack of data on feed imports, this study cannot calculate the net loss in terms of foreign exchange earnings resulting from this disease outbreak.

Economic Assessment of the Sri Lanka Shrimp Sector at the Local Level

Besides the reduction in export income, the disease outbreak that took place in Sri Lanka towards the second half of 1996 also caused a liquidity problem among farm operators. Many shrimp farms and shrimp processing factories could not make bank payments on their loans. This led lenders, especially the commercial banks such as the Development Finance Corporation of Ceylon (DFCC), to come up with a loan rescheduling programme for shrimp farmers. This loan rescheduling programme includes 1) differed instalments up to 15 months, 2) a rescheduled loan repayment for another five years at, 3) an interest rate reduction by 5% and 4) capitalisation of accumulated interest payments. This programme was extended to about 125 bank borrowers, and it constitutes another type of cost Sri Lanka had to face as a result of shrimp disease outbreaks.

This study conducted a survey in Sri Lanka during April 1998 to examine the extent of economic loss at the farm level. An interview survey was carried out with government officials and farm owners in Chilaw in the North Western Provinces. The following reports how shrimp disease outbreaks affected farmers in the Chilaw area.

The interview with government officials at the North Western Provincial Council (NWPC) showed that the disease outbreak that took place in the second half of 1996 had severely affected shrimp farms in this area. This disease outbreak affected two crops: the second crop of 1996 and the first crop of 1997. From the provincial statistics, it was shown that about 4,600 acres of land in the province were used as shrimp ponds, from which 15,000 mt of shrimp were produced in 1995. In 1996, the provincial statistics show that the disease outbreak had led to about 60% reduction (of 1995 output level) in farm output and another 80% reduction (of 1995 output level) in 1997.

As a consequence of this disease outbreak, many farmers had to forego two additional crops after the disease outbreak. This loss of potential economic gains from abandoning the farms for two crops also represented an additional economic loss to the local economy as income that would have been generated.

In addition to the above losses, the local farmers and the government made some investment towards disease control. Through the Dutch Canal User Group, some shrimp farmers contributed labour in cleaning the canal, and the local government made some small financial contribution. Statistics on the amount of this investment were not available, but officials from the NWPC revealed that the investment was small.

In addition to interviewing government officials, visits were made to some shrimp farms, processing factories and hatcheries in Chilaw. Information on economic losses resulting from shrimp disease outbreaks was obtained through personal interviews. The following provides some baseline information on how this disease outbreak affected the farmers in Chilaw.

- The Wanigana Farm operates on 20 ha of land, of which 4 ha were used as shrimp ponds. During the 1996 second crop, the farm invested about 10 million Rupees in variable costs, such as feed, seed, labour, electricity and other inputs. The revenue they expected was 20 million Rupees, but due to the disease outbreak, they only received 10 million Rupees in revenue. Hence, the disease outbreak led to a 100% loss of profit of about 10 million Rupees. In the following period, the farm also had to forego another profit loss of 10 million Rupees, as they had to abandon shrimp for another crop following the disease. In addition, during the time when shrimp ponds were put to rest for one crop cycle, labour was hired to work around the farm and bank loan interest had to be paid. These additional costs totalled about 1 million Rupees. In sum, this disease outbreak reduced the financial returns to this farm by about 21 million Rupees.

- The Seafood Exporter Consortium (SECO) is a privately owned shrimp-processing factory that generally produces about 177 mt of processed/frozen shrimp for export markets. The disease outbreak led to a reduction in profit of 35 million Rupees. Following this loss in 1996, SECO also had to forego production in the first part of 1997, and hence, all the expected profit was lost. In addition, as the company complied with trade union regulations, they had to maintain their staff for another six months. During this time, a full salary was paid to all 180 workers.

- A small farm operating on a three-hectare plot was cultivating three shrimp ponds (total pond area of 1.5 ha) during 1996. This small farmer hired four workers and experienced disease towards the second half of 1996. The disease affected their farm about two to three weeks after stocking, and hence, zero revenue was obtained. This disease outbreak thus led to a loss in terms of foregone profit and costs incurred. The foregone profit was around 100% of the total operating costs of 400,000 Rupees. Therefore, this small farmer would have experienced a financial loss of about 800,000 Rupees resulting from the 1996 disease outbreak (400,000 Rupees in terms of foregone profit and another 400,000 Rupees in terms of input cost invested for this crop).

Thus, it is concluded that the disease outbreak in Sri Lanka affected the local farmers through 1) reduction in expected profits; 2) foregone benefit for another crop, as ponds were generally put to rest for one crop cycle; and 3) expenses for maintaining workers (union workers who are generally on large, licensed farms) when ponds were not stocking during the resting period. There were also benefits associated with the shrimp disease outbreak: 1) release of some workers to other economic activities, such as fishery, and 2) reduction in shrimp feed imports into the country.

Recommendation for Future Assessments and Application of the Model

Due to limited observations, this study could not apply the economic loss concept and the economic value of disease-control estimation procedure to Sri Lanka. In order to implement such economic methodology, a large data set is required. This data set should contain information on the breakdown of cost and revenue stream, information as to when the disease takes place, and the bio-physical characteristics of the farms. An example of a full questionnaire is given in Annex I for future research activities in Sri Lanka. This study recommends that the aquaculture authority in Sri Lanka should develop a consistent data collection mechanism. This database will be useful for assessing the impact of disease outbreaks and will help determine appropriate investment in disease control expenditures.

CONCLUSIONS

This study recognises the importance of quantifying the economic loss caused by aquatic animal disease. The magnitude of economic loss can be used as a guideline for determining optimal investment in aquatic animal disease control. The study shows that measuring economic loss by using the volume of dead animals multiplied by the market price tends to result in overestimation of the loss. Use of this method can result in an over-investment in aquatic animal disease control. A more accurate method is to measure the farmers' economic loss by examining the difference between the expected income when the animal is fully grown and the actual income realised, and the farmers' expenditure on disease control inputs. The empirical results show that the economic loss of the farmers decreases as cultivating time increases.

In examining the economic loss caused by aquatic animal disease at the national level, it is found that the processing and exporting industries are better able to protect themselves from losses than are the farmers. During disease outbreaks, these sectors took a smaller share of economic loss as compared to the farmers.

To investigate farmers' investment behaviour, this study developed a profit maximising model to examine how well shrimp farmers are able to cope with aquatic animal disease. The calculated Value of Marginal Products for applying aquatic disease control inputs showed that Thai farmers tend to invest rather optimally in this regard.

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Annex I

Questionnaire

<u>Section I</u> Farm data

1. Name of data collector : ....

2. Date of survey: Day .... Month .... Year 19..........

3. Location of farm: City...........................Country.....................

4. Year this farm began operation in 19........

5. Crop duration being interviewed:

   From Day .... Month .... Year 19 ....

   To Day .... Month .... Year 19..........

6. Total farm area of crop in Question (5) .... acre.

7. Total pond area of crop in Question (5) .... acre.

8. Number of ponds cultivated in crop in Question (5) ....

9. Treatment pond area used during crop in Question (5) ....acre.

10. Source of water supply:

   o 1. Sea water o 2. Channel/rivers
   o 3. Ground water o 4. Recycle from treatment pond

11. Water discharge/exchange:
   o 1. into channel o 2. into treatment pond

<u>Section II</u> Revenue from Crop in Question (5)

12. Expected harvest amount .... tons.

13. Actual amount harvested .... tons.

14. Expected number of cultivation days .... days.

15. Actual number of cultivation days........................... days.

16. Survival rate .... percent. [100*(13)/(12)]

16. Size of shrimp when harvested .... cm.

17. Price of shrimp when sold .... Rs/kg.

18. Total REVENUE (not profit) obtained .... Rs.

<u>Section III</u>: Costs of Shrimp Culturing During Crop in Question (5)

Type of Costs	Quantity	Market Price Today (Rs)	Costs (Rs) (Quantity*Price)
Fixed Costs			
19. Own land	acre		
20. Lease land	acre	/year	/year
21. Aerator	units		
22. Boat	units		
23. Motorcycle	units		
24. Vehicles	units		
25. Water pump	units		
26.Electricity generators	units		
27. Land grading	NA	NA	
28. Pipes	NA	NA	
Pond Preparation Costs			
29. Number of drying days	days	NA	NA
30. Lime	kg		
31. Chlorine	kg		
32. Fertiliser	kg		
33. BKC	kg		
34. Formalin	kg		
35. Others	NA	NA	
36. Total preparation costs	NA	NA	
Operating Costs			
37. Labour	workers		
38. Dry Feed	kg		
39. Seed	kg		
40. Fertiliser	kg		
41. Tea seed cake	kg		
42. Fuel	litres		
43. Wet feed	kg		
44. Lime	kg		
45. Chlorine	kg		
46. Medicine	NA	NA	
47. Vitamin	NA	NA	
48. Electricity	NA	NA	
49. Sludge cleaning	NA	NA	
50. Others	NA	NA	
51. Total Operating Costs	NA	NA	

<u>Section IV</u> : Disease During Crop in Question (5)

52. Did your farm experience disease during crop in Question (5)?

o 1. Yes o 2. No, then go to Section V Question (58)

53. If Yes, how many days after stocking did the disease occur? .... days.

54. Why type of disease did you experience?

o 1. White spot o 2. Yellow spot

o 3. others, please specify ....

55. How much did this disease cost you in terms of additional inputs required to cope with the disease?............................Rs.

56. At the beginning of crop, how much <u>PROFIT</u> did you expected from this crop (not counting initial fixed investment costs) .... Rs?

57. At end of this crop, how much <u>PROFIT</u> did you actually obtain ...……....¼¼....Rs?

<u>Section V</u> Farmer Bio-Data

58. Age of the farmer .... years.

59. Numbers of years practised shrimp farming .... years.

60. Type of training received:

o 1. Training from Govt. o 2. Learned from friends

o 3. Training by private companies (e.g., fertiliser company)

61. Education:

o 1. Primary o 2. Secondary o 3. Technical diploma

o 4. Bachelor o 5. Graduate studies o 6. No education

<u>Section VI</u> Quality of this Interview

62. What is the interviewer opinion about the quality of this interview?

o 1. Very Reliable o 2. Reliable o 3. Rather unreliable

********** END OF QUESTIONNAIRE **********

<u>QUESTIONNAIRE INSTRUCTIONS FOR THE INTERVIEWER</u>

Following are the definitions and clarification of some of the technical terms used in the questionnaire.

5. Crop duration being interviewed:
From Day .... Month .... Year 19 ....
To Day .... Month .... Year 19..........
You are required to ask the farmer about the situation of his/her farm only <u>DURING ONE PARTICULAR CROP</u>, and not the situation of his/her farm through out the year. This question directs you to the particular crop that you are asking. If you want to ask the farmer about the situation during other crops, you have to use more than one questionnaire. For instance, a farmer supplies information about the past three crops, then you will need three questionnaires to collect all the data - one questionnaire for each crop.

9. Treatment pond area <u>USED</u> during crop in Question (5) ....acre.
If the farmer practices extensive farming and discharges all the wastewater into the canal, put zero. This question applies mainly to large farms that practice water exchange or intensive farming. Make sure that the number you put in is the area of treatment ponds that were <u>USED</u> during that crop and <u>NOT</u> the total area of treatment pond the farmer <u>HAS</u> on his/her farm.

16. Size of shrimp when harvested .... cm.
If shrimp are sold at different age, then use the average size.

17. Price of shrimp when sold .... Rs/kg.
If shrimp are sold at different prices, then use average price.

Market Price (Rs)
This refers to the market price <u>DURING THE CROPPING PERIOD BEING INTERVIEWED</u>. For instance, a farmer bought an aerator for 10,000 Rs five years ago, but this aerator is <u>WORTH</u> only 4,000 during the cropping period being interviewed. In this case, you would put 4,000 Rs in the appropriate column, not 10,000 Rs. that he paid for five years ago.

Costs (Rs) (quantity * price)
You have to do some calculation along with the farmer to double check that the total cost of each input is approximately correct with the farmer's own calculation.

EXTENSION METHODOLOGIES FOR AQUATIC ANIMAL HEALTH MANAGEMENT IN RURAL POND CULTURE - LESSONS FROM BANGLADESH

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ABSTRACT

Bangladesh has a long history of rural, small-scale aquaculture, most of it carp culture, either traditional, improved traditional or polyculture, although other species are cultured in both monoculture and polyculture. Freshwater prawn farming, integrated with rice cultivation and certain fish species, is also practised. Disease problems are occasionally observed, and these are mainly attributed to poor husbandry. However, a serious outbreak of epizootic ulcerative syndrome (EUS) occurred in 1998, and viral infections of marine shrimp occurred in 1994 and 1996. These outbreaks served to highlight the importance of aquatic animal health management in Bangladesh. Intensification of traditional aquaculture systems, promoted by many extension projects, is considered to be the cause of many of the problems encountered. This paper describes ongoing aquaculture extension projects and the role of the government extension services in the provision of fish health management.

INTRODUCTION

In Bangladesh, homestead pond-fish culture is an age-old traditional practice of the rural people. Most rural fish farmers practice traditional, improved traditional or carp polyculture using major carps, common carp and Chinese carps. A variety of other species including silver barb, catfishes and tilapias are also used in polyculture and monoculture systems. Increasing numbers of relatively advanced and experienced farmers have adopted the semi-intensive culture systems introduced by various projects. Although the number of intensive pond-culture systems is small, a number of small-scale commercial farmers are now in business. Nowadays, freshwater prawn farming is well integrated with paddy production and the culture of certain fish species. Due to the low intensity of culture practices carried out by the majority of farmers in rural ponds, only occasional disease problems are observed, which are mainly attributed to poor husbandry.

There was a serious outbreak of epizootic ulcerative syndrome (EUS) in freshwater fish in 1988 and outbreaks of viral disease in 1994 and 1996 in the coastal shrimp farms, highlighting the importance of aquatic animal health management in the country. Intensification of culture systems, involving such practices as increased stocking rates, increased feeding and fertilisation programmes, which sometimes result in nutrient accumulation, algal blooms, dissolved oxygen deficiency and other water quality problems, caused disease problems in ponds in rural areas (Kumar 1992). As a result of degraded water quality and environmental problems in rural pond culture, occurrences of infectious disease are encountered, and their prevention and control are considered by the aquaculture extension services to be important.

PROJECT-BASED AQUACULTURE EXTENSION APPROACHES

In Bangladesh during the ten years from 1987 to 1997, total fish production increased from 0.83 million mt to 1.3 million mt, while aquaculture production increased from 176,000 to 432,000 mt, which was mainly due to the impact of project-based aquaculture development and extension services in the rural areas. In Bangladesh, there are over 1.3 million ponds, covering an estimated area of 0.147 million ha, some 6,000 ha of ox-bow lakes and 0.5 to 0.7 million ha of non-conventional, semi-closed and seasonal waters in the form of roadside ditches, borrow pits and irrigation canals. There are also 0.114 million ha of natural depressions and 0.143 million ha of coastal polders suitable for aquaculture. A programme has been undertaken to bring perennial and seasonal water bodies under the aquaculture extension programme during the current Fifth Five Year Plan (1997-2002), in order to increase the present total production of fish from 432,000 to 628,000 mt.

The extension service of the Department of Fisheries (DOF) has been weak since its inception. In 1983, the department was reorganised, creating one professional Thana Fisheries Officer and two technical support staff in each thana[1], providing fish-culture extension services throughout the country. A large number of foreign-funded aquaculture development and extension projects were implemented by the DOF during the last ten years. Aquaculture infrastructure facilities, fish and shrimp hatcheries, fish seed multiplication farms, training and demonstration farms and aquaculture training centres were developed in the public sector through these projects. Infrastructure developed through these extension projects is presently used to provide extension support services to the rural fish farmers. Different donor-aided aquaculture development projects have been implemented with strong fish-culture extension components, with different approaches and methodologies, and for different target groups of farmers. Aquaculture extension programmes may be categorised by taking into consideration pond-fish culture technology packages, the target group of farmers, fish-culture training demonstration and awareness methods, demonstration farm operating cost sharing, cost effectiveness and replicability. The important project-based extension approaches and methods are as follows:

Second Aquaculture Development Project

The Asian Development Bank (ADB)-assisted Second Aquaculture Development Project focused on semi-intensive carp polyculture in 21 districts of the country for all categories of farmers (Bhuiyan *et al.* 1996). The staff of the DOF, working in the selected districts and thanas, was trained to organise demonstrations of improved fish-culture techniques. The extension teams worked with the farmers to implement improved pond management, following the principles of good fish husbandry. The project provided production inputs to the participating fish farmers in exchange for their agreement to follow the improved pond production strategy and to allow neighbouring farmers to visit and observe improved farming activities; the cost of inputs was recovered during harvest. There was a programme for provision of credit

[1]A thana is an administrative unit equivalent to a sub-district.

to commercial fish farmers; however, the disbursement and recovery rate of the credit scheme was not satisfactory. The cost of extension services was high in respect to their sustainability. As the government could not provide a budget after completion of the development activities, the extension activities of the project were discontinued.

Mymensingh Aquaculture Extension Project (MAEP)

The Danish International Development Agency (DANIDA)-assisted Mymensingh Aquaculture Extension Project has developed individual farmer training through intensive supervision suitable for poor rural fish farmers. Poor fish farmers in the project area have been organised and trained by project personnel (MAEP 1996). A micro-credit scheme has been introduced in co-operation with a commercial bank and a non-governmental organisation (NGO) in the project area. The experience of this project was extended in adjacent districts and replicated in greater Noakhali and Potuakhali districts, with some modification of extension approaches (i.e., individual farmer training to group training approach). The cost of this intensive extension approach appeared to be very high in respect to its sustainability, and the government was unable to provide budget for continuation after its completion.

North-West Fisheries Extension Project

The Department for International Development (DFID)-assisted North-West Fisheries Extension Project was formulated to develop a fish hatchery and training centre at Parbatipur during its first phase. During the second phase, the project provided training and extension services to fish farmers of the greater districts of Dinajpur and Rangpur through the extension personnel of the DOF and a local NGO micro-credit programme, using model-village extension approaches (Islam and Faruk 1996). Extension personnel identified villages with fish culture potential and organised interested fish farmers into groups. The project provided technical services for fish culture, and the NGOs provided the required operational funding for pond-culture inputs. This extension approach seems to be successful, and costs were moderate in respect to its sustainability. This approach will be replicated in 200 thanas under the International Development Assistance (IDA)-assisted Fourth Fisheries Project.

Ongoing Aquaculture Extension Projects

During the Fifth Five Year Plan (1997-2002), 23 Aquaculture Development and Extension Projects have been undertaken. In most of the projects, aquaculture training and extension are considered as major activities. A list of aquaculture extension projects with investment cost, location, number of farmers, expected output and source of funding, is shown in Table 1. The bilateral donor-assisted projects funded by DANIDA and DFID focused on food security, poverty alleviation and income generating activities of rural farmers, whereas, multinational donor (IDA, International Fund for Agricultural Development (IFAD))-assisted projects are mainly for infrastructural/institutional development to increase overall fish production. The Government of Bangladesh (GOB)-funded projects focused on appropriate aquaculture technology and cost effectiveness for all categories of rural fish farmers. It is estimated that nearly 500,000 farmers in rural areas are being provided with technical assistance and extension services, and incidental to this support, about 300,000 mt of fish will be produced by the farmers.

Table 1. On-going aquaculture extension projects (source: Department of Fisheries).

Name of Project	Cost (Million Taka)[1]	Period	Location	No. of Farmers	Production Output
Foreign-aided Projects					
Mymensingh Aquaculture Extension Project (DANIDA)	365.70	1993-2000	7 Districts 26 Thana	25,000	30,000 mt fish
Patuakhali Aquaculture Extension Project (DANIDA)	242.34	1993-2000	2 Districts 11 Thana	12,000	10,000 mt fish
Noakhali Aquaculture Extension Project (DANIDA)	378.00	1993-2000	3 Districts 14 Thana	25,000	10,000 mt fish
North-West Aquaculture Extension Project (DFID)	212.30	1995-2000	8 Districts 58 Thana	60,000	15,000 mt fish
Fisheries Training and Extension Project (DFID/GOB)	245.86	1997-2002	13 Districts	4,100	Technical assistance
GOB-funded Projects:					
Thana Level Aquaculture Extension Project	71.20	1994-2000	59 Districts 400 Thana	79,200	31,680 mt fish
Freshwater Prawn Hatchery Development and Extension	50.00	1998-2003	20 Districts	3,000	10.2 M PL 400 mt
Coastal Shrimp Hatchery Development and Extension	75.00	1998-2003	4 Districts 21 Thana	10,000	2,000 M PL 20,000 mt
Aquaculture Entrepreneur Development	147.40	1997-2002	Country Wide	18,400	75,000 mt fish
Poverty Alleviation Through Fish Culture	256.46	1998-2003	Country Wide	27,760	4,560 mt fish

[1] 1 US $ = 49.75 Taka.

SUSTAINABLE RURAL AQUACULTURE EXTENSION SERVICES

Rural Pond-fish Culture Extension

The technical assistance projects Institutional Strengthening in the Fisheries Sector (UNDP/FAO/BGD/87/045) and Strengthening of Rural Pond Fish Culture Extension Service (FAO/TCP/BGD/4451/T) developed an appropriate aquaculture extension service for all categories of small-scale rural fish farmers called the "Trickle Down Aquaculture Extension Approach." The ideology of this approach was the development of self-reliance and awareness in the minds of fish farmers by repeated training, demonstration, and close supervision by field-level extension personnel. This system of extension activity provided farmer-to-farmer extension through small groups, each consisting of one result demonstrator fish farmer and five fellow fish farmers. Farmers with access to ponds and ability to invest operating costs for fish culture were the target group of these projects. This programme did not require cash or input assistance for the farmers. It was observed that farmer-to-farmer extension services in a small group had many advantages for sustainability.

The resulting demonstrator fish farmers under the two technical assistance projects achieved an average production of 3,539 kg/ha and 4,105 kg/ha, respectively.

Thana Level Aquaculture Extension Services

In light of the experience of the UNDP/FAO/BGD/87/045 and FAO/TCP/BGD/4451/T projects, the "Thana Level Aquaculture Extension Services," which covers 400 thanas in 59 districts, was formulated with government funding. An annual work plan and implementation matrix have been drawn up, with six groups consisting of a total of 36 fish farmers (one result demonstrator and five fellow farmers) during the first three years (1995-96 to 1997-98), and nine groups consisting of a total of 54 fish farmers during the last two years (1997-98 to 1999-2000). Implementation over this period in each thana will result in the training of 79,200 rural fish farmers in improved methods of fish culture. This project will create an opportunity to enhance average annual fish production at the rate of 3.5 mt/ha in the ponds of result demonstrators and 2.5 mt/ha in the ponds of fellow farmers groups. At the end of the project period, total fish production enhancement would be 31,780 mt. In addition, 79,200 trained farmers will have part or full-time job opportunities as a result of project extension activities. Analysis of fish production data for the last three years of the project (1995-96 to 1997-98) indicates that an average production of 3,070 kg/ha has been achieved by the result demonstrator fish farmers, and 2,342 kg/ha has been achieved by the fellow fish farmers during 1997-98 (Table 2). It was observed that the result demonstrator and fellow fish farmers achieved 78% and 86% of the targeted fish production, respectively (Islam and Moniruzzaman 1999). The essence of the project is that its benefits will not stop at the end of the project. Fish-culture extension services will continue as a regular activity of the DOF. By this means, all ponds in each thana will be utilised for fish culture using improved and appropriate technologies. An extension channel to send any useful aquaculture package to the field has already been established using this network of contact farmers (result demonstrator fish farmers and fellow fish farmers).

