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Final report

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2 Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AMP	Animal Movement project (ACIAR AH/2006/025)
BPHH	Best Practice Health and Husbandry of Cattle and Buffalo, Lao PDR
BK	Bokeo Province
CIAT	International Centre for Tropical Agriculture
CSU	Charles Sturt University
DAFO	District Agriculture and Forestry Office
DLF	Department of Livestock and Fisheries, Lao PDR
EASLPP	Extension approaches to scaling out livestock production project (ACIAR ASEM 2005/124)
FMD	Foot and Mouth Disease
HP	Hua Phan Province
HS	Haemorrhagic Septicaemia
KAP	Knowledge, Attitudes and Practices
LAK	Lao Kip (currency)
Lao PDR	Lao People's Democratic Republic
LDP	Livestock Development project (same as NRSLLDP)
LNT	Luang Namtha Province
LPB	Luang Prabang Province
MAF	Ministry of Agriculture and Forestry
NAFC	Northern Agriculture and Forestry College, Pakseung campus
NAFES	National Agriculture and Forestry Extension Services
NAFRI	National Agriculture and Forestry Research Institute
NRSLLDP	Northern Region Sustainable Livelihood through Livestock Development Project (or LDP= Livestock Development Project)
NUOL	National University of Laos, Nabong campus
PAFO	Provincial Agriculture and Forestry Office
UoS	University of Sydney
VVW	Village Veterinary Worker
XK	Xieng Khouang Province

3 Executive summary

Cattle and buffalo are a very important in Lao PDR, accounting for approximately 20% of agricultural GDP with 95% of the 2 million animals owned by rural households that farm on a subsistence basis. Livestock provide upland farming families with up to 50% of their annual cash income although productivity constraints are many, including trans-boundary and endemic diseases, poor feed supplies and traditional subsistence-based husbandry practices including an almost complete lack of breeding management. Large ruminants in northern Laos are used as cash reserves, family consumption and ceremonial needs (and despite their growing importance, this economic sector is still undeveloped with very limited farmer knowledge of modern livestock production techniques and biosecurity practices that could assist management of the major constraints.

This project completed a detailed study of current knowledge and practices of large ruminant smallholder livestock productivity in northern Lao PDR. The research aimed to identify which interventions are most appropriate to increase large ruminant productivity. The project was a collaboration between the University of Sydney (UoS) and the Department of Livestock and Fisheries (DLF), and worked alongside the Northern Region Sustainable Livelihood through Livestock Development Project (NRSLLDP *or simply* LDP), enabling research findings to be rapidly extended across all the northern provinces. The research involved participatory implementation of technologies to improve cattle productivity, examining the impacts of best practice interventions in the areas of nutrition, animal health, husbandry management and marketing on smallholder livelihoods.

Project participants included smallholder farmers, village chiefs, village veterinary workers, district and provincial veterinarians and central DLF staff, working in six villages within the three provinces of Hua Phan (HP), Luang Prabang (LPB) and Xieng Khouang (XK). Two villages in each province were designated as either 'high intervention' (HI) or 'low intervention' (LI). A best practice participatory research and farmer education program was delivered over 4 years to the HI sites, with interventions including education in animal health, biosecurity, nutrition, reproduction and marketing, delivered by participatory 'applied field research', 'on the job' training and 'formal training' modes. Practical interventions including forages technologies, regular vaccination programs against Haemorrhagic Septicaemia (HS) and Foot and Mouth Disease (FMD), plus anthelmintic treatment for *Toxocara vitulorum* and occasionally *Fasciola gigantica*, occurred in HI sites. The LI sites received HS and FMD vaccination only, and served as a baseline to measure and compare to any HI gains until the final 12 months of the study when the interventions used in the HI sites were provided.

An important finding was that FMD control through vaccination and potentially improved biosecurity was critical during the regional epidemic of 2009-2011, with studies of the XK 'hotspot' revealing disease risk factors that can help mitigate disease spread and serological evidence of protection from vaccination. Following our training of field extension staff, farmer learning of most aspects of large ruminant husbandry improved significantly during the project and this translated into improved farmer income, particularly in the HI sites in LPB and XK. Epidemiological studies of Toxocariasis and Fascioliasis confirmed the widespread occurrence of these parasites and their importance as causes of calf mortality and adult morbidity. Knowledge of the control of parasites was found to be almost absent despite considerable training of extension staff in basic parasitology, plus reproductive management and marketing knowledge also still remain at very low levels.

The project confirmed that several best practice interventions are required to increase productivity and profitability of smallholder cattle production. The systems approach used to addressing the multiple health and productivity constraints proved very successful in engaging farmer cooperation and is recommended for extension workers, researchers and policy makers aiming to facilitate smallholder cattle production in the Greater Mekong Subregion (GMS) as a means of addressing both regional food security and rural poverty. Further research on the economic evaluation of individual interventions (e.g. trans-boundary disease control through biosecurity practices), strategies to improve cattle market chains, and interventions to improve

breeding management are required to provide additional evidence of how this strategic approach more rapidly encourages smallholder farmer to move from a subsistence to a production focus in managing cattle.

4 Background

Lao PDR is the least populated country in South-East Asia with a population of 6.2 million (Lao Department of Statistics, 2010). A large proportion (73%) of Lao's population live in rural areas (Khounsy and Conlan, 2008) and around 74% of them are very poor living on or less than US$ 2 per day (World Bank, 2007).

The livestock sector, including buffalo and cattle keeping, are crucial livelihood activities for smallholder farmers in rural areas, providing up to 50% of household annual cash income (Nampanya 2010; UNDP, 2009; Wilson, 2007; ADB, 2005). In Laos more than 94% of all livestock products are produced by smallholder farmers. Smallholder farms in Laos, as in other parts of the GMS, are predominantly mixed (rice/livestock) production systems operating with low inputs and outputs, mostly at subsistence or semi-subsistence levels. The main difference with upland northern Lao smallholder farms is that the traditionally swidden (shifting) agriculture that was practiced over the last decade is being phased out through government policies plus most rice grown is dry-land rice predominantly cultivated on steep mountainsides.

Large ruminant production in Laos is undeveloped, involving mostly smallholders using traditional practises. Households generally own less than 10 cattle and/or buffalo kept as a cash reserve, for meat, a source of fertilizer (manure), cultural purposes and increasingly less commonly, draught power (Nampanya et al., 2010; Millar and Phoutakhoun, 2008; Wilson, 2007). Constraints to more modern and optimal production techniques and productivity include limited availability of land, major endemic disease issues, poor husbandry knowledge, minimal extension capacity with a lack of knowledge transfer, and a low capacity animal health reporting and response system with sub-optimal disease surveillance, few outbreak investigations, minimal confirmation of disease diagnoses, plus poor disease prevention and control management. Isolation without all year road access or alternate transport systems is a further constraint for many villages, particularly during the wet season. These constraints and subsistence production levels make the northern Lao smallholder farming systems very vulnerable to both disease and climate shocks affecting their crops and livestock (Khounsy et al., 2012).

There is rapidly increasing demand for red meat in South-East Asia that has been projected to continue growing to at least 2020 (Delgado, 1999) by around 3-5% annually. This demand is driven by the fast growing economies and urbanisation in the more developed countries of the region including China and Thailand, but particularly from Vietnam where strong demand for large ruminants has persisted throughout the project and driven a consistent demand of animals through XK province of northern Laos that has outgrown supply with a doubling of meat prices during the project. Addressing this demand by improved large ruminant productivity in Laos requires rapid changes by smallholder farmers from large ruminant keepers to producers. Although this appears to present smallholder farmers with an opportunity to increase their income by providing ruminants to this market, the multitude of constraints to improving their current practices needs to be addressed (Windsor 2011). Successfully engaging this market with increasing supplies of better quality animals could contribute to poverty reduction for the rural population of Laos and address the growing regional food insecurity manifest as increasing concerns about meat prices.

The 'Best Practice Health and Husbandry of Cattle and Buffalo in Lao PDR' (BPHH) project was originally developed for Cambodia and Laos, but for operational reasons it was split into two individual projects covering each country (this project and AH/2005/086). The Lao project commenced in June 2008 and was scheduled for completion in June 2012, but was extended to December 2012 to enable additional time for completion of fieldwork, data collation, analysis and reporting. The project involved collaboration between the Australian and Lao PDR governments and was implemented by a team from the University of Sydney (UoS) and the Lao PDR Department of Livestock and Fisheries (DLF), with occasional collaboration with Charles Sturt University, the National Agriculture and Forestry Extension service (NAFES), the International Center for Tropical Agriculture (CIAT) and a small number of private consultants.

The project's main objectives were to:

1. Confirm current knowledge of disease limitations to large ruminant production.
2. Implement, test and demonstrate the value of interventions preventing key diseases, preventing introduction of diseases and managing reproduction.
3. Assess attitudes of farmers in targeted communities to health, husbandry and market issues, and communicate project outcomes to large ruminant stakeholders.
4. Improve knowledge of the cattle supply chain and key drivers in the targeted communities.

These objectives aim to answer the core research question:

"Does best practice animal health and husbandry lead to increased profitability and increased smallholder benefits?"

Farmer in Ban Hardpang project village, Luang Prabang province
Photo: L. Rast)

5 Methodology

The project team consisted of researchers from the University of Sydney (UoS) and Lao Department of Livestock and Fisheries (DLF) staff, including a full time Australian research officer (also servicing AH/2005/086) and part-time experts in ruminant nutrition and livestock economics from the UoS. Fieldwork was implemented through three PAFO and six DAFO staff and for administrative support was provided by a full time Lao administrative assistant, with occasional inputs from a UoS administrative assistant. For the last two years of the project a full time Lao research officer was appointed. Important contributions were made by UoS students, with two on-going PhD research projects (one a Lao national), 6 completed honours projects, and 14 BVSc final year students undertaking 'Rural Public Practice' rotation projects as part of their degree requirements. Topics ranged from studies on trans-boundary (e.g. FMD, HS) and endemic diseases (e.g. *Fasciola*, *Toxocara*, and blood parasites), trader and farmer surveys to assess and describe the cattle/buffalo market and farmer and trader knowledge, attitudes and practices (KAP) surveys. A list of the student projects is attached (Appendix 1).

Using a participatory approach, the research examined which interventions are accepted and can be implemented by farmers in the areas of animal health, nutrition, reproduction management and marketing. This provided a learning opportunity for smallholder farmers to increase their household income through improved productivity and profitability of their large ruminants. As the research project collaborated closely with a very large development project 'The Northern Region Sustainable Livelihood through Livestock Development Project' or LDP, (ADB, 2007) that was co-located in the Luang Prabang office with Dr Syseng Khounsy from DLF as the Lao project leader of both projects, providing numerous opportunities for the research to be immediately implemented by the LDP (working in 18 priority poor districts in the 5 northern Lao provinces of Bokeo, Hua Phan, Luang Namtha, Luang Prabang, and Xieng Khouang).The LDP involved 314 villages, 12,000 households and 102,000 people, with 5,000 households likely to benefit from increased incomes from cattle and buffalo. Our research project facilitated a training program for 28 LDP staff from 20 districts, consisting of a series of seven 2-4 day workshops on large ruminant health and production, conducted between 2008 and 2010 (section 4.7 and Table 2).

5.1 Project site and animal selection:

Six villages (project sites) with two villages located in each province were selected in the three northern provinces of Hua Phan (HP), Luang Prabang (LPB) and Xieng Khouang (XK), through discussion and consultation with relevant national and local agencies and the research team. Inclusion was based on criteria including: (i) high level of willingness from farmers, village authorities, district and provincial DLF staff to participate; (ii) at least 250 large ruminants in each village; (iii) some evidence of intensification of large ruminant production systems such as forage growing for supplementary feeding; (iv) perceived active or potential market for sale of fattened cattle and or buffalo, particularly if exported; (v) local interest in uptake of potential technologies offered; (vi) sufficient distance between villages (10 km); and (vii) all year road access.

Three of the villages (one in each province) were classified as 'high intervention' (HI) villages where a best practice health and production package of interventions was gradually implemented. The remaining three villages were classified as 'low intervention' (LI) or control villages where for the majority of the study only the vaccination program was implemented as a participatory incentive. This design enabled objective longitudinal measurement of changes in productivity attributable to knowledge interventions, rather than a simple 'before and after' measure of progress. In the last 6-12 months of the study, those interventions shown to be efficacious in the HI were introduced to the LI sites.

