**ORIGINAL ARTICLE**

**Assessment of Farmer Knowledge of Large Ruminant Health and Production in Developing Village-Level Biosecurity in Northern Lao PDR**

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**Summary**

The purpose of this study was to determine baseline knowledge and identify knowledge gaps of farmers on biosecurity, risk of transmission of transboundary diseases and large ruminant health and production in three provinces of northern Laos, Hua Phan (HP), Luang Prabang (LPB) and Xieng Khoung (XK). The survey was conducted in six villages that are project sites for an Australian Centre for International Agricultural Research (ACIAR) project, with two villages located in each of the three provinces. A census survey was conducted by interview with all 238 farmers participating in the ACIAR project, using a structured questionnaire. The interviews were conducted in Lao language and took 1–2 h per farmer. The answers were recorded in Lao and the survey data were translated into English and transcribed into Microsoft Excel, and a linear mixed model in the Genstat statistical analysis package was used to compare quantitative traits between the target provinces. The results showed that the prediction mean of farmer knowledge scores on parasitic disorders, infectious disease, reproduction and nutrition management were significantly different between the target provinces. The prediction mean of farmer knowledge scores on infectious disease questions ranged between 5.11 in HP to 8.54 in XK of 24 marks (\(P < 0.001\)). The prediction mean of total knowledge scores was 13.48 in LPB and 19.29 in XK of 42 marks (\(P < 0.001\)).

The results indicate both the need for and scope required to attain improvements in farmer knowledge of large ruminant health and production. It was concluded that a participatory research and extension programme to address village-level biosecurity and reduce disease risks, plus enhance large ruminant production capabilities of smallholder producers, is a valid and potentially important strategy to address transboundary disease risk and rural poverty in northern Laos.

**Keywords:** farmer knowledge; Lao PDR; large ruminant health and production; transboundary disease; risk of transmission; village-level biosecurity

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**Introduction**

The Lao People’s Democratic Republic (Lao PDR) is a landlocked country located in the heart of South-East Asia, with a population of 5.61 million in 2005 and a land area of 236,800 km\(^2\) (Department of Statistics, 2005). It is one of the smallest and least developing countries in the world and was ranked 133rd of 179 nations in 2006 [United Nations Development Programmes (UNDP), 2008]. In Lao PDR, 73% of the population live in rural areas and 74% of these live on US$ 2 per day (World Bank, 2007).

Agriculture employs more than 85% of the labour force, contributes up to 47% of the gross domestic product...
(GDP) and of total GDP, 16% is derived from livestock and fisheries (Wilson, 2007). Livestock is one of the most important economic sectors in the Lao economy (Khouansy and Conlan, 2008) providing up to 50% of annual family cash income from the raising of large ruminants, pigs and poultry (Asian Development Bank; ADB, 2005). In particular, the raising of buffalo and cattle is a crucial livelihood activity for farmers in rural areas. In addition to their use for cash reserves and family consumption and ceremonial needs, large ruminants provide draught power and manure for fertilizer (Stür et al., 2002; Millar and Phoutakhoun, 2008; Windsor et al., 2008). Despite the importance of large ruminant production, this economic sector is still underdeveloped with 94% of all livestock products produced by smallholder farmers owning <5 head of cattle and buffalo (Wilson, 2007). Improving large ruminant production may contribute to a substantial reduction in rural poverty in Lao PDR.

At present, the main constraints to cattle and buffalo production in Lao PDR are feed deficiency and diseases (Stür et al., 2002; ADB, 2005; Millar and Phoutakhoun, 2008). This probably reflects that smallholder producers have limited knowledge on large ruminant health, nutrition and diseases (Windsor et al., 2008). Foot and mouth disease (FMD) and haemorrhagic septicaemia (HS) are two of the most important large ruminant diseases in Lao PDR with annual mortality rates estimated at approximately 10% (ADB, 2005) and outbreaks in this region common (Rast et al., 2010). Liver fluke (Fasciola gigantica) is also regarded as an important parasite of cattle and buffalo in Lao PDR. Approximately 12–26% of the large ruminant population is considered infected with F. gigantica (Copeman and Copland, 2008), although the economic impact of the disease requires further evaluation.