Table. 2. Fish production of farmers under the Thana Level Aquaculture Extension Project.

Year	Result Demonstrators				Fellow Farmers		
	Pre-project Production (kg/ha)	No. of Farmers	Pond Area (ha)	Production (kg/ha)	No. of Farmers	Pond Area (ha)	Production (kg/ha)
1995-96	924	1,742	506	2,332	8,528	1,526	1,815
1996-97	1,067	1,582	555	2,833	8,361	1,519	2,351
1997-98	1,173	1,890	519	3,070	8,454	1,525	2,342

Aquaculture Technology Packages

Several aquaculture technology packages have been developed and employed in rural pond culture through different extension approaches, although not all of them have faired equally well. The culture systems include: a) carp polyculture, b) raising fry and fingerlings of carps, c) freshwater prawn with carp polyculture, d) integrated fish cum duck/chicken farming, e) integrated rice cum fish farming, f) culture of silver barb, g) culture of pungas, and h) culture of tilapias. Among these technology packages, carp polyculture is considered the most appropriate technology for extension to small-scale rural pond culture (Islam and Moniruzzaman 1999).

FISH HEALTH MANAGEMENT THROUGH EXTENSION SERVICES

Under different projects, various aquaculture intensification approaches, such as increased stocking rates, and increased feeding and fertilisation programmes, have sometimes resulted in nutrient accumulation, frequent appearance of algal blooms, dissolved oxygen deficiency and other water quality problems in undrainable ponds, causing occasional disease outbreaks. Consequent to this, risk prevention and control of diseases are considered important by the aquaculture extension services of the country. Providing a fish disease diagnosis and treatment service is difficult with the existing extension set up of the DOF and with the limited husbandry knowledge of rural fish farmers. Aquaculture extension implementation manuals, pond-fish culture manuals, fish health management manuals and water analysis kits have been supplied to all the extension personnel of the DOF. Farmers have also been trained to use these manuals and kits.

General Causes of Fish Health Hazards

The extension project identified the following general hazards to fish health in rural pond culture:

- Degradation of water quality of ponds due to poor pond management.
- Overstocking of fingerlings in unprepared and poorly prepared ponds.
- Stocking of stressed and unhealthy fingerlings.
- Overuse of fertilisers, manures and feed in pond culture.
- Introduction of floodwater with a high concentration of suspended solids, causing high turbidity.
- Accumulation of toxic gases due to decomposition of organic matter in the thick bottom sediments of old/derelict ponds.
- Transfer of fish pathogens through water, carrier birds, aquatic animals and insects.

Fish Health Hazard Preventive Measures

The extension project identified the following preventive measures for fish disease in rural pond-culture systems (BAFRU 1996, Islam and Moniruzzaman 1998):

Pre-stocking measures

- Maintain the desired level of water quality parameters for pond-fish culture.
- Eradicate or control aquatic weeds, predator fish and insects.
- Control overgrowing of undesired bushes and branched trees on the pond embankment that are overshadowing the pond, in order to ensure maximum light fall.
- Remove decomposed organic matter and accumulated thick bottom sediments from old or derelict ponds.
- Dry ponds every 3-5 years.
- Apply the correct dose of lime in preparation for stocking the pond.
- Apply the correct dose of organic manure and inorganic fertiliser during pond preparation and post-stocking pond management.

Stocking measures

- Select apparently healthy and vigorous fingerlings, and transport them in well-oxygenated water, preferably in an oxygen-filled closed system, to reduce stress.
- Disinfect fingerlings before stocking by giving a dip treatment in 1-2% common salt solution.
- Acclimatise fingerlings to the pond-water environment during stocking.
- Ensure proper stocking densities and species composition.

Post-stocking measures

- Periodically remove toxic gases by manually pulling a dredge across the pond bottom.
- Periodically check fish growth and health condition by sampling, and release the fish back into the pond following a dip in potassium permanganate or salt solution.
- Disinfect nets, containers and other equipment used in pond culture.
- Control potential pathogen carriers i.e., birds, aquatic animals and insects.
- Periodically monitor water quality for dissolved oxygen deficiency, algal bloom and accumulation of toxic gases.
- Periodically monitor the natural food availability in the pond.

Recommended Physico-chemical Conditions of Pond Water

All extension officers are provided with water analysis kits and pond fish culture equipment to provide farmers with technical support to analyse the physico-chemical conditions of pond water (Kumar 1992). The optimum parameters are given in Table 3.

Table 3. Optimum levels for physic-chemical parameters in pond water (from Kumar 1992).

Parameter	Optimal Level
Temperature	25 to 35 °C
Colour	Green-brown
Transparency	25-50 cm
Turbidity	< 300 ppm
Plankton	> 25 mL/m^3
Dissolved oxygen	5-7 ppm
Free carbon dioxide	< 12 ppm
Ammonia	< 0.025 ppm
Nitrite (NO_2)	< 0.1 ppm
Hydrogen sulphide (H_2S)	< 0.002 ppm
pH	7-9
Alkalinity	40-200 ppm
Inorganic nitrogen	> 0.2 ppm
Inorganic phosphorus	> 0.2 ppm

Among these parameters, turbidity, dissolved oxygen, pH and alkalinity are considered the most important.

Common Chemicals and Drugs for Fish Disease Control

Extension officers and their technical support staff have received training on basic diagnostic methods for the common fish diseases of rural pond culture, as well as on fundamental disease control measures (Chinabut *et al.* 1993, Ahmed and Kumar 1993). Common treatment methods are given in Table 4.

Table 4. Common treatment methods for aquatic animal diseases.

Chemical/Drug	Dose	Purpose
Lime	1-2 kg/decimal[1]	Disinfection of pond water & soil. Preventive measure for common fish diseases.
Bleaching powder	2-3 kg/decimal	Disinfection of pond water & soil. Preventive measure for common fish diseases.
Dipterex	0.25-0.50 ppm (prolonged bath)	Eradication of external parasites of fish (not for shrimp)
Malathion/ Sumithion	0.25-0.50 ppm (prolonged bath)	Eradication of copepods and other crustacean parasites of fish
Formalin	25-50 ppm (prolonged bath)	Eradication of external parasites of fish
Malachite green	0.15 ppm (prolonged bath) 2 ppm in water (30-60 min bath)	Eradication of fungi &, cysts of parasites of fish
Methylene blue	3 ppm (prolonged bath)	Eradication of bacteria & fungi
Potassium permanganate	4 ppm (prolonged bath) 10 ppm (30-60 min bath)	Eradication of external parasites & fungi
Sodium chloride	2.5% (for 20-30 min bath; repeat in 48 hr) 0.55% (48 hr bath) 1% (60 min bath) 4% (2 min bath)	Eradication of bacteria & external parasites of fish
Copper sulphate	0.50-1 ppm (quick bath)	Eradication of bacteria, fungi & external parasites of fish

[1] 1 decimal=40 m^2.

Some chemicals are applicable for dip or bath treatment, while others are applicable for pond treatment. However, due to cost considerations, dose calculation and also, method of application, only limited measures can be taken up by small-scale farmers. Among these treatment measures, liming, dipterex, malathion/sumithion, potassium permanganate and sodium chloride treatment are most important.

FISH HEALTH MANAGEMENT-PROBLEMS AND RECOMMENDATIONS

Problems and Constraints

A number of diverse and complex problems confront aquaculture extension services directed towards fish health management in rural pond culture. Some of these are listed below:

- Lack of information on aquatic animal husbandry problems and fish disease outbreaks in different aquaculture systems of the country.

- Weak institutional capabilities of aquaculture extension services in relation to specific problems of health management.

- Lack of understanding on the part of rural fish farmers of the basic principles of aquatic animal husbandry, and prevention and control of fish disease outbreaks.

- Lack of experienced extension personnel in the DOF on aquatic pathobiology, disease control measures etc. to provide extension and technical services for the aquatic animal health management programme.

- Lack of facilities for fish disease diagnosis at the field level of the DOF, and limited access to modern disease diagnostic facilities at the DOF's regional Aquaculture Training Centres.

- Lack of co-ordination between fish farmers, extension workers and researchers for fish health management.

- Lack of fish-culture extension policy and strategy for aquatic animal health management measures to cope with future increases in aquaculture production through intensified culture systems.

Issues and Recommendations

- ***Policy and strategy for aquaculture extension methodology**:* The government should develop and periodically review the aquaculture extension policy and strategy. This policy should include the goals, objectives, activities and programmes for aquaculture extension in general, and for aquatic animal health management measures specifically.

- ***Extension approaches, programmes and methods**:* An overall extension strategy should be developed and implemented by evaluating the existing extension projects and selecting appropriate programmes and methods.

- ***Human resources development**:* The technical capacity of aquaculture extension should be strengthened by developing, at the field level, an aquaculture extension service cadre consisting of well-trained and experienced extension personnel who can communicate technological messages relating to fish health management that are appropriate for the primary target group of rural fish farmers.

- ***Impact and effectiveness of extension**:* Aquaculture extension systems should be strongly encouraged to establish and use monitoring procedures and evaluation studies, both to improve extension performance and to communicate the results of extension programmes to policy makers. This would help sharpen extension objectives, improve system performance and increase programme impact.

- ***Financial support to extension activities**:* Public extension services are an essential national investment that will generate significant financial and economic return by increasing productivity through vertical and horizontal expansion of aquaculture systems. Aquaculture extension services should have a separate revenue budget line, and the national aquaculture extension system should ensure effective use of public money.

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MAKING HEALTH MANAGEMENT RELEVANT IN THE CONTEXT OF RURAL AQUACULTURE DEVELOPMENT: LESSONS FROM THE CARE LIFE PROJECT

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ABSTRACT

The CARE project, Locally Intensified Farming Enterprises (LIFE), is examining the potential for farmer participatory research to provide solutions to problems confronted by the farmers. Currently, the project is operating in two districts, Kishoreganj and Rajashahi, which are located in northern Bangladesh. In each project village, the farmers are grouped into participatory action research groups (PARG). These groups are provided with support to improve their knowledge in order to research the problems that they have identified, using resources that they can easily access. Most of the farmers involved in pond-fish culture have identified epizootic ulcerative syndrome (EUS) as the major problem encountered during the winter season. A number of farmers have carried out research to solve this problem using materials such as lime, ash, salt and a combination of lime and salt. Application of these materials not only reduced the prevalence and intensity of disease, but also in some cases, infected fishes recovered from the disease. In addition, farmers felt that the growth and appearance of fish improved in ponds treated with these substances. Farmers were most happy with the results obtained from the application of ash, since this resource was easily available in the villages as a non-purchased input. The results indicate that the participatory research process is helpful in finding solutions that are appropriate to farmers.

INTRODUCTION

With the increasing population and consequent decrease in available land, food security is a major concern in Bangladesh. The average family size is around six, and the average land holding of families is less than 1.5 acre. The Locally Intensified Farming Enterprises (LIFE) Project, initiated by the Agricultural and Natural Resources Sector of CARE Bangladesh, has the primary objective of increasing productivity from this limited land resource, on a sustainable basis, through farmer participatory research. The project looks at problems encountered by farmers in different areas of agriculture including fisheries but excluding animal husbandry. As fish is the most important component of the diet, the project has placed special emphasis on increasing fish production from existing ponds, in addition to encouraging farmers to undertake rice-fish cultivation. The project encourages farmers to undertake research on the problems that they encounter, and to use the resources that are easily available to them to generate farmer/farm-specific information to address the problems.

MATERIALS AND METHODS

Formation of Participatory Action Research Groups

The project employs participatory experiential learning as a tool to create interest among farmers and, through analysis, identify production constraints. Since the project does not provide credit or any incentives other than knowledge transfer, an elaborate process is adopted to identify farmers who are interested in solving problems that they encounter using their own resources. As a first step in this process, project objectives and working principles are presented to the farmers at a general meeting in the village, and those farmers interested in taking part in such a process are invited to join the group. The target of the project is to serve those farmers in the community who are affected by food insecurity. Generally, in the selected village, a maximum of 30 farmers who meet the selection criteria of the project are invited to form the participatory action research group (PARG). The criteria are: possession of less than two acres of land; food insecurity, and interest in working with the project using the resources available to them. These farmers elect leaders through a participatory process and set their own norms to ensure proper functioning of the groups. Separate female and male groups are formed, and at present, one female staff member manages three female groups and two male groups, while a male staff member manages three male groups and two female groups. The project works with each group of farmers for a period of one year. Each year, 120 groups of farmers graduate a total of more than 3000 farmers.

Participatory Needs Assessment

In the first learning session after formation of the group, participatory needs assessment (PNA) is carried out in order to understand the different problems encountered. Based on the problems encountered, different learning sessions and action research trials are formulated to address them.

During the PNA session, about 30% of the farmers were identified as having fishponds, and most of them identified ulcerative disease as one of the major problems during the winter season. During 1998, in the majority of the PARGs, ulcerative disease was identified as one of the major problems. Based on this finding, a learning session on epizootic ulcerative syndrome (EUS) was planned for those PARGs where it was recognised as a major issue. This learning session included information on the history of EUS, the causative agent, and alternative management techniques that have been used for this disease. In designing the learning session, extensive consultations were held with farmers to obtain their views on management of the disease, while researchers were consulted to obtain the latest information available on treatment procedures and how these could best be applied at the field level.

Action Research on EUS Prevention and Control

Farmers decided to experiment with lime, salt and a combination of lime and salt and ash, with the objective of preventing occurrence of the disease. Application of lime or salt at the rate of 1 kg/400 m^2 prior to the onset of the cold season had been suggested by the Department of Fisheries. Studies conducted by ICLARM in Bangladesh have also revealed that farmers who used lime had fewer occurrences of EUS when compared with others (Ahmed and Rab 1995). However, there is no information available on the frequency of application of these chemicals. Therefore, it was decided to apply an initial dose at the rate 1 kg/40 m^2, followed by application of half the initial dose at fortnightly intervals until the end of February, during which time the weather would be cold. Researchers also suggested combining lime and salt by mixing them at 50% of the individual dose, but retaining the frequency of application. Farmers also suggested using ash to control this disease. This reasoning was based on its wide availability and that it had been used to control insect pests in horticulture. Farmers were of the opinion that ash, with an action similar to lime, might prevent the disease. Studies conducted by ICLARM have indicated that, among the different types of ash, wood ash could be a good substitute for lime, although the application rate is higher (Jamu 1990). It was agreed that ash would be applied at 3 kg/400 m^2 followed by 1.5 kg/400 m^2 at fortnightly interval.

Farmers decided to examine the ponds once every 15 days during the learning sessions and to share their observations with other farmers. Fish were examined by cast netting and checking for infection by visual observation for gross clincial signs. Farmers kept a record of their activities, including the application of treatments. At the end of the season, apart from holding focus-group discussions, a questionnaire was developed and used to gather information on various aspects of fish culture, production and disease management. The information gathered was processed using Microsoft Excel and Statistical Program for Social Analysis (SPSS).

RESULTS AND DISCUSSION

Altogether, 123 farmers covering 36 PARGs from Rajashahi, and 192 farmers covering 49 PARGs in Kishoreganj, took part in the study on management of EUS. Among these farmers, there were also farmers who did not use any of the treatments, but acted as controls by agreeing to provide information on the impact of non-adoption of the treatment processes.

Pond Size

The majority of the farmers in both areas owned ponds that were less than 800 m^2. The percentage of farmers owning ponds of either 400 or 800 m^2 was more or less same in both the project sites. However, in Rajashahi, the number of farmers owning bigger ponds was greater when compared with Kishoreganj (Table 1). Ponds in Rajashahi, being located in the dry zone, are generally larger in size and deeper. In Rajashahi, the average area of the ponds was 1000 m^2, while in Kishoreganj, it was 600 m^2. Generally, ponds are filled with rain water, but in some cases, they are connected with beels [flood plains] and also receive water from there. In Rajashahi, more than 50% of the farmers removed the wild fish, while in Kishoreganj, less than 50% did so. Farmers used various methods for removal of wild fish, such as poisoning, netting and drying. The use of poison (mostly pesticides) was common in Rajashahi (26.8%), but less frequent in Kishoreganj (5.7%). Pond drying was also practised as a common tool to eliminate wild fishes in Rajashahi (27.6%), but in Kishoreganj, only 12.5% of the farmers adopted this technique. In Kishoreganj, netting was most commonly used (23.9%).

Table 1. Size range of ponds in Kishoreganj and Rajashahi districts.

Pond Area (m^2)	Rajashahi (%)	Kishoreganj (%)
< 400	33.3	34.9
400-800	31.7	42.7
800-1200	10.6	15.1
1200-1600	10.6	5.2
>1600	13.8	2.1

Pond Ownership

More than 50% of the ponds were under single ownership (Table 2). In both project sites, there were also a good percentage of ponds that were jointly owned [26% in Rajshahi and 58% in Kishorganj]. In Rajashahi, the percentage of leased ponds was higher (17.1%) when compared to Kishoreganj (5.7%). The ownership pattern has an influence on the cultivation practice, and it is common for multiple-ownership ponds to have many more management problems than single-ownership ponds.

Table 2. Pond ownership pattern.

Ownership Pattern	Rajashahi	Kishoreganj
Single	69 (56.1)[1]	123 (64.1)
Multiple	33 (26.8)	58 (30.2)
Leased	21 (17.1)	11 (5.7)
Total	123 (100)	192 (100)

[1]Figures in parentheses are percentages.

Seed Source

In Bangladesh, patilwalas (seed traders) carry fish seed to almost every part of the country. The majority of farmers in both project sites obtain seed from these patilwalas, although the percentage doing so was higher in Kishoreganj (Table 3) than in Rajashahi, where a higher percentage of farmers obtained seed from hatcheries. This is probably because of the low density of ponds in this area, and the fact that the patilwalas are less active in this area; as a result, many farmers obtain seed directly from the hatcheries.

Table 3. Source of seed for the pond.

Source	Rajashahi	Kishoreganj
Patilwala	75 (61.0)[1]	147 (76.6)
Nursery	40 (32.5)	22 (11.5)
Patilwala & nursery	8 (6.5)	23 (12.0)
Total	123 (100)	192 (100)

[1]Figures in parentheses are percentages.

Management Practices

Application of lime was not practised by all farmers. In Rajashahi, only about 41% of the farmers used lime prior to stocking; however, in Kishoreganj, it was about 21%. Although lime usage was poor in most of the areas, the pH of the water was alkaline, since soils in Bangladesh are generally alkaline. Cow dung was the organic manure most commonly used prior to stocking of fish, along with other inorganic fertilisers like urea and TSP. Some farmers also used small quantities of chicken manure. Ponds were stocked from April onwards with the available carp seed, namely, silver carp (*Hypophthalmichthys molitrix*), common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idellus*), catla (*Catla catla*), rohu (*Labeo rohita*), mrigal (*Cirrhinus cirrhosus*), Kuria labeo (*Labeo gonius*) and Java barb (*Barbodes gonionotus*).

Stocking density varied from farmer to farmer, although the density adopted by most farmers was much higher (two or three times greater) than the recommended level. Farmers have a tendency to stock large numbers of fish and resort to periodic harvesting (Table 4). In addition, farmers did not follow any recommendations for species composition, and stocked different species depending on their availability.

Table. 4. Average overall stocking densities in the two districts.

Treatment	Rajashahi (Number of Fish/ha)	Kishoreganj (Number of Fish/ha)
Salt	20,007.0	34,787.1
	(20,609.3)[1]	(19,512.5)
Lime+salt	15,699.8	25,846.9
	(16,206.4)	(14,722.8)
Ash	28,828.5	36,857.9
	(33,721.9)	(28,726.5)
Lime	57,706.8	33,612.7
	(60,609.6)	(36,239.0)
Control	30,433.4	35,164.9
	(19,856.0)	(33,077.1)

[1]Figures in parentheses are standard deviations.

Some farmers practised feeding, with rice bran being the most common feed ingredient used. Some farmers also fed mustard oilcake; however, in most cases, feed was not given on a regular basis.

Management of EUS

All the farmers who took part in the trial indicated that they had suffered from EUS at some time in the past year, but not necessarily on a continuous basis. Farmers decided whether or not to take part in the treatment trials based on the information they gathered from the learning sessions; that participation could help prevent the disease and, as a secondary benefit, that the treatments might promote the growth of fish. Based on information gathered from the farmers, it appears that a major outbreak of EUS occurred in 1988. Nearly 50% of the ponds belonging to the farmers surveyed were affected, and the disease caused substantial damage. Information for 1997 indicates that the occurrence of EUS was higher in

Kishoreganj than in Rajashahi. The disease affected more than 50% of the ponds, mrigal, Java barb, snakehead and catfish were most often affected.

Specific treatments for the management of the disease were decided by the farmers themselves based on the knowledge received in training and the ready availability of cash to purchase the treatment compounds. In Kishoreganj, the majority of farmers opted for the salt and ash treatment, while in Rajashahi, the majority opted for lime (Table 5).

Table 5. Number of ponds under different treatments.

Treatment	Rajashahi	Kishoreganj
Salt	16 (13.0)[1]	48 (25.0)
Lime	46 (37.4)	30 (15.6)
Salt + lime	20 (16.3)	33 (17.2)
Ash	16 (13.0)	47 (24.5)
Control	25 (20.8)	34 (17.7)
Total	123	192

[1]Figures in parentheses are percentages.

Occurrence of EUS and Its Causes

The occurrence of EUS was higher in the combined salt and lime treatment and the ash treatment in both Rajashahi and Kishoreganj districts. In terms of recovery of diseased fish, the percentage was higher in the salt treatment and lime treatment. Farmers assessed recovery from the disease based on the disappearance of clinical signs of infection, which were monitored by periodical sampling of the fish.

Table 6. Number of ponds in each district infected with EUS and recovered.

Treatment	Rajashahi		Kishoreganj	
	No. Infected	No. Recovered	No. Infected	No. Recovered
Salt	3 (18.8)[1]	3 (100)	7 (14.6)	6 (85.7)
Lime	6 (13.0)	4 (66.7)	5 (16.7)	5 (100)
Salt + lime	6 (30.0)	3 (50.0)	10 (30.3)	7 (70.0)
Ash	5 (31.2)	3 (60.0)	10 (21.3)	7 (70.0)
Control	13 (52.0)		24 (70.6)	
Total	33 (26.8)	13 (39.4)	56 (29.2)	25 (44.6)

[1]Figures in parentheses are percentages.