Table 1. Project village details and intervention classification, 2008

Village Name	Intervention Classification	District	Province	Number of Households*	Numbers	
					Cattle	Buffalo
Hardpang	High	Pak Ou	LPB	73	134	125
Hueypaen	Low			35	272	0
Nong	High	Paek	XK	26	305	163
Nadee	Low			37	429	168
Nakud	High	Vienthong	HP	93	175	59
Navieng	Low			29	282	190

* Each household comprises of 4-6 people on average and might have more than one family in each household.

5.2 Interventions

The potential animal health and production interventions considered most relevant for introduction were based on recommendations of previous projects and outcomes of the short research activity (SRA) AH/2006/077 project entitled: 'Identifying research priorities for development for the beef industry in Cambodia and Lao PDR with special reference to animal health intervention' (Windsor et al., 2008). This pre-project SRA was conducted in 2007 and included a farmer attitude survey in northern Lao to establish priority issues related to large ruminant production by smallholder farmers. The SRA and subsequent communications with villagers in project sites provided the necessary 'participatory' process to engage the project participants. Relevant work from previous projects was examined to assist in establishing potential interventions, including work from previous ACIAR-funded projects on FMD (Laos) and *Fasciola gigantica* (Cambodia), the CIAT 'Forages and Livestock Systems Project' (forages as an entry point for improving cattle production; short-term fattening prior to sale of animals; treatment of calves against *Toxocara vitulorum*), and the documentation that led to the Livestock Development Project (LDP) in northern Laos (step-wise introduction of best practice production and health interventions), plus published work and anecdotal experiences from other countries in the region.

5.3 Longitudinal survey

Between December 2008 and December 2011, a longitudinal survey was conducted in the six project sites to collect baseline data on large ruminant productivity parameters, providing productivity benchmarks for assessing the impact of the interventions over time. At each of the six project villages the project staff and farmers established large ruminant handling facilities, included holding yards and a locally made metal crush with a wooden platform enabling attachment of electronic weight scales (Tru-Test™, New Zealand).

The locally responsible DAFO and PAFO staff recruited 250 cattle and/or buffalo per village and the project animals were permanently identified with numbered ear tags at the first of the 10 data collection periods, being December 2008. The animals remained under the care of their owners for the duration of the project.

Data collection sheets (Appendix 2) were developed to gather baseline productivity data for the project cattle and buffalo, collected over the three years and maintained for each enrolled animal, with data recorded at each of the 10 data collection points. After each data collection, copies of the sheets were sent to the project office in LPB and the data entered by the same staff member into a customized Access database (Microsoft 2003). The data collection sheets and records used in the field were in Lao language, with data was translated into English by the administrative staff member. Descriptive analyses were conducted regularly through the study and quantitative analyses used a restricted maximum livelihood (REML) in GenStat 14th edition statistical package program.

5.3.1 Weight tape for Lao cattle and buffalo

In 2010, 7,800 weight and girth measurements obtained from the data collections from all six project villages were used to develop a prototype weigh band for Lao cattle and buffalo. The prototype weigh bands were trialled in subsequent data collections in each project village and during slaughterhouse surveys in 2011. The extensive data-set was then fully re-analysed by the UoS team, providing a readily useable single information sheet enabling correlation of girth measurement provided by any measuring tape, with body weight. The sheet contains separate tables for both Lao indigenous breed cattle (*Bos indicus*) and Asiatic water buffalo (*Bubalus bubalis*) and this information was published progressively in two conference proceedings (Bush et al., 2010; Bush et al., 2012).

5.4 Disease surveys and investigations

In addition to the longitudinal production survey, targeted disease surveys for the identified priority diseases including FMD, Toxocariasis, Fascioliasis, blood parasites and bovine brucellosis were conducted, plus sporadic disease outbreak investigations including a major mortality due to hypothermia (Khounsy et al., 2012). These surveys were implemented by the DLF extension project staff, the Lao and Australian project research officers and UoS and NUOL students.

5.4.1 Foot and Mouth Disease

Limiting the impact of FMD in large ruminants by vaccination: a case study in northern Lao

Clinical and financial impact of FMD at village and individual animal level was assessed following an FMD outbreak in XK province in January 2009. The impact of the outbreak was compared between Ban Nong and Ban Nadee (the two BPHH project villages in XK province) where large ruminant vaccination for FMD occurred just prior to the outbreak as part of the animal health interventions for the BPHH project, and two nearby villages that had not been vaccinated for FMD. The FMD outbreak reputably affected all 111 villages of Paek district in XK province including Ban Nong and Ban Nadee. In Ban Nadee 323 or 54.2% of the cattle and buffalo were vaccinated between 17 and 22 December 2008 for FMD and HS and in Ban Nong all 289 cattle and buffalo were vaccinated between 8 and 10 December 2008.

The village veterinary workers in the four villages were interviewed face to face using semi structured questionnaires between February and March 2009 to obtain information on the FMD outbreak. The financial impact was calculated as a total and per animal cost for each village using assumptions based on local advice (Rast et al., 2010), including: (1) the mean value of cattle or buffalo is US$ 230 each for an animal in moderate body condition score weighing around 200 kg; (2) the mean value of calves is US$ 58 based on the average value of cattle calves <12 months old and of moderate body condition; (3) the cost of treatments including medications and labour is US$ 10 per animal; (4) FMD affected animals lose up to 30% of their bodyweight during an FMD outbreak if affected, reducing their value by around 30% or US$ 69 per animal; (5) cost of feeding an animal to pre-illness weigh levels is US$ 85 based on weight gain of 1 kg/day, requiring 45 kg of grass per kg weight gain or 2700 kg of grass to regain 60 kg at a cost of US$ 0.63 per 20 kg of grass; and (6) the cost of vaccination is US$ 0.89 per dose/animal consisting of US$ 0.69 for the vaccination and US$ 0.20 for administration and equipment.

Investigation of FMD hotspots in northern Lao PDR

Particular areas in South-East Asia appear more vulnerable to re-infection with FMD, described as FMD ‘hotspots’. In these areas, outbreaks occur regularly and during the most recent regional epidemic between 2009 and 2011, either annually or every second year. To define the northern Lao FMD hotspots, we examined records of FMD reports to the DLF between 2009 and 2011 and investigated the FMD hotspot of Paek district in XK province.

The two project villages Ban Nong and Ban Nadee in Paek were selected as study sites. They had been vaccinated in 2008 for FMD shortly before an outbreak occurred in early 2009, but had not been vaccinated in late 2009 due to local difficulties in sourcing vaccine.

A farmer survey was conducted in Ban Nong in July 2010, six months after the initial report of the 2010 FMD outbreak. Risk factors for FMD were investigated and pre- and post-vaccination serological surveys were conducted in Ban Nong and Ban Nadee in October 2010 and January 2011 to assess the likelihood of protection against further outbreaks. Hotspots were considered to have large ruminant populations, extensive animal trading and contain transit routes for trans-boundary movements (Nampanya et al., 2012) and are similar to FMD 'critical nodes' where the additional risk of accumulation and holding of transported animals occurs.

5.4.2 Internal parasites: *Toxocara vitulorum* and *Fasciola gigantica*

Prevalence and clinical impact surveys

At the first staff training workshop held in Luang Prabang, livers collected from the local slaughterhouse were found to be heavily infected with *Fasciola gigantica*. This precipitated several pilot surveys in 2009-10 in the six project villages using faecal egg counts (FEC), to examine the parasite populations present in the region and establish if further parasitic work was required. This indicated there was a largely unrecognised and unmanaged problem with Fascioliasis in adults and Toxocariasis in calves, precipitating a series of prevalence surveys for both parasites in cattle and buffalo across the five northern provinces of BK, LNT, LPB, HP and XK. At the time of sample collection, additional data collected included owner and village name, age and monetary value of animals provided, species, gender, body condition, coat condition, morbidity (including disease symptoms) and faecal consistency as assessed or observed by the researchers. These internal parasite surveys were expanded beyond the BPHH project to determine the prevalence and clinical impact across northern Lao, requiring a large sampling frame.

These studies on *Toxocara vitulorum* and *Fasciola gigantica* targeted young calves (<90 days) and adult animals (>12 months) for faecal sampling respectively, using a two stage sampling technique. Firstly, sites were randomly selected from a list of 198 villages participating in the LDP that had > 20 cattle/buffalo present. Secondly, faecal samples were collected from 10 calves (for *Toxocara vitulorum*) or 10-20 adult animals (for *Fasciola gigantica*) that were randomly presented or available during the research team visit. The surveys also included all six villages participating in the BPHH project.

Faecal samples were analysed using flotation (*Toxocara vitulorum*) and sedimentation (*Fasciola gigantica*) techniques at the Luang Prabang veterinary laboratory. Statistical analysis was conducted using logistic regression modelling and SAS statistical software version 9.3 (© 2002-2003 by SAS Institute Inc., Cary, NC, USA).

Treatment trials

A treatment trial was conducted to examine Fascioliasis therapy in Ban Nong, XK province. The prevalence of *Fasciola gigantica* as determined by FEC in this location was >50% during the prevalence survey conducted in 2010. The trial included two treatment and one control (untreated) groups, comparing use of imported triclabendazole oral drench (Fasinex®, Novartis, Animal Health Inc.) and locally available triclabendazole/albendazole (Handertil-B, Hanvet, Vietnam) tablets, respectively Animals were weighed and faecal samples collected on four occasions a month apart, commencing in August 2011.

For the Toxocariasis treatment trial calves <50 days old were treated in Ban Hardpang and Ban Nakud with a single pyrantel treatment at a dose rate of 10 mg/kg bodyweight. Faecal samples were collected and calves weighed at week 0, 4 and 12 of the trial starting in October 2011. In two other nearby 'control' villages, calves were faecal sampled and weighed at the same time and intervals as in the two treatment villages.

5.4.3 Haemo-parasites

Between 19 and 30 blood samples were collected in each of the six project villages between June and July 2009 by DLF staff previously trained in blood collection during project training workshops. Thin blood smears were made using a drop of jugular blood and air dried. A further 8 samples were collected in Ban

Hardpang in February 2012 and processed using the same method. The smears were stained with Giemsa stain and examined using microscopy under 100 x magnifications for the presence of blood parasites at the Luang Prabang veterinary laboratory. Any white blood cell abnormalities were recorded but not quantified.

5.4.4 Brucellosis

Thirty blood samples were collected in each of the six project villages by DLF staff and analysed at the Vientiane veterinary laboratory for *Brucella abortus* using a rapid field agglutination test (Life Biosciences, South Korea).

5.4.5 Investigation of a major cattle and buffalo mortality event: Hypothermia

An unusually cold weather event occurred in northern Lao between 14-19th of March 2011 and major mortalities were reported in cattle and buffalo across northern Lao at that time. Summary data on mortalities was collected by DLF staff in seven provinces (LNT, LPB, HP, Phonsali, Vientiane, Xaiabouli and XK) as well as village level data in the four ACIAR project sites in HP and XK provinces 2- 4 weeks after the mortalities occurred. This investigation identified and published the risk factors that contributed to the extent of the deaths, assessed the financial losses and provided advice on management of future similar events (Khounsy et al., 2012).

5.5 Slaughterhouse surveys

In northern Lao, slaughter of large ruminants occurs in small, basic, privately owned slaughterhouses during the night prior to sale of unrefrigerated meat products at local wet markets within a few hours of slaughter.

A small pilot survey to examine lesions suggestive of disease was conducted in three slaughter points in Luang Prabang in April and June 2009. The slaughterhouses were visited 3-4 nights over a 2 week period. Animals were examined pre-and post-slaughter, their origin determined from discussions with traders, and lesions and other findings recorded, including dentition to determined age (FAO, 2002) and gross pathology in the liver and other organs. Although livers were examined closely for liver fluke, minimal dissection of liver and bile ducts was possible as both are highly valued commodities. Findings were recorded on a predesigned data collection sheet.

A larger survey was conducted between March and June 2011 involving the main slaughterhouse in each provincial capital of BK (Huayxay), HP (Sam Nua), LNT (Luang Namtha), LPB (Luang Prabang) and XK (Phonsavanh). Each slaughterhouse was visited on three to five consecutive nights and all cattle and buffalo slaughtered were examined with samples collected as per the pilot survey. In all facilities visited, 5-10 large ruminants were killed and processed each night by different trader and butcher teams.