Introduction of interventions such as biosecurity awareness that can improve farmer knowledge of livestock health and production may limit the losses from these diseases and enhance the potential for large ruminant productivity gains. This opportunity is particularly relevant in the northern region of the country where livestock production has considerable potential to expand (ADB, 2005; Wilson, 2007; Millar and Phoutakhoun, 2008). To provide effective interventions and extension activities to smallholder producers, an understanding of their current knowledge of production and disease is required.

The objective of this study was to determine the baseline knowledge and identify the knowledge gaps of farmers on both the risk of transmission of transboundary diseases and large ruminant health and production in three provinces of northern Lao PDR, Hua Phan (HP), Luang Prabang (LPB) and Xieng Khouung (XK). The aim was then to use these results to formulate a village-level biosecurity training programme that can address the real and present risk of transboundary diseases in the region (Rast et al., 2010).

Methodology

This study was conducted within the Australian Centre for International Agricultural Research (ACIAR) project ‘Best Practice Health and Husbandry of Cattle and Buffalo in Lao PDR’ (Windsor, 2006). The survey was conducted between December 2008 and February 2009 and progressed recent research carried out in the region (Stür et al., 2002; Millar and Phoutakhoun, 2008).

Site selection

The study was conducted in six villages of three Northern provinces of HP, LPB and XK with two villages located in each province. These six villages were selected for the research project in 2008 through discussion and consultation between local and national concerned agencies and the research team based on criteria that there should be:

1. A high level of cooperation from farmers, village authorities, department of agriculture and fisheries district and provincial staff.
2. High potential for uptake of technologies offered.
3. Evidence of intensification of cattle production system such as forage establishment for supplement feeding.
4. Perceived active market for the sale of fattened cattle and/or buffalo, preferably with an export element.
5. At least 200 cattle in each village (>100 adults, >50 weaners, >50 calves).
6. Year round road access.
7. Sufficient distance between villages (10 km).

Three of the six target villages (one in each province) were classified as the project’s ‘high intervention villages (HIV)’, where a best practice health and production package has been gradually implemented. The package includes a vaccination programme, planting of forages as well as large ruminant disease and prevention knowledge training. The remaining three villages were classified as the project’s ‘low intervention villages (LIV)’ where only the vaccination programme has been implemented (Windsor, 2006; Rast et al., 2010).

Farmer selection

All farmers recruited to the research project were invited to participate in the knowledge survey. Initially, the target farmers were selected through consultation between the research project staff, village headman and the farmer requiring participation to own at least one head of cattle.
and/or buffalo and display a high level of receptivity to possible introduction of new technologies.

Survey

A census survey was conducted and 238 farmers were interviewed using a questionnaire developed by the research project team. A semi-structured (categorical and quantitative) questionnaire, consisting of open, closed and semi-closed questions was developed. The questionnaire was written in English and translated into Lao. Questions covered socio-economic parameters and large ruminant marketing, with a focus on farmer knowledge of biosecurity, animal husbandry and large ruminant diseases particularly FMD and HS. Design and wording of the questionnaire was aimed at keeping it as simple and brief as possible to accommodate the interview process.

The survey team included six district-level agriculture and fisheries field staff (two from each province) and was led by the senior author. Prior to the survey, a detailed explanation of the survey questions was undertaken with the survey team members to ensure that all of the questions were understood. The team interviewed the head of each household or the person that was the primary carer for the family livestock. The interview was conducted in Lao language and took about 1–2 h per farmer or 4–5 days per village.

Data management and data analysis

The survey data were translated from Lao into English and then transcribed into spreadsheets on Microsoft Excel. For large ruminant knowledge questions, each farmer’s answers were marked, based on answer guidelines developed by the project research team. A correct answer was given 1 mark, an incorrect or ‘I do-not-know’ answer was given a zero mark. Scores for each section and the entire interview were added to calculate knowledge scores for each farmer interviewed. These knowledge scores were used for data analysis.