Treatments

As EUS is associated with a number of management and ecological factors (Lilley *et al.* 1998), information was gathered during the survey on a number of potential contributory factors. The factors monitored included drying of ponds, application of lime, removal of wild fish, pond shading by trees, flooding of ponds in the wet season, connection of ponds to beels, presence of ducks in ponds, use of borrowed nets and species stocked, particularly in respect of mrigal and Java barb. Examination of results from the two districts reveals no obvious differences in terms of those farmers who carried out the above practices and those who did not (Tables

7 and 8). The absence of any clear relationship indicates that a combination of several factors may ultimately influence the occurrence of the disease. Although the farmers adopted the treatments, not all of the farmers continued the treatment for the entire period. The maximum number of applications was six, in respect of ash, while the frequency of application of other purchased inputs varied greatly from farmer to farmer (Tables 9 and 10).

Table 7. Occurrence of EUS under different situations in Rajashahi District.

Parameter	Number of Ponds	Disease Status	
		Yes	No
Pond drying			
Yes	56	11 (19.6)[1]	45 (80.4)
No	67	16 (22.4)	51 (77.6)
Application of lime			
Yes	51	10 (19.6)	41 (80.4)
No	72	17 (23.6)	55 (76.4)
Removal of wild fish			
Yes	63	12 (19.0)	51 (81.0)
No	57	15 (25.0)	45 (75.0)
Pond shading: trees			
Yes	64	17 (26.6)	47 (73.4)
No	59	11 (19.0)	47 (81.0)
Flooding last season			
Yes	42	10 (23.8)	32 (76.2)
No	81	17 (21.0)	64 (79.0)
Rice field / beel connection			
Yes	33	9 (27.3)	24 (72.7)
No	90	19 (21.1)	71 (78.9)
Ducks in ponds			
Yes	116	27 (23.3)	89 (76.7)
No	7	1 (14.3)	6 (85.7)
Net Usage			
Borrowed net	63	13 (20.6)	43 (68.3)
Own net	56	13 (23.2)	34 (60.7)
Borrowed & own net	3	1 (33.3)	2 (66.7)
Presence of mrigal			
Yes	80	28 (35.0)	52 (65.0)
No	43	5 (11.6)	38 (88.4)
Presence of Java barb			
Yes	55	10 (18.2)	45 (81.8)
No	68	23 (33.8)	45 (66.2)

[1]Figures given in parentheses are percentages.

Table 8. Occurrence of EUS under different treatments in Kishoreganj District.

Parameter	Number of Ponds	Disease Status	
		Yes	No
Pond drying			
Yes	45	15 (33.3)[1]	30 (66.7)
No	147	41 (27.9)	106 (72.1)
Application of lime			
Yes	41	13 (31.7)	28 (68.3)
No	151	43(28.5)	108 (71.5)
Removal of wild fish			
Yes	85	22 (25.9)	63 (74.1)
No	107	33 (30.8)	74 (69.2)
Pond shading: trees			
Yes	84	24 (28.6)	60 (71.4)
No	108	30 (28.0)	78 (72.0)
Flooding last season			
Yes	23	9 (39.1)	14 (60.9)
No	169	46(27.5)	123 (79.4)
Rice field / beel connection			
Yes	52	11 (21.2)	41 (78.8)
No	140	44 (31.4)	96 (68.6)
Ducks in ponds			
Yes	138	43 (31.2)	95 (68.8)
No	54	11 (20.4)	43 (79.6)
Net usage			
Borrowed net	105	32 (30.5)	73 (69.5)
Own net	57	14 (24.6)	43 (75.4)
Borrowed & own net	30	9 (30.0)	21 (70.0)
Presence of mrigal			
Yes	90	36 (30.8)	54 (69.2)
No	102	7 (6.9)	95 (93.1)
Presence of Java barb			
Yes	117	18 (15.4}	99 (84.6)
No	75	43 (57.3)	32 (42.7)

[1]Figures given in parentheses are percentages.

Lime

Six of the 40 farmers from Rajashahi encountered EUS, while five of the 30 farmers in Kishoreganj encountered the disease. All farmers except two were able to promote recovery of the fish through the continuous application of lime. There was considerable variation between farmers in the quantity of lime applied, depending on the number of applications. However, the disease occurred even in the ponds of those farmers who had made more than three or four applications.

Table 9. Quantity of materials applied in each treatment with number of applications - Kishoreganj District.

Treatment	Number of Participants	Number of Applications	%	Quantity		Disease Affected/ Not Affected[1]
				Mean	SD	
Lime	4	1	13.3	210.0	47.3	N=4
	6	2	20.0	337.8	46.4	Y=2, N=4
	7	3	23.3	474.0	46.0	Y=2, N=5
	7	4	23.3	509.1	252.7	N=7
	4	5	13.3	625.7	64.8	Y=1, N=3
	2	6	6.7	825.7	54.9	N=2
Total or average	30		100	463.4	200.3	Y=5, N=25
Salt	14	1	29.2	235.8	57.4	Y=3, N=11
	3	2	6.3	281.0	117.3	N=3
	15	3	31.3	425.9	113.8	Y=1, N=14
	7	4	14.6	641.2	221.8	Y=1, N=6
	6	5	12.5	573.6	256.5	Y=1, N=5
	3	6	6.3	769.3	31.8	Y=1, N=2
Total or average	48		100	434.4	221.7	Y=7, N=41
Salt + lime	5	1	15.2	212.7	69.0	Y=3, N=2
	20	3	60.6	478.0	92.3	Y=5, N=15
	5	4	15.2	802.1	173.0	Y=1, N=4
	3	5	9.1	658.7	99.1	Y=1, N=2
Total or average	33		100	503.3	199.6	Y=10, N=23
Ash	5	1	10.6	741	0.00	Y=2, N=3
	5	2	10.6	1098.4	108.4	N=5
	8	3	17.0	1487.4	592.7	Y=1, N=7
	12	4	25.5	1911.5	163.5	Y=2, N=10
	7	5	14.9	2036.4	398.8	Y=2, N=5
	10	6	21.3	2118.1	525.7	Y=2, N=8
Total or average	47		100	1690.8	591.3	Y=9, N=38

[1]Y=affected, N=not affected.

Table10. Quantity of materials applied for each treatment with number of applications - Rajashahi District.

Treatment	Number of Participants	Number of Applications	%	Quantity		Disease Affected/ Not Affected[1]
				Mean	SD	
Lime	6	1	13.0	173.3	73.6	N=6
	21	2	45.6	399.7	90.6	Y=4, N=17
	14	3	30.4	523.6	125.5	Y=1, N=13
	4	4	8.7	415.6	291.6	N=4
	1	5	2.2	905.7	-	Y=1
Total or average	46		100	418.4	178.9	Y=6, N=40
Salt	7	2	43.8	392.8	107.9	Y=2, N=5
	8	3	50.0	445.5	150.1	Y=1, N=7
	1	4	6.3	617.5	-	N=1
Total or average	16		100	433.2	135.2	Y=3, N=13
Salt + lime	5	2	25.0	352.0	124.3	Y=3, N=2
	7	3	35.0	289.4	207.3	Y=2, N=5
	3	4	15.0	571.1	60.3	Y=1, N=2
	5	5	25.0	202.6	370.8	N=5
Total or average	20		100	326.8	241.0	Y=6, N=14
Ash	3	1	18.8	327.6	334.1	Y=2, N=1
	5	2	31.2	940.3	344.2	Y=2, N=3
	2	3	12.5	3112.2	2584.9	N=2
	2	4	12.5	1852.5	-	N=2
	1	5	6.2	463.1	-	N=1
	3	6	18.8	1914.2	875.5	Y=1, N=2
Total or average	16		100	1331.2	1227.3	Y=5, N=11

[1]Y=affected, N=not affected.

Salt

Sixteen farmers in Rajashahi and 48 in Kishoreganj attempted this treatment. In this treatment also, the quantity applied and the number of applications varied. Disease problems were encountered by 18.8% of the farmers in Rajashahi and 14.6% of the farmers in Kishoreganj. Interestingly, in both locations, application of salt assisted in the recovery of almost all of the infected fish (in Rajshahi fish in all infected ponds recovered, while in Kishoreganj recovery was seen in six of the seven affected ponds). It is interesting to note the impact of salt at such a low dose rates on the prevention/cure of the disease [initial dose of 1kg/40 m^2 followed by fortnightly application at 0.5 kg/40 m^2).

Lime and Salt

Thirty-three farmers from Kishoreganj and 20 farmers from Rajashahi adopted this treatment. The percentage of farmers who encountered EUS was almost 30% in both places. Of the affected ponds, 30-40% did not be recover. This may indicate that the combined effect of these two chemicals at this low dose [initial mixture of 1:1 given at 1 kg/40 m^2, followed by fortnightly application of 0.5 kg/40 m^2.) may be poor. Although higher doses of these chemicals might be effective, increased costs would hamper adoption of this treatment.

Ash

In Kishoreganj, 47 farmers took part in the trial compared to 16 in Rajashahi. The occurrence of EUS in Rajashahi was 31.2% and in Kishoreganj, 21.3%. Using this treatment, the percentage of ponds recovering after occurrence of the disease was lower when compared to other treatments. *S*tudies conducted by Jamu (1991) indicate that the neutralising effect and increased alkalinity occurring when ash is applied varies depending on the type of ash, the most effective being wood ash applied at 3 mt/ha. Most of the farmers in the project area used rice-husk ash, whose value when compared to wood ash is not known. From the results, it appears that higher doses may give better results in disease prevention and control, although farmers might find it impractical to adopt higher dosages.

In general, farmers were happy with the results obtained, since they witnessed the impact of the treatments on EUS. Of the different treatments tried, farmers preferred ash treatment, as they can obtain ash as a non-purchased input. This is particularly important, as farmers prefer to use non-purchased inputs, even though the results may not be completely satisfactory.

Species Affected

Infections were common in both wild and cultured species, but predominated in wild species (Table 11). Most of the wild species, such as snakeheads, barbs and catfishes, are highly susceptible to EUS. In beel areas, farmers have reported a severe decline in the numbers of these species since the first occurrence of EUS.

Among the cultured species, silver carp was commonly reported as being affected in all treatments, and in some treatments, grass carp was also listed as infected. While the occurrence of EUS has been reported in Indian major carps, Chinese carps appear to be much less susceptible. Although lesions similar to those seen in EUS were evident on all these species, no tests were carried out to confirm that the lesions were actually due to EUS.

Table 11. Species affected by EUS.

Treatment	Rajashahi			Kishoreganj		
	Species Stocked	Species Affected	Wild Species [1]	Species Stocked	Species Affected	Wild Species
Salt	rohu, catla, mrigal, silver carp, grass carp, Java barb, common carp	mrigal, stinging catfish, Java barb silver carp	pool barb, spotted snakehead, stinging catfish, walking catfish, climbing perch, badis, snakehead murrel, barred spiney eel, tiretrack eel, mola carplet	catla, rohu, mrigal, Java barb, silver carp, Kuria labeo, common carp, grass carp	mrigal, Java barb, snakehead, silver carp	pool barb spotted snakehead, stinging catfish, walking catfish, climbing perch, badis, snakehead murrel, barred spiney eel , tiretrack eel, mola carplet
Lime + salt	rohu, catla, mrigal, silver carp, grass carp, Java barb, common carp	mrigal, common carp, catla, rohu, silver carp		catla, rohu, mrigal, Java barb, silver carp, Kuria labeo, common carp, grass carp	mrigal, Java barb, silver carp	
Ash	rohu, catla, mrigal, silver carp, Java barb, grass carp common carp	mrigal, rohu, Java barb, silver carp		catla, rohu, mrigal, Java barb, silver carp, Kuria labeo, common carp, grass carp	mrigal, Java barb, silver carp	
Lime	rohu, catla, mrigal, silver carp, Java barb, grass carp, common carp	catla, mrigal, common carp, Java barb, silver carp		catla, rohu, mrigal, Java barb, silver carp, Kuria labeo, common carp, grass carp	mrigal, Java barb, silver carp	
Control	rohu, catla, mrigal, silver carp, Java barb, grass carp, common carp	catla, common carp, mrigal, Java barb, grass carp, silver carp		catla, rohu, Java barb, mrigal, silver carp, Kuria labeo, common carp, grass carp	silver carp	

[1]Scientic names for wild fishes are as follows: pool barb (*Puntius sophore*), spotted snakehead (*Channa punctata*), stinging catfish (*Heteropneustes fossilis*), walking catfish (*Clarias batrachus*), climbing perch (*Anabas testudenius*), badis (*Badis badis*), snakehead murrel (*Channa striata*), barred spiney eel (*Macrognathus pancalus*), tiretrack eel (*Mastacembelus armatus*), mola carplet (*Amblypharyngodon mola*).

PRODUCTION

Farmers were encouraged to observe the growth and appearance of fish grown using these treatments. Production statistics for the treatment year and previous year were compared, and it was seen that there had been a general increase in production in all the treatments (Table 12). The increase ranged from 9% to 30%, depending upon the treatment. In Rajashahi, the increases in production were generally less than in Kishoreganj. For both areas, the production increases in the salt and ash treatments were higher than for the other treatments. Farmers in Andhra Pradesh, India commonly include salt in the artificial feed to reduce stress and promote the growth of fish (Veerina *et al.* 1993). Controlled studies conducted at the College of Fisheries, Mangalore, India, have confirmed that salt can be used to reduce stress and enhance growth in carp when incorporated into the diet at a level of 1%.

Table 12. Production in different treatments.

Treatment	Rajashahi (kg/ha)			Kishoreganj (kg/ha)		
	1997	1998	Increase (%)	1997	1998	Increase (%)
Salt	1616	1919	18.8	2216	2719	22.0
	(734)[1]	(723)		(976)	(787)	
Lime	2091	2280	9.0	2056	2428	18.0
	(1268)	(1136)		(928)	(758)	
Salt & lime	2266	2507	10.6	2331	2766	.0
	(914)	(916)		(1187)	(1348)	
Ash	1723	2246	30.4	1995	2513	26.0
	(823)	(1120)		(848)	(855)	
Control	1570	1695	8.0	1589	1748	9.9
	(934)	(910)		(959)	(855)	

[1]Figures in parentheses are standard deviations.

Ash contributed to the highest increase in yield in both Rajashahi (30.6%) and Kishoreganj (26%). Ash is commonly used by farmers as a fertiliser in both vegetable and paddy cultivation. With its high mineral content, it appears that the addition of ash contributed to substantial increases in production in both the project areas. The improved production added to the farmers' satisfaction regarding the use of ash as a treatment for EUS.

Happiness of Farmers with Production

The percentage of farmers happy with production was higher in Rajashahi than in Kishoreganj (Table 13). A good percentage of farmers from both the areas (29.3% in Rajshahi and 35.4% in Kishoreganj) were not happy with their production. The reason that production did not reach their expectations may be due to the fact that, in most cases, farmers did not follow practices like fertilisation and feeding, which are essential to increase growth of fish. Additionally, stocking densities were, in most cases, three to four times the maximum recommended for composite culture of carps.

Table 13: Happiness of farmers with their production (%).

Response	Rajashahi	Kishoreganj
Happy	67.5	59.4
Moderately happy	3.2	5.2
Unhappy	29.3	35.4

Attitude of Farmers towards the Results of EUS Treatments

More than 70% of the farmers in Kishoreganj and 63% of those in Rajashahi were happy with the results (Table 14). However, a small percentage of farmers (about 6%) were not happy with the results obtained. The majority of the farmers from the control group opted not to provide comments, while a considerable percentage of farmers in Rajashahi indicated that they could not decide on the results obtained. Also, some of the farmers who encountered disease problems provided no comments, and other farmers who got mixed results felt that they needed to verify the results in the coming season before they could decide on the merits of the treatment. The farmers gave various reasons for their happiness; these included better growth, no occurrence of disease, and better appearance of the fish.

Table 14. Happiness of farmers with the EUS results (%).

Response	Rajashahi	Kishoreganj
Happy	63.4	71.4
Unhappy	5.7	6.3
Can't decide	10.6	3.1
No comments	20.3	19.3

Economic Impact

Information was collected for the base year (1988) when the disease was first noticed, the year before experimentation commenced (1997), and the treatment year (1998). These figures, based on what the farmers could recall, provide interesting observations on both project sites (Tables 15 and 16). The results clearly show that there has been an increase in economic loss due to disease over the period 1988 to 1997, and even during 1998, the losses incurred by the control group of farmers were still very high. Adoption of different treatments not only resulted in the reduction of loss, but also helped to increase production, which has compensated for additional costs incurred in applying the treatments.

Lime has a proven capability to increase productivity, but many farmers are yet to use this as a common pond input. Non-availability of lime in rural areas is also a limiting factor, and although farmers are aware of its benefits, its use is limited. Experimental evidence exists to show that salt acts as a growth promoter and reduces stress; however, this being a purchased input, farmers do not have access to it. In view of its availability at the village level as a non-purchased input, ash appears to be a good input. Most farmers felt happy with the results obtained from its use and will promote it as a common pond input. However, ash is a commonly used fertiliser in paddy fields and is also used in vegetable gardens for the management of insect pests; there will, therefore, be competition for this resource.

Table15. Economic loss encountered by farmers in Rajashahi District due to EUS (Taka/ha/yr; 1US$ = 48 Taka).

Treatment	1988	1997	1998
Salt	4,644.34 (11,150)[1]	8,392.05 (10,627.02)	00 (00)
Lime	7,579.25 (15,223.35)	7,527.71 (11,799.73)	561.36 (2,173.5)
Salt + lime	3,560.69 (9,196.09)	16,406.09 (22,552.85)	823.33 (2,078.81)
Ash	3,164.68 (6,450.99)	9,142.26 (10,610.85)	2,117.7 (8,220.91)
Control	4,532.05 (8,154.82)	4,780.77 (8,316.18)	6,750.3 (14,477.99)
Total	5,293 (11,521.72)	8,785.33 (13,725.09)	2,043.74 (7,743.02)

[1]Figures in parentheses are standard deviations (n =123).

Table16. Economic loss encountered by farmers in Kishoreganj District due to EUS (Taka/ha/yr; 1 US$ = 48 Taka).

Treatment	1988	1997	1998
Salt	9,029.22 (17,817.96)[1]	20,515.51 (20,947.46)	1,852.5 (5,995.66)
Lime	9,714.61 (14,704.07)	11,740.88 (17,948.30)	637.26 (2,246.23)
Salt + Lime	12,835.36 (25,876.58)	13,218.62 (15,717.72)	2,699.46 (8,975.31)
Ash	11,527.4 (19,681.61)	15,776.34 (19,217.47)	1,713.03 (4,203.87)
Control	11,134.03 (20,561.03)	27,333.46 (62,691.97)	17,589.1 (28,468.91)
Total	10,839.01 (19,534.02)	17,114.94 (31,400.66)	4,446.81 (14,223.20)

[1]Figures in parentheses are standard deviations (n =192).

CONCLUSIONS

The results of this study indicate that experimentation by farmers, to develop a system that is appropriate to them, is a useful way to develop sustainable technologies through participatory approaches. Although these results have limitations, the observations of the farmers could be used as a baseline for more controlled studies, which might produce results that could be returned to the field for testing. Different results obtained for the same treatments indicate that the ecology of the ponds are different, and that each farmer needs carry out experiments to decide on the treatment procedures appropriate for his/her pond ecosystem. It is because of this difficulty in prescribing standard packages appropriate for all farmers, that the LIFE Project has been experimenting with the process of “extension through research,” where every farmer is encouraged to experiment, but using variables which involve low risks. This provides an opportunity for farmers to decide what is appropriate to them through their own investigation or through investigation by other members of their community.

The results obtained by participating farmers were shared within PARGs through workshops. For wider dissemination of these results, selected farmers from these PARGs presented results in the farmers' science seminar at the thana (sub-district) level and at the farmers' science congress held at the district level. The experience of the LIFE Project in EUS experimentation, as well as in addressing several other agricultural issues involving farmers, indicates that, given the opportunity and confidence, farmers can become good partners in research and can help evolve techniques appropriate to their farming systems.

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FARMER TRAINING AND EXTENSION: THE KEY TO HEALTH MANAGEMENT IN EXTENSIVE BRACKISHWATER SHRIMP AQUACULTURE IN BANGLADESH

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ABSTRACT

The shrimp aquaculture industry in Bangladesh has gained an important place in the national economy and is the third highest foreign income earner. Of the Taka (TK) 13,400 million (US$335 million) earned as export earnings from the fisheries sector in 1996 to 1997, TK 11,880 million (US$297 million) came from the exportation of 25,742 mt of shrimp. There are a total of 13,076 extensive and improved-extensive shrimp farms, covering an area of 134,488 ha, and 72 semi-intensive shrimp farms, covering an area of 995 ha. Since 1994, shrimp farming in Bangladesh has suffered from viral epidemics and other disease conditions. Lost production due to diseases valued at TK 4,688 million (US$117.2 million) was recorded in financial year 1996-97.

The techniques developed for semi-intensive and intensive shrimp farming in other countries cannot be applied to low-input/low-output shrimp farming systems. Awareness of the major contributing factors to the poor health of shrimp and the low production levels in these extensive culture systems has not reached the farmer. Hence, an extension programme was developed to educate farmers about health management aspects of shrimp culture applicable to extensive systems. The methodology adopted in this training programme was farm-site training and establishment of demonstration farms. Much emphasis was placed on educating the farmers about problems relating to low production and health management in the extensive systems, and on low-technology (low-tech), low-cost management measures to improve health and productivity. Remedial measures involving high-tech, high-cost or major engineering modifications were considered as "beyond the farmers' capabilities." This paper discusses the five management measures, based on low-tech and low-cost techniques, that were disseminated and demonstrated.

INTRODUCTION

Shrimp aquaculture in Bangladesh has gained an important place in the national economy and is the third highest foreign income earner. Of the Taka (TK) 13,400 million (US$335 million) export earnings from the fisheries sector in financial year 1996-97, TK 11,880 million (US$297 million) came from the exportation of 25,742 mt of shrimp. This figure includes both cultured and captured shrimp, as no reliable figure is available solely for cultured shrimp production. A total of 13,148 shrimp farms, consisting of traditional or extensive, improved-extensive and semi-intensive farms, cover an area of 134,560 ha, providing an estimated 380,000 employment opportunities, of which 350,000 are direct employment.

Since 1994, shrimp farming in Bangladesh has suffered from repeated viral epidemics and other disease conditions. Various management strategies to address health management problems and low yields, particularly in extensive and improved-extensive shrimp farming in Bangladesh, have been described (Karim and Stellwagen 1998); however, there appears to be a reluctance or inability to implement these strategies (Karim and Stellwagen 1998). In 1996, the Government of Bangladesh requested assistance from the Food and Agriculture Organization of the United Nations (FAO) to address the health management problems in coastal shrimp culture. This paper presents the management problems and inadequacies in extensive and improved-extensive systems that lead to health management problems and low yields, and also presents the five management measures disseminated to farmers in 1997 under the FAO-assisted project. This paper also reports some of the statistical information resulting from a linked survey of 8,600 shrimp farms in Bangladesh.