Faecal samples were analysed using the sedimentation method for liver fluke eggs at the Luang Prabang laboratory.

5.6 Knowledge surveys

5.6.1 Farmer knowledge surveys

An initial farmer knowledge survey was conducted to identify smallholder farmer knowledge gaps to be addressed by the project, with two further surveys to measure knowledge improvements and assess the effectiveness of the training interventions.

A census farmer knowledge survey of 238 farmers that owned the large ruminants enrolled in the research project, using face-to-face interviews, was conducted in February 2009. The questionnaire used was initially written in English and then translated into Lao and contained open, closed and semi closed questions on large ruminant diseases (parasites, FMD, HS), nutrition, reproduction and biosecurity (Appendix 3).

The project research team developed answer guidelines prior to the survey and farmer's answers were allocated scores consistent with these guidelines, with a correct answer being scored as 1 point and an incorrect answer or an 'I don't know' answer being scored as 0 to allow quantification of farmer knowledge. The interviews were conducted in Lao by the six appointed district DLF project staff and led by the Lao project research officer, with results published (Nampanya et al., 2010).

The initial census knowledge survey established that a sample of 20 farmers was sufficient to obtain an assessment of the knowledge in a particular village. The subsequent surveys were able to use a smaller sample size with a modified questionnaire to explore knowledge, attitudes and practices (KAPs) and were conducted in May 2011 and June 2012 as part of the KAP survey process (section 5.6.2).

5.6.2 Farmer Knowledge, Attitudes and Practices survey

Surveys of farmer knowledge, attitudes and practices (KAP) were conducted in May 2011 and May 2012 in ten villages from the five northern provinces of Lao, involving 200 smallholders from either the BPHH research or the LDP project sites. Twenty famers in each village were randomly selected for interview following discussions with the village chief and veterinary worker, with the majority of the surveyed participants involved in both interviews. The interviews were informal, offering open questions on the topic, followed by probing questions to clarify the answers and fill in the information needed in the questionnaire. Questions focused on farmer KAPs on large ruminant health, basic biosecurity and disease risk management for FMD and HS (Appendix 4).

5.7 Marketing - Trader survey

A trader survey was conducted in February 2009 using face-to-face interviews with traders operating in the six project villages.

A second trader survey was conducted between December 2010 and January 2011 again using face-to-face interviews with traders operating in the project villages (Appendix 5).

5.8 Training and Capacity building

Early in the project it became apparent that large ruminant health and production capacity within DLF, especially among district extension staff was low. Collaborative efforts between UoS and DLF delivered an extensive staff training program to optimise project interventions and enhance extension, farmer training and other project activities and outcomes.

5.8.1 DLF Extension Staff

Large ruminant health and production workshop series

The project management team secured additional funding from the Australian Crawford Fund to conduct a series of seven 2-4 day workshops that addressed topics in large ruminant health and production. The workshops involved theory and practical sessions plus interactive case studies and problem solving sessions in small groups. At the final workshop, all participants completed a knowledge quiz to assess their learning and were asked to provide feedback and an assessment of the workshop series. Further funding was also achieved to extend this training into the institutions that were responsible for training future extension workers, being NUOL and NAFC.

'On the job' field training

Extension staff strengthened the knowledge gained from the workshop series through implementation of the project activities, including vaccination, sample collection, record keeping, large ruminant handling, farmer training, farmer interviews and disease investigations. The same staff assisted in various student sub-projects during the project, gaining skills and knowledge in research practices including sample collection, record keeping, interview techniques, treatment trials and descriptive analysis.

5.8.2 Farmers

The training introduced to the HI villages by the research project consisted of three components including 1) participatory ‘applied field research’; 2) ‘on the job’ training; and 3) 'formal' training with farmer group meetings and cross visits.

Only the participatory ‘applied field research’ component was introduced to the LI villages. Nevertheless, informal discussions on various large ruminant health topics between district staff and participating farmers in LI sites did occur. In addition public awareness via posters of FMD, HS and Toxocariasis were distributed and displayed in all project village meeting halls, temples and schools.

5.8.3 Laboratory staff

Faecal sample processing was conducted at the local veterinary laboratory in Luang Prabang where three staff members were trained in floatation and sedimentation techniques and faecal egg identification.

5.8.4 Project leader professional development

The project management team secured an AusAID AFA (Australian Fellowship Award) that provided professional development opportunities for the Lao and Cambodian project leaders (ACIAR project AH/2005/089), Drs Syseng Khounsy and Suon Sothoeun. Professional development included participation in the on-site residential and completion of tasks in both the Project Management and Leadership Management units of the UoS Veterinary Public Health Management postgraduate program. The professional placements occurred in July 2010 and February 2011 in Sydney, Australia. On both occasions a broad range of Australian ruminant industry stakeholder organisations and enterprises were very obliging hosts for the AFA fellows providing them with very extensive understanding of the large ruminant production and animal health policy, education and delivery mechanisms and institutional structures in Australia.

5.8.5 Lao undergraduate student training

The project management team secured additional funding from the Australian Crawford Fund to adapt the workshop series developed and delivered for the DLF extension staff for delivery to final year agricultural students at NAFC (the Northern Agricultural and Forestry College) located near Luang Prabang and final year veterinary students at NUOL (the National University of Laos) located near Vientiane. Four workshops were held between September 2011 and May 2012 and trainers included the Lao and UoS project management team and lecturers from both institutions.

Visit of ALA Fellows to the Department of Agriculture, Fisheries and Forestry in Canberra, from left – Dr Mike Nunn, Professor Peter Windsor, Dr Suon Sothoeun (Cambodia), Dr Andy Carol, Dr Syseng Khounsy (Laos).

6 Achievements against activities and outputs/milestones

Objective 1: To confirm current knowledge of disease limitations to large ruminant production

no.	activities	outputs/ milestones	completion date	Comments
1.1	Consolidate, evaluate and report currently existing disease information	Assessment of current information in DLF on status of large ruminant diseases. Disease priorities confirmed	Dec 2008	FMD, HS, Toxocariasis, liver fluke, dermatitis of unknown cause are disease priorities. There is an ongoing gap in disease surveillance, monitoring and recording capacities at district/provincial and national level.
1.2	Conduct longitudinal survey targeting specific diseases	Disease surveillance, control and prevention information for 3 year survey period	Dec 2011	FMD, HS, Toxocariasis, Fascioliasis surveys surveillance control and prevention information obtained.
1.2.1	Select implementation staff	Recruitment of provincial and district DLF staff	Jun 2008	2 DLF district staff and 1 provincial DLF in each of the 3 selected district and provinces appointed.
1.2.2	Select six project villages, meeting set criteria	Selection of six Project sites	Oct 2008	Villages selected in consultation with DLF staff and village authorities.
1.2.3		Equipment (weight scales, sampling equipment) purchased and yards constructed	Nov 2008	No adequate large ruminant handling facilities exist in any of the villages. Once built, yards were regularly used by farmers for various husbandry practices i.e. year tagging, applying permanent head halters.
1.2.4	Conduct training workshops for the project staff	Project staff trained in best practice concepts, research and extension methods, husbandry, disease investigation, sample collection, surveillance reporting, disease control and biosecurity and food safety	Sep 2008(first) Dec 2010 (final)	Low capacity required increased training and seven short 2-4 day workshop series were developed and implemented for staff with additional funding from the Australian Crawford Fund.
1.2.5	Conduct project site field days for producers	6-7 farmers from HI village of LPB and XK were taken for farmers cross visits in XK	Mar 2012	Provided opportunities for farmers to discuss and share ideas and knowledge on large ruminant health and production techniques.
1.3	Attend annual planning meetings of other projects and workshops attended by project staff from different projects working in similar field	Linkages of extension expertise with DLF and NAFES and other extension and development projects	Jun 2008 to Jun 2012	Close collaboration with LDP throughout and with AMP and EASLP projects for first two years. Ongoing collaborations with NAFC and NUOL.

1.4	Farmer knowledge surveys (start/mid/end) project	Large ruminant smallholder's baseline knowledge of large ruminant health and husbandry their attitudes to best practice plus their training needs determined	Feb 2009 May 2011 May 2012	The research provided baseline knowledge and measured progress of the mainly knowledge-based interventions in delivering, through participatory research and extension practices, potentially positive benefits to participating farmers.
1.5	Identify and test cost effective means of sample delivery to laboratories for confirmation and reporting of a diagnosis	VVW's and project staff able to report and submit samples to NAHC, following trials conducted at each site to ensure the optimal method of sample submission is achieved	Ongoing	DLF and LPB Lab staff capacity increased through workshop and field training and processing of samples at the Luang Prabang lab. Constraints included lack of timely disease reporting by farmers, lack of sampling equipment and expertise by local staff, lack of laboratory capacity, cost of sample analysis and limitations in transport system remain and need to be gradually addressed.
1.6	Student projects	Students selected Topics defined, completed and findings presented	Jan 2009 Jun 2012-	Student projects list attached (Appendix 1). Capacity building of local staff enhanced by working with UoS students on various sub-projects. Several students have or are considering to seek employment in international work.

Objective 2: To implement, test and demonstrate the value of interventions preventing key diseases, preventing introduction of diseases and managing reproduction

no.	activity	outputs/ milestones	completion date	Comments
2.1	Measure key indicators of performance as baseline information for evaluation of outcomes based on interventions Develop production indicators Conduct 3-4 monthly data collections each village	Methodologies to assess productivity i.e. Annual Calving rates, calving interval, Condition score, Growth rate, Morbidity rate, Mortality rate, Monthly VVW report on animal treatments, numbers sick and dead, Causes of morbidity & mortality (lab supported), Cost of inputs and financial returns achieved on sale of livestock	Dec 2008(first) Dec 2011(last 10th)	With training staff were generally able to collect baseline weight data and implement interventions. However some data proved difficult to collect due to lack of observation and recording by farmers (e.g. calving dates to establish calving rates and inter-calving intervals, morbidity and mortality rates). Lab staff capacity insufficient to establish laboratory supported diagnostics although this was addressed by using internal parasite surveys to ensure and basic reproduction, morbidity and mortality data was collected in these surveys, enabling the determination of base line reproductive, morbidity and mortality rates for Lao cattle and buffalo.
2.2	Develop, introduce and evaluate key interventions	Key interventions developed agreed on and implemented	2008 to Jun 2012	Animal Health, nutrition, husbandry and marketing interventions introduced in HI villages. AH only in LI sites (Table 2).

2.3	Evaluate performance of ‘intervention sites’ compared with baseline data from ‘control’ sites	Production, husbandry and disease data recorded every 3 months. Analysed and reported annually	2008 to Dec 2012	The study showed initial low production performance of large ruminant due to variable seasonal feed availability and risks of endemic disease (FMD, HS internal parasites). This improved with uptake of vaccination, parasite treatment, and forage and nutrition for fattening interventions. This demonstrates that improved large ruminant productivity can be achieved and provide opportunities for famers to increase income.
2.4	Conduct economic evaluation of the project impacts	Costs and benefits of additional investment in interventions quantified and used to assess project cost effectiveness Outcomes analysed and reported	Dec 2012 & On-going	A small impact assessment of 10 farmers was undertaken in December 2012 investigating financial impacts on project farmers from HI village Hardpang in LPB. This small group of farmers reported average income increases of 130% between 2008 and 2012. All 10 farmers reported this was a result of increased large ruminant weight and nutrition, and a reduction in mortality. Further financial impact studies are on going (in PhD project of Sonvilay Nampanya).
2.3	Introduce and assess various livestock handling approaches	Animal restraint, soundness examination, sampling and fertility procedures gradually introduced during project visit field days competencies assessed and reported	Jun 2012	3-4 monthly data collection including weighing, ear tagging, vaccination and oral Toxocariasis treatment, as well as sample collection completed by project district staff together with farmers. Animal record card for provided for participating farmers in all villages, but limited uptake probably due to low literacy rates.

