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 between 13 - 48 kg.capita\(^{-1}\).yr\(^{-1}\), representing between 22% - 55% of animal product consumption. Livestock and fish production are the principle forms of income generation and the average value of fish production was $81 per household; overall family income ranged between $372 - $594.household\(^{-1}\).yr\(^{-1}\).

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\(^{-1}\).yr\(^{-1}\)) 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 aquaculture ponds and rice fields encourages importation from neighbouring countries. These imported fingerlings are often 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.
INTRODUCTION

Lao PDR is a landlocked country with an area of over 236,800 km²; 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 percent (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 education 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 5 project target provinces. This was conducted because of the general lack of reliable information nationwide 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 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, value etc.). 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. 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 2,000 - 3,600 kg.ha\(^{-1}\).crop\(^{-1}\)). Flat or terraced rice paddy is typical in most valleys and this land is at a premium. For 5 provinces the range of family (wet) rice paddy holding was 0.9 - 1.7 ha.household\(^{-1}\). 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. Stabilization 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.

Fertilization of rice fields is minimal due to lack of manure from penned livestock, and chemical fertilizers are rarely used. The cost of fertilizers is a principal constraint to their use. Chemical fertilizers 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 principally used 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 that 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 recognized 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 per 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 for 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 women would have the time available to include this activity. Other significant daily activities include: water carrying, care for babies, food collection/foraging, firewood collection, cooking. Elder children usually also help with all of these activities (Murray et al, 1998).

It is still uncommon to find houses located away from villages due to security concerns. 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 5 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 5 provinces)**

<table>
<thead>
<tr>
<th>Description</th>
<th>Household(^{-1})year(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Household income</td>
<td>$372 - $594</td>
</tr>
<tr>
<td>(sale of livestock/rice etc. pension/relatives)</td>
<td></td>
</tr>
<tr>
<td>2) Purchase of foods &amp; commodities</td>
<td>$302 - $447</td>
</tr>
<tr>
<td>3) Self-produced foods</td>
<td>$313 - $543</td>
</tr>
<tr>
<td>(theoretical value no actual income)</td>
<td></td>
</tr>
<tr>
<td>4) Net cash income</td>
<td>$70 - $261</td>
</tr>
<tr>
<td>5) Theoretical income</td>
<td>$413 - $638</td>
</tr>
<tr>
<td>(including self-produced)</td>
<td></td>
</tr>
</tbody>
</table>

**Nov-Jan 1997, $1 = 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 5 provinces was estimated at 189 - 458 kg.capita\(^{-1}\).yr\(^{-1}\). 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

**Table 2. Consumption of animal products by type**

<table>
<thead>
<tr>
<th>Animal products consumed</th>
<th>% consumed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish (fresh, dried, fermented, pickled, tinned), amphibians, molluscs, crustaceans</td>
<td>37</td>
</tr>
<tr>
<td>Chicken, duck, eggs, turkeys, other birds</td>
<td>24</td>
</tr>
<tr>
<td>Pork, buffalo, beef, goat, dried meat</td>
<td>23</td>
</tr>
<tr>
<td>Reptiles, forest game, insects</td>
<td>15</td>
</tr>
</tbody>
</table>

**1997 survey data LAO/97/007**
kg.capita\(^{-1}\).yr\(^{-1}\). Of this animal product consumption, aquatic products (17-23 kg.capita\(^{-1}\).yr\(^{-1}\)) provided 22-55\% (Table 2). Actual fish consumption ranged between 10-19 kg.capita\(^{-1}\).yr\(^{-1}\).

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 Vietnam. This is possibly because, unlike these two countries, flooding of paddies in Lao PDR occurs as runoff from hillsides, rather than flooding up from rivers and streams.

The long dry season and deep river courses do not provide habitats for some of the more usual rice field 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 farmer’s 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 5 provinces surveyed.

**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 conditions deteriorate, especially if the ponds are being fed or fertilised. This may predispose fish to a range of water quality related health problems.

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 of ponds 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 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 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 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 fish culture is less susceptible to disease than 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 3cm or whatever is available. Nursing of small fish in cages prior to release to the pond has been pioneered by the 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.

During the survey, the majority of farmers did not explain the cause of fish mortality or 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. 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-

<table>
<thead>
<tr>
<th>Cause of fish mortality</th>
<th>Number of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unspecified mortality</td>
<td>40</td>
</tr>
<tr>
<td>Unspecified disease</td>
<td>29</td>
</tr>
<tr>
<td>Ulcerated bodies</td>
<td>14</td>
</tr>
<tr>
<td>Red Spots</td>
<td>5</td>
</tr>
<tr>
<td>Spots</td>
<td>4</td>
</tr>
<tr>
<td>Red scales</td>
<td>1</td>
</tr>
<tr>
<td>Predation</td>
<td>2</td>
</tr>
<tr>
<td>Mortality at stocking</td>
<td>2</td>
</tr>
<tr>
<td>Water too hot</td>
<td>2</td>
</tr>
<tr>
<td>Low oxygen</td>
<td>3</td>
</tr>
<tr>
<td>Insufficient water</td>
<td>2</td>
</tr>
<tr>
<td>No disease returned</td>
<td>269</td>
</tr>
</tbody>
</table>

Total 373

1997 survey data LAO/97/007
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 metacercaria.

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%, 55-60% respectively (Unpublished data 1991 & 1999). Lack of latrines and runoff into paddies and ponds is probably the mechanism by which trematodes are transmitted between humans, fish and snails. 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. Equally, aquaculture fish that are not infected could provide a safer 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 growout 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 fish 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.

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 fish fry) in with the Chinese or Indian carp 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 etc.

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 in 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.

<table>
<thead>
<tr>
<th>Source</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local village</td>
<td>46</td>
</tr>
<tr>
<td>Provincial hatchery</td>
<td>45</td>
</tr>
<tr>
<td>Vietnam/China/Thailand</td>
<td>22</td>
</tr>
<tr>
<td>Own production</td>
<td>20</td>
</tr>
<tr>
<td>Local market</td>
<td>16</td>
</tr>
<tr>
<td>Another province</td>
<td>7</td>
</tr>
<tr>
<td>Wild caught</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>163</strong></td>
</tr>
</tbody>
</table>

Table 6. Source of fingerlings for stocking in ponds

1997 survey data LAO/97/007

*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>
<thead>
<tr>
<th>Type</th>
<th>Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Irrigation reservoirs</td>
<td>34,480</td>
</tr>
<tr>
<td>Hydro reservoirs (Nam Ngum ~ 40,000 ha)</td>
<td>48,196</td>
</tr>
<tr>
<td>Natural ponds &amp; lakes</td>
<td>7,019</td>
</tr>
<tr>
<td>Wetlands (seasonal)</td>
<td>27,029</td>
</tr>
</tbody>
</table>

Table 7. List of areas of large and small water bodies in Lao PDR.
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 Lernea, are untreatable due to cost or lack of availability 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=150 g) is required to offset 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 wild fish 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 aquaculture 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 health management 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 5 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 start to also 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 may be considered as contributing to lost potential rather than 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