Quantitative traits were analysed using a linear mixed model in Genstat 10th edition statistical package, and quantitative traits between low and high intervention villages and between provinces were compared (Table 1). Data transformations were not conducted for the farmer knowledge scores as the data was found to meet assumption of the test (normality and equal variances). Log-transformation was carried out for socio-economic data including cultivated areas, number of cattle and buffalo per household. Categorical data were analysed with the use of a Pearson’s square test in Genstat 10th edition. A P-value <0.05 was used to indicate significant differences.

Results

The number of farmers interviewed in each target village and province, an outline of data analysis and quantitative traits of the survey results were tabulated (Table 1).

The average number of buffalo per household ranged from 0.07 head in the LIV of LPB to 7.95 head in the HIV of HP. The mean of farmer knowledge scores on infectious disease questions (/24) was 4.21 and 8.31 in the LIV of HP and the HIV of XK, respectively. The mean of knowledge scores on reproduction questions (/6) was 2.40 in the LIV of LPB and 2.92 in the HIV of XK.

Farmer’s resource availability and forages growing activity

There were significant differences in farmer socio-economic factors, including total cultivated area and number of large ruminants per household across the target provinces (Table 2).

The prediction mean of the total cultivated area per household ranged from 1.28 ha in HP to 3.31 ha in LPB (P < 0.001). The prediction mean of number of buffalo per household was 2.37 heads in LPB and 6.34 heads in HP (P < 0.001), and the mean of number of cattle per household was 4.49 and 7.30 heads in LPB and XK, respectively (P = 0.002).

A comparison between the LIV and HIV did not show significant differences between quantitative traits, with the exception of the number of cattle per household parameter where the prediction mean of cattle per household was 4.56 and 6.53 heads in HIV and LIV, respectively (P = 0.002).

The number of farmers growing forages was significantly different across the provinces and villages (Table 2). The proportion of the interviewed farmers growing forages ranged between 1% in HP and 52% in LPB (P < 0.001), and 10% in LIV to 33% in HIV (P < 0.001).

Farmer knowledge on large ruminant health and marketing

Knowledge on large ruminant health and disease

The prediction mean of farmer knowledge scores on parasitic disorder, infectious disease, reproduction and nutrition management questions showed significantly different results between the target provinces (Table 3).

The prediction mean of farmer knowledge scores on infectious diseases questions (/24 marks) ranged between 5.11 in HP and 8.54 in XK (P < 0.001). When asked whether the farmer knew about HS and FMD, only 5% and 29% of the total respondents said they knew about...
these two diseases, respectively. The mean of farmer scores on reproduction questions (/6 marks) ranged from 2.30 to 2.89 in LPB and XK, respectively (P = 0.002). The mean of total farmer knowledge scores (/42 marks) was 13.48 in LPB and 19.29 in XK (P < 0.001).

A comparison between the LIV and HIV did not show significant differences between quantitative traits, with the exception of farmer scores on nutrition questions. The prediction mean of farmer knowledge scores on nutrition questions (/6 marks) ranged from 3.17 to 3.52 in the HIV and LIV, respectively (P = 0.030).

Knowledge on large ruminant market
The level of farmer’s perception on large ruminant marketing was significantly different between the provinces (Table 4).

The proportion of farmers that knew the market price before selling their livestock was 41% in HP to 63% in XK (P = 0.027). In HP and LPB, respectively, 49% and 87% of farmers obtained a quote from more than one trader before selling their cattle and buffalo (P < 0.001). Approximately one-third of the surveyed farmers across all the selected villages and provinces responded that they knew the destination of their livestock after selling (P = 0.890).

Discussion
This study is the first farmer knowledge survey to accurately determine farmer knowledge and identify farmer knowledge gaps on large ruminant health and production, plus risk of transboundary disease and biosecurity in the northern provinces of Laos. A response rate exceeding 95% for each survey question was achieved. The high response rate was accomplished by conducting face to face interviews using an interview team with good working relationships with the surveyed farmers. The high response rate helped to limit non-response bias in the survey which can be differential in nature (Dohoo et al., 2004). As the survey was conducted in local

Table 1. Number of interviewed farmers, a survey data analysis outline and quantitative traits in the target provinces and villages