Objective 3: To assess attitudes of farmers in targeted communities to health, husbandry and market issues, and communicate project outcomes to large ruminant stakeholders.

no.	activity	outputs/ milestones	completion date	Comments
3.1	Targeted surveys at the start, mid-point and end of the study Questionnaires to clarify the learning objectives of participants	Learning objectives of farmers identified Training materials for development of best practice large ruminant production	Feb 2009 Jun 2011	There was low extension staff capacity and training of extension staff (i.e. train the trainer) was necessary prior to farmer training (section 5.8 and 7.8)
3.2	Conduct mid-project workshop with interviews of producers	Progress in knowledge of health and husbandry and further training needs identified		As above

3.3	Conduct Year 4 site workshops to evaluate attitudes of large ruminant producers	Gains in knowledge and skills of health and husbandry and attitudes to best practice identified	May 2011 and May 2012	Two KAP surveys to assess progress of KAP of farmers over time and to get an indication of sustainability and gaps that need further addressing
3.4	Final project completion workshop involving all stakeholders in the large ruminant livestock sector	Project outcomes delivered to farmers, extension workers, regional and central government staff, donors, development agencies NGO's and others Meeting held, outcomes reported and strategies for further research plus extension of findings developed	July 2012	Final workshop attendees were split in small groups to work through project outcomes, identify how to best scale out outcomes and identify gaps for further work. Group outcomes are attached in (Appendix 6).
3.5	Training of VVW's outside of project sites	Successful interventions delivered through VVW association meetings	2011-2012	Instead of training VVW's the project developed a training programmes for the participating farmers in HI villages including the VVW. Result of the KAP survey show the positive impact of training.
3.6	Form a Consultative Committee and conduct annual meetings with stakeholders	Ownership of project mgt. and outputs achieved throughout course of project by mutual learning	2008-2012	Management of the project from the Luang Prabang office with close liaison with UoS, enabled a local committee to manage the project, with regular workshops involving senior Ministry personal enabling higher level participation.

Objective 4: To improve knowledge of the cattle supply chain and key drivers in the targeted communities

no.	**activity**	**outputs/ milestones**	**completion date**	**Comments**
4.1	Describe the supply chain, key drivers for profit and opportunities for value- adding based on profit drivers and market organization provides understanding of the marketing process and strategies to improve productivity through marketing	Survey of producers, advisors and traders involved in project sites (i.e. weight targets, group sales, forward contracts) Supply chain described and marketing strategies identified and reported for testing.	Feb 2009 (initial survey) Jan 2011	Major issue identified was shortages of animals with increasing demand, plus need to increase accessibility, especially in HP as close to lucrative export markets in Vietnam. Problems traders face includes complicated and non-standardised taxes across provinces, valuing schemes that are considered unfair and difficult access to farmers and villagers. Full trader survey report attached (Appendix 10).

4.2	Implement and test approaches that increase value for livestock owners	Testing of best practice marketing approaches identified from surveys implemented in the intervention sites provided evidence of success of the marketing strategies and are reported	Continuous	Farmer-Trader workshop held in XK in 2010 to improve farmer knowledge of trader preferences and better understand trader practices. Evidence of trader preference for project cattle due to vaccination status and lower disease risk was clear.

Use of a girth tape and weigh scales at a training workshop in Ban Nong in Xieng Khouang Province to develop the Lao weigh tape.

7 Key results and discussion

7.1 Site selection

The six project villages selected provided a representative cross section of characteristics and production techniques typical of northern Lao. The farmers and village authorities remained cooperative, enthusiastic and very grateful for the opportunity to participate throughout the project.

Farmers in the six project villages belonged to two (Lue and Poun) of over 40 ethnic groups in Laos and it is possible that some different outcomes may have emerged working with different ethnic groups of farmers.

Some 'leakage' of intervention technologies occurred between HI and LI villages, especially calf Toxocariasis treatment in XK and forage technology in LPB, most likely due to the same district staff working in both villages in XK (after movement of one staff member to NUOL) and familial relationships of villagers in the HI and LI site in LPB, respectively. This indicates the increasing desire of farmers in the region to implement more modern production techniques to improve large ruminant productivity.

With a significant number of research and development projects working in northern Lao and limited reliable all-year road access, plus the outlook of economic benefits for participating villages, there was a risk that several projects may work in the same villages. Prior to site selection, participation in other projects (whilst not a selection criterion) was considered and some of the six project villages initiated or were concurrently participating in other projects during the BPHH project. Close collaboration with other livestock projects operating in northern Lao at the same time prevented conflicting project aims and minimise potential fatigue.

7.2 Interventions

The interventions trialled included:

- Animal health:
    - Vaccination biannually for FMD and HS
    - Parasite management: pyrantel or mebendazole treatment of young claves
    - Biosecurity: quarantining introduced animals, segregating sick animals
    - Treatment trials for Fascioliasis using imported triclabendazole and locally available triclabendazole/albendazole tablets
    - Treatment trial for Toxocariasis using a single pyrantel treatment in young calves (2 weeks of age)
- Nutrition
    - Forage plot establishment
    - Forage conservation (silage)
    - Fattening of cattle and buffalo in stalls
- Reproduction management
    - Introduction of castration
    - Preliminary training in bull selection and breeding management
- Marketing interventions
    - Farmer training in weight measurement and value estimation

Underpinning the interventions was DLF staff training followed by a farmer training program (sections 5.8 and 7.8). Table 2 shows the type and timing of the interventions that were implemented.

Table 2: Summary of interventions and dates of introduction in the six project villages of the BPHH project, AH 2006/159

Village Name	Ban Hardpang	Ban Hueypaen	Ban Nong	Ban Nadee	Ban Nakud	Ban Navieng
Province	LPB	LPB	XK	XK	HP	HP
District	PakOu	PakOu	Paek	Paek	Vienthong	Vienthong
Intervention classification	High	Low	High	Low	High	Low
Weighing dates, includes participatory applied field research farmer training	2008: Dec 2009: Mar, Jun, Oct 2010: Jan, May, Oct 2011: Feb , May, Oct	2008: Dec 2009:Mar, Jun, Oct 2010: Feb, May, Sep 2011: Feb , May, Oct	2008: Dec 2009:Mar, Jul, Oct 2010:Jan, May, Oct 2011: Feb, May, Oct	2008: Dec 2009:Apr,May, Oct 2010:Jan, May 2011: Jan, May, Sept, Oct	2008:Dec 2009:Mar, Sep, Nov 2010:Apr, Jun, Nov 2011: Mar, July, Nov	2009:Jan, Apr, Jul, Oct 2010: Feb, Aug, Nov 2011: Mar, July, Nov
FMD vaccination dates	2011:May 2012:Feb, Jul 2013: continued through LDP and OIE support	2011 May 2012:Feb, Jul 2013: continued through LDP and OIE support	2008:Dec 2011: Jun, Oct 2012: Feb, Jul 2013: continued through LDP and OIE support	2008 Dec 2011: Jun, Oct 2012 Feb, Jul 2013: continued through LDP and OIE support	2011: Aug 2012: Jan	2011: Aug 2012: Jan
HS vaccination dates	2008: Dec 2009: May, Sep 2010: May, Sep 2011: May, Sep 2012-13: continued by farmers' initiatives and LD support	2008:Dec 2009:May Dec 2010:May, Sep 2011: May, Sep 2012-13: continued by farmers' initiatives and LD support	2008: Dec 2009: May ,Jul 2010: Jan, Jun 2011: May, Sep 2012-13: continued by farmers' initiatives and LD support	2008 Dec 2009:may, Nov 2010:May, Sep 2011: May, Sep 2012-13: continued by farmers' initiatives and LD support	2008:Dec 2009:Jul, Nov 2010: Jun 2011: Jul, Oct 2012-13: limited continue	2009:Jan, Jun, Oct 2010:Jul, Oct 2011: Jul, Oct 2012-13: limited continue
Toxocara treatment calves	2008, Dec 2009, Jan Nov-De 2010: Jan Nov-De 2011: Jan Nov-De High Uptake	Osmosis knowledge transformation Increasing uptake	2008, Dec 2009, Jan Nov-Dec 2010: Jan Nov-Dec 2011: Jan Nov-Dec High uptake	Osmosis knowledge transformation Increasing uptake	2008, Dec 2009, Jan Nov-Dec 2010: Jan Nov-Dec 2011: Jan Nov-Dec Increasing uptake	2009:Jun Limited uptake
Toxocara treatment trial	2011 Oct to 2012 Feb				2011 Oct to 2012 Feb	
Fasciola treatment trial			2011: Aug-Nov			
Forage plot establishment	May 2009-4.4 ha (13 hh) May 2010 12.1 ha (19 hh) 2012: increasing	May 2009:1.95 ha(7hh) May 2010::5.7ha(11hh) 2012: increasing	June 2009: 2.5ha-(26hh) June 2010: 7.05ha (35hh) 2012: slow expansion		August 2009:0.2ha (43hh) August 2010:1.1ha (93hh) 2012: Limited uptake	August 2010: 0.7ha (29hh)8 Limited uptake
Fattening pens and fattening activities	2010 13 pens (13 farmers) 2011: 15 pens (6 farmers Increasing uptake	2010 :2 pens (farmers)	2010: 19pens (19 farmers) 2011: 5 pens (5 farmers Slow but steady uptake			

Forage conservation **- Bag silage** **- Concrete silage**	2010 380 bags, 13 hh 2011: 5 farmers and concrete silage sites- slow uptake	2010:40 bags, 2hh	2010: 372bags 35hh 2011: 5 farmers and concrete silage sites- slow uptake			
Bull castration, selection	Commenced 2010, increasing		Commenced 2010, increasing			
Formal Farmer training	Jun 2011: 22 farmers Mar 2012: 25 farmers		Jun 2011: 35 farmers Mar 2012: 40 farmers		Jun 2011: 40 farmers Mar 2012: 42 farmers	
Farmer and staff cross visits	May 2012: 15 hh 2 staff		May 2012: 5 hh 2 staff		May 2012: 5 hh 2 staff	
Large ruminant trader awareness	Mar 2012: meeting on trading rules and biosecurity involving Dr. Syseng, 14 and 4 traders from Hardpang and Houypaen respectively, plus the District Vice Governor and livestock officers discussing animal movement issues and good biosecurity.					

All interventions were implemented using a participatory approach as part of ongoing farmer training. Vaccination coverage of the village cattle/buffalo population was between 30-86% of the large ruminant population for HS at each vaccination and 50-100% of the large ruminant population vaccinated for FMD in the project villages. The variation in coverage reflects the high level of trading of animals from villages (estimated at 11% per annum), difficulties of accessing vaccine in the appropriate quantities, problems that some farmers had in presenting animals at certain times (animals located away from the village in common grazing areas), plus the lack of farmer knowledge and appreciation of the importance of vaccination as a disease prevention tool. To achieve and maintain good herd (population) immunity, it is generally considered that 70-80% of the population needs to be vaccinated; this is a challenge for many villages in northern Laos. The positive impact of vaccinations for disease prevention and in reducing clinical and financial impact of infectious diseases was clearly demonstrated for FMD by both epidemiological and serological analyses, even with only 50% of the population vaccinated (Rast et al., 2010; Nampanya et al., 2012; section 7.3.2).

Between 2008 and 2011 in all six villages farmers, VVW and staff did not report any outbreaks of HS. However there were numerous reports of HS outbreaks in July 2009 in northern provinces, causing more than 300 cattle and buffalo deaths in HP province alone (Lao News Agency, 2009). This and anecdotal information from project farmers of protection of their animals during outbreaks in neighbouring villages, provides evidence for the success of vaccination in preventing this disease, reinforcing the importance of continuing regular vaccination of large ruminants for both FMD and HS using effective vaccines and vaccination methods.

Forage technology (plantation, establishment, maintenance and use) was successful in enabling fattening in some HI villages (LPB HI and LI and XK HI). However ‘scaling-out’ is necessary to provide sufficient supplementary nutrition for achieving specific production targets, considering that up to 1,000 m^2 of forages are needed for fattening of one large ruminant. The current small scale uptake of forages probably reflects the relatively good natural grasses available in the wet season in upland areas to enable sufficient nutritional status of animals for much of the year (compared to rice-growing lowlands of southern Cambodia where there is an all year feed deficit). In XK temperatures can get to below 0º Celsius between November and February and more work on suitable forages for that climate is needed, especially legumes. Continued farmer and extension staff training plus cost/benefit case studies from targeted feeding of cattle/buffalo for specific production objectives as occurred in late 2012 in XK is required.