SHRIMP FARMING SYSTEMS

According to the terminology used for shrimp farming in Bangladesh, three different types of culture system are practised: traditional or extensive, improved-extensive and semi-intensive shrimp culture. Semi-intensive farms represent a small proportion in number (0.54%) and production area (0.74%). The extensive system operates with minimal inputs and depends on the tidal amplitude for both water intake and discharge. Some farmers culture what is naturally recruited with incoming water, while others stock additional postlarvae. The extent of a single extensive shrimp-culture pond varies from 4 to 200 ha, with an average water depth of 60 cm. Most of these ponds are irregular in shape and bottom morphometry, and have only a single canal for both intake and discharge of water. Some of these ponds have one or more nursery compartments with or without a gate connection to the main grow-out pond. The extent of the nursery compartments varies from 0.5% to 20% of the total pond area.

Improved-extensive shrimp culture is basically similar to the extensive system, except for the use of certain inputs such as lime, fertilisers, and in some cases, feed. Extensive and improved-extensive shrimp culture systems sometimes include crop rotation with either salt production or rice cultivation. These classifications of culture practice are based solely on the degree of management intervention and do not relate to the productivity or the health of the shrimp cultured in the system concerned. This is an important point, since yields from both extensive and improved-extensive systems are often similar. The only difference between these two systems is that the production cost in the improved extensive system is slightly higher.

DISEASE AND ITS IMPACT ON PRODUCTION

Semi-intensive farms are not currently in production. This is considered to be principally due to repeated production losses between 1994 to 1997 which have been attributed to white spot syndrome virus (WSSV), also known as systemic ectodermal and mesodermal baculovirus (SEMBV), and this has been confirmed in some cases (Funge-Smith 1997). The route of infection is thought to be via importation of infected postlarvae from other countries. Since the first outbreak of WSSV in semi-intensive farms, it has occurred in all the other farming systems. Significant production losses are often observed during the rainy season (June to September) and cold months (December to January).

According to an estimation made by the Department of Fisheries (DOF), 13,284 mt of cultured shrimp valued at TK 4,688 million (US$117.2 million) was lost due to disease in 1996. This amounts to a loss of 42.3% when compared to the foreign income generated from export of shrimp in 1995.

It is worth noting that there is a tendency to blame shrimp mortality and production losses in extensive and improved-extensive farms on WSSV, although the descriptions of the condition of the shrimp and the manner in which they were affected are not always consistent with what is known about this viral disease (Siriwardena 1997). Bacterial infections appear to be a significant contributory factor to these mortalities. It was observed that 80% of the farms had shrimp with pale and red discoloration on the body and tails with rotten, broken or swollen edges, indicating deterioration of pond environment and pond bottom.

EXTENSION STRATEGY

Viable training and extension strategies to improve the health of shrimp and increase the yield from extensive and improved-extensive shrimp-culture systems must take into consideration the environmental and socio-economic constraints. In this regard, the following strategy was adopted to design the training and extension programme:

- Identify the environmental factors that affect health and productivity in extensive and improved-extensive shrimp farms.
- Identify management measures to mitigate the problems.
- Disseminate management measures to mitigate the problems.

Identification of the Environmental Factors that Affect Health and Productivity in Extensive and Improved-extensive Shrimp Farms

In a broad sense, environmental problems are site specific and also relate to larval quality and pond environment conditions. Most of the site-specific problems are caused by the fact that farms are built where there is land available, and not necessarily in sites suitable for shrimp farming. The following have been recognised as site-specific problems (Siriwardena 1997):

- Improper pond-bottom elevation and location of farms too far inland, where the tidal amplitude is minimal, leading to difficulties in proper water management.

- Exposure of acid-sulphate soils, causing leaching of acid into ponds.

- Failure to adequately compact dikes, leading to soil erosion and sediment accumulation.

- Low salinity water that becomes completely fresh during rains, causing stress to the shrimp.

In Bangladesh, extensive and improved-extensive shrimp farming is largely dependent on wild seed collection for stocking (BOBP 1993). The method of handling during collection and the conditions used for holding and transport stress the postlarvae. Hence, the postlarvae may be in poor condition when they reach the farmer. Exposure of postlarvae to stressful conditions can cause an increase in the occurrence of disease and low survival at stocking, and this immediately limits the potential yield of the pond. Neither quality assurance nor acclimation of postlarvae to the pond environment is being carried out before stocking. Thus, the health management of shrimp under culture should begin with postlarval collection and holding.

Shallow water in ponds in many shrimp farms (74% of ponds are around 60 cm in depth) causes problems due to fluctuations in water quality parameters, such as temperature, salinity, dissolved oxygen and pH, and possibly, toxic compounds such as ammonia and hydrogen sulphide. The salinity of the ponds in many farms is low (63.6% of farms have a maximum salinity below 10 ppt). Low salinity, together with shallow depth, causes sudden drops in salinity to fresh water, which severely stresses the shrimp.

Identification of Management Measures to Mitigate Problems

Shrimp-only culture is carried out by a small percentage of farmers (2.5%). The majority practice shrimp-fish polyculture. By-catch of shrimp other than *Penaeus monodon* (“bagda”), and of fish, plays an important role in the shrimp farmers’ lifestyle by providing alternate income and species diversity. Should production of *P. monodon* fail, there is always the by-catch to provide food security. Hence, suggesting management measures to enhance production of *P. monodon* at the expense of fish and other shrimp species would not be acceptable to the farmers. Shifting the composition of the shrimp species in the pond towards *P. monodon* to enhance its yield would be acceptable, as this would increase the income from the pond. Thus, the management measures suggested for extensive and improved-extensive shrimp culture in Bangladesh should suit a shrimp-fish polyculture situation more than a shrimp monoculture situation**.** Recommendations to correct site-specific environmental problems would not be acceptable to the farmer, as they involve high-cost engineering modifications, which he could not afford. Moreover, most farmers are lessees (15.5%) or sub-lessees (53.5%) and will not invest in improvements to land for which they do not have long-term tenure. Therefore, the training and extension strategy took into consideration that low technology, low-cost management measures should be used to improve the environment for *P. monodon*. The criteria used to identify the five management measures recommended for dissemination included (i) management within farmer capability, and (ii) the acceptability of the recommended management measures to the farmer.

Dissemination of Recommended Management Measures

Dissemination of the recommended management measures was carried out by conducting 120, one-day farm-site trainings for groups of 30 to 40 farmers, fry collectors and fry holders. This training was conducted during the period December 1997 to December 1998 in the districts of Cox's Bazar, Satkhira, Khulna and Bagherhat at the union level.[1] A total of 3,459 shrimp farmers, fry collectors and fry holders and 113 officials, including Thana Fisheries Officers and Assistant Thana Fisheries Officers from the DOF and Scientific Officers from the Fisheries Research Institute (FRI), received field training in the recommended management measures. In addition to these training sessions, three Experimental Demonstration Farms (EDUs) were established to demonstrate the recommended management measures. These EDUs were selected from among the operational farms in Teknaf (Cox's Bazar District), Botiaghata (Khulna District) and in Tala (Satkhira District). It is expected that these 113 officials, and the demonstration farmers, will serve as "master trainers" for further training of farmers, fry collectors and fry holders.

TRAINING ON THE RECOMMENDED MANAGEMENT MEASURES

The training programme aimed to improve the environment for *P. monodon* culture in ponds and to improve the quality of postlarvae at stocking by minimising the stress caused during collection and holding (Siriwardena 1998].

Grow-out Farmer Training

Grow-out farmers were made aware of the following management measures:

Stock at the correct time

When *P. monodon* culture is carried out alternately with rice production (46.7% of farmers), the stocking of postlarvae is carried out in February. If culture is carried out alternately with salt production (5.6% of farmers), stocking is carried out from June to September, which is the rainy season. When crop rotation is not practised, stocking is carried out throughout the year, whenever the postlarvae are available (45.1% farmers stock throughout the year). The cold months, December to January, which have significant diurnal temperature fluctuations (around 5 to 10 ^{0}C) and rainy months, when sudden salinity drops lead to completely fresh water in the ponds and heavy loading of silt, create an unfavourable pond environment for postlarvae. Stocking postlarvae during these unfavourable months increases their susceptibility to disease and may result in mass mortalities soon after stocking. Thus, timing of stocking plays and important role in minimising production losses and avoiding health-related problems.

February to March, which is the peak season of availability of natural postlarvae, appears to be the correct time for stocking, as this will allow harvesting of the crop at the onset of the rainy season in June to July. Therefore, salt-shrimp culture is not a recommended type of crop rotation. Culture of shrimp-rice or shrimp-freshwater fish would be a more suitable crop rotation to reduce health management problems and to enhance production. It is evident that Bangladeshi farmers should culture shrimp for only one cycle a year.

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[1]In Bangladesh, each district is subdivided into thanas, and each thana into unions.

Proper pond preparation

Some farmers prefer multiple stocking and multiple harvesting without an adequate fallow period to allow the pond bottom to dry (39.2% of farmers do not dry the pond bottom). In order to maintain a healthy pond bottom, it is essential to clean it before filling with water and stocking with postlarvae. As shrimp spend most of their time foraging for food on the bottom, it is important to promote a healthy pond bottom during the culture cycle, since accumulated sediments consume more oxygen and produce higher levels of toxic gases, such as ammonia and hydrogen sulphide. Such conditions can stress shrimp and increase the likelihood of disease (Chanratchakool *et. al*. 1995).

Farmers also lack knowledge on the type and quantity of lime and fertiliser to be used in pond preparation (62.9% and 77.0% of the farmers do not use any lime or fertiliser, respectively). The quantity and type of lime is selected arbitrarily and not based on the soil pH. Due to the use of inappropriate quantities and types of lime and fertiliser and their incorrect application, maintenance of a healthy plankton bloom is not possible (77.2% of the farms had transparent to very light green water throughout the culture cycle). In many instances, favouring of benthic algal growths was observed. Farmers were, therefore, made aware of the importance of a fallow period during which the pond could be dried, and taught the importance of proper selection and use of lime and fertilisers.

The importance of maintaining a healthy plankton bloom at stocking and during rearing was emphasised. It was also emphasised that proper pond preparation should be carried out, at least in the nursery area, even though farmers may not be able to do so for the grow-out pond, due to the large area and high costs involved.

Maintenance of the nursery

According to the recent survey, 74.3% of the farmers do not maintain a nursery for stocking and rearing of postlarval *P. monodon*. The nursery provides an area in which a predator-free environment can be easily maintained and where postlarvae are able to grow in better conditions than in the main pond. This enhances survival prior to release into the main pond. It also concentrates the postlarvae, allowing them to be more carefully monitored and fed than in the main pond (Chanratchakool *et. al.* 1995). Use of a supplementary feed in the nursery will be more effective than in the main pond. Hence, the training and extension programme included nursery maintenance to provide a predator-free environment for rearing postlarvae as the third essential management measure to enhance production and to minimise health management problems.

The training and extension programme advocated the use of a 0.4 ha nursery for a 6 ha pond. Larger ponds should include more than one 0.4 ha nursery for better management. Recommended stocking densities are 20 to 25 postlarvae/m^2 in order to release one juvenile shrimp/m^2 into the main pond, based on an assumed survival rate in the nursery area of 60%. Prior to stocking, acclimation of postlarvae is recommended. To avoid predators and competitors and enhance survival in the nursery area, it was emphasised that proper water control, including the installation of net screens (89 holes/cm^2) on water inlets, be maintained.

Most farms have problems changing adequate amounts of water, maintaining sufficient water depth and draining the pond completely. Most farmers (88.3%) depend on full moon and new moon days to change water in their ponds, restricting the frequency of water exchange to twice a month. In order to overcome this problem to some extent, and to prevent the entry of predators and competitors, it is necessary to design and install the water control structures (gates) properly, so that animals cannot enter around the gate. It was advised that the floor of the gate should be installed lower than the lowest pond bottom, preferably lower than the lowest tide at the site, and should rest on a foundation to enhance water exchange and drainage. The height of the gate should be as high as the main dike, and the sides should be sealed properly into the dikes to prevent seepage.

Supplementary feeding

Supplementary feeding in the nursery is recommended in order to enhance survival and grow *P. monodon* to healthy, large juveniles for release into the main pond. Large, healthy juveniles will have the ability to avoid predation and will be less susceptible to disease. Whole wet fish (50 to 60%), rice bran (20%) and cooked rice or potato (20 to 30%) should be prepared as a feed. Inclusion of other shrimp, mussel, cockle or clam should be avoided, as these may transmit shrimp viruses (Funge-Smith 1997).

Health checks

Early detection of clinical signs of a disease is essential in order to save the crop or to decide if an emergency harvest is required. The shrimp should thus be examined at regular intervals for any signs of disease. Farmers were trained to assess shrimp health by visual checks. The nine visual checks that should be carried out are examination of the carapace and head region, body colour, gill colour, appendages, tail region, gut, muscle, cleanliness of the body and gills and behaviour (Siriwardena 1998). Farmers were provided with a range of possible observations and causes.

The estimated costs involved in implementing the improvements are presented in Table 1.

Table 1. Estimated costs involved in implementing the recommended improvements for a farm of 6 ha area.

Item	Cost (US$)
Nursery dike construction	80
Sluice modification	70
Lime	50
Fertiliser	30
Tea seed powder	70
Supplemental feed	80
Total	380

Fry Collector and Fry Holder Training

There is a heavy dependence on wild seed for postlarval supply, as extensive and improved-extensive farmers believe that the route of infection for many viral epidemics is via stocking of hatchery-bred postlarvae and that wild postlarvae are free from viral infections as they have been subject to natural selection. Most of the surveyed farms (79.7%) stocked postlarvae collected from the wild, while another 17.2% depended on both wild and hatchery-bred postlarvae. Only 3.1% of the farms stocked only hatchery-bred postlarvae. The methods of collection, holding and transport are severely stressful to wild postlarvae. Postlarvae are held for long periods in the collecting gear, transfer from collecting gear to the sorting containers is carried out without adequate care, sorting water is often in poor condition and sorting is carried out in direct sunlight. The holding conditions involve very high stocking densities (1,000 PL/L without aeration), inadequate water depths (10–15 cm) in the holding facilities, use of water with high silt loads, holding for long periods without feeding and vigorous scooping to collect larvae. The following were recommended as immediate measures to reduce stress on the postlarvae:

- Remove postlarvae from the collecting gear at regular, short, time intervals.
- Instead of using a hand or a scoop-net to remove postlarvae from the collecting gear, immerse it in water in a container.
- Sort the postlarvae in a container with silt- and debris-free water from the same source from which they were collected.
- Sort the larvae under a shade.
- Hold not more than 100 postlarvae/L of water.
- Hold the postlarvae in silt- and debris-free water from the same water source from which they were collected.
- Aerate the postlarval holding tanks.
- Use tanks with a large surface area as holding facilities instead of barrels.
- Maintain a water depth of at least 30-45 cm in the holding facility.
- Siphon, rather than scoop, the postlarvae to remove them from the holding facility.
- Feed the postlarvae if they are to be kept for a long period.

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PRELIMINARY RESULTS OF THE FISH HEALTH SURVEY IN RURAL AQUACULTURE OF TIEN GIANG PROVINCE, VIETNAM

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ABSTRACT

A survey of fish health in rural, small-scale aquaculture in Tien Giang Province, southern Vietnam was carried out in September 1999, in co-operation with the Network of Aquaculture Centres in Asia-Pacific (NACA). There were 99 farms surveyed by questionnaire. Farms were selected from respondents to the baseline survey of the Mekong River Commission's Rural Extension Aquaculture Development Project (MRC READ Project). The socio-economic status of the farms is described in the MRC READ baseline survey report (MRC 1999). In general, farmers obtained fish seed from hatcheries or from traders. The farmers considered the quality of fish seed good, and they were able to select seed for themselves. The most important environmental problems that occurred on farms were flooding, bad water quality, acidic soil and the use of pesticides; farmers did not keep records of disease problems. Diseases occur immediately after stocking and during the cold and rainy seasons. Farmers seek advice from other farmers, as well as from government extension officers. Abnormal behaviour and appearance, as well as diseases with noticeable external clinical signs, are recognised by the farmers as criteria for sickness in fish. The most frequently observed disease was a group of ulcerative syndromes. For prevention of diseases, farmers applied a series of measures, most often as follows: careful pond preparation, provision of abundant natural food by manuring, application of appropriate stocking densities, stocking of healthy fish of a similar size, and bathing of fish in salt solution prior to stocking. When disease occurred on the farms, the following treatments were applied: use of lime and salt, feeding with antibiotics, use of local herbs for water treatment, feeding with food containing higher doses of vitamin C, use of salt solution to bath the fish, stopping water flow, applying a complete water exchange and moving the fish to another pond. The average cost of the treatments applied was 64,400 Vietnamese Dong (VND) (US$4.60), the maximum was 200,000 VND (US$14.30) and the minimum was 5,000 VND (US$0.35). Traditional methods of treatment using various medicinal herbs were frequently applied. Preliminary results show that diseases can play an important role in small-scale aquaculture, but that this role is often not recognised due to a lack of knowledge

and veterinary backstopping services. Attention should be paid to the high prevalence of ulcerative diseases.

INTRODUCTION

There are few data available on the status and importance of fish diseases in small-scale aquaculture of the Mekong Delta of Vietnam. Earlier findings of the West-East-South (WES) Project in two provinces of the Mekong Delta suggested that in spite of low intensity of production, diseases may play an important role in small-scale aquaculture (Jeney *et al.* 1998). The Mekong River Commission's Rural Extension for Aquaculture Development in the Mekong Delta Project (MRC READ Project) is being implemented in Cambodia and Vietnam. Tien Giang Province is the project site in Vietnam. Following the baseline survey of the project, it was decided to join the regional initiative of the Network of Aquaculture Centres in Asia-Pacific (NACA) by implementing the fish health management survey in the project area. Preliminary results of the survey are presented here.

SURVEY METHODS

The objective of the survey was to collect information on the impact of disease on production of fish in the small-scale aquaculture systems of Tien Giang Province. A questionnaire was prepared, and the survey was carried out over a period of two weeks (6-17 September 1999) in seven districts of Tien Giang Province. The original survey form provided by NACA contained two parts. The first part gathered data on the socio-economic circumstances of the farmers and the production techniques that are employed. Since the farmers were selected from 361 respondents of the MRC READ Project baseline survey of the previous year, data on their overall socio-economic status and production practices were retrieved from the baseline survey. The second part of the survey form contained 64 questions relating to health issues, management, knowledge and contact with extension services and other forms of assistance. If specific diseases were mentioned, an additional form was completed; this contained questions relating to prevalence, frequency, farmers' perceptions and knowledge of disease, treatments applied and types of assistance available. Ninety-nine forms were completed.

RESULTS

The overall socio-economic status of the respondents is described in the baseline survey report (MRC 1999). Of the 99 farms surveyed, 53 practised fish culture in ponds, 26 practised the "VAC-model" ("vuon-ao-chuong" or "garden-pond-pigsty," integration of aquaculture with gardening and livestock), and 20 practised integrated rice-fish culture. Tilapia (*Oreochromis niloticus*), Java barb (*Barbodes gonionotus*), giant gourami (*Osphronemus gourami*), common carp (*Cyprinus carpio*), hybrid catfish (*Clarias gariepinus* x *C. macrocephalus*), silver carp (*Hypophthalmichthys molitrix*) and sutchi catfish (*Pangasius hypophthalmus*) are the most widely cultured species in the province. The average age of the farms was 7.1 years, the oldest being 20 years and the youngest being three years.

The reasons for growing fish are presented in Table 1. The majority of farmers grow fish for income (41 responses); the other first-ranked reasons were for food (23) and hobby (29). The second-ranked response (47) most often given was for food. The third-ranked reason was hobby (27), and the fourth-ranked reason was status (34 responses).

Table 1. Reason for growing fish (total number of farmers surveyed = 99).

Ranking:	1 (N)[1]	2 (N)	3 (N)	4 (N)	5 (N)
Income	41	19	26	7	0
Food	23	47	24	2	0
Hobby	29	22	28	14	1
Status	3	3	9	34	10
Others	0	0	0	0	0

[1]N = number of farmers giving reason.

Problems Faced by Farmers

Farmers were asked to rank, in order of significance, the problems that they encountered (Table 2). The major problem was flooding, followed by theft. Disease was ranked fourth, and too little water was ranked sixth. Predation figured highly in the second and third ranking.

Table 2. Problems encountered by farmers (total number of farmers surveyed = 99).

Ranking:	1 (N)[1]	2 (N)	3 (N)	4 (N)	5 (N)	6 (N)
Too little water	6	7	2	11	10	13
Too hot	2	4	10	5	5	7
Too cold	0	1	1	9	14	7
Theft	18	24	11	10	9	2
Disease	4	6	5	13	12	13
Predation	6	24	27	11	3	1
Flooding	34	9	6	4	2	4

[1]N = number of farmers reporting problem.

Farmers' Perceptions of Aquaculture

Farmers' responses when asked what they thought about aquaculture are presented in Table 3. The majority of farmers considered aquaculture to be profitable and to have high status; only a few farmers acknowledged that aquaculture is a risky business. Disease was also seen as an important issue, but not in small-scale farms.

Availability and Quality of Fry

Half of the farmers said that they were able to choose fry (52), while the other half (46) must take what is available. The same tendency was observed in the question about the physical condition of the fry: 54 farmers said the fry were healthy, while the remainder (45) did not know.

Table 3. Farmers' perceptions of aquaculture (number of farmers responding = 99).

	Agree (N)[1]
Aquaculture is a risky business	7
Aquaculture is profitable	98
Aquaculture has high status	67
Aquaculture is only profitable for large-scale farmers	44
Disease is an important issue	53
Disease doesn't occur in small-scale farms	47

[1]N = number of farmers agreeing with statement.

Disease Occurrence

Of the 99 farmers interviewed, 24 reported that they had experienced disease problems in the last year, seven had problems in the last four months and two had problems in the last month. The majority of farmers (52) had disease problems, but could not remember when. The outcome of the majority of the problems encountered was that "some" of the fish died; only three farmers reported that "all" the fish died. The significance of the disease to the household, as felt by the farmers, is indicated in Table 4.

Table 4. Economic results of fish disease problems (total number of farmers surveyed = 99).

Response	Yes (N)[1]	No (N)
Reduced price at market	12	46
Increased debt	12	46
Reduced household income	44	15

[1]N = number of farmers responding.

Disease Patterns

Farmers were asked if they associated any particular pattern with the disease occurrence (see Table 5). According to the farmers, most of the diseases occurred after stocking, as well as in the cold and rainy seasons.

Table 5. Pattern associated with the disease (total number of farmers surveyed = 99).

Pattern	(N)[1]
During dry season	14
During rainy season	20
During hot season	9
During cold season	23
Just after stocking	27
Just before harvesting	4
Just after drought	12
Others	0

[1]N = number of farmers responding.