<table>
<thead>
<tr>
<th>Variables</th>
<th>HP</th>
<th>LPB</th>
<th>XK</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total farmer interviewed</td>
<td>24</td>
<td>30</td>
<td>37</td>
</tr>
<tr>
<td>Female</td>
<td>0</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>49</td>
<td>35</td>
<td>44</td>
</tr>
<tr>
<td>Median age (years)</td>
<td>52</td>
<td>36</td>
<td>48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean economic parameters</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultivated areas (ha/hh)</td>
<td>1.53 (±1.04)</td>
<td>3.21 (±1.90)</td>
<td>1.49 (±0.92)</td>
</tr>
<tr>
<td>No buffalo (head/hh)</td>
<td>3.71 (±3.43)</td>
<td>0.07 (±0.36)</td>
<td>3.55 (±2.91)</td>
</tr>
<tr>
<td>No cattle (head/hh)</td>
<td>8.46 (±8.85)</td>
<td>7.73 (±6.80)</td>
<td>6.97 (±5.69)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mean of knowledge scores on</th>
<th>Parasitic questions (/6)</th>
<th>Infectious questions (/24)</th>
<th>Nutrition questions (/6)</th>
<th>Reproduction question (/6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total farmer interviewed</td>
<td>61</td>
<td>60</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>1</td>
<td>3</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>40</td>
<td>44</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Median age (years)</td>
<td>39</td>
<td>42</td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>

Mean ± standard deviation. HP, Hua Phan; LPB, Luang Prabang; XK, Xieng Khoung; hh, household.
language and dialect using the same survey team, interview bias because of interviewer’s voice creating bias by implying desirable answers (Thrusfiled, 2005) was limited. However, because the target villages and farmers were selected purposively for the ACIAR research project and there was variation in education and development across provinces and regions in Laos (DoS, 2005; Epprecht et al., 2008), it is wise to interpret the results with caution. This study provides detailed information on farmer knowledge gaps on large ruminant health and production in the selected provinces, but it might not be representative of farmer knowledge gaps for other provinces in Laos.

Farmer knowledge gaps and disease outbreak risks

The survey confirmed that smallholder producers in the northern Laos had limited knowledge on health, nutrition and disease of cattle and buffalo (Table 3). This was probably correlated with the current husbandry practices

Table 2. Total cultivated area, number of larger ruminant owned per household and number of forage growers in the target provinces and villages

<table>
<thead>
<tr>
<th>Variables and categories</th>
<th>Across province</th>
<th>Across village</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HP</td>
<td>LPB</td>
</tr>
<tr>
<td>Cultivated area (ha/ha)</td>
<td>1.28</td>
<td>3.31</td>
</tr>
<tr>
<td>Prediction mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>No of buffalo (head/ha)</td>
<td>6.34</td>
<td>2.37</td>
</tr>
<tr>
<td>Prediction mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>1.08</td>
<td>1.14</td>
</tr>
<tr>
<td>No of cattle (head)</td>
<td>4.64</td>
<td>4.49</td>
</tr>
<tr>
<td>Prediction mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>1.11</td>
<td>1.09</td>
</tr>
<tr>
<td>Forage grower (%)</td>
<td>1</td>
<td>52</td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>99</td>
<td>48</td>
</tr>
<tr>
<td>HP, Hua Phan; LPB, Luang Prabang; XK, Xieng Khoung; LIV, low intervention village; HIV, high intervention village; hh, household.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Indicates significant different between the mean of each parameter (P &lt; 0.05).</td>
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</tr>
</tbody>
</table>

Table 3. Farmer knowledge scores on large ruminant health and disease in the target provinces and villages