Reproduction management interventions were limited due to the extremely low initial staff and farmer knowledge and skills of basic reproductive practises, including reproductive physiology, breeding soundness, animal segregation and bull selection/castration. Despite extensive training of field staff, throughout most of the project it was very difficult to obtain reliable baseline reproductive data due to ongoing difficulties with observation and record keeping. Although some success was achieved towards project completion, the available lead-in time to test interventions was inadequate to obtain measurable outcomes within the project period. At the reproduction training workshop for project staff in March 2010, the project provided 2 sets of castration tools (Burdizzo clamps) for each district and staff worked with farmers, informing them about basic reproduction management and the importance of sex separation, breeding selection and castration, particularly in the project HI villages in LPB and XK province where this was well received. However reproduction interventions is an important area that needs further research and extension, particularly with the high demand for buffaloes into Vietnam and our observations that about 70% of female buffaloes slaughtered were pregnant. Our current assessment of reproduction benchmarks indicate they are significantly below optimum, with calving frequency being 0.5 calves/year for cattle and 0.6 calves/year for buffalo, first calving age for both species being 36 months (unpublished). Despite our efforts, there is currently minimal reproductive management practiced by farmers in northern Lao, with male and female animals rarely segregated and no breeding selection occurring. Hence there is both an urgent need for and a significant potential for interventions that improve reproduction using the currently available local genetic pool of large ruminants in Laos.

There is limited large ruminant marketing information available across northern Laos and this is also an area that requires further work. A trend of improved farmer knowledge on market demands and value of animals was demonstrated from the KAP survey results (section 7.6.2.). 'Scaling out' of the weight band that we developed should occur to further assist farmers in accurately gauging and assessing their animals' growth, weight gain and market value prior to sale.

7.3 Longitudinal survey: large ruminant production

Large ruminant populations

Table 3. Large ruminant populations in the six project villages over the project period from 2009 to 2012

Village Name	2009		2010		2012	
	Cattle	Buffalo	Cattle	Buffalo	Cattle	Buffalo
Hardpang	280	425	295	386	384	354
Huaypaen	272	0	324	11	217	16
Nong	305	163	371	97	416	136
Nadee	429	168	348	226	408	189
Nakud	175	650	212	639	225	437
Navieng	282	190	163	150	165	103

The animal population figures may not be as accurate as was desired, partly as farmers avoid revealing their actual livestock numbers due to concerns of local level tax payments calculated per number of animals farmers owned.

Between 2009 and 2010 there appeared a general trend in most locations for increases in large ruminants as farmers increased stocking due to increasing local demand for large ruminant meat and especially buffalo. However in Nong and Navieng, the numbers of large ruminants declined between 2009 and 2010 and this is considered most likely to reflect the overwhelming demand for buffaloes for transport to Vietnam and China and inability to replace these locally, in addition to replacement of draft buffalos with small tractors. However by 2012 the numbers of large ruminants were mostly stagnant or in decline, particularly the buffalo population, presumed due to consistent demand exceeding supplies and increased restrictions on available grazing areas from the land allocation process and infusion of other enterprises. For example in Luang Prabang where land use planning and land allocation has now been completed, the limited availability of grazing areas has been placing increasing pressure on large ruminant smallholders to sell some of their livestock despite the significant increase in prices due to growing demand for beef. The 2009 price for butchered beef in the local market of Luang Prabang was LAK 35,000 or US$ 4.50, whereas the current price of butchered beef in early 2013 is now reportedly LAK 70,000 or US$ 9.00. In addition to restrictions on grazing land, high level mortalities from an extreme climate shock event in March 2011 in XK and HP is considered to have negatively impacted the large ruminant population in the project sites in these provinces (Khounsy et al., 2011) plus FMD outbreaks between 2009-10 in XK may also have impacted on large ruminant reproductive performance and population data (Rast et al., 2010, Nampanya et al., 2012).

Baseline production data

Weight gain/growth rates

Over the 10 data collections between 2008 and 2011 the mean weight of cattle in HI and LI sites was 153-227 kg and 149-215 kg respectively (Table 4). Overall average daily gain (ADG) was 70 and 73 g/d in HI and LI, respectively. ADG of 212 and 208 g/d was observed in data collection 2-3 in HI and LI, respectively, whereas in the data collection 4-5, ADG of 9 and -40 g/day respectively. The mean weight of the observed buffalo in HI and LI was 285-380 kg and 305-349 kg respectively. Overall ADG was 86 and 96 g/d in HI and LI respectively (Table 4). In the data collection 2-3, ADG of 282 and 212 g/d was observed in HI and LI whereas in the data collection 4-5, ADG of 2 and -67 g/d was observed respectively.

Table 4. Descriptive data analysis of observed large ruminants across the province and village between 2008 and 2011

Date of sampling	Variable	Cattle		Buffalo	
		LI	HI	LI	HI
Data collection 1 Dec 2008	- No Animal observed - Mean age (yrs) - Mean weight (kg)	597 3.37(±4.87) 146(±70.19)	400 3.16(±1.96) 153(±70.29)	138 4.25(±2.72) 304(±113.45)	347 4.03(±2.94) 285(±114.50)
Data collection 2 Mar 2009	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	624 3.50(±4.705) 149(±63.65) 71(±190)	416 3.63(±1.92) 151(±63.96) -9(±253)	137 4.60(±2.73) 301(±110.50) -21(±163)	366 4.28(±2.96) 290(±105.90) 23(±290)
Data collection 3 Jun 2009	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	606 3.81(±4.67) 170(±63.42) 208(±186)	407 3.62(±1.93) 174(±64.23) 212(±154)	136 4.67(±2.68) 323(±117.0) 282(±249)	358 4.61(±2.93) 320(±101.20) 223(±206)
Data collection 4 Oct 2009	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	602 3.98(±4.76) 180(±59.68) 122(±200)	408 3.80(±1.93) 183(±63.05) 102(±185)	129 5.04(±2.79) 335(±111.0) 147(±287)	344 4.95(±2.97) 332(±97.97) 123(±245)
Data collection 5 Jan 2010	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	591 4.28(±4.79) 175(±55.45) -40(±187)	405 4.05(±1.86) 183(±60.34) 9(±178)	133 5.22(±2.71) 327(±98.80) -67(±249)	330 5.25(±2.92) 329(±91.50) 2(±263)
Data collection 6 May 2010	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	584 4.51(±4.82) 186(±56.75) 117(±227)	395 4.36(±1.86) 186(±57.66) 41(±195)	139 5.25(±2.80) 333(±102.20) 176(±207)	329 5.53(±2.91) 343(±85.58) 129(±285)
Data collection 7 Sep 2010	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	562 4.88(±4.87) 196(±56.75) 77(±154)	394 4.67(±1.86) 205(±57.20) 142(±128)	141 5.43(±2.94) 340(±97.26) 139(±195)	314 5.82(±2.86) 357(±80.83) 133(±209)
Data collection 8 Feb 2011	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	505 5.09(±2.40) 197.5(±54.64) 0(±148)	359 5.10(±1.86) 201(±58.00) -1(±157)	121 5.75(±2.99) 327(±81.22) -48(±222)	248 6.09(±2.88) 355(±72.79) 20(±222)
Data collection 9 July 2011	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	425 5.46(±5.37) 206(±52.45) 61(±138)	317 5.36(±1.92) 216(±59.04) 88(±148)	89 6.24(±2.97) 355(±72.75) 207(±193)	177 6.23(±2.60) 368(±70.13) 76(±240)
Data collection 10 Nov 2011	- No Animal observed - Mean age (yrs) - Mean weight (kg) - Mean ADG (g/day)	367 5.84(±5.74) 215(±53.52) 44(±121)	269 5.64(±1.84) 227(±59.44) 53(±125)	71 6.24(±2.97) 349(±79.31) 54(±211)	145 6.56(±2.58) 380(±72.81) 53(±242)

HP; Hua Phan, LPB; Luang Prabang and XK; Xieng Khouang. LI; low intervention village, HI; high intervention village.
Means ± standard deviations

The on-farm fattening trial demonstrated that significant ADG of 320 g/d for local breed cattle can be achieved when quality and quantity of feed and improved husbandry practices are provided. A similar study in northern Vietnam showed that local cattle under different supplement feeds had ADG of 337, 408 and 477 g/d for cattle groups fed cassava, stylo and the mixture of forages, respectively (Thang et al., 2010).

Reproductive performance

During the longitudinal survey it eventually became apparent that the requested ongoing reproductive data due could not be collected due to insufficient time at collections and lack of farmer records. To obtain this data, information on births and calf morbidity and mortality was collected retrospectively during farmer surveys on internal parasite practices (in the PhD project on parasites by Luzia Rast) and during the Knowledge and KAP surveys between 2009 and 2011 (Table 5).

The calving frequencies were 0.6 calves per year and 0.5 calves per year for buffalo and cattle respectively. The minimum age farmers reported for both species to have their first calf was 36 months. Future work addressing reproductive efficiency issues is greatly needed and with increasing receptivity to permanent identification of animals and signs of improved record keeping developing during the project, improved reproduction management research appears more feasible.

From the KAP surveys, the calving rate of cattle ranged from 51.3 to 74.8% in HI village of XK and LPB province, respectively (Table 5), with a calving rate for buffalo of 0.4 and 0.5 for cattle in the LI of XK and HI of LPB respectively. The average inter-calving interval was calculated for reproductively active females only (i.e. producing 2 calves within the project period) as 13.60 - 15.67 and 18.60 - 20.64 months for cattle and buffalo respectively.

Table 5. Contingency table of large ruminant reproductive performance between 2009 and 2011

	LPB		XK	
	LI*	**HI**	**LI**	**HI**
Cattle				
- No. of cows observed	435	417	111	228
- No. of cows gave birth	315	312	57	117
▪ 1 calf	22 (7%)	25 (8%)	14 (24%)	32 (27%)
▪ 2 calves or more	293 (93%)	287 (92%)	43 (76%)	85 (73%)
- Calving rate (%)	72.41	74.82	51.35	51.31
- Inter-calving interval (months)	14.47 ±4.53	13.60 ±3.12	14.68 ±4.63	15.67 ±5.41
Buffalo				
- No. of cow observed		120	66	66
- No. of cow gave birth		63	27	33
▪ 1 calf		17 (27%)	13 (48%)	10 (30%)
▪ 2 calves		46 (73%)	14 (52%)	23 (70%)
- Calving rate (%)		52.50	40.90	50.50
- Inter-calving interval (mths)		20.64 ±6.11	19.85 ±5.27	18.60 ±5.08

* Note that in the LI of LPB there were few buffalo kept as many farmers replaced their buffalo with a hand tractor for draft power.

Calf morbidity and mortality

Calf morbidity and mortality were obtained from data collected at farmer interviews in 2010 (in PhD research on *Toxocara vitulorum* by Luzia Rast) (Table 6).

Table 6. Annual calf morbidity, mortality and case fatality percentages in the six project villages, 2010

Village name	N[1]	Annual calf morbidity	Annual calf mortality	Case fatality
Ban Nong (HI)	8	75.0	18.2	24.2
Ban Nadee (LI)	8	32.0	24.0	75.0
Ban Nakud (HI)	6	40.7	14.8	36.4
Ban Navieng (LI)	8	28.6	28.6	100
Ban Hardpang (HI)	7	30.8	7.7	25.0
Ban Hueypaen(LI)	7	25.0	0	0

[1] Number of Households interviewed

Annual calf morbidity was higher in all three HI villages than in the LI villages, although this could reflect more intensive calf surveillance by farmers in the HI villages due to greater farmer awareness and knowledge on calf diseases and importance of early treatment, rather than an absolute difference in morbidity rates. This is supported by annual calf mortality rates and case fatality rates (% of sick calves that die) being lower in the HI villages.

Most commonly reported signs in sick calves were diarrhoea and weight loss. Calf morbidity but especially mortality rates were high and there is significant potential to increase productivity by reducing calf mortality. The high case fatality rates probably indicate that sick calves are either not treated early enough or that treatments applied are ineffective (incorrect treatment or dose). Further work to improve calf disease diagnosis and prompt effective treatment is indicated.

7.3.1 Weight tapes for Lao cattle and buffalo

Data for the final weight tapes for both Lao cattle and buffalo are attached (Appendix 7) and these data sheets can be used with any tape measure or if desired, used to produce dedicated weight tapes for local use by farmers and traders.