Farmers were asked if the occurrence of disease changed their attitude towards aquaculture (Table 6). Disease problems did not change their attitude towards aquaculture, but they considered changing the species cultured.

Table 6. Did the problem result in a change in attitude towards aquaculture? (total number of farmers surveyed = 99).

Response:	Yes (N)[1]	No (N)
Resistance to continuing aquaculture	3	56
Stopped aquaculture	4	56
Change species	27	33
Reduced importance	1	59
Stopped promoting aquaculture	5	53
Other	20	1

[1]N = number of farmers responding.

Information Sources

Farmers were asked if they contacted anyone when they had a problem. Fifty percent said that they did, and the greatest number (39) contacted other farmers for information. Thirty-six farmers contacted government extension officers, 31 contacted drug and chemical salespersons, 25 contacted hatchery owners, 20 contacted fry traders, and only one contacted nongovernmental organizations (NGOs). When a request for assistance was made, 41 farmers said that response was prompt, 11 said that it was slow, and none said that no response was received. Government extension officers were considered to be the most useful source of information, with hatchery owners being the second most useful. Drug and chemical salespersons and fry traders were also considered good sources of information.

Disease Recognition

Farmers were asked about their ability to recognise disease. Thirty-one farmers said that they could recognise some diseases, while 28 said that they could not recognise any disease. No farmer said that he/she could recognise all or most diseases. The ability to recognise disease was based on a number of factors; the most frequently cited were mortality, abnormal behaviour, abnormal appearance and reduced growth.

Response to Disease

Farmers were asked what they did in response to disease. Forty-eight farmers said that they sought help, 47 attempted treatment and 21 did something else (not specified). Ten farmers said that they carried out emergency harvest, while 11 farmers did nothing. If treatment was attempted, it generally involved the use of chemicals (36) or antibiotics (35); 29 farmers changed water, 16 stopped feeding and 12 stopped fertilising. Farmers said that they learned about these treatments from government extension officers (35 responses), other farmers (34), hatchery owners (34), drug salespersons (31), fry traders (31) and feed sales persons (20).

Types of Disease Problems

The most common problems reported are listed in Table 7.

Table 7. Problems reported and the age of fish affected.

Disease	Frequency	Average Age of Fish (days)
Bad water quality, fish gasp	3	110
Black discoloration	3	87
Ulcers	20	233
Ulcers	3	88
Deformed head (catfish)	3	80
Loss of mucus	2	150
Parasites	6	92
Swollen belly	3	45/260
White discoloration	4	115

Disease did not seem to cause catastrophic losses; a large number of the farmers (38) reported that only a few fish died. There were, however, 11 cases reported where most of the fish died. As the losses were measured by mortalities, it is not possible to estimate the loss of production due to reduced growth.

Treatment

A diverse number of treatments were reported, many in multiple combinations. Liming was the most common treatment, in combination with antibiotics. Copper sulphate, salt and malachite green were also applied. Information on the cost of treatments is included in Table 9.

The average cost of the treatments applied was 64,400 VND (US$4.60), the maximum was 200,000 VND (US$14.30), and the minimum was 5,000 VND (US$0.35). Only six farmers said that the treatment was "always" successful; 23 farmers said that it was "sometimes" successful, 21 said that it was "usually" successful and four said that it was "never" successful.

Farmers generally used two or more chemicals at a time for any disease problem, according to the recommendation of chemical suppliers. Farmers learned about the treatment that they used from government extension services (32 responses), chemical salespersons (30), other farmers (28) fry traders (15), feed salespersons (10) and hatchery owners (8). Six farmers reported that they learned the treatments themselves.

Traditional methods of treatment are presented in Table 10.

Table 9. Treatments and costs.

Treatment	Frequency	Estimated Cost (VND)[1]
Antibiotic	4	60,000
Antibiotic, copper sulphate, change water	1	70,000
Antibiotic, lime, salt, change water	1	100,000
Antibiotic, malachite green	1	50,000
Antibiotic, move fish to other pond	1	200,000
Antibiotic, salt, lime	1	100,000
Antibiotic, spread lime, salt	1	100,000
Change water, lime, antibiotic	1	20,000
Change water, lime, salt	1	30,000
Change water, lime, salt, antibiotic	1	30,000
Copper control, antibiotic, vitamin, change water	1	100,000
Copper control, vitamin, antibiotic	1	100,000
Copper sulphate, antibiotic	1	100,000
Copper sulphate, antibiotic	2	100,000
Copper sulphate, antibiotic, change water	1	100,000
Decrease stocking density, lime, antibiotic	1	150,000
Herbs	2	0
Herbs, antibiotic	1	50,000
Lime	3	14,000
Lime, antibiotic	4	50,000
Lime, antibiotic, bath fish	1	40,000
Lime, antibiotic, herbs	1	20,000
Lime, antibiotic, salt	2	32,500
Lime, bath fish, antibiotic	1	20,000
Lime, change water, cut trees covering pond	1	15,000
Lime, cut tree covering pond, antibiotic	1	10,000
Lime, salt, change water	1	40,000
Lime, urea & salt	1	150,000
Malachite green, antibiotic, move to other pond	1	100,000
Move to other pond	1	50,000
Stop changing water, salt, antibiotic	1	60,000
Vitamins	1	30,000
Vitamins, copper sulphate, change water	1	50,000

[1]1 US$ = 140 VND.

Table 10. Traditional treatments (treatments are grouped according to separate disease signs as described by the farmers. If more than one treatment is applied, they were ranked by their importance).

Group of Clinical Signs	Ranking of Treatments by Importance			
	1	2	3	4
Red gill & fungus	Use herb			
Black body	Use salt, herb ("xoan," "giac" leaf)[1]			
Ulcers in giant gourami	Use herb ("xoan"leaf)	Stop water exchange	Use salt solution (3%)	
Dark body in giant gourami	Use herbs deep into pond			
Ulcers	Use herbs deep into pond			
Ulcers	Use herbs	Bath/immerse fish with salt solution	Manuring to keep water colour	Don't change water in flood season
Black/dark body	Use herbs	Treat water using lime	Change water	Cut trees & grass around pond
Ulcers	Use herbs	Keep water green	Put salt into the pond	Spread lime into the pond
Ulcers	Use herb			
Swollen belly in hybrid catfish	Treat water using lime	Bath fish with salt solution		
Ulcers	Treat water using lime	Manuring to keep water green	Use herbs	Bathe fish with salt solution
Black/dark body	Spread salt on pond, don't feed	Use herbs		
Ulcers	Manuring to keep green water	Use herbs		
Ulcers	Manuring to keep green water	Spread lime	Use herbs	
Ulcers	Keep water green	Use herbs	Bathe fish with salt solution	Treat water using lime
Ulcers, fish gasp	Immerse fish in salt solution	Use herbs	Spread lime	Change water frequently
Swollen belly	Change water, keep environment clean			
Fish gasp because of parasite	Change water, bathe fish with salt solution	Spread lime on pond	Use herbs	
White tail fin, fish gasp	Change water & use lime	Keep water clean	Keep water not too cold	
White tail fin	Change water	Spread salt on pond		

[1]"Xoan" and "giac" are the Vietnamese names for *Melia azaderach* and *Tetrastigma strumarium*, respectively.

The average cost of these treatments was US$0.96, with a minimum of US$0.35 and a maximum US$2.14. The majority of the farmers learned about these treatments from other farmers (21). Some of them (12) learned from government extension officers, fry traders (5) and chemical traders (4). Nine farmers reported that they knew about treatments from their own experience.

Occurrence of Disease

Farmers were asked when diseases were last seen. As can be seen from Table 11, the majority of diseases were reported to have occurred within the last year.

Table 11. When disease was last seen.

	Do not Know	Last 2 Months	Last 4 Months	Last 8 Months	Last Year
Total	6	1	5	2	35

Frequency of Disease

Farmers were asked how often these diseases were seen, and their response was that most were seen every year, but not more frequently. When asked when in the growing cycle the disease occurred, the farmers reported no distinct pattern of disease occurrence. However, as can be seen from Table 12, the cold and wet seasons were cited as the most likely times for disease to occur, as well as the period after stocking fry.

Table 12. When in the growing cycle disease is likely to occur (total number of farmers surveyed = 99).

Dry Season	Wet Season	"Winter"	After Stocking	Just Before Harvest	Other
7	11	18	13	3	1

Lost Production

Farmers were asked if they had lost production due to disease. The frequency of occurrence of lost production and the cost of additional inputs to control the ulcerative diseases were remarkable. Farmers' estimated the value of lost production in a year at 569,588 VND (US$40.7) on average (N=44), and the cost of additional inputs to control the disease at 2,624,643 VND (US$187.5) on average (N=29).

Farmers were asked if they would eat fish from a pond with sick fish. Thirty-one replied that they would, and 14 replied that they would not.

CONCLUSIONS

The results of this survey show that disease can play an important role in small-scale aquaculture, but that this role often not recognised, due to lack of knowledge and veterinary backstopping services. Attention should be paid to the high frequency of certain ulcerative diseases. Further studies are needed to better understand the importance of fish diseases and to elaborate plans for development of fish health management systems in the area.

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SOCIAL AND ECONOMIC IMPACTS OF DISEASE IN INLAND OPEN-WATER AND CULTURE-BASED FISHERIES IN INDIA

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ABSTRACT

The inland fishery resources of India (e.g., rivers, wetlands, lakes, reservoirs and ponds) have a rich production potential; however, sub-optimal water quality or detrimental ecological conditions have limited their fish production. Although, in general, reports of fish kills are not properly documented in India, outbreaks of epizootic ulcerative syndrome (EUS) initiated establishment of a disease surveillance and monitoring system for the country. Assessment of disease impacts is hampered by inadequate baseline data on fish production and market intelligence statistics. Thus, an economic evaluation of fish losses is also difficult. In this paper, the results of investigations conducted on these aspects are presented, and the socio-economic impacts of EUS are described through a case study made at three levels viz., the producers, the fish traders and the consumers. The extent of fish and monetary losses suffered as a result of EUS are estimated, the effects on fish consumption and trade assessed, and the role of the media during disease outbreaks examined.

INTRODUCTION

The inland fisheries resources of India are noted as much for their heterogeneity in composition as for as their opulent productive potential. India is endowed with a vast expanse of open inland waters in the form of rivers, canals, estuaries, lagoons, reservoirs, lakes, ponds, tanks etc. (see Table 1).

Table 1. Inland fishery resources of India.[1]

Type	Quantity
Rivers and canals	45,000 km + 126,334 km
Reservoirs	3.15 million ha
Estuaries	2.7 million ha
Floodplain wetlands	0.24 million ha
Pond and tanks	2.25 million ha

[1]Data from Sinha (1999).

Although the vast and varied inland fishery resources of India have a rich production potential, this potential has not been achieved. The production potential of the major river in India, the Ganga, in its lower reaches, is estimated at 198.3 kg/ha/yr, whereas the actual fish yield is 30.0 kg/ha/yr, and thus, only 15.2% of the potential is harvested (Sinha 1999). At the present level of management, the yield from the Indian reservoirs, on average, is about 30 kg/ha, whereas a production of 50-100 kg/ha can be easily achieved from large and medium reservoirs, while the small reservoirs have the potential to yield 100-300 kg/ha. The floodplain wetlands, commonly called beels in India, have a rather poor yield, 100-300 kg/ha, against a production potential of 1,000-1,800 kg/ha/yr through scientific management. The present average productivity from aquaculture ponds and tanks is 1,830 kg/ha/yr against a much larger potential.

ECOLOGICAL STATUS OF THE WATER BODIES AS GOOD HABITAT FOR FISH

Most of the rivers and their tributaries, the floodplain wetlands (beels and bheries), and the lakes, reservoirs and small water bodies have either sub-optimal water quality or detrimental ecological conditions that limit their production. The rivers, due to water extraction, siltation and, in many cases, sewage or factory effluents discharge, have become degraded as fish habitat, and quite obviously, there is mortality and decline in fish production. There are various reports of fish mortality from the different regions of the country (Table 2).

Table 2. Reports of mass mortalities of fish in India.

Place	Year	Cause	Source
Kalukaria Lake, Ahmedabad	1982	domestic waste	Varandani and Oza 1985
Naini Lake, Nainital	1980-81	domestic waste	Joshi 1994
River Gomti, Lucknow	1983, 84, 86	distillery waste	Joshi 1994
River Chahar, Alwage	1974	pesticide	Joshi 1994
River Tingabhadra, Harihar	1984	polyfibre, rayon	Murthy 1984
River Ganga, Monghyr	1968	oil refinery	Sunderesan *et al.* 1983
River Adyar, Madras	1981-82	tannery	Joshi 1994
Rihand Reservoir	1970, 78, 80	chemical factory thermal effluent	Arora *et al.* 1970 Panwar *et al.* 1979 Chandra *et al.* 1985
River Gomti, Tripura	1988	epizootic ulcerative syndrome (EUS)	Das and Das 1993
River Shella, Meghalaya	1988	EUS	Das 1999
River Churni, West Bengal	1997	distillery waste	M.K. Kukhpadhyay (pers. comm.)
River Yamuna, Haryana	2000	sudden increase in turbidity	Anon. 1999
River Burhi, Gandak, Bihar	2001	sugar mill effluents	Alam *et al.* 2001

The floodplain wetlands (beels and bheries), the second-most important inland resource in India, are located in the states of West Bengal and Assam, and are mostly in various stages of eutrophication, the majority of them choked with submerged or floating vegetation and having sub-optimal water quality (Sugunan and Bhattacharjya 2000). This has affected the general fish health condition, and most fishes are stressed and have retarded growth. The water quality of Garapota Beel, a typical wetland fairly representative of the ecological status of such water bodies in India, is given in Table 3. The dissolved oxygen (DO) level is reduced to nearly 3.5 mg/L around 10 PM at night, and remains below this level for nearly eight hours, causing stress to resident fish. Moreover, un-ionised ammonia levels are in the range of 0.05-0.25 mg/L, which also act as a stress factor. As a result, the normal growth of fish has been affected, and the average yield of fish from this beel was 550 kg/ha.

Table 3. Physico-chemical characteristics of Ganrapota Beel during 1991.[1]

	Range	Diurnal Variation of Water Quality Parameters											
		10 AM	12 PM	2 PM	4 PM	6 PM	8 PM	10 PM	12 PM	2 AM	4 AM	6 AM	8 AM
Temp[2]	26-36	22.5	24.0	24.5	24.0	22.0	21.0	21.5	20.5	20.5	21.5	22.0	22.5
Alk	133-212	212	214	201	206	214	209	212	210	209	210	215	210
Hard	120-199	195	199	187	190	193	195	198	198	190	197	199	196
Amm	0.05-0.25	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1
CO_2	1.0-8.0	1.0	1.0	1.0	1.0	1.5	1.0	1.5	2.0	2.0	2.0	1.5	1.0
Chl	3.7-9.5	7.5	7.0	7.8	6.9	7.2	7.5	7.5	7.3	7.4	7.9	7.8	7.0
DO	6.0-9.0	6.5	8.0	9.0	9.0	7.5	5.2	3.5	3.0	2.0	2.0	2.0	3.0
pH	7.8-8.0	8.0	8.0	8.1	8.0	8.0	8.0	7.9	7.9	8.0	7.8	8.0	8.0

[1]Data from Das (1999).
[2]Temp=temperature (°C), Alk=alkalinity (mg/L), Hard=hardness (mg/L), Amm=un-ionised ammonia (mg/L), Ch=chloride (mg/L), DO=dissolved oxygen (mg/L).

In West Bengal, the sewage-fed bheries where fish are reared in nearly 4,000 ha of water area can be cited as an example where, although it is a unique and inexpensive system of rearing fish, the ecological conditions limit the average production to only 1,500 to 2,000 kg/ha (Patnaik 1990). A picture of the water quality in these bheries is presented in Table 4 to emphasise the point that the water quality is creating stress to fish. Here the high microbial consumption of dissolved oxygen (1.8 mg/L/hr) indicates exhaustion of DO for a few hours at night, creating stressful conditions for fish. Moreover, un-ionised ammonia levels are also high.

Table 4. Environmental parameters of sewage-fed wetlands (average values).[1]

Parameter	Maligada Bheri	Beel Samity	Kathore Bheri	Tripley Bheri	Agamura Bheri	Barachak Bheri
Transparency (cm)	17	21	15	18	25	20
pH	8.6	8.5	8.6	9.0	8.3	8.3
Alkalinity (mg/L)	125	126	127	147	127	114
Hardness (mg/L)	3,000	3,000	2,800	3,200	11,000	2,300
Un-ionised ammonia (mg/L)	1.1	0.5	0.3	0.2	0.1	0.4
Salinity (ppt)	9.0	10.2	6.4	7.0	9.0	10.0
Microbial O_2 consumption (mg/L/hr)	-	1.8	-	-	-	-

[1]Data from Das (1994).

OCCURRENCE OF FISH DISEASES IN THE INLAND WATERS OF INDIA, WITH SPECIAL REFERENCE TO EPIZOOTIC ULCERATIVE SYNDROME

At the very outset, it must to be mentioned that reports of fish mortalities occurring in the water bodies of India are infrequent. The reason for this inadequate reporting is that the monitoring of such information has yet to find a place in the framework of fisheries management practices prevailing in the country. However, with the outbreak of epizootic ulcerative syndrome (EUS), a system of disease surveillance and monitoring was initiated in a structured manner, and reports have been obtained. Table 5 summarised information on the occurrence of EUS in India.

Table 5. Summary Data for outbreaks of EUS in India.

Range in Prevalence (%) by Affected Fish Species		Range in Prevalence (%) by Geographic Area (in All Species Affected)	
Species	**Prevalence**	**State**	**Prevalence**
Channa spp.	20-100	Assam	30-60
Puntius spp.	5-100	Tripura	35-70
Glossogobius spp.	10-60	Meghalaya	10-35
Mystus sp.	5-75	West Bengal	15-65
Notopterus spp.	3-25	Bihar	20-30
Wallago attu	7-20	Orissa	20-45
Mastacembelus spp.	10-35	Uttar Pradesh	15-20
Anabas testudineus	10-55	Tamil Nadu	5-25
Amblypharyngodon mola	5-10	Maharashtra	5-10
Rhinomugil corsula	1-5	Kerala	30-65
Clarias batrachus	10-30		
Heteropneustes fossilis	10-20		
Catla catla	5-15		
Labeo rohita	5-10		
Cirrhinus cirrhosus	5-20		
Cyprinus carpio	10-25		
Ctenopharyngodon idellus	2-5		

[1]Data from Das (1994).

An important investigation of fish diseases in India was carried out by Paria and Konar (1999) in West Bengal in 1994-96. The survey included 17 districts, covering a total of 1,332 impounded water bodies selected at random. Estimates of the prevalences of various diseases seen in the ponds are given in Table 6. The prevalence of EUS ranged from 32.7 to 72.7%; argulosis, from 0.8 to 9.8%; malnutrition, from 10.0 to 32.3%; gill rot, from 8.3 to 34.4%; dropsy, from 3.3 to 14.4%; tail and fin rot, from 2.4 to 10.4%; tumours, from 0.8 to 7.3% and fungal diseases, from 1.1 to 2.2%.

Table 6. Estimates (%) of disease in infected ponds in West Bengal.[1]

District	Argulosis	Mal-nutrition	EUS	Gill rot	Dropsy	Tail & fin rot	Tumors	Fungi
Darjeeling	0	18.2	72.7	9.1	0	0	0	0
Cooch-Behar	7.3	14.5	52.7	10.9	7.3	0	7.3	0
Jalpaiguri	1.7	21.7	58.3	8.3	3.3	5.0	0	1.7
Uttar-Dinajpur	1.7	20.0	46.7	15.0	11.7	5.0	0	0
Dakshin Dinajpur	3.2	10.0	71.0	6.4	0	6.4	3.2	0
Malda	0	31.5	46.1	1.4	5.6	3.4	0	1.1
Murshidabad	0.8	32.3	45.4	10.8	7.7	3.1	0	0
Birbhum	0	24.6	36.4	24.6	5.9	7.6	0.8	0
Purulia	0	14.6	35.4	34.4	5.2	10.4	0	0
Burdwan	9.8	27.5	32.7	13.1	5.2	9.8	2.0	0
Bankura	4.4	11.7	40.9	29.2	5.8	3.6	2.2	2.2
Midnapore	1.2	22.0	41.7	15.8	12.6	5.1	1.6	0
Hooghly	4.3	12.8	50.0	17.0	9.6	4.2	2.1	0
Howrah	0.8	14.6	53.7	19.5	5.1	2.4	3.3	0
Nadia	0	22.9	42.4	11.0	14.4	4.2	5.1	0
Parganas (North)	3.6	10.9	54.3	9.4	13.0	6.5	2.2	0
Parganas (South)	0.8	14.6	60.0	12.3	7.1	3.1	1.6	0

[1]Data from Paria and Konar (1999).

Assessment of the Impact of Fish Diseases in India

One of the major factors limiting assessment of the impact of specific disease outbreaks is inadequate baseline data on the production figures for different fish species caught from inland waters. This weak database on inland fisheries resources has been one of the serious constraints that has plagued the development process. Even market intelligence statistics suffer from various drawbacks due to the disposal of an appreciable quantity of catch directly from the primary producers to consumers. This is precisely the reason that limits evaluation of production losses in India due to disease and other causes. However, a picture of the decline in production due to EUS was obtained from a case study conducted at the Jorhat Fish Assembly Centre in Assam, India to evaluate the damage caused by the disease to fisheries of the Brahmaputra river system (see Das 1994) (Table 7).

The little information that is available from some Indian states on the economic impact of fish losses due to EUS is given in Table 8.

A very interesting and significant investigation by Bhaumik *et al.* (1991) serves as a case study on the impact of EUS on society in India. Generally, during an outbreak of disease, society is affected at three levels, the producers, the fish traders and the consumers. Thus, it is essential to collect information on the following three aspects: (i) the socio-economic conditions of the fish farmers and extent of suffering caused by disease, (ii) the impact of disease on the fish traders and consumers, and (iii) the role of the communications media in the creation of mass awareness.