<table>
<thead>
<tr>
<th>Variables and categories</th>
<th>Across province</th>
<th>Across village</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>HP</td>
<td>LPB</td>
</tr>
<tr>
<td>Scores on parasitic questions (/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction mean</td>
<td>3.85</td>
<td>2.69</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.16</td>
<td>0.15</td>
</tr>
<tr>
<td>Scores on infectious disease questions (/24)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction mean</td>
<td>5.11</td>
<td>5.92</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.31</td>
<td>0.29</td>
</tr>
<tr>
<td>Scores on nutrition questions (/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction mean</td>
<td>3.73</td>
<td>2.57</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.11</td>
<td>0.11</td>
</tr>
<tr>
<td>Scores on reproduction questions (/6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prediction mean</td>
<td>2.35</td>
<td>2.30</td>
</tr>
<tr>
<td>Standard error</td>
<td>0.12</td>
<td>0.12</td>
</tr>
<tr>
<td>Total scores (/42)</td>
<td>15.04</td>
<td>13.48</td>
</tr>
<tr>
<td>Prediction mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard error</td>
<td>0.454</td>
<td>0.44</td>
</tr>
<tr>
<td>HP, Hua Phan; LPB, Luang Prabang; XK, Xieng Khoung; LIV, low intervention village; HIV, high intervention village; hh, household.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Indicates significant different between the mean of each parameter (P &lt; 0.05).</td>
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</tbody>
</table>
and production systems of smallholder farmers, where large ruminants are raised predominantly by traditional methods that are low-input and output enterprises (Wilson, 2007). Cattle and buffalo are free to graze extensively in the common grassland, forest and paddy fields in the dry season. There is limited input in both reproduction and management, with supplementary feeds including salt and minerals, rarely provided. Reproductive management including bull selection is not practiced in the study areas. Consequently, there is a high risk that large ruminant farmers obtain less than optimum production from their animals. In addition, the risk of losses of large ruminants from disease outbreaks is also high, as documented recently (Rast et al., 2010).

The practice of allowing livestock to graze in the forest and communal grassland is in accord with the traditional shifting cultivation practiced by upland farmers for many generations (Rasul and Thapa, 2003; Collis, 2004). However, this traditional farming practice is considered unsustainable in the future and farmers cannot rely on it for much longer. The Lao Government aims to stop shifting cultivation in the country by 2010 (Lao Government, 2005) and has launched land use planning and land allocation programmes to allocate land for villagers and communities where the majority of land ownership has not been allocated (Thongmanivong and Fujita, 2006). This places pressure on smallholder farmers to look for alternative livelihood activities and more intensive large ruminant production is one of these alternatives (Lao Government, 2005; Millar and Phoutakhoun, 2008).

Despite significant differences in farmer knowledge across the target provinces, their knowledge scores were generally low. This confirms that farmers have very limited knowledge on large ruminant health and disease, especially on HS and FMD, the most important diseases of cattle and buffalo in Lao PDR. When asked whether they knew these diseases, of the total respondents, 29% and only 5% said they knew about FMD and HS, respectively, with the result for FMD being higher because of the exception that in XK, many FMD outbreaks have occurred in the last 10 years (ADB, 2005; Khounsy and Conlan, 2008; Khounsy et al., 2009; Rast et al., 2010) and 44% of interviewed farmers knew of FMD as they had experienced it. Because of their low level of knowledge of transboundary disease risks and lack of understanding of biosecurity, farmers in the study areas face continuing high risk from both FMD and HS outbreaks as these diseases are endemic and disease preventative measures are generally not practiced.

The significant difference in farmer knowledge scores across the selected provinces was considered to possibly be correlated to variability in economic and educational development in the study sites. However, it was interesting to note that farmer knowledge scores in LPB, the province with the highest level of development and literacy rate than other selected provinces (UNDP, 2008; Department of Statistics (DoS), 2005; Epprecht et al., 2008), the knowledge scores were lower than in the other provinces. Reasons for this were unclear and further study of this finding is recommended.

As discussed, FMD and HS are the two most important large ruminant diseases in Laos, with many outbreaks occurring repeatedly over the last 10 years (ADB, 2005; Khounsy and Conlan, 2008; Khounsy et al., 2009; Rast et al., 2010). Foot and mouth disease virus type O, A and Asia I were detected between 2003 and 2006 across many northern provinces, with the exception of LPB and HP province (Gleeson, 2002; Perry et al., 2002; Khounsy and Conlan, 2008; Khounsy et al., 2009). The most recent FMD outbreaks in the northern provinces of Laos occurred in early 2009 (Rast et al., 2010) and early 2010 across many provinces and in XK in particular but not in HP province, affecting many villages (Khounsy, Rast and Windsor, unpublished observations).