7.4 Disease surveys and investigations

7.4.1 Foot and mouth disease (FMD)

Case study of limiting the clinical and financial impact of FMD through vaccination

Morbidity rates during an FMD outbreak investigated in XK in January 2009 in Ban Nong (100% of large ruminants vaccinated) were 1%, in Ban Nadee 7.9% (54% of large ruminants vaccinated) and 61% and 74.3% in two nearby villages where no vaccination had occurred. Estimated financial losses were US$ 1.7-1.9 per animal in Ban Nong (fully vaccinated), US$ 6.9 - 8.1 per animal in Ban Nadee (partly vaccinated) and US$ 52.4 - 70.8 per animal where no vaccination occurred. The magnitude by which clinical and financial impact of FMD was reduced by vaccination indicates that vaccination in high risk FMD areas provides significant financial benefits. The proximity of the vaccination program to the onset of the FMD outbreak indicates that vaccination in the face of an FMD outbreak may also be a cost effective approach to FMD control in endemic areas to minimize the cost to producers and control the disease. Importantly, this case study provided evidence on the substantial clinical and financial impacts of FMD despite the generally low mortality rates, as published (Rast et al., 2010).

Investigation of FMD Hotspots in northern Lao

Examination of DLF records identified the three provinces of HP, XK and Xaiabouli, with eight districts classified as 'FMD hotspots', with the peak highest risk period for FMD outbreaks identified as December to March and June to August Thirty farmers in Ban Nong in XK were interviewed and it was identified that animal movements were most likely the relevant risk factor for introduction of FMD into the area, although the mode of transmission within the village is uncertain. Poor housing, nutritional deficiency, unrestricted animal movements and lack of control of 'in-contact' animals and people are thought to be important factors for increasing the risk of FMD infection and transmission in this and other FMD hotspots in the region. The impact was significant with >90% morbidity reported in cattle and buffalo. A need for village based biosecurity training and strengthening of local disease reporting networks through continued education of farmers and animal health workers were identified. In northern Laos this will require continued involvement of all stakeholders (farmers, traders, livestock extension officers, researchers and policy makers).

Blood samples collected prior to and post-FMD vaccination were tested by LPB-ELISA. Antibodies were present in pre-vaccination samples attributable to previous FMD exposure and titres significantly increased post vaccination, indicating the likely temporary post-vaccination protection against future FMD infection. It was concluded that to provide sufficient control of FMD in identified 'hotspots' in northern Laos, regular vaccination especially prior to the identified high risk period from December to February and improvement in farmer knowledge on biosecurity and disease transmission risks are needed. This should be accompanied by timely and accurate surveillance, disease reporting and diagnosis and importantly, emergency response interventions including effective movement controls and quarantine of infected animals, as published (Nampanya et al., 2012).

7.4.2 Internal parasites

Prevalence survey of Toxocara vitulorum in calves

A total of 899 cattle and buffalo claves <90 days old were tested from 69 villages located in BK, LNT, LPB, HP and XK provinces for this parasite by faecal egg examination. The overall prevalence was 22.6% (95% CI 0.17-0.28) and 76.8% of sampled villages had at least one calf with a positive faecal egg count, indicating significant and widespread Toxocariasis amongst cattle and buffalo calves in northern Lao. When comparing the prevalence of infection between species, 25.5% of buffalo and 20.9% of cattle claves were infected, although the difference between species was not statistically significant (p=0.107). The trend of higher prevalence among buffalo calves than in cattle calves has been reported in the literature and anecdotal reports from farmers and field staff suggesting Toxocariasis is more common in buffalo than cattle calves. The severity of infection (as determined by EPG counts and assuming higher counts means higher worm burden) was clearly found to be higher in buffalo calves (mean EPG count 7,573) compared to cattle calves (mean EPG 2795) and was significant (p<0.05).

Of note was that the commonly reported clinical signs of rough coat and diarrhoea, as well as species (cattle, buffalo) were not significantly associated with positive or negative faecal egg count results. Further, at 8.2% overall, treatment rates were very low and often ineffective with 16.2% of treated calves having positive FEC's for *T. vitulorum*. A prevalence of 17.5% was found amongst calves reported to be aged 1-21 days at time of sampling. This is within the pre-patent period of 21 days for *Toxocara vitulorum* (Roberts 1993) and possibly indicates earlier patent infection than generally acknowledged occurring in Laos, or more likely, uncertainty by farmers about the birth date of calves. The findings of our study indicate that all young cattle and buffalo calves in northern Laos should be treated for *T. vitulorum* and not only buffalo calves with a rough coat and white scours. Infection is common and widespread in both cattle and buffalo calves and importantly, neither the presence of clinical signs nor species at risk, were reliable indicators for infection, as published (Rast et al, 2012).

Prevalence survey of Fasciola gigantica in large ruminants in northern Lao

The apparent prevalence of Fascioliasis in northern Laos, as estimated from the field survey was 17.2% (95% CI 13.5-20.9%) and as estimated from the slaughterhouse survey was 34.1 % (95% CI 26.0-42.2%). In the field survey, a total of 1,268 large ruminants >12 months old were sampled, consisting of 462 buffalo and 806 cattle from 75 villages. Of the animals sampled, 68.5% were female and 31.5% were male. Among the sampled villages, 55 (73.3%) had at least one animal with a positive faecal sedimentation test. Prevalence varied from 12.9% in Luang Prabang to 24.7% in Hau Phan province. At sampling 32 (2.5%) of the animals sampled were reported as sick and 15 (46.9%) of the sick animals had positive fecal egg count results. Average fecal egg counts were 132.6 EPG in cattle and 158.9 EPG in buffalo. Multivariable analysis showed that province, being sick, gender (female) and species (buffalo) were significantly ($P < 0.005$) associated with *F. gigantica* infection status. Linear regression models for level of infection amongst positive cattle and buffalo indicated that being sick was the only variable significantly associated ($P = 0.0001$) with EPG levels.

This survey identified widespread presence of *Fasciola gigantica* in large ruminants in northern Laos using a test with reputedly low sensitivity. Hence the true prevalence is likely to be much higher and some evidence for this is provided by the high rates of liver damage due to *Fasciola gigantica* infection observed at the slaughterhouse surveys (section 7.5).

The result of this survey indicate that control of Fascioliasis is important in both cattle and buffalo as infection causes production losses and potentially poses a human health risk with water plants and raw meat products (including liver) common dietary items for humans in northern Laos. The clinical impacts of liver fluke are chronic and obscure and as knowledge of the parasite by farmers is minimal, research on potential drivers for sustainable liver fluke control is needed. It would appear that intensive education of livestock production stakeholders is required if Fascioliasis control is to be achieved in Laos and similar developing countries, as described (Rast et al., 2013; ACIAR Proceedings No. 138).

Treatment trials for Toxocara vitulorum and Fasciola gigantica

Fasciola gigantica:

Details of the results of the *Fasciola gigantica* treatment trial are shown (Table 7) and attached (Appendix 8).

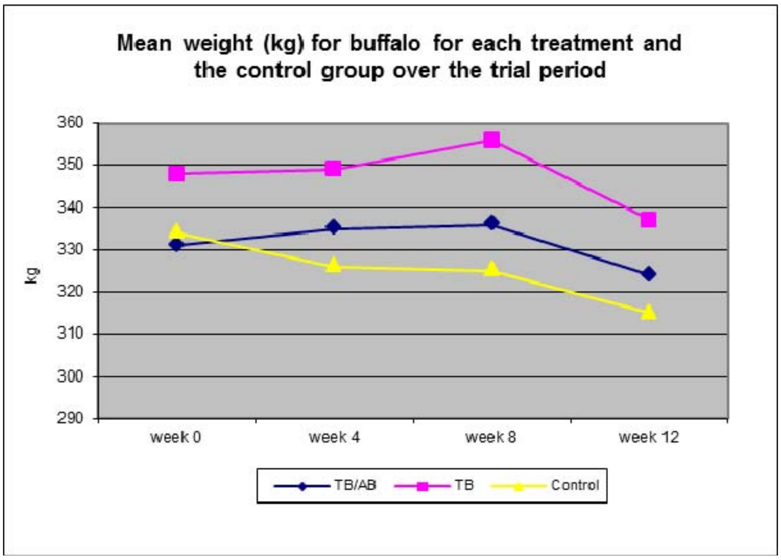
Table 7: Mean egg per gram of faeces counts (EPG) and faecal egg count reduction in percentage reduction for cattle and buffalo in each treatment group over the three month trial period in Ban Nong, Lao, 2011

Week	Variable	Treatment Group					
		ABZ/TBZ		TBZ		Control	
		Cattle	Buffalo	Cattle	Buffalo	Cattle	Buffalo
0	EPG	20.17	19	39.75	14	5.70	10.57
4	EPG	0.33	0	0.38	1.00	4	7.71
	FECR	97.67	100	98.64	90.21	-	-
8	EPG	0	1	1.38	0.86	4.3	7
	FECR	100	92.05	95.40	90.72	-	-
12	EPG	0	0.4	0.50	0.29	2.4	4.14
	FECR	100	94.62	97.01	94.71	-	-

Trial results showed that both locally available albendazole and triclabendazole tablets (ABZ/TBZ) plus imported oral triclabendazole drench (TBZ) anthelmintics were effective in both cattle and buffalo, with fecal egg count reduction rates of > 90% over the trial period (Table 7).

There was a trend of increased weight gain in buffalo in the treated animals compared to the untreated group (Figure 1) during the trial, although this was not evident for cattle. However the trial period was likely to have been too short and as it was necessarily conducted in the field during the dry season to enable access with nutrition not controlled, there was likely to be insufficient dietary energy present for weight gain during the 3 month trial.

Figure 1: Mean weight (kg) of buffalo over *Fasciola gigantica* treatment trial period of different treatment groups in Ban Nong, 2011



***Toxocara vitulorum*:**

A summary of the calf numbers, age, weight and treatment at the start of the trial are provided (Table 8).

Table 8: Number, age, weight and dose rates of pyrantel for calves in the four trial villages, October 2011.

Village	Calf numbers		Mean Age (range) in days	Mean Weight (range) in kg	Number calves treated	Dose Range (mg/kg)
	Cattle	Buffalo				
Hardpang	11	9	19.5 (12-29)	29.7 (17- 51)	20.0	12.5 – 15.6
Hardkhor	5	6	16.5 (2-28)	28.0 (15-35)	0.0	-
Nakud	4	16	20.6 (8-50)	32.7 (16-48)	20.0	5.2 – 11.9
Thamla	0	10	21.6 (12-32)	31.7 (18-44)	0.0	-

This data suggest there is not a vast difference between the means of ages at initial sampling, with the treatment average of 20.1 days and the control average of 18.9 days old (although the range of ages was substantial). The dosage of pyrantel varied between 5.2 mg/kg and 15.6 mg/kg. This variation did not affect the response as all dosages resulted in a FEC reduction, although the dose rates may not be accurate due to discrepancies in weight. Weight was assessed in this study by rice scales with calves were lifted onto their backs and placed onto the scales, providing a minimum of time to determine the weight of the calf before it overbalanced and was caught by the farmers. As correct dose range of anthelmintics (and other therapeutics) is important, a method for farmers and extension staff to more correctly weigh smaller animals and calculate accurate doses is required. Further as optimal treatment and prevention of *Toxocara vitulorum* infection is achieved if treatment with pyrantel occurs when calves are 10-20 days old, more accurate determination of age of calves is necessary. This could be achieved through controlled joining, surveillance of calving animals and record keeping and is recommended for future studies.

Average weight gain and percentage of FEC positive calves in each village over the trial period are presented (Table 9) and show there was a large reduction in FEC positive calves after treatment, although no significant increase in weight gain occurred in the treated calves over the trial period.

Table 9: Percentage of calves with FEC positive results and weight gain over trial period in four trial villages from October 2011 to January 2012

Village	FEC Positive (%)			Average Weight Gain (kg)		
	Week 0	Week 4	Week 12	Week 0-4	Week 4-12	Week0-12
Hardpang	40.0	0.0	6.3	+13.5	+14.9	+28.4
Hardkhor	90.9	100.0	27.3	+9.5	+15.6	+25.1
Nakud	25.0	6.7	0.0	+5.4	+6.6	+12
Thamla	40.0	40.0	37.5	+3.9	+4.3	+8.2

The effectiveness of pyrantel treatment of *T. vitulorum* in cattle and buffalo calves in the field in smallholder farming system in northern Lao was confirmed, as described in the literature (Roberts, 1992). The trial period was likely to have been too brief and other contributing factors including nutrition of the calves and the mother plus possible presence of other diseases may have influenced the weight gain of the calves in the trial.