Table 7. Species-wise landings (kg) of EUS-affected fish during 1987-91 and percentage increase or decrease (in parentheses) relative to 1987-88 landings.[1]

Species or Species Group	1987-88 Total	1988-89 Total	1989-90 Total	1990-91 Total
Puntius spp.	34,804	12,696 (-63.5)	3,623 (-89.6)	10,401 (-70.1)
Amblypharyngodon mola	22,616	7,712 (-65.9)	14,153 (-37.4)	6,601 (-70.8)
Labeo rohita	17,316	6,350 (-63.3)	8,170 (-52.8)	8,823 (-49.0)
Catla catla	13,046	8,434 (-35.4)	8,029 (-38.5)	8,151 (-37.5)
Puntius sarana	5,100	9,359 (+83.5)	4,072 ((-20.2)	5,097 (-0.1)
Cirrhinus cirrhosus	2,089	702 (-66.4)	1,499 (-28.2)	908 (-56.5)
Labeo bata	1,701	783 (-54.0)	219 (-87.1)	651 (-61.7)
Heteropneustes fossilis	13,848	13,816 (-0.2)	22,333 (+61.3)	18,291 (+32.1)
Mystus sp.	7,006	5,219 (-25.4)	3,228 (-53.1)	5,067 (-27.7)
Ompok spp.	5,009	3,683 (-26.5)	1,926 (-61.5)	2,065 (-58.8)
Channa punctata	30,091	4,649 (-84.6)	1,829 (-93.9)	2,622 (-91.3)
Channa striata	22,332	2,777 (-87.6)	3,941 (-82.4)	3,406 (-84.7)
Channa marulius	8,079	4,309 (-46.7)	7,992 (-1.1)	7,419 (-8.2)
Anabas testudineus	10,189	5,963 (-41.5)	15,555 (+52.7)	13,142 (+29.4)
Colisa spp.	1,888	805 (-57.4)	871 (-53.9)	2,095 (+11.0)
Nandus nandus	2,816	500 (-82.2)	62 (-97.8)	150 (-94.7)
Gudusia chapra	100	883 (+783.0)	339 (+239.0)	376 (+276.0)

[1]Data from Das (1994).

Table 8. Economic losses due to EUS outbreak.[1]

State	Year	Economic Loss (Rs million)[2]
Bihar	1990	4.8
Orissa	1989-1991	3
Kerala	1991-1992	20

[1]Data from Das (1994).
[2]1US$ = approximately Rs 31.

The study was carried out in five districts of West Bengal, involving producers, traders and consumers. Under each district, there are a number of Community Development (CD) Blocks to facilitate developmental activities. In this study, at the producer level, two such CD blocks where maximum water resources exist were selected from each district. A list of fish farmers was prepared, and 500 farmers who were randomly selected from the list constituted the study sample (Table 9). At the trader and consumer levels, the study categorised the data into three sectors: urban, suburban and rural areas. A total of three markets was selected for each, and drawing a sample of 22 from each, a total of 198 fish traders and consumers was selected. All clientele were personally interviewed using a structured schedule developed for the purpose. For assessing the extent of consumption, scores of 3, 2 and 1 were assigned to "most often," "often" and "sometimes," respectively. To study the role of communications media in the creation of mass awareness of the disease, scores of 3, 2 and 1 were assigned to most "effective," "negligible" and "never, respectively. On the basis of the frequency of the responses given, these were finally ranked.

Table 9. Distribution of a sample of 500 respondents questioned on the occurrence and impacts of epizootic ulcerative syndrome.[1]

Category	Number (%)	Break-down by of Type of Fish-farming Operation		
		Traditional	Semi-scientific	Scientific
Respondents affected by EUS	365 (73.0)	176 (48.2)	129 (35.4)	60 (16.4)
Respondents not affected by EUS	135 (27.0)	48 (35.6)	65 (48.1)	22 (16.3)

[1]Data from Bhaumik *et al*. (1991).

Extent of the effect of EUS

The fish species most severely affected by EUS were predominantly bottom-dwelling fishes, like murrels and air-breathing catfishes; other miscellaneous fishes (*Puntius* sp., *Nandus* sp. etc.) were also affected. It is interesting to note that in all ponds under a traditional system of culture where both desirable and undesirable varieties of fish occur, murrels were affected at the first stage of the outbreak, followed by miscellaneous fishes and finally by the carps. In scientifically and semi-scientifically managed ponds where piscicides were used to control predatory fish, the carps were affected at the start of outbreak, since no other fishes were present (Bhaumik *et al.* 1991). The respondents also reported the presence of the disease in more than one species in their ponds. Thus, the pooled data for traditional, semi-scientific and scientific culture operations (see Table 10) indicate that the effects of EUS were maximal on carps (311 responses), followed by miscellaneous fishes (300 responses), catfishes (191 responses) and murrels (186 responses). The effect on carps appears to be most pronounced here due to the fact that most of the ponds belong to the semi-scientific and scientific management categories where the total population of fish cultured consists of carps, whereas in the traditional system carp comprise only a fraction of the total fish cultured.

A maximum number of respondents (154) indicated that the amount of fish lost was between 31 and 40% of the total crop (Table 10), while mortality of the fish crop was reported from the ponds of 17 respondents; in other words, no fish could be harvested from these ponds (Bhaumik *et al.* 1991). The pecuniary loss suffered by the affected fish farmers was most frequently in the range of Rs 1,001 to 5,000 (213 respondents), followed by Rs 5,001 to 10,000 (72 respondents) (1 US$ = Rs 31). A number of respondents (17) expressed that during the rest of the season they had to search for alternative sources of livelihood, since they had completely lost their fish crop. All of the respondents univocally expressed the need for financial assistance to restore aquaculture and to get relief from the losses incurred due to the disease.

Table 10. Extent of the effect of epizootic ulcerative syndrome on the 365 respondents who reported disease outbreaks.[1]

Characteristic		Frequency of Response (N=365)	Percentage of Total Respondents
Species affected	a) murrels	186	50.9
	b) catfishes	199	51.8
	c) misc. fishes	300	82.2
	d) carps	311	85.2
Extent of loss of fish in water body (% total crop)	a) 1-10	14	3.8
	b) 11-20	47	12.9
	c) 21-30	106	25.0
	d) 31-40	154	42.2
	e) 41- 50	27	7.4
	f) >50	17	4.6
Pecuniary loss (Rs)[2]	a) 100-1,000	47	12.9
	b) 1,001-5,000	213	58.4
	c) 5,001-10,000	72	19.7
	d) >10,000	33	9.0

[1]Data from Bhaumik *et al*. (1991).
[2]1 US$ = 31Rs.

Effect of epizootic ulcerative syndrome on fish consumption

Table 11 indicates that a maximum number of respondents (88) consumed fish "often" in the sampled areas. The consumption behaviour before the outbreak was found to be maximal in the suburban sector, followed by the urban sector and the rural sector (scores of 163, 157 and 122, respectively). Most consumers liked carp (115), followed by miscellaneous small fishes (35). Consumers in rural areas had somewhat more affinity for murrels and catfishes as compared to consumers from urban and suburban areas.

The study revealed that the frequency of fish consumption declined due to the outbreak of EUS. Only 15.1% of the sample consumed diseased fish, with the majority of these respondents belonging to the rural sector. The consumption rate was found to be decreased by 28.7, 23.3 and 20.5% in the urban, suburban and rural sectors, respectively. A maximum number of the respondents who used to consume fish "most often" (78) and "often" (88), changed their habit of fish consumption to "sometimes" (90), and their preference was restricted mainly to healthy carps. Most of the respondents declined to purchase even healthy fish when these were kept along with diseased fish in the markets. Again, excepting rural markets, respondents expressed their apathy towards purchase of diseased fish, even if these were sold at a cheaper rate.

A maximum number of respondents expressed that they did not like to consume diseased fish due to "hatred" (120), followed by "fear of transmission of disease" (38) and "unknown fear" (10), even including fear of death. A negligible percentage of consumers showed a change of habit in the consumption of marine fish during the affected period. Thirty-seven percent of the respondents expressed their anxiousness about the disease, and they tried to obtain information regularly from various sources. No occurrence of any disease was reported in the sample of respondents who consumed or handled the diseased fish.

Table 11. Effect of epizootic ulcerative syndrome on fish consumption.[1]

Variable	Dimension	Urban (U)	Sub-urban (SU)	Rural (R)	Total[4]
Fish consumption habit before disease outbreak[2]	Most often	28 (42.4)[3]	33 (50.0)	17 (29.8)	78 (39.4)
	Often	35 (53.1)	31 (47.0)	22 (33.3)	88 (44.4)
	Sometimes	3 (4.5)	2 (3.0)	27 (40.9)	32 (16.2)
Fish consumption habit after disease outbreak[2]	Most often	12 (18.2)	16 (24.3)	12 (18.2)	40 (20.3)
	Often	22 (33.3)	27 (40.9)	19 (28.8)	68 (34.3)
	Sometimes	32 (48.5)	23 (34.8)	35 (53.0)	90 (45.5)
Comparison of consumption behaviour	Consumption score before outbreak	157	163	128	-
	Consumption score after outbreak	112	125	97	-
	% decrease	28.7	23.3	20.5	24.4
Fish preferred for consumption[1]	Carp	49 (74.2)	43 (65.2)	23 (34.8)	115 (58.1)
	Murrel	2 (3.0)	6 (9.1)	16 (24.3)	24 (12.1)
	Marine/ brackishwater fish	4 (6.1)	9 (13.6)	2 (3.1)	15 (7.6)
	Catfish	1 (1.5)	2 (3.0)	6 (9.1)	9 (4.5)
	Miscellaneous small fishes	10 (15.2)	6 (9.1)	19 (28.8)	35 (17.7)
Consumption of diseased fish	Most often	0	0	0	0
	Often	0	0	6 (9.1)	6 (3.0)
	Sometimes	0	7 (10.6)	17 (25.8)	24 (12.1)
	Never	66 (100)	59 (89.4)	43 (65.1)	168 (84.9)
Reason for not consuming[2]	Unknown fear	6 (9.1)	4 (6.8)	0	10* (6.0)
	Fear of disease transmission	23 (34.8)	15 (25.4)	0	38* (22.6)
	Hatred	37 (56.1)	40 (67.8)	43 (100)	120* (71.4)

[1]Data from Bhaumik *et al*. (1991).
[2]Subsample sizes: U (N=66), SU (N=66), R (N=66).
[3]Figures in parentheses indicate percentages.
[4]N=198 for all categories except those marked with an asterisk, for which N=168.

Impact on Fish Trade

The majority of the respondents experienced a decrease of fish sales in urban, suburban and rural markets owing to the disease outbreak (Table 12). This supports the view of the consumers as explained in Table 11. Moreover, a large number of the respondents (177) did not undertake the sale of diseased fish, as they were concerned about their business reputation (151), "lack of customers" (23) and resistance from the public towards the sale of affected fish (3). Most of the respondents suffered pecuniary loss.

Table 12. Effect of epizootic ulcerative syndrome on fish trade.[1]

Variable	Dimension	Urban (U)	Suburban (SU)	Rural (R)	Total[3]
During outbreak of EUS, fish sale (U: N=66; SU: N=66; R: N=66)	Increased	0	0	2 (3.0)[2]	2 (1.0)
	No difference	15 (22.7)	6 (9.1)	22 (33.4)	43 (21.7)
	Decreased	51 (77.3)	60 (90.9)	42 (63.6)	153 (77.3)
EUS-affected fish sale (U: N=66; SU: N=66) R: N=66)	Undertaken	3 (4.5)	7 (10.6)	11 (16.7)	21 (10.6)
	Not undertaken	63 (95.5)	59 (89.4)	55 (83.3)	177 (89.4)
Reason for not selling (U: N=66; SU: N-66; R: N=55)	Resistance from public	0	1 (1.7)	2 (3.6)	3* (1.7)
	Lack of customer	11 (17.5)	4 (6.8)	8 (14.6)	23* (13.0)
	Scared	52 (82.5)	54 (91.5)	45 (81.8)	151* (85.3)
Pecuniary loss (U: N=66; SU: N=66; R: N-66)	Suffered	47 (71.2)	63 (95.4)	66 (100)	176 (88.9)
	Not suffered	19 (28.8)	3 (4.6)	0	22 (11.1)

[1]Data from Bhaumik *et al*. (1991).
[2]Figures in parentheses are percentages.
[3]N=198 for all categories except those marked with an asterisk, for which N=177.

Role of the Media

The study revealed that the fish farmers got the maximum information on the various aspects of EUS from the communications media in the following order: radio, extension functionaries of the state fisheries departments, newspapers, extension functionaries of the Central Inland Fisheries Research Institute (CIFRI), extension functionaries of Comprehensive Area Development Council (CADC), voluntary organizations, television, and publications [see Table 13].

Table 13. Role of communications media in disseminating information about epizootic ulcerative syndrome.[1]

Source of Information	Total Score	Rank
Extension functionary of state fisheries department	357	II
Extension functionary of Central Inland Fisheries Research Institute (CIFRI)	222	IV
Extension functionary of Comprehensive Area Development Council (CADC)/Volunteer organisations	150	V
Publications	48	VII
Newspapers	316	III
Radio	566	I
Television	62	VI

[1]Data from Bhaumik *et al*. (1991).

CONCLUSIONS

In India, since, aquaculture or inland capture and culture-based fishery activities are predominantly rural based, the adverse effects of disease outbreaks are felt mainly by the poor fishermen. It is thus essential that adequate attention be given to the management of fish habitat and fish health in India. This would involve firstly, developing trained manpower and infrastructure for fish health research, diagnosis and extension; and secondly, establishing a proper network for dissemination of information on fish disease and fish health management to interested parties during disease outbreaks.

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Appendix I

Summary Report of the Asia Regional Scoping Workshop on Primary Aquatic Animal Health Care In Rural, Small-scale, Aquaculture Development

Held in

Dhaka, Bangladesh

from

27th - 30th September 1999

INTRODUCTION TO THE WORKSHOP

Background

The first training workshop of the FAO/NACA regional technical co-operation programme (TCP) project "Assistance for Responsible Movement of Aquatic Animals in Asia" was held in Bangkok from 16th - 20th January 1998. The workshop, attended by aquatic animal health experts, national co-ordinators from 21 regional countries and representatives of concerned regional and international organizations and projects, identified a number of activities designed to support the development of national strategies and Asia-wide regional technical guidelines on aquatic animal quarantine and health certification for the responsible trans-boundary movement of live aquatic animals (FAO/NACA/OIE 1998). An important issue raised during the workshop was the need to ensure that aquatic animal disease control and preventative measures are relevant to rural farmers. This issue was considered of particular importance because the majority of Asian aquaculture production comes from small-scale farms and special attention may be required to developing strategies that meet their specific needs and circumstances. Information that emerged from data collected by the DFID-supported South East Asia Aquatic Animal Disease Control Project (SEAADCP) of the Aquatic Animal Health Research Institute (AAHRI) and NACA suggested a serious under-reporting of disease in this region and a consequent lack of prevention, diagnosis and intervention. Such a problem may be due to lack of awareness, monitoring, or capacity; however, it is an indicator that avoidable losses were occurring. The effects of this on small-scale rural aquaculture development and rural livelihoods are potentially more serious than on more intensive or "industrial systems", as development of aquatic animal health management systems has traditionally been "top down", with greater attention being paid to export commodities and development of national institutions. Preventative aquatic animal health management directed at the rural, small-scale, aquaculture appears to have been less of a priority in countries in the region, despite the fact that such an approach is likely to be cost effective, focused, and beneficial to those with least access to currently available aquatic animal health services. It also follows that incursions of disease and consequent low productivity in aquaculture systems arising from poor attention to primary health care in rural aquaculture management are likely to impact on investments in poverty alleviation programmes that involve aquaculture and enhanced fisheries. Given the importance of ensuring that disease control and prevention measures provide genuine assistance to small-scale aquafarmers, and recognising the particular difficulties in: (a) the current lack of good assessments of impacts of disease on small-scale farmers and poverty alleviation programmes through rural aquaculture; and (b) the likely special need for assistance programmes which specifically address the needs of small-scale farmers and "managers" of enhanced fisheries programmes, DFID, FAO and NACA, in cooperation with AAHRI/SEAADCP, proposed a scoping workshop to review information on socio-economic impacts, risks of disease incursions and health management strategies in small-scale aquaculture and enhanced fisheries programmes and to develop a regional strategy and a framework for better health management. This report gives the outcome from this workshop.

Aquaculture Development and Trends

Aquaculture provided 28.8 million tonnes or (24%) world fishery production (excluding aquatic plants) in 1997. Most aquaculture production (17 million tonnes) originated in fresh water. Of the remainder, 10.1 million tonnes were produced in marine environments and about 1.6 million tonnes in brackishwater environments. These figures are excluding the production of aquatic plants, which amounted to 7.2 million tonnes in 1997. Global production of aquaculture continues to be dominated by China, which in 1997 accounted for more than 67% of world output. The dominant global aquaculture activity in 1997 continued to be finfish production, accounting for about 52% of total aquaculture production by weight and 57% by value. As in previous years, freshwater finfish, in particular Chinese carp, accounted for the greatest share (42%) of total aquaculture production. Aquatic plants, 70% of which come from China, were valued at nearly US$5 billion and represented almost one-quarter of total production in 1997.

Aquaculture production is carried out predominantly in low-income food-deficit countries (LIFDCs). By 1997, 29.1 million tonnes, or around 81% of world total cultured finfish, shellfish and aquatic plant production originated in LIFDCs. The contribution of this group of countries to world production has increased sharply since 1990. At 14%, between 1990 and 1997 the average expansion rate of the aquaculture sector within LIFDCs was over three times that in non-LIFDCs, which recorded 4.2% overall. It is generally agreed that capture fisheries, both marine and fresh water, are declining, or at least not expanding rapidly enough to fulfill the protein needs of the rapidly increasing populations.

Sustainable Livelihoods and Aquatic Resources Management

The primary goal of many development agencies is now focused on elimination of poverty. In 1997 the British government published a white paper on International Development, with a commitment to working towards the elimination of abject poverty (UK Government 1997). The Department for International Development, Rural Livelihoods and Environment Division concluded that the sustainable livelihood approach has the potential to play an important part in the challenge of eliminating poverty. The approach aims to better address the priorities of poor people, both directly and at the policy level. It is essentially people-centered, supporting people to achieve their own livelihood goals, whilst aiming to ensure sustainability. A livelihood comprises the assets (natural, physical, human, financial and social capital), the activities, and the access to these (mediated by institutions and social relations) that together determine the living gained by an individual or household. Sustainable livelihoods are resilient to shocks and stresses, independent of external support (or dependent upon sustainable levels of support), maintain the long-term productivity of natural resources and do not undermine the livelihoods of others. Livelihood diversification is a key survival strategy of rural households in developing countries. The management of aquatic resources (including aquaculture) is often a component of poor peoples livelihoods, characterised as terrestrial farming systems, depending on access to resources and knowledge and the returns (economic and otherwise) from available opportunities. Rural small-scale aquaculture is the extensive or semi-intensive, low-cost farming of aquatic organisms by farming households or communities, using technology appropriate to their resource base (Edwards and Demaine 1997). Production can be for household consumption, though a proportion may also be sold to generate income. Aquaculture integrated with other agricultural activities can also improve the productivity of small and marginal farms or areas of land that cannot be used for traditional agricultural activities (Townsley 1998). The activity can be more flexible than livestock production, providing opportunities to prioritise household activities. Aquaculture can be an entry point for other development initiatives due to rapid results and high acceptance. Acceptability of aquaculture among rural households is particularly high in areas with poor access to capture fisheries resources.

Health Management in Small-scale Aquaculture

Disease is defined as any impairment of normal physiological function affecting all or part of an organism. Disease encompasses genetic, nutritional and environmental as well as infectious (bacterial, parasitic, viral, fungal) diseases. Although disease diagnosis and control programmes have generally tended to focus on more intensive aquaculture systems, it is known that small-scale low input aquaculture systems are also prone to disease, however, the scale of the problem and its cost to rural households has never been quantified. It should be said that the cost to more intensive systems of aquaculture has similarly not been quantified. One of the objectives of this workshop is to shed some light on the scale of the existing aquatic animal disease problems, indicating if they are a constraint to development or a threat to rural livelihoods. There is also the opportunity to identify methods for monitoring the health of these systems and to develop affordable interventions tailored for the needs of the poorer members of the rural aquaculture community.

The opportunity also exists to reverse the trend of top-down development in aquatic animal health management and to develop a holistic approach that will benefit small- scale producers and those that are most vulnerable. The workshop approach also emphasises "primary health care". Primary health care, whilst poorly defined in relation to aquaculture, is taken to mean integrated, accessible medicine that is delivered by generalists rather than specialists. It is primarily low technology, rather than high technology, and places greater emphasis on prevention, through management of factors in the environment that impact on health, or lack thereof, of the animal. It recognises the importance of the health of populations, i.e., of population medicine and is practised in the context of the community. It tends to be less costly than the speciality approach that is often practised at present. In human and veterinary medicine, primary health care is often delivered by non-physicians and non-veterinarians and provides an opportunity for continuity of observation. It opens possibilities for disease prevention and health promotion as well as early detection of disease. Primary health care is information intensive rather than technology intensive. Primary health care is taken to mean a health approach that integrates at the community level all the elements necessary to make an impact upon the health status of the population.

THE WORKSHOP

Objectives

The workshop was held at the Sonargoan Hotel, Dhaka, Bangladesh from 27th – 30th September 1999 with the following objectives:

1) To review current assessments of social and economic impacts of aquatic animal diseases, including the specific impacts of disease on rural livelihood programmes involving aquaculture and enhanced fisheries;
2) To review case studies on disease/health impacts and their management in rural aquaculture and enhanced fisheries programmes;
3) To assess current strategies for primary aquatic animal health care which target small-scale farmers, including case studies from particular countries;
4) To identify specific indicators to monitor impacts of aquatic animal diseases on poverty alleviation programmes involving aquaculture and enhanced fisheries;
5) To identify follow up actions needed to minimise risks associated with disease incursions in rural aquaculture; and
6) To prepare as appropriate a regional co-operative strategy for follow up that will provide an opportunity for international, regional and national agencies to contribute towards achieving a common goal, within their development and research programmes, targeted at poverty alleviation through aquaculture and enhanced fisheries.

Organisers, Sponsors and Agencies involved

The workshop was jointly organised and funded by DFID, FAO and NACA and hosted by the Ministry of Fisheries and Livestock of the Government of Bangladesh. Further support was provided to a number of participants by DFID Research, British Council, International Development Research Centre Canada (IDRC), Canadian International Development Agency (CIDA), and the Southeast Asia Aquatic Disease Control Project (SEAADCP) of the Aquatic Animal Health Research Institute (AAHRI).

A total of 48 aquatic animal health specialists and development professionals attended the workshop from nine countries in Asia and from the United Kingdom and Canada. The participants came from government and nongovernment agencies and from national, regional and international organisations. The list of participants is give as Annex I.

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Opening Ceremony

The opening ceremony was held in the Sonargoan Ballroom, and the welcome address was given by Mr M.A. Matin, Director General of the Department of Fisheries of Bangladesh. The meeting was introduced by Mr Masudur Rahman, Director (Marine) Department of Fisheries. The FAO represented by Dr. K.G. Pillai, Dr Rohana Subasinghe (FAO Rome) and the Chairperson, Mr Ayub Quadri, addressed the meeting. Welcoming remarks were made by Mr Pedro Bueno on behalf of NACA and by Mr Tim Robertson on behalf of DFID. Chief Guest, Mr A S M Abdur Rob, the Honourable Minister of Fisheries and Livestock welcomed the participants and expressed his thanks to the organisers for a timely meeting that addressed the concerns of his government with regard to food security, employment generation and poverty alleviation. The Minister wished the meeting success and formally declared the meeting open.