Haemorrhagic septicaemia is an endemic disease in Lao PDR, particularly in remote areas of the northern provinces where husbandry practices are poor, animals are kept under free-range system (De Alwis, 1999; Benkirane and De Alwis, 2002; Rushton et al., 2002) and vaccination is limited. A recent outbreak of HS occurred in July 2009 across many provinces and caused the deaths of over 300 cattle and buffalo in HP province alone (Lao News Agency, 2009). The prevalence of HS in buffalo and cattle ranges from 2% to 12%, but case fatality rate is very high ranging from 43% to 73% (De Alwis, 1999; Chander et al., 2004; Singh et al., 2007). Further investigations are recommended to determine more accurate data on the
prevalence and economic impacts of HS in northern Laos.

External and internal parasites, such as ticks, *Fasciola gigantica* and *Toxocara vitulorum*, are cattle and buffalo production health risks that are often overlooked and the economic impact of these parasites on production and farmer income has not been thoroughly studied. The likely presence of the disease causing agents combined with traditional large ruminant production systems of the target farmers enhances the risk of significant parasitic disease losses, particularly through confounding factors such as poor housing, nutritional deficiency, unrestricted animal movements and lack of biosecurity controls (Stür et al., 2002; ADB, 2005; Millar and Phoutakhoun, 2008). Further study of the impact of internal parasites in northern Laos PDR is occurring.

**Limitation of large ruminant market information**

The study identified that farmer knowledge of market information was poor and probably reflected the complexity of trading practices and the limited market information available in the study areas. About half of the interviewed farmers responded that they knew about the market price prior to selling their animals, with the remaining farmers indicating that they had no knowledge on current market prices and relied on middlemen or traders for this. Often there are only one or two traders working in a village or cluster of villages providing farmers with limited trading options and bargaining power. In addition, smallholder farmers generally sell old or sick animals when they need large sums of money for special or emergency events, further reducing their bargaining power. Traders are usually able to set a low price, particularly for sick and old animals, knowing that farmers are keen in selling their animals to obtain money and cut their losses (Rweyemamu et al., 2008). The imbalance of bargaining power between livestock traders and farmers can reduce incentives for smallholders to improve product quality. The system may also prevent them from seeking reliable information on market conditions because of their geographic, social and economic isolations (Chadwick et al., 2008).

**Resource availability and production level**

The total cultivated area per household showed significant differences across the selected provinces. The total cultivated area ranged between 1.5 in HP and XK and 3.5 ha per household in LPB. The average of 1.5 ha per household was in accord with previous studies that determined that Lao farmers utilised 1.5–2 ha of land per household (Steering Committee for the Agricultural Census, 2000). However, the prediction mean of available land per farmer in this study might be under-estimated because the survey data focused on cultivated areas that farmers actually owned, but did not include communal and national grass land that farmers can utilise to graze their livestock during the dry seasons. This is of relevance in HP and XK where land use planning and land allocation have not been yet implemented. Land utilised by upland farmers differed at both village and district level (Darr and Ubrig, 2004) because of both the size of the village and the land available.