7.4.3 Haemo-parasites

In three of 152 (2.0%) blood smears examined, *Theilleria evansi* was identified. One positive sample was from a female buffalo in Ban Nakud, HP province and two were from a cattle bull and cow in Ban Nong, XK province. None of the animals tested showed any clinical signs. Results suggest that haemo-parasites are possibly not an endemic production limiting disease in cattle and buffalo in northern Laos.

7.4.4 Brucellosis

All blood samples analysed showed negative results for bovine brucellosis, providing some evidence that bovine brucellosis is possibly not an endemic disease problem in large ruminants in northern Laos.

7.4.5 Study of a significant mortality due to hypothermia

Following unusual cold weather with minimum temperatures of 6.7 to 7.5º Celsius; and rainfall of 36.6 to 61.7 mm (recorded at XK Thong Haihin meteorological station) between 14 to 19th March 2011 across northern Laos, deaths of 7,162 cattle and 3,744 buffalo were reported in six northern and one central Lao province. Affected animals were observed to shiver, have slow and shallow respiration, lose consciousness and eventually die. Many deaths occurred during the night and were recorded in both males and females and all ages of large ruminants. Mortalities occurred mostly in free grazing animals that were exposed to the cold weather. Some animals that were provided with warmth (housing/fires) and supplementary feed including silage developed by the research project, did not die.

Total financial losses were estimated at US$ 2,463,912. The event and our detailed investigation as published (Khounsy et al., 2012) indicate that strategies to minimise the impact of extreme cold weather events need to be included in livestock development extension programs.

7.5 Slaughterhouse survey

Fasciola gigantica

A total of 125 animals were examined and sampled. A majority (66.3%) of animals slaughtered were >5 years old. Of the 123 examined livers, 87 (70.7%) had gross liver lesions categorised as mild (22.8%), moderate (17.9%) or severe (30.1%). Buffalo had higher rates of hepatic and biliary tract pathology with 95.6% (n=68) having a grossly abnormal liver compared to 40.0% (n=55) of cattle. Of the 44 *F. gigantica* positive animals where livers could be examined, 37 (84.1 %) had hepatic and biliary tract pathology, with 29 (78.4%) of these being buffalo and 8 (21.6%) cattle. Interestingly of the 79 animals determined as not currently infected with *F. gigantica*, 50 (63.3%) had hepatic and biliary tract pathology; 36 (72.0%) of these being buffalo and 14 (28.0%) cattle. It is of note that no condemnations of any abnormal livers were observed during the survey. Liver damage and low BCS were the only variables that tested as significantly associated ($P < 0.05$) with *F. gigantica* infection status. Species (buffalo), age (≥3 years) and *F. gigantica* infection status (positive) were significantly ($P < 0.05$) associated with liver damage.

There was a much higher *Fasciola gigantica* FEC prevalence (34%) in the slaughterhouse animals than in the field survey (with a prevalence of 17%). This probably reflects that the slaughterhouse study population comprises animals chosen for sale, with smallholder farmers tending to sell animals when there is a sudden need for cash for the household (i.e. health emergencies, ceremonies, education costs) rather than for maximum profit when the animal is in good condition. They may choose older, ‘sick’ or ‘poorer’ animals to sell despite this being discouraged by authorities, as they often cannot afford treatment or fear their animals may die, greatly affecting their household assets. Some evidence of this practice was apparent with 65.3% of animals at the main slaughterhouse surveys being >5 years old.

Other findings

While the main purpose of the slaughterhouse survey was to assess carcass damage for liver fluke, some important additional findings included:

- 44% of female cattle and 47% of female buffalo were pregnant at slaughter.
- FMD gross lesions differed in each province, with lesions in buffalo detected in LPB in 9/14 buffalo, in XK in 1/38, in LNT in 1/15 and in HP in 1/40 animals.
- Meat/health inspection and condemnations of any part/products did not occur.
- Slaughter and butchering practices were basic, done on the ground with minimal hygienic standards resulting in potential high risks to food safety, animal and human health and welfare.

The slaughterhouse surveys confirmed this approach to be a practical surveillance method in areas with limited animal health capacities for collecting regional or provincial disease information. This surveillance method could easily be implemented regularly and be expanded geographically and for other diseases (i.e. clinical and subacute foot and mouth disease, other internal parasites) and production benchmarks, such as weight, body condition and reproductive status. The likely bias of the slaughterhouse population needs consideration prior to policy decisions based on such information, although slaughterhouses have been shown to be important sites for disease surveillance and management in FMD and could also provide an opportunity for implementing a system of quality control in disease control programs (Windsor et al., 2011).

7.6 Knowledge surveys

7.6.1 Farmer Knowledge survey

For the initial survey in 2009, all 238 farmers with cattle and/or buffalo enrolled in the longitudinal production survey of the project in the six project villages, were interviewed. There was a significant difference of knowledge scores on internal parasites, infectious diseases, reproduction and nutrition management between the three provinces. The prediction mean of total knowledge score on infectious diseases ranged from 5.1 in HP to 8.5 in XK of 24 total score. The prediction mean of the total knowledge score was 13.5 in LPB and 19.3 in XK of a total 42 marks/score. Results identified the scope of the knowledge gap amongst smallholder farmers in large ruminant production and identified the need for addressing this gap through farmer training, as published (Nampanya et al., 2010).

The KAP surveys conducted in 2011 and 2012 identified significantly higher scores (Table 10) providing evidence that the training interventions had been successful in increasing farmer knowledge. Knowledge scores increased in both the high and low intervention villages but to a larger extend in the high intervention villages where a more intensive training program was implemented. The similar knowledge scores between 2011 and 2012 were not statistically significant and indicate that the knowledge was retained; suggesting that knowledge gained is potentially sustainable.

Table 10: Mean knowledge scores of farmer knowledge surveys in 2009, 2011 and 2012 and of DLF extension staff workshop participants in 2010 on large ruminant diseases, reproduction and nutrition in northern Lao.

Year	Parasite question score (max 6)		Infectious disease question score (max 24)		Nutrition question score (max 6)		Reproduction question score (max 6)		Total score (max 42)	
	HI	LI	HI	LI	HI	LI	HI	LI	HI	LI
2009	3.5	3.4	6.2	6.5	3.2	3.5	2.4	2.7	15.2	16.1
2011	5.2	4.1	14.8	11.5	4.9	4.5	3.4	3.1	28.9	23.3
2012	5.1	4.1	13.7	10.3	5.5	4.4	3.4	3.1	27.7	21.8
Extension staff (2010)	5.0		19.3		4.3		4.4		32.6	

7.6.2 Farmer Knowledge, Attitude and Practices surveys

Surveys of farmer knowledge, attitudes and practices (KAP) were conducted between May 2011 and May 2012 involving 200 smallholders in five northern provinces of Lao PDR, including the six project villages. There were significant differences in farmer knowledge scores across the observed provinces and villages in both the 2011 and 2012 surveys. The predicted mean of farmer knowledge scores in HI villages in the 2011 survey and again in 2012 were significantly higher than in the other surveyed villages (28.86/42; $p < 0.001$ and 21.83/42; $p<0.00$ respectively). A comparison of the total knowledge scores in HI villages in the 2011 and 2012 surveys was not statistically different, indicating retention of knowledge and suggesting that the learning had been potentially sustainable.

The results indicated that improved farmer KAP on large ruminant health and production in northern Lao PDR can be achieved through intensive training programs, although some farmers have yet to apply their knowledge gained into improved husbandry and biosecurity practices. In HI villages, farmers tend to have positive attitudes towards FMD vaccination, forage plantation and parasite control, with the multiple interventions addressing large ruminant health and production encouraging smallholders to participate in FMD disease risk management. Continuation of learning support is recommended, as is investigation of methods of the 'scaling-out' of farmer learning if this approach is to provide significant support for the progression of Lao PDR on the progressive control pathway for FMD. The results of these surveys have been prepared for publication and a copy of the submitted/draft manuscript is attached (Appendix 9).

7.7 Trader surveys/meetings

During January and February 2011, 32 traders operating in the three project provinces were interviewed. The mean number of large ruminants purchased annually per trader was 295. Details of animal characteristics purchased and percentages are presented (Table 11) and a detailed report of the trader survey is attached (Appendix 10).

Table 11: Characteristics of animals traded between Jan/Feb 2010 and Jan/Feb 2011 by 32 traders in HP, LPB and XK provinces

Animal Characteristic		Total	Percentage (n = 8,860)
Species	Cattle	3249	36.67
	Buffalo	5601	63.22
Sex	Male	4231	47.75
	Female	4629	52.25
Body condition	Skinny	56	0.63
	Medium	5475	61.79
	Fat	3345	37.75
Age	<2 years	252	2.84
	2-8 years	7341	82.86
	>8 years	1267	14.30
Season of Purchase	Wet	4089	46.15
	Dry	4697	53.01

Most traders (60%) paid the owners a price calculated on estimated meat weight of the animal, although some (23%) based prices on the general appearance (body condition) and others (17%) primarily negotiated the price based on past experiences of livestock pricing with other farmers or traders.

Traders responding that they paid a price on estimated meat weight, paid rates ranging from 38-45,000 LAK/kg. Importantly weights are estimates as no large ruminant weight scales are routinely used in northern Lao by traders or farmers. Mean prices paid for different animals are presented (Table 12).

Table 12: Mean prices paid by traders for large ruminants in millions of LAK.

Cattle				Buffalo			
Male		Female		Male		Female	
Fat	Store	Fat	Store	Fat	Store	Fat	Store
3.8	2.6	2.5	2.0	5.6	4.4	4.2	3.5

Exchange rate Feb 2012 1 million LAK=AUD 120

Traders purchased stock directly from farmers (51.3%) or from other traders (48.7%), with the majority (71%) of traders selling exclusively into the domestic market, and 29% of surveyed traders selling some animals for export to Vietnam. Fees and costs incurred by traders varied greatly and included: health checks prior to slaughter (6,000-15,000 LAK/head); slaughter fees (30,000-112,000 LAK/head); marketing fees (4,000-15,000 LAK/day); other taxes (30,000-850,000 LAK/month), and transport costs (80,000-200,000 LAK/head). Extra costs mentioned by some traders included days of care for animals if sale or slaughter was delayed (10,000 LAK/head/day)

The majority (90%) of traders preferred to purchase vaccinated animals as this provided some investment security. However, very few traders would actually check if stock were vaccinated. All said they would not buy stock from areas with an outbreak due to investment security but also government regulations. None of the surveyed traders felt they had reliable access to as many animals as they would like to purchase. Over half (55%) experienced the greatest shortage during the wet season, 24% in the dry season, 10% during the rice harvest and planting season, 3.4% all year and during the Vietnamese New Year. Survey results confirmed the variability that exists in large ruminant marketing in the three project provinces of LPB, HP and XK. Shortages of cattle and buffalo occur throughout the year but often associated with higher demands during festivals.

7.8 Capacity building

7.8.1 DLF extension staff

Extension staff received theoretical and practical training at the workshop series including small group problem solving and presentation sessions. A schedule of these workshops is presented (Table 13). The workshops were attended by 28 DLF provincial and district extension staff who were working on both the ACIAR and LDP projects and some by lab staff and a Northern Agriculture and Forestry College teacher.

The six project staff appointed to the BPHH trained at these workshop applied and deepened their skills by involvement in activities of the project. This included regular visits to the project sites for data collection, implementation of interventions and sample collection; all activities involving close working relationships with the farmers. Staff attending the workshops that were involved in the LDP project, applied their new knowledge and skills through their work with the LDP project and assisting in research project surveys.