The meeting then moved to the Titas Room of the Sonargaon Hotel for the technical sessions. Twenty-five papers (including reports of case studies and surveys), two review papers and two keynote papers were presented during the first two and a half days of the meeting, which broadly covered the following themes:

Session I: Introductory and Background Session

The session started with an inaugural address on aquaculture for poverty alleviation that introduced the concept of “rural livelihoods” and emphasised the importance of aquaculture in rural development. The presentation highlighted many of the issues, problems and challenges to be addressed and provided an important framework for discussions during the workshop. Subsequent speakers introduced the objectives and expected outputs of the workshop and lessons from the rural livestock sector which may be useful for consideration during formulating programmes on health management in small–scale aquaculture.

Session II: Aquatic Animal Diseases and Health Problems within the Context of Rural Aquaculture Development – Regional Reviews and National Case Studies

This session was opened by a review of social and economic impacts of diseases and health problems in some rural aquaculture systems, following which a number of case studies on various aspects of aquatic health management were presented. Cases covered included several studies of health problems and impacts in freshwater aquaculture systems in several countries; national overviews of the social and economic impacts of disease from Bangladesh, Lao PDR, China and India; and results from surveys of disease impact and awareness among farmers involved in freshwater pond aquaculture and *Macrobrachium* farming in Bangladesh.

The session continued with a review of the potential socio–economic and biological impacts of aquatic animal pathogens arising from hatchery–based enhancement of inland open–water systems and possibilities for their minimisation, followed by a case study on the social, economic and biodiversity impacts of EUS. There followed presentations on health issues in fish hatcheries and nurseries, the impacts of “red spot” disease on small-scale fish culture in Vietnam, three case studies on coastal shrimp systems and five case studies on health aspects of fish cage culture. The session closed with a paper on aquatic animal health management in Tam Giang Lagoon, Vietnam.

Session III: Methodological Issues and Intervention Strategies

This session looked into methodologies for assessing social and economic impacts of aquatic animal disease, and potential strategies for intervention. The session included a case-study on an aquatic animal health assessment and institutional analysis to support health management in small-scale aquaculture development in Southern Lao PDR, an overview of economic modelling of aquatic animal health problems and presentations on extension methodologies and a paper on strategies for making health management relevant to the context of rural aquaculture development based on lessons from the CARE LIFE project in Bangladesh.

Session IV: Working Group Discussions

Following the presentations, participants divided into three working groups to discuss the major issues raised during workshop presentations and discussions. The guidelines and Terms of Reference for the Working Groups are provided in Annex II. The reports of the findings of each of the Working Groups, which were presented and discussed in plenary during the final part of Workshop Session IV are given in Annexes III-V.

Closing Ceremony

Following the presentation and discussion on the conclusions and recommendations, the workshop was officially closed, with short speeches of thanks by D.K. Chowdhury, Joint Secretary, Ministry of Fisheries and Livestock, Tim Robertson, Fisheries and Natural Resources Adviser, DFID Bangladesh, Rohana Subasinghe, FAO and Pedro Bueno, Coordinator's Representative, NACA.

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ANNEX II - GUIDELINES FOR WORKING GROUP SESSIONS AND TERMS OF REFERENCE

BACKGROUND

The workshop is expected to review information on socio-economic impacts, risks of disease incursions and health management strategies in rural, small-scale aquaculture and enhanced fisheries programmes. It should identify potential interventions for better health management in rural aquaculture, and follow up actions from the workshop, which can be carried out at local, national and regional levels. The workshop is complementary to ongoing efforts of FAO/NACA and others to assist countries within the region to develop effective policy and capacity to control serious shrimp and fish disease outbreaks. However, the focus of this workshop is to look specifically at the occurrence of aquatic animal health problems, their impacts and management within small-scale rural aquaculture and livelihood programmes involving aquaculture and enhanced fisheries. It will emphasize low external input fisheries and aquaculture rather than more intensive systems and will focus on populations rather than pathogens and on livelihoods rather than production.

Expected Outputs from Working Group Sessions

1) An assessment of the impacts of aquatic animal diseases on rural aquaculture, including where available poverty alleviation programmes involving aquaculture. The assessment would identify where possible direct and indirect impacts, and 'nature of the impacts'.
2) An assessment of the risks to poverty alleviation programmes through disease incursions and lack of primary aquatic animal health.
3) An assessment of the impact of current strategies for disease control targeted at rural communities, including extension programmes, special diagnostic requirements etc. Analysis on comparative costs and benefits of different strategies would also be included where available.
4) Identification of possible model intervention strategies for primary aquatic animal health care.
5) Identification of strategies for effective integration of aquatic animal health management within national and regional rural aquaculture development and enhanced fisheries livelihood programmes.
6) Identification of indicators of aquatic animal health and indicators for monitoring the impacts of primary health care interventions in aquaculture and enhanced fisheries development initiatives.
7) Identification of research and associated needs to clarify various matters related to aquatic animal health management.

Organization of Working Groups

The workshop will split into three Working Groups, which will develop conclusions and recommendations on the following issues. All groups should look at the appropriate interventions and provide detailed recommendations as to how GO/NGO/private sector institutions, donor agencies, etc., could assist in facilitating implementing the identified interventions. The interventions should also be prioritized. All working groups should broadly think of the regional situation -

different status/circumstances - different issues and solutions. The following issues should also be considered:

- Aquaculture technology for small-scale rural aquaculture is largely developed and tested.
- There is an on-going requirement for adjustment of basic technical messages to suit specific farming systems/nontechnical requirements.
- Whilst farmers are very capable of recognizing what will and will not work in their specific situations they are often not capable of identifying effective management strategies. This is largely due to lack of experience/skills – especially in cases where aquaculture has recently been introduced.
- Increasing production is not always a priority for smallscale rural farmers.
- Similarly, best management practice is not employed due to increased requirement for management control and inputs to the system. The result of this is that smallscale aquaculture systems will have many pre-disposing characteristics for health management problems.
- The inevitability of losses in the small-scale system is acceptable to farmers and is probably found elsewhere in their system. This is probably why farmers do not ratedisease ahead of other factors (until a specific problem causes mass mortality – and forces farmers to revise their opinion of the risk level of the system).
- The dependence of small-scale aquaculture upon hatcheries for their seed fish exposes them to diseases of intensity (focal nature of hatcheries in some countries/more intensive stocking densities etc.). This emphasizes that intensive/higher income aquaculture is linked to the rural aquaculture system.
- There is a greater focus towards management of artisanal inland fisheries and aquatic resources rather than aquaculture in some countries. Aquaculture has the ability to significantly impact wild fisheries that are a far more important resource (food security) in some countries (e.g. Cambodia, Lao PDR others?).
- Importance of different levels of interventions for different countries depends on capacity, capability, and infrastructure availability.
- Include interventions within inland stock enhancement programmes - especially to minimise transfer of pathogens, movement of species, obtaining good quality seed, stocking healthy fry, etc.
- National policy development - assistance, sector reviews,etc., technical co-operation among farmers for self-help opportunities, risk management for poor people - accessto credit, trans-boundary issues impacting rural aquaculture health, vulnerability of different groups and farming systems related to health problems, and
- Aquaculture systems where disease/pathogens may impact on poor households should also be considered.

Terms of Reference - Working Group 1

This group will focus on impacts and risks to farmers/ fishers, producers/consumers, strategies for the management of risks, and appropriate skills development. The group will specifically address the following:

- What are the impacts and risks of disease/healthproblems in small-scale rural aquaculture and enhanced fisheries?
- How does this impact/risk influence farmer investment/management decisions?
- What are the differences between farmers/farming systems and livelihood systems?
- What can realistically be done about them - how can risks be minimized?

- What intervention/management strategies are appropriate?
- What is the present knowledge and success of intervention strategies? Can the group identify models of appropriate intervention strategies?
- How to develop management skills within poor farming households - what is practical/possible.
- What resources are needed? How can access to information, knowledge, and skills be improved?
- Can health management be a "lever" for improved farm practices, leading to better livelihoods and environmental conditions?
- Surveillance systems, early warning, etc.· How separate is health management from pond/system management?
- The group should also identify opportunities for health management as "entry point" for sustainablerural livelihoods.

The group will identify recommendations on follow up required – directed at different levels/organizations as required at GO/NGO/private sector national, regional and international levels, including capacity building, policy development, research as appropriate.

Terms of Reference - Working Group 2

This group will look into the institutional environment, what does it deliver and how should it deliver more to address needs. More specifically it will address:

- What is currently delivered by GO/NGO/private sector in the low external input sector? However, many systems involving poor people areresource intensive – should these be included?
- What are institutional priorities and are they appropriate (livelihoods vs. revenue)? How can the supply of goods and services to minimize risks and improve management be supported?
- Identify examples, where available, of appropriate institutional support.
- How to reach large numbers of farmers in 'extension'programmes?
- How can education be most effectively delivered?

The group will identify recommendations for follow up directed at different levels/organizations as required at GO/NGO/private national, regional and international levels, including capacity building, information exchange, policy development, research as appropriate.

Terms of Reference – Working Group 3

This group will look into the research needs, programmes, monitoring aspects, and indicators for monitoring management of health in rural, small-scale aquaculture sector. They will consider the following:

- Modelling/assessment methodologies – what can be done to improve methods?
- How can we best measuredirect and indirect impacts?
- Health assessments – can we make some recommendations on better approaches?
- Is there a bigger role for participatory assessments?
- Indicators for aquatic animal health and for monitoring effectiveness of interventions to improve health management in aquaculture and enhanced fisheries development initiatives.

- How to design simple analytical tools – analysing what is happening in their ecology – is this a basis for dialogue on health issues?
- What further information needs to be generated to further reduce current risks and minimize the impacts of future risks to farmers. Where should this work take place and how can it integrate better with current livelihoods programmes.
- What research approaches/methodologies are most appropriate?Should there be more emphasis on action research? Consider - issues, timeliness, improving linkages – what can be done now?
- Where are the common interests of researchers and development professionals? Can opportunities for co-operation be identified? What strategies of knowledge building, research, linkages with development projects might be proposed at the operational level.

The Group should also bear in mind the following statement – "...looking very narrowly at only pathogens/bugs which would further fuel supply-driven research rather than concentrating on what would really benefit small-scale fishers/farmers. It is this last point that is the real challenge".

The Group will identify recommendations on follow up required – directed at different levels/organizations as required at GO/NGO/private national, regional and international levels, including capacity building, information exchange, policy development, research as appropriate.

ANNEX III – WORKING GROUP 1 REPORT

The group focused on risks and impacts of aquatic animal health problems to farmers and fishers and root causes of such risks and impacts.

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The group discussed the risks of occurrence of diseases and epizootics in rural small-scale aquaculture systems and enhanced/stocked fisheries, their impacts on resource-poor rural communities, and the potential interventions for minimising and managing such risks.

It was agreed that there is a perceived risk of pathogen transfer, disease incursion, and subsequent outbreaks of disease in rural, small-scale aquaculture systems and enhanced/stocked fisheries in Asia, impacting the livelihoods of rural, resource-poor aqua-farmers, fishers, and their dependants, through loss of production, income and assets. As the risks and impacts of disease in aquaculture systems and fisheries may be different between countries and farming systems and circumstances, the interventions for mitigation may be different.

The group also agreed that health problems in aquaculture systems and fisheries can occur without involving the introduction of pathogens, due to management inadequacies, and such problems may cause significant negative impacts on rural livelihoods of small-scale aquaculturists.

The risks to livelihoods from introduction of pathogens and health problems originate from several fundamental inadequacies, but the main cause appears to be the "***inadequate knowledge-base***". Fundamental inadequacies include:

- Lack of appropriate national policies and enforceable regulatory frameworks, including effective health certification and quarantine, to prevent entry of pathogens through movement of live aquatic animals and animal products.
- Inadequate opportunities for farmers to improve management skills, through transfer of knowledge beyond basic operational knowledge, to identify effective management strategies and take decisions to prevent disease outbreaks in their aquaculture systems.
- Unplanned development programmes, including commercial aquaculture, and their residual effects, which can have negative impacts on natural water bodies and water resources resulting in aquatic animal diseases and mortalities in rural aquaculture and stocked fisheries.
- Poor management of aquaculture systems, resulting from inadequate knowledge and lack of suitable input resources such as a) quality water, seed and feed; b) effective extension; c) appropriate knowledge; d) access to information and mechanisms for effective transfer; and e) access to credit.

Many of the disease occurrences, mortalities and aquatic animal health problems in stocked systems are often beyond the control of rural communities. Measures to reduce such occurrence should be undertaken by all stakeholders (community, state and nongovernmental organisations (NGOs)) in consultation and partnership. Consensus should be built on identifying interventions and implementing them.

The perceived cause of outbreaks of disease in enhanced/stocked fisheries is stocking of poor quality seed without screening for pathogens. Although, some diseases and pathogens may not be controlled effectively, due to free movement of water and animals with associated pathogens and natural calamities such as floods in some countries, stocking with better quality seed screened for significant diseases and pathogens can have a significant positive impact.

The group considered the following measures to minimise risks of disease incursions and health problems in rural, small-scale aquaculture systems and enhanced/stocked fisheries.

Aquatic animal health management should be considered as a component within the efforts to integrate aquaculture and enhanced fisheries into overall rural development and livelihood programmes. Adequate emphasis should be given to including health management concepts within overall management strategies.

National aquaculture and fisheries policy should incorporate relevant components to address the overall aquaculture and stocked fisheries health, both commercial and rural.

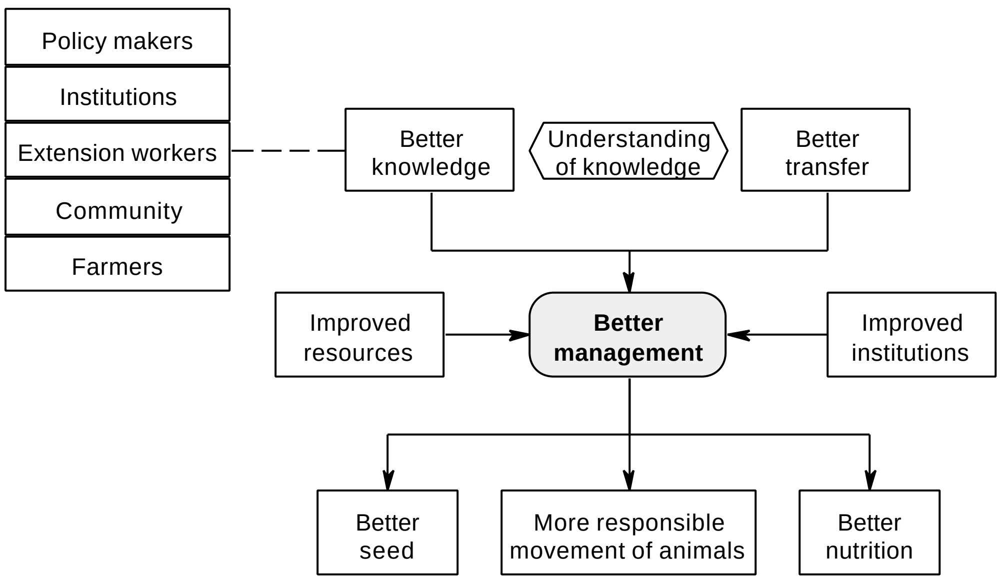
In many countries, there is a need to review and evaluate the extension machinery and mechanism, and necessary improvements and reforms should be made to make extension more practical, effective and responsive to farmers' needs. This may involve getting extension workers involved in practical hands-on aquaculture within the extension process i.e., "experience training."

Since larger-scale commercial aquaculture, including hatcheries and nurseries, may pose certain risks impacting on the health of rural aquaculture and enhanced fisheries within rural development programmes, due consideration should be given for minimising such risks and impacts within commercial aquaculture development. Such strategies will benefit small and larger-scale producers alike.

It is imperative that communication between farmers, farmers' communities, NGOs, extension personnel and state instruments (including both development and research establishments), is improved so that farmers and fishers knowledge base for better management and decision making can be improved. Interventions for knowledge and resource-base improvements could be categorised into the following three areas: (a) better knowledge, (b) better transfer of knowledge and (c) improved resources.

Better Knowledge: The group considered that improving the knowledge base of the farmers and fishers, farming and fishing communities, extension instruments, institutions involved, and the policy makers and planners is important for overall management and minimisation of the risks and impacts of aquatic animal health and disease (see Chart 1).

Chart 1 - Knowledge transfer for improved management



The group felt that understanding the knowledge base of farmers, fishers and their communities, and identifying their needs are important for developing strategies to address the health-related negative impacts and risks. Evaluating the existing knowledge among farmers in using indigenous strategies and interventions, and transferring this information to extension personnel are also important.

The efforts to build farmers' knowledge base should not be based solely on technology. Farmers require science-based knowledge, combined with indigenous knowledge as appropriate, taking into consideration that farmers often have considerable practical experience in production using indigenous knowledge.

It was the opinion of the group that efforts are required to exchange knowledge within and between farmers, fisheries, communities, research and development agencies and countries. Special focus should be given to building the knowledge and skills of women involved in aquaculture.

Building awareness among the communities on the importance of small-scale aquaculture and stocked fisheries for improving livelihoods was also considered appropriate and timely.

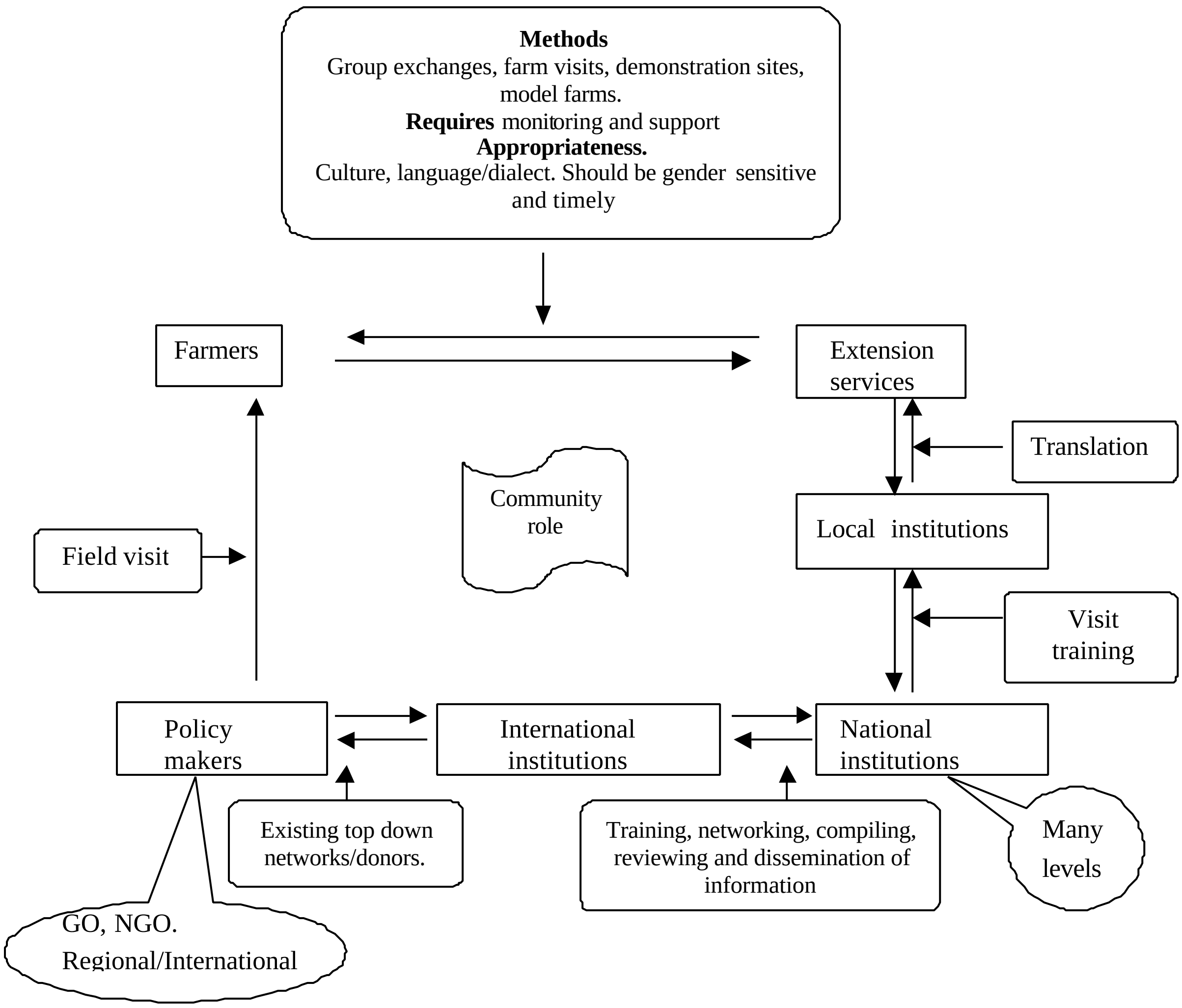
The group recognised the importance of identifying the educational background of the extension workers and providing them with needs-based training to make extension more effective. Communication skills of extensionists should be improved, and the extension should be geared towards improving the farmers' knowledge through harnessing their own knowledge and making them to think and to take decisions. Extension should not focus on training farmers on specific technical activities, unless this knowledge is identified as a specific requirement.

The institutions involved in aquatic animal health management do not appear to have adequate access to much-needed information. Efforts are required to improve the access to information, and to disseminate information to farming communities more effectively and efficiently. Institutional capacities should be developed to meet the needs of farming and fishing communities.

Creating awareness among planners and policy makers on the importance of aquatic animal health care in rural, small-scale aquaculture and updating and upgrading their knowledge base to enable them to make correct and appropriate decisions were considered critical.

Better Transfer of Knowledge: The group agreed that the transfer of knowledge should reflect the path given in Chart 2 below.

Chart 2 - Knowledge Transfer Route



Improved Resources: The group believes that the need for resources is mainly for improving knowledge. There is also a need for improvement of physical resources and access to finance and credit.

Among farmers, fishers and their communities, improved communication through demonstrations, radio, TV, manuals, and by providing appropriate and adequate extension methodologies was recognised as highly important. Training programmes on specific topics, as appropriate for specific needs, as and when required, should be conducted to improve the knowledge of the community.

Development of community leadership in health checks and record keeping is highly relevant and will result in better communal management practices. Demonstration farms and field diagnostic facilities, perhaps maintained by better farmers, may be practical in maintaining the community approach to health management.

The resource base of the extension machinery should also be improved by providing specific training in practical issues, making practical material and tools for demonstration (identify relevant tools) and providing communication resources to keep them up-to-date (periodicals, bulletins, magazines, newsletters etc.).

Researchers and scientists should focus on local and specific problems and should make adequate linkages to other researchers within their communities. Networking should be encouraged. The institutions and researchers should have access to relevant, up-to-date books and journals.

Policy makers and planners should also be provided with adequate, relevant, up-to-date information and should create reasonably close linkages to technical experts in relevant fields. They should also be included in the information feedback networks for better understanding.

