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Primary aquatic animal health care in rural, small-scale, aquaculture development

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DEPARTMENT FOR INTERNATIONAL DEVELOPMENT OF THE UNITED KINGDOM

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GOVERNMENT OF BANGLADESH

NETWORK OF AQUACULTURE CENTRES IN ASIA-PACIFIC

Primary aquatic animal health care in rural, small-scale, aquaculture development

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Technical proceedings of the
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PREPARATION OF THIS DOCUMENT

This document is the technical proceedings of the Asia Regional Scoping Workshop on "Primary Aquatic Animal Health Care in Rural, Small-scale, Aquaculture Development," jointly organized by the Department for International Development of the United Kingdom (DFID), the Food and Agriculture Organization of the United Nations (FAO) and the Network of Aquaculture Centres in Asia-Pacific (NACA), and hosted by the Government of Bangladesh (GoB) in Dhaka, Bangladesh, from 27 to 30 September 1999.

A summary report on the meeting has been published as:

> DFID/FAO/NACA/GoB. 2000. Primary Aquatic Animal Health Care in Rural, Small-scale Aquaculture Development. Report of an Asia Regional Scoping Workshop held in Dhaka, Bangladesh, from 27th-30th September 1999. Department for International Development, Food and Agriculture Organization of the United Nations and the Network of Aquaculture Centres in Asia-Pacific, 36 p.

It includes the background, a brief summary of proceedings, Working Group reports, conclusions and recommendations and the list of participants. A modified version of this report is included as Appendix I of the present document.

Distribution:

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FAO field projects
Directorates of Fisheries
Fish Health Institutions of the Asia-Pacific
Other interested parties
Workshop participants

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ABSTRACT

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 to 30 September 1999. The workshop was organized by the Department for International Development of the United Kingdom (DFID), the Food and Agriculture Organization of the United Nations (FAO) and the Network of Aquaculture Centres in Asia-Pacific (NACA), and hosted by the Ministry of Fisheries and Livestock of the Government of Bangladesh (GoB). 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 was attended by 48 participants from 12 countries and is complementary to efforts of FAO, NACA and others to assist countries within the Asian Region to develop effective policies and improve capacities to minimize the impacts of aquatic animal disease outbreaks. The workshop was preceded by several case studies in countries of the Asian Region that explored the social and economic impacts of aquatic animal disease on the livelihoods of people involved in small-scale aquaculture and enhanced fisheries. 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. From the information derived from specific case studies, it was clear though that health problems impact on the livelihoods of rural, resource-poor aqua-farmers, fishers and their dependants, through loss of production, income and assets. A necessity to quantify better the livelihood impacts was clearly identified. The workshop agreed that the risks to sustainable livelihoods from the introduction of aquatic animal pathogens and health problems originate from several fundamental inadequacies, with lack of knowledge in understanding and managing risks being a major basis for concern. The workshop considered that health management interventions should be a component within programmes aimed at harnessing aquaculture's potential for rural development. It was also recognized that aquatic animal health problems in inland enhanced fisheries systems are often beyond the control of rural communities, making the livelihoods of rural poor most at risk when serious disease outbreaks occur. Whilst the risks and impacts of disease in small-scale aquaculture and enhanced fisheries vary between countries and localities, and the management interventions for mitigation may differ, the workshop identified a number of strategies with the potential to reduce risks to livelihoods from such problems. This Technical Proceedings, including the case study papers, presentations, discussions and findings from the workshop, represents a valuable and unique collection of information on aquatic animal health in small-scale aquaculture and enhanced fisheries within the Asian Region.

(Key words: Asia, Rural development, Aquaculture, Fisheries enhancement, Fish disease, Health management)

CONTENTS

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 Viet Nam, 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 Viet Nam (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.

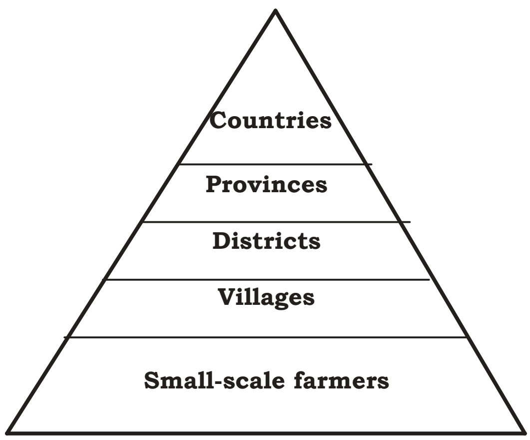
HOW IMPORTANT IS THE SMALL-SCALE LIVESTOCK SECTOR?

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 Province of China, 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.

[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.*

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[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 m2.

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
Viet Nam/China/Thailand	22
Own production	20
Local market	16
Another province	7
Wild caught	7
Total	163

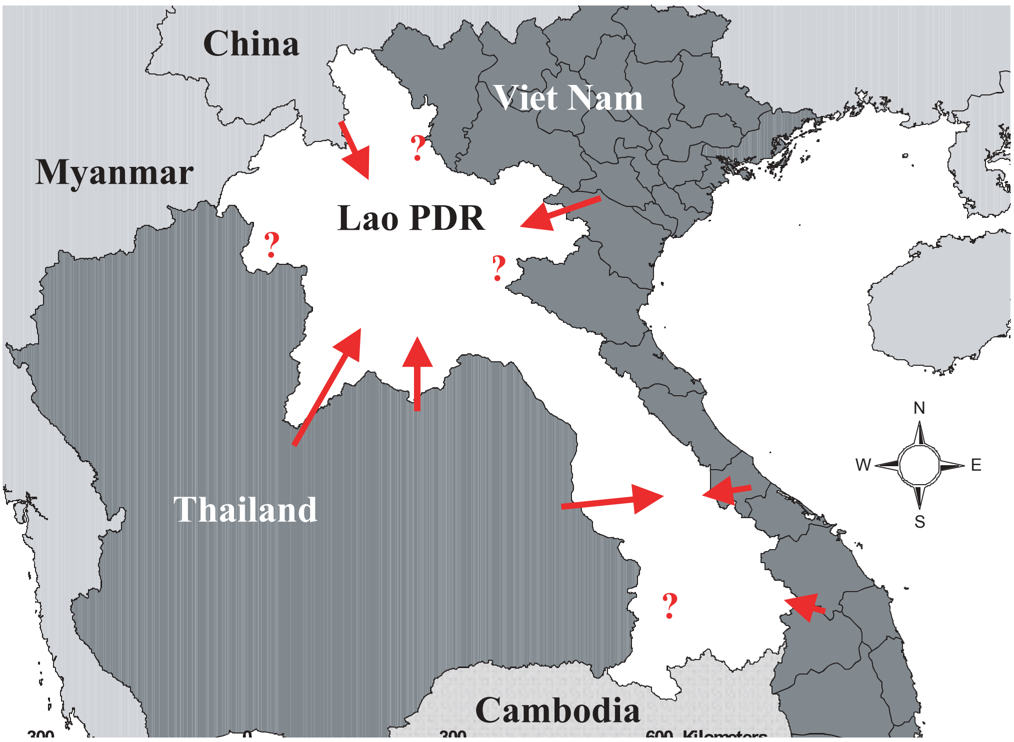
[1]From 1997 survey data, LAO/97/007.

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.

REFERENCES

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