There were significant differences in number of large ruminants per household across the provinces. Farmers in HP keep more buffalo with an average of 6.7 heads per household and farmer in XK keep more cattle with an average of 7.4 heads per household. This may be correlated to many factors. Firstly, the introduction of hand tractors to replace buffalo in recent years, particularly in LPB, could be one of the reasons of low number of buffalo per household in this province, as recently observed (Wilson, 2007). In HP and XK, many farmers still use buffalo for draught power and also keep large ruminants as a source of manure for their rice cultivation (Stür et al., 2002; Millar and Phoutakhoun, 2008) as their soil is considered insufficiently fertile for rice production (personal communication with local village headmen). Secondly, market demand and accessibility to the market might be another reason for differences in livestock numbers between provinces. As buffalo meat is more preferred in LPB than beef (personal communication with local large ruminant traders) and the majority of buffalo meat in the LPB markets comes from near-by provinces including HP, smallholder buffalo producers in HP have incentives to keep more buffalo to satisfy the high demand for buffalo meat in LPB. On the other hand, beef is preferred and in high demand in other major urban cities in Lao PDR including Vientiane (the Lao capital city). Beef is also in demand for export markets on the basis of taste and texture (Delgado et al., 1999; FAO, 2004; Chadwick et al., 2008). At present, meat consumption in urban areas in Lao PDR is 33 kg/person/year, which is predicted to increase to 70 kg/person/year by 2020 (FAO, 2004; ADB, 2005). As XK is closer to Vientiane than LPB and HP, transportation of cattle to the capital city market is more convenient. Xieng Khouang is also adjacent to Vietnam and it is estimated that Vietnam will increase their import of beef products from 43 Kilotons in 2001 to 89 Kilotons in 2020, a 9.4% annual growth (Quirke et al., 2003). Market demand and location advantage provides incentives for farmers in XK to keep more livestock than farmers in the other target provinces. Thirdly, productivity could be another reason for farmers in XK to keep more cattle. There is a belief among XK farmers that...
their local cattle breed has superior reproductive performance to local buffalo, encouraging smallholder cattle farmers in XK to keep more cattle as they feel that their cattle will reach market weight and generate cash income more quickly. In comparison with European cattle breeds, indigenous breeds have very poor productivity and reproductive performance with an average first calving at 3–3.5 years of age (Stür et al., 2002). Further research is needed to determine the potential for improving the reproductive performance of Lao indigenous cattle and buffalo breeds.

The need for knowledge improvement and introduction of village biosecurity

The farmer knowledge gaps on large ruminant health and diseases identified in this study indicated the need and potential for improvements in disease awareness and introduction of biosecurity programmes in northern Laos. Biosecurity programmes refer to all the hygienic practices designed to reduce the risk of infectious diseases occurring or being introduced into a herd, as well as the practices that control the spread of infectious agents within a herd (Dargatz et al., 2002; Morley, 2002; Larson, 2008). Basic farming practices that Lao cattle and buffalo farmers can apply include the following: awareness of disease outbreaks, isolation of sick from healthy animals, minimizing contact between introduced animals via quarantine procedures, herd health monitoring and reporting, and vaccination programmes. Introduction of village-level biosecurity programmes may contribute to a reduction in the risk of disease outbreaks and enhance the capacity of cattle and buffalo farmers to improve their livestock husbandry practices and productivity.

Extension and intervention activities aimed at improving farmer knowledge are best carried out at a speed adapted to the low education level of farmers (Department of Statistics (DoS), 2005; Epprecht et al., 2008). Furthermore, intervention activities need to be introduced using a participatory approach to avoid the ‘sun rise and sun set’ project phenomenon, that is, working very well when the project is still running but collapsing when project assistance ceases.

Development of biosecurity programmes for Lao PDR farmers should focus on farm management and husbandry practices but need to be acceptable and able to be implemented by farmers. For instance, the use of a ‘test and cull’ to control FMD is considered an inappropriate tool for Lao farmers, because of their limited financial resources and likely lack of farmer cooperation. Smallholder cattle and buffalo producers will not let authorities slaughter their FMD-infected or carrier animals unless they receive reasonable compensation. In addition, biosecurity programmes should focus on groups of farmers or villages rather than individual farmers, reflecting the small number of animals per owner and farming systems that are predominantly subsistence agriculture rather than livestock focused (Gleeson, 2002; Stür et al., 2002; Wilson, 2007). Finally, biosecurity programmes need to be adaptable as in some villages, where FMD and HS vaccines are available and farmers are able to pay for the vaccination cost, vaccination should be an important component of the village-level biosecurity programme.

Conclusions

This study in three northern Lao PDR provinces identified that the surveyed farmers had very low understanding of large ruminant health, risk of transboundary disease and biosecurity. This reflected their traditional husbandry practices where large ruminants are free to graze extensively in communal areas and have high risks of disease from exposure to disease causing agents, particularly FMD and HS. The study identified the need for farmer knowledge improvements including disease awareness and has informed the development and introduction of village-level biosecurity programmes to reduce the risk of disease outbreaks and enhance cattle and buffalo production capabilities of the Lao upland farmers. Further research to determine the prevalence and economic impacts of HS and FMD and other diseases of potential economic importance in the northern Laos is recommended.

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