The group recommended that:

- Significant resources should be allocated for effective transfer of information nationally, regionally and globally.

- Health management approaches and concepts should be integrated into aquaculture development, within the existing extension services. The extension resources should be enhanced substantially.

- Compilation and dissemination of information on aquatic animal health impacts and management interventions should be given higher priority within rural development programmes involving aquaculture and fisheries enhancement.

- Introduction of cross-level job swapping (placements/secondments of extensionists within practical farming systems and vice versa), and stakeholder involvement in allocation of resources, such as research funding, would help bring greater understanding and accountability into the system.

ANNEX IV – WORKING GROUP 2 REPORT

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The group discussed the institutional environment, what does it deliver and how should it deliver more to address needs.

In discussing institutional issues, the group (as had Group 1) also recognised that the type of interventions appropriate for different countries would vary depending on institutional capacity, resources and infrastructure availability. Institutional interventions within inland enhanced fisheries programmes – especially to minimise transfer of pathogens, movement of species, obtaining good quality seed, stocking healthy fry etc. – were not considered because of the lack of understanding of health issues within the context of stock enhancement programmes within the group.

The group also did not discuss the institutional issues related to the development of national and regional quarantine protocols, which are being covered through complementary FAO/NACA/OIE Asia programmes. It recognised, however, the importance of providing conditions in the aquaculture sector that minimise risks from disease outbreaks caused by trans-boundary movements of aquatic animals.

Following this background, group discussions focused on institutional issues and interventions to:

- Support building of skills among farmers to analyse their aquatic farming systems and to solve problems and manage them effectively; and

- Provide a responsive institutional framework to deal with aquatic animal health problems such as major disease outbreaks, which are a major risk to livelihoods.

In general terms, the group considered that ongoing national, regional and international efforts to strengthen aquatic animal health management institutions should give greater attention to the identification of aquatic animal health risks and their management within small-scale aquaculture in the rural livelihood context.

Aquaculture systems to be considered

The group discussions considered both low-input systems and resource-intensive systems involving poor people – the emphasis was on livelihoods. Some of the more resource-intensive systems within the region which can involve the rural poor include: small-scale marine and freshwater cage culture; fish nursing systems; improved extensive shrimp culture (e.g., in India and Bangladesh); and pond culture, including integrated farming systems, ornamental fish and community-based hatcheries.

The group considered that some culture systems could be made less resource intensive and more appropriate to the poor. The group recognised that, before a technology is deployed, it must be researched and the social and cultural environment in which its use is intended should be considered, before it is disseminated to resource-poor groups as a potential livelihood option. The risk of disease incursions and outbreaks is generally linked to poor management.

It was emphasised that intensive/higher income commercial aquaculture is linked to the rural aquaculture sector in various ways, and it is often difficult to make a clear distinction between the two. For example, the dependence of small-scale aquaculture upon hatcheries for their seed fish can expose small-scale producers to diseases (due to the focal nature of hatcheries in some countries, more intensive stocking densities etc.). Such relations emphasise the importance of a national aquatic animal health management system that is responsive to aquatic animal health problems in national aquaculture development – low-input livelihood systems and commercial, larger-scale aquaculture. The group also noted that when disease occurs, then small-scale farmers may be particularly vulnerable and may share more of the burden.

Entry points should be identified for effective aquatic animal health interventions. The group recognised that disease problems may – in some circumstances – be entry points for an overall improvement in aquatic system management and better livelihoods.

What do the government, non-government and private sector currently deliver?

As stated in national plans, governments have a range of priorities from export earnings to support to small-scale producers, food security and livelihoods, and allocate resources to meet these priorities. The working group considered that small-scale livelihood systems should be given higher priority in national plans. Existing aquatic animal health management and technical packages have historically been technology, production or yield orientated, approaches that have not always delivered sustainable benefits to small-scale farmers.

Recently, there is more emphasis on the livelihood approach to aquaculture; a more holistic approach that attempts to understand the needs, crucial resources and abilities of farmers, and their linkages, through a participatory approach. Aquatic animal health interventions should be "delivered" using this participatory approach.

Broadly speaking, the following organisations are available for delivery of aquatic animal health information:

- ***Government Organisations (GOs) -*** GOs deliver extension and training (often using technical packages), credit, organising of farmer groups, education, quarantine programmes, market promotion, regulations and access arrangements;

- ***Non-governmental Organisations (NGOs) -*** NGOs deliver extension and training, education, technical packages, credit, empowerment of different social groups, organising of social groups and advocating users rights; and

- ***Private Sector -*** The private sector is involved in production, input supplies (seed, nursing, feed) and marketing aspects.

How can the supply of goods and services to minimise risks and improve management be supported?

The management of aquatic animal health problems and of risk associated with the movement of pathogens can be improved through identification of potential key "control points." This approach, whilst not well tried, should be a cost-effective way of managing risk of pathogen spread to small-scale producers, and to improve support for aquatic animal health management and management in general.

The group discussed and identified a number of potential ***formal and non-formal entry and control points*** for delivery of management advice:

- ***Fry producers*** **–** They include both government and private hatcheries, nurseries, and their networks. Infected fry are recognised as a serious health threat, making fry producers an important consideration in any search for control points.

- ***Fry traders*** **-** Fry traders are particularly very important control points, because they select and distribute fry and they have access to large numbers of farmers.

- ***Local government extension officers*** **–** They may provide quality and non-commercially biased information, but in some cases have limited access to the large numbers of small-scale farmers. However, an effective use of these technical skills may be to use them to provide technical advice at key control points – e.g., fry traders and demonstration/lead farmers.

- ***Farmer-to-farmer networks*** **-** Such networks (formal and informal) can be effective in disseminating information, although the quality of information provided can be an issue. The group noted there are considerable country-to-country differences in the potential use of such networks.

- ***Chemical and feed suppliers*** **-** Whilst such groups tend to be involved with more capital-intensive aquaculture, they may offer opportunities to provide technical assistance. However, the information provided may be biased and can impact the quality and effectiveness of information disseminated.

- ***Non-governmental organisations*** **-** In some countries, NGOs have a direct link and can provide technical assistance to farmers or farmers' groups who are not reached through government extension programmes. However, NGOs can be technically weak. Where NGOs are involved in direct support to farmers, better linkage to technical support, such as government technical support, could be considered.

- ***Fish buyers and processors*** **-** This group has widespread contact with, and a potentially strong influence on farmers. They may suffer from potential limited messages, as product quality/quantity is the main issue of concern. They can also have a strong influence on government in dealing with health problems, or in influencing the focus of support.

- ***Universities, fisheries colleges and research institutes*** **-** These institutions, in some countries, can be remote from small-scale farmer problems and can have a tendency to address "commercial issues." They can be a source of quality information and have expertise in aquatic animal health and other relevant areas.

How to reach large numbers of farmers in extension programmes?

Impact and cost-effectiveness can be enhanced by building on existing government structures and through better co-operation and linkages among different agencies and institutions involved in the rural sector. For example, health and pond management messages can be extended through Departments of Fisheries, Departments of Agriculture and Departments of Livestock and Veterinary Services.

Information dissemination can be made more effective through use of alternative extension channels and promotion of better linkages and co-operation with farmer groups, NGO's, schools and non-formal channels such as media/TV. Linkages between government extension officers and private/non-government organisations should be promoted.

Technical co-operation among farmers and within farmer groups for self-help opportunities and to promote self-reliance in identification and management of problems should also be promoted.

How to build more effective linkages?

A recurrent theme during group discussions was building of more effective linkages for dissemination of aquatic animal health management messages among concerned stakeholders. These linkages might include: (a) National research institutes (NRIs) and government extension, (b) Commercial farms and national research institutes, (c) Seed suppliers/producers and small-scale farmers, (d) NGOs and small farmers, (e) Government extension, NGOs and small farmers, (f) Donors and NGOs, and (g) Regional research and national research institutes. There are opportunities to strengthen these linkages to disseminate messages on primary health care. How and what is to be done? Some possible linkages are noted below:

Seed producers/fry traders and small-scale farmers –More emphasis needs to be given looking into the potential use of this important linkage and dissemination channel, with potential to interact with large numbers of farmers.

National research institutes (NRIs) and small-scale farmers - Research between NRIs and small-scale farmers should be promoted to analyse management entry points, control points and information delivery and surveillance systems.

Government hatcheries/extension and small-scale farmers - There is a need to better integrate health messages into the extension programmes and for extension to focus more on small-scale sector. It may be necessary to work with partners for improving impact to overcome serious staff shortages in many countries.

NGOs and small-scale farmers - NGOs in some countries often have good links with small-scale farmers, although there is a need to look at mechanisms to improve technical information delivered.

Government extension and NGO's extension - Better exchange of experiences between NGOs and government through building of long-term relations should be promoted for more effective communication with farmers.

Farmer groups - Linkage among farmers involved in farmers groups can make extension more effective. Where possible efforts to improve dissemination of information should be based upon existing groups.

Private-sector research/experience - linkages are mainly with commercial farms. In some countries, relevant information on health management can be accessed from the private sector.

The group emphasised that the co-operation between aquatic animal health management professionals and extensionists and farmers in the identification of problems and development of extension messages should be promoted. In-country networking and development of a national aquatic health management system, which is responsive to needs and able to deal with serious epizootics, is also required.

The Importance of Appropriate Extension Messages

The development of extension messages needs to be based on ***careful understanding of target groups – their needs, problems and circumstances***. Much can be learnt also from careful evaluation of the success and/or failure of existing extension programmes. There are also opportunities to better understand the success of basic management measures in reducing risk to livelihoods from aquatic animal disease.

The ***relevance and impact of extension messages*** needs careful consideration. Messages should be appropriate to the target group and practical and cost-effective to implement. The methodologies for formulation of the messages, therefore, require careful attention and close interaction with farmers during their development.

Practical "hands-on" training - active participation of farmers and on-farm demonstrations should be emphasised in extension programmes. The design of simple analytical tools – for example analysis of what is happening in farm ecology – could be an important basis for better dialogue with farmers on aquatic animal health issues. Farmer capacity building ***to analyse and solve on-farm problems*** should be promoted, based on understanding of needs and how it can be done.

Better co-ordination and exchange of information on training programmes, their activities and impacts, at the national and regional levels, would also be cost-effective and useful in the design and development of appropriate means of supporting farmers.

Improving Sustainability of Extension/Aquatic Animal Health Services

The sustainability of extension programmes and technical support to farmers in dealing with health problems needs to be given careful attention at an early stage in the design of such programmes. Sustainability can be improved by ensuring that extension services ***are farmer driven*** (i.e., responsive to farmers' needs). Consideration might also be given to cost recovery mechanisms for the services provided by government and non-government services to ensure their sustainability.

Responding More Effectively to Aquatic Animal Health Problems

Much can be done to reduce the impacts of aquatic animal health problems on livelihoods through an early and effective response to problems. To assist farmers in recognising and responding to problems, an essential requirement is ***better dialogue with farmers.*** Government has a key role and responsibility in promoting better dialogue, but is often constrained by numbers (large numbers of farmers, compared to small numbers of government extension officers).

On-farm monitoring and self-evaluation of aquaculture systems by farmers would help in early diagnosis and correction of on-farm problems, and is likely to be very cost-effective. Simple analytical tools, as used for IPM (integrated pest management) programmes, could support such an approach.

Increasing awareness among extension officers of ***health management issues and better systems of farm level surveillance and monitoring*** (e.g., such as record keeping, where possible) are required.

The group recognised that many aquatic animal health problems could be avoided or controlled through improved basic farm-level management; however there is a need to improve the institutional response to serious epizootics and other major aquatic animal disease problems. Institutional co-operation, improved capacity and an appropriate level of diagnostic or other support are necessary in such cases to respond quickly and effectively to such problems.

To build more effective health management support, better understanding of current problems through consultation with ***farmers, analysis of institutional responsibilities and training needs analysis*** are required so that systems are need based and realistic in being able to effectively respond to farmer problems.

At the national level, ***monitoring and evaluation of existing projects*** can help provide a basis for further improvement, and should be encouraged

Research in support of aquatic animal health needs to be evaluated in the field. Farmers/field workers should be made partners in the identification and implementation of research projects.

Recommendations

The working group made the following recommendations to improve aquatic animal health management and minimise the risk of health problems affecting the livelihoods of small-scale farmers and their households:

- ***Improve information exchange on aquatic animal health management*** within the rural development context, so that all can learn from existing activities in the various countries of the region.

- ***Develop simple tools to support farmers in the analysis of their farming systems***. An analogous set of tools to IPM/threshold level of disease or health problems that would help farmers know when a health problem is severe enough to require attention should be developed. Much could be learned through co-operation with other sectors and educational professionals to develop such farm-based tools for aquatic animal health and improved farming systems management.

- ***Fry traders and farmers groups.*** A regional co-operative study on fry/fingerling trading systems in different countries, under different conditions, and their role in aquatic animal health management and disease control should be implemented. Existing information and knowledge on this subject could be pulled together to identify whether the traders are a key point in the culture cycle and how they might be used to improve aquatic animal health management and control risk.

Case studies/pilot projects should be undertaken to assess aquatic animal health problems and better understand the relative risk to livelihoods, and to explore strategies and means for effective delivery of services to the small-scale sector. Exchange of information and experiences arising from such pilot projects should be promoted.

- ***Donors/supporting agencies*** should consider aquatic animal health management under aquaculture and enhanced fisheries within the overall framework of livelihood projects and programmes.

- ***Impacts on livelihoods and biodiversity of aquatic animal disease in open water systems.*** A more comprehensive assessment on this topic is required, and appropriate as a regional activity to share experiences from the various countries.

ANNEX V – WORKING GROUP 3 REPORT

The group considered research needs, monitoring aspects and indicators for monitoring management of health in the rural, small-scale aquaculture sector.

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Identification of research needs should originate from the grassroots level (farmers, fishermen, fry traders and market traders). The issues should be identified in the broader context of problems and constraints to aquaculture.

How? Strong linkages are essential among different players (farmers, extension workers, university, private, others) using an interdisciplinary approach, and health problems can be identified through Participatory Rural Assessment (PRA), passive monitoring and surveillance.

Why? Situation analysis should look at who is most affected by the problems (producers, farmers, traders etc.), and strategies should be developed to mitigate or manage the problem.

How much? Research scope should be defined and the required resources identified. What is the nature and extent of the research required to overcome the problem? It is acknowledged that this cannot always be predicted, and that there is a need for flexibility in approach. Getting locked into unprofitable avenues of research, simply because these are outlined in research proposals or project documents, must be avoided.

Problem-orientated (action) research is more practical, although it should also be acknowledged that much basic research eventually has some applicability. There is also the need to ensure that action research is well conceived and conducted. Local or country-wide research and advanced level research should also be considered.

What are the possible constraints to identifying research needs?

In general, farmers are often unable to recognise problems. In some instances, farmers are unwilling to report problems, perhaps due to commercial interests and/or differences in priorities. The existing networks for communication between farmers and researchers also tend to be weak. It is also recognised that career interests and scientific preoccupations can lead to a narrow outlook and an inability to focus research. The government interests and priorities, resource limitations, trade issues, donor priorities and shifting trends in development assistance make long-term planning of research difficult for developing countries.

Research methodologies

PRA, using an interdisciplinary approach, which will result in problems being clearly identified and prioritised, is a useful tool. A review of previous experience should be carried out and the need for laboratory-based analysis assessed. A preliminary case-definition should be developed. This should be applied to all problem-solving situations in aquaculture, regardless of whether it is specifically a health management problem that is suspected. This will result in the problem being well defined and easily recognised by other workers.

Observational studies are necessary to assess the extent of the problem and to identify determinants and risk factors.

Intervention trials with farmers would be meaningful to assess management or treatment interventions that would prevent the problem or reduce the risk of it arising.

On-farm trials to develop farmer capability are desirable. It is recognised that farmers may already have capacity for certain types of "enquiry" that provide useful answers for them; however, this is often more evident in terrestrial systems than in aquatic systems.

Constraints - Competition between research groups may reduce collaboration and unnecessarily increase resources applied to the problem. However, it should be noted that competition provides stimulation, keeps researchers "honest" and provides verification of findings. There is an obvious need for competitive groups to interact through some forum or reporting format. Pressure on researchers to publish in peer-reviewed journals increases time scale and reduces availability of output. Monopoly of research topics results in reduced access by scientists to fields of research regarded as the "property" of established institutions and scientists. This may lead to capacity-led research within institutes that have developed expertise in certain areas, and poor access to information that results in unnecessary replication of research and poor direction. Differing priorities of many of the players and lack of capacity and human resources are significant constraints.

Dissemination, Monitoring of Progress/Relevance/Performance

The flow and spread of information - Health management should be integrated into aquaculture development. Farming communities (farmer, farming and marketing co-operatives, farmers groups) should be the main target. Information transfer must be a two way process. Researchers (government/university), extension services, NGOs, the private sector (fry trader, feed and supply etc.), and policy and decision makers should all be involved.

Linkages between the scientific community and farmers

Pictorial extension manuals, pictorial posters, TV and radio, training programmes, workshops, commercial magazines, calendars, demonstration, journals, newsletters, oral presentations and conferences, mobile extension units and fish fairs are some examples of potentially effective communication channels between the scientific community and farmers. There is a need to strengthen communication between farming communities and researchers. Researchers must share responsibility for monitoring the uptake and progress of research results, perhaps by introducing feedback sessions with farmers and farming communities. Feedback should help determine the relevance and performance of the research undertaken. There is also a need for key agencies, donors etc., to act as focal points to initiate the co-operation that is necessary.

Who decides? Who does it? Who funds it?

Farmers and researchers should identify the problem together with implementers at the grass-roots level, develop together the research/project plan, and identify common goals and outputs that meet the needs of stakeholders.

A generalised summary of the priorities, relevance, competence and source of funding for research in the region is presented in Tables 1 and 2 below.

Table 1. Research funding sources and their relevance to small-scale aquaculture.

Funding sources	Prepared to fund small-scale farm research
Government through DOF	Yes
Research Councils	Yes
Commercial interests through Universities or Government	Often no
agencies	Yes
Donor agencies	Yes
Farmers	Yes
Farmer associations and cooperatives (self and others)	

Table 2. Generalised picture of regional research priorities, relevance and competence.

Who does it	Priority	Type of research	Resources available	Resources required to assist small-scale farmers	Relevance to small-scale aquaculture	Competence
Government through Departments of Fisheries	Emphasis may be on export commo-dities	Normally applied	Limited?	Varies from country to country	Relevant	Yes
Universities	Usually academic	Usually fundamental	Varied?	Limited	Less relevant	Yes
Feed companies, drug companies, commercial research, processors and cold storage	Emphasis on own interests and commer-cial activities	Commercial research, product development, vaccine development, drug testing. Rapid identification kits.	Utilise external resources	N/A	Not relevant	Sometimes
Farmers	Emphasis on own interests	Farm-based, applied	On-farm resources – limited	Very limited	Very relevant	Limited
Farmers' Associations/ Cooperatives	Emphasis on own interests	Farm based	Limited – may use some external resources	Limited	Relevant	Sometimes
Private research organisations	Whatever they are paid to do	Whatever they are paid to do	Limited by available funding	Available if funded	Relevant if focused	Yes
NGOs	Usually focused on small scale	Farm-based trials, etc.	Limited by available funding	Available if funded	Relevant if focused	Sometimes

ANNEX VI – CONCLUSIONS AND RECOMMENDATIONS

There is strong consensus among the participants that inadequate aquatic animal health management is a risk to rural livelihoods of people involved in small-scale aquaculture and enhanced/stocked fisheries in Asia. Health problems can impact on the livelihoods of rural, resource-poor aqua-farmers, fishers and their dependants, through loss of production, income and assets.

The workshop recognises that health problems in enhanced fisheries (i.e., flood-plain stocking, open-water enhancement etc.) are often beyond the control of rural communities, although rural poor are most at risk from such problems.

The risks and impacts of disease in small-scale aquaculture systems and fisheries are different in different countries and the interventions for mitigation may be different.

The participants are of the strong opinion that the root cause of these risks is the *"inadequate knowledge-base"* within the system. There are many fundamental inadequacies. They include:

- Lack of appropriate national policies and enforceable regulatory frameworks to prevent entry of pathogens through movement of live aquatic animals and animal products.

- Existing extension and knowledge transfer systems inadequately recognise or respond to the needs of resource-poor households.

- Lack of research addressing small-scale farmers' needs.

- Inadequate opportunities for farmers to gain knowledge and improve skills.

- Poorly planned development programmes, including commercial aquaculture, and their residual/spillover effects.

- Poor management of aquaculture systems, resulting from lack of knowledge, skills and resources.

There is a need to better understand aquatic animal health risks, impacts and their management within the context of improving rural livelihoods. Follow-up activities should be developed to rectify this shortfall.

The development of institutional capacity, structure and mechanisms for delivering effective extension and training, taking into consideration the farmers skills and knowledge, is required. Learning from farmers and improving interaction between different stakeholders is vital to the overall health management process in rural aquaculture.

Research, geared to find solutions to field problems, designed and conducted with farmers, leading towards cost-effective and practical solutions, is necessary for successful aquatic animal health management in rural aquaculture.

The workshop further recommended that FAO, NACA, and DFID continue to collaborate, in partnership with other relevant and interested agencies and institutions, in support of the above.

The following more specific follow-up actions were also identified to assist implementation of the above recommendations:

- Promotion of country or thematic ***case studies*** based on the major recommendations arising from the working groups, covering the required impact assessments, management strategies, collation of information from relevant on-going projects and activities, and sharing of information deriving from such studies.

- Development of a well-focussed ***electronic information system*** on aquaculture and fisheries within rural development, incorporating health management concepts and components, to facilitate access, dissemination and transfer of knowledge and support to effective extension, in collaboration with relevant ongoing activities.

- Support design of a project to assess opportunities for development and use of problem-based learning for aquatic systems management.

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This document is the Technical Proceedings of the Asia Regional Scoping Workshop on "Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development," held in Dhaka, Bangladesh from 27 - 30 September 1999. The objectives of the workshop were twofold: (1) to review information on socio-economic impacts, risks of disease incursions and health management strategies in rural, small-scale aquaculture and enhanced fisheries programmes; and (2) to identify potential interventions for their better health management and appropriate follow-up actions. The workshop largely focused on understanding the impacts of aquatic animal health risks in small-scale rural, low-input aquaculture and enhanced fisheries and evaluating their impacts on rural livelihoods. The workshop also attempted to derive appropriate management interventions to deal with health risks within rural livelihood programmes involving aquaculture and enhanced fisheries. The workshop was a unique event bringing together experienced aquatic animal health specialists, aquaculturists, sociologists, economists, extension specialists and rural development practitioners in the Asian Region. Although quantitatively estimating the overall impacts of disease on rural livelihoods was difficult due to lack of adequate socio-economic information, the consensus among the workshop participants was that aquatic animal health problems are a risk to the livelihoods of people involved in small-scale aquaculture and enhanced fisheries in Asia.