Interactive group sessions were a novel teaching/learning method experienced by most participants. Their participation and interaction quickly increased and by the second or third workshop, most participants became very enthusiastic contributors. The average mark of the assessment was 32.62 ± 2.49 out of 42 possible marks (Range: 25-37). The assessment showed very positive and successful knowledge improvement of the participating staff trainees, although the assessment questions were of a basic standard reflecting the low initial capacity of their knowledge and skills. Knowledge of extension staff in the region, whilst greatly improved, is still low and continued training is required

Table 13: Summary of district and provincial DLF extension staff large ruminant production training series in Lao 2008-2010

Workshop title	Topics	Location	Date
Initial Staff training	Background on large ruminant health and production, project methodology	LPB	29-30 Sep, 2008
Animal health	Diseases (FMD, HS, Blackleg, internal and external parasites), epidemiology, outbreak investigation, sample collection	LPB	6-7 Feb, 2009
Nutrition	Forage establishment, quality and quantity assessment, body condition scoring, feed requirements	LPB	6-8 Apr, 2009
Biosecurity	Disease risk assessment and management and basic biosecurity measures for village level	LPB	21-22 Jul, 2009
Reproduction	Reproduction physiology, breeding soundness examination, reproduction management	LPB	16-18 Mar, 2010
Nutrition & Marketing	Forage conservation, large ruminant nutrition physiology, value assessment for different markets, reproduction & marketing interventions	XK	15-17 Jun 2010
Extension & village-level biosecurity	Development of extension strategies from all topics covered in previous workshops	LPB	6-8 Dec 2010

Australian staff include Ms Lynne Henry, Ms Luzia Rast, Professor Peter Windsor, Dr Russell Bush, with students Ms Rachel Bailey and Ms Tara MacDonald, accompanying Dr Syseng and Mr Sonevilay Nampanya in Phonsavan in Xiengkhouang Province in 2010

7.8.2 Farmer Training

The three training components implemented by the district and provincial extension staff, were as follows:

1. Participatory ‘applied field research’ consisted of the project-enrolled farmers presenting their cattle and buffalo on 10 occasions over a 3 year period between December 2008 and 2011 for weighing, vaccination, sample collection (e.g. faeces, blood) and recording of additional health and production information. As the farmers and project team worked closely together and there was general discussion on the aims and progress of the project, farmers were able to develop relationships with project staff and ‘informally’ learn new information and skills.
2. The ‘on the job’ training consisted of extension staff working with small groups of farmers to improve cattle health and production through ‘best practice’ interventions. These included regular vaccination and anthelmintic treatments (when required) plus importantly, substantial improvements to nutrient availability through implementation of forages technology.
3. The ‘formal training’ was conducted between June 2011 and April 2012 for Village Animal Health Workers and 25 – 35 farmers in each of the three HI villages. This was conducted by a trained district livestock extension team and involved 2 days of training with a half day group discussion, plus various farmer 'cross visits' and meetings. The training consisted of five modules including:
    I. Prophylaxis for controlling major animal diseases
        a. Good husbandry practices
        b. Nutrition
        c. Vaccination
    II. Basic biosecurity measures (quarantine and separation of sick animals)
        a. Infectious diseases in cattle and buffaloes
        b. Haemorrhagic septicaemia (HS)
        c. Foot-and-mouth disease (FMD)
    III. Basic information on parasitic disease management in cattle and buffaloes
        a. Toxocariasis
        b. Fascioliasis
    IV. Forage cultivation and management
        a. Importance of forages and nutrition
        b. Selection of sites for cultivation
        c. Land preparation and planting techniques
        d. Forage management
    V. Farmer group meetings and cross visits
        a. Group discussion and village meeting on large ruminant health
        b. Cross visits to share experiences of champion farmers within and outside village

Farmer knowledge was assessed through the farmer knowledge and KAP surveys and is described in detail (sections 5.6.1 and 7.6.1). The knowledge assessments demonstrated a significant improvement in farmers' knowledge over the project period, providing evidence of the success of the training methods used.

7.8.3 Lao and Cambodian project leader professional development

The success of our application for the AusAID Australian Leadership Award Fellowship program for Round 7 2009, entitled 'Strengthening Animal Health and Production Capacities, Cambodia and Lao PDR' enabled both fellows to complete a program that included studies in the Leadership and Project Management units in the UoS VPHM program (Veterinary Public Health Management). In addition, visits to UoS and CSU exposed them to adult teaching/learning techniques. Professional placements included DAFF in Canberra, NSW DPI EMAI Veterinary Laboratories at Menangle, Animal Health Australia and the Australian Veterinary Association, plus mixed private veterinary practices. This provided experience in disease surveillance, diagnostics and disease control at local, state and national level, as well as insights into animal health policy and organisational structures and management. Further placements included a cattle feedlot, export abattoir, dairy farms and saleyards, providing knowledge on marketing and processing as well as large scale farming practices.

7.8.4 National University of Laos and Northern Agriculture and Forestry College collaboration

The training program developed for the research and extension staff was delivered in part to students and staff at NUOL and NAFC in 2011-12. Both theoretical and practical training was delivered in a workshop series on large ruminant health and production, involving 25 4th year veterinary science students at NUOL, and 35 3rd year agriculture college students at NAFC (Table 14). The workshops provided opportunities for Lao students as well as participating teachers to learn of current knowledge in topics of relevance to large ruminant health and production, plus research project outcomes in addressing current large ruminant health and production constraints in northern Laos. Additional funds (non-project and Crawford Fund) were located and used to establish large ruminant training facilities at both locations, including cattle restraining and weighing equipment and weigh scales, plus assistance with forage plantations.

Table 14: The Crawford Fund workshop series for Lao students at NUOL and NAFC

Workshop Name	Topics	Participants	Location	Date
Animal health I	Diseases, epidemiology, outbreak investigation, sample collection	NUOL 26 4th year veterinary student: NAFC: 34 final year college student	VTE LPB	Sep 2011
Animal health II	Diseases, epidemiology, outbreak investigation, sample collection	NUOL 26 4th year veterinary student:, NAFC: 34 final year college student	VTE LPB	Nov 2011
Nutrition	Forage establishment, quality and quantity assessment, body condition scoring, feed requirements	NUOL 26 4th year veterinary student:, NAFC: 34 final year college student	VTE LPB	Feb 2012
Reproduction	Reproduction physiology, breeding soundness examination, reproduction management	NUOL 26 4th year veterinary student:, NAFC: 30 2nd year college student	VTE LPB	May 2012

7.8.2 Capacity building of project team

The sections above describe the more formal capacity building and learning, especially of the partner country team members. Of importance was the very significant ‘informal’ learning and capacity building by all team members working collaboratively in designing and implementing this research project.

8 Impacts

Prediction is very difficult especially about the future (Robert Stan Peterson, 1882-1949)

8.1 Scientific impacts – now and in 5 years

Global scientific impacts that this and the 'sister' project in Cambodia can claim is their influence in changing scientific attitudes and thus practices towards both the development of the smallholder large ruminant resource as a strategy for improving food security, plus addressing the constraints of FMD on this trade. This includes definition and identification of FMD 'hotspots', financial assessment of losses due to FMD, and promotion of village-level biosecurity in the smallholder farming system. The scientific literature has been generally dismissive of the impact of FMD on smallholders due to the low mortality rates, claiming that the beneficiaries of TAD control have been considered to be largely the commercial producers. Both projects gathered evidence that this was not the case and have stimulated a re-assessment of this paradigm, with a new ACIAR funded Biosecurity project to address the issue through a collaboration with OIE, approaching inception. Further, progression of farmer and trader knowledge of biosecurity has emerged in this project as an important strategy to be developed in future FMD control efforts in the region in collaboration with OIE. A direct impact was evidence of the effectiveness of FMD vaccination in reducing morbidity, contributing to the case presented to OIE that resulted in the current extensive vaccination program of FMD hotspots in northern Laos following significant supplies of FMD vaccine by donor countries.

Regional scientific impacts were facilitated by the implementation of the most successful interventions into the LDP project as soon as they were available. These included forage plantation establishment, fattening of large ruminants, treatment of calves for *T. vitulorum*, basic biosecurity measures (i.e. quarantine of introduced animals and vaccination for HS and FMD) and improved husbandry management (i.e. large ruminant housing overnight, manure pit construction, weighing or use of weight bands and recording of animal production). Findings from this project have enormous potential to provide impact into the future but will require significant strengthening of institutions, capacities and knowledge transfer. They include:

- Enhanced control of FMD through improved vaccination and biosecurity strategies
- Knowledge on the significant and widespread prevalence and clinical impact of *F. gigantica* and *T. vitulorum* in large ruminants in northern Laos, providing the base information needed to develop local management strategies
- Effective uptake and adoption of technologies for forage establishment, maintenance and conservation with evidence of improved productivity through fattening trials
- Local production and wider use of the locally developed weight band to provide more accurate assessment of live weight, providing farmers and traders with a tool to more accurately assess values and monitor growth and weight gain.
- Identification of needs for improved reproductive management to address the rapidly developing deficiencies in supply of large ruminants in the region.

8.2 Capacity impacts – now and in 5 years

The 28 Lao livestock extension officers from the PAFO and DAFO greatly improved their skills as documented in assessment of their large ruminant production training following attendance at the project workshop series (sections 5.8.1 and 7.8.1). These staff also improved their research skills, particularly in interviewing techniques, faecal sampling and record keeping, by participation in and implementation of several surveys (Knowledge & KAP surveys, Trader surveys, *Toxocara vitulorum* and *Fasciola gigantica* prevalence surveys, Farmer KAP surveys for *Fasciola gigantica* and *Toxocara vitulorum*, slaughterhouse surveys, disease outbreak investigations, hypothermia related mortality studies, FMD & HS investigations).

Participating farmers/households improved their large ruminant production skills through the participatory research used, cross visits and through some formal training delivered by DLF staff.

Three government staff of the Luang Prabang livestock section were trained in faecal egg count techniques (floatation and sedimentation) processing and analysing a large percentages of the samples. The project sites provided project opportunities for students from UoS and a recent graduate from CSU to carry out their postgraduate research and final year rotation placements. Several of these students are now conducting postgraduate work (e.g. Sonevilay Nampanya, Luzia Rast) or developing their careers in international rural development (Luke York, Jenny Hanks). In addition, as 4th year students and staff of NUOL and final year students and staff of NAFC participated in four workshops on large ruminant production (see section 5.8.1 and 7.8.1), it is likely that this knowledge of the project outcomes can be embedded in the curriculum of both institutions, plus it is very likely their skills in large ruminant production techniques can be progressed in their careers.

Capacity improvements also included establishment of large ruminant handling facilities including holding yards, crush and weight scales in all six project villages and NUOL and NAFC, plus establishment of fattening stalls, provision of veterinary kits, post mortem kits, castration tools and motorbikes to the DLF. The skills extended over the project duration by a vast array of adult learning opportunities, are very likely to be sustained and increased into the future, providing staff and farmers can continue to apply them. Future project opportunities that include similar training components are recommended as the KAP surveys have clearly identified superior pathways that can be used to develop large ruminant health and production in the region.

8.3

Oral examination of a buffalo at a training course in Luang Prabang for extension staff

Community impacts – now and in 5 years

8.3.1 Economic impacts

There were significant differences between provinces and villages in farmer socioeconomic factors, including total cultivated areas, number of large ruminants per household and income from the sale of large ruminants (Table 15). The predicted mean of the total cultivated areas per household ranged from 1.27 ha in HP to 3.38 ha in LPB ($p < 0.001$). The prediction mean of number of large ruminant per household was 6.25 heads in LPB and 13.03 heads in XK ($p < 0.001$) and number of large ruminants in HI and LI were 10.49 and 8.79, both being superior to the prediction mean of large ruminants in villages in the LDP of 6.37 ($p < 0.001$). The average income from selling large ruminants across the province ranged from US$ 142 and 760 in LNT and HP, respectively ($p < 0.001$) and across the village were US$ 621 and 547 in HI and LI villages, compared to 225 in LDP villages respectively ($p < 0.001$).

Table 15. **Smallholder farmer income from large ruminants in observed provinces and villages**

	Across province						**Across village**			
	LNT	**BK**	**HP**	**LPB**	**XK**	***p***	**HI**	**LI**	**LDP**	***p***
A. Cultivated areas (ha/hh)										
- Total	1.92	3.32	1.27	3.38	2.15	<0.001	1.67	1.74	3.62	0.020
- Paddy field	0.24	0.78	0.78	0.93	1.22	<0.001	0.85	0.69	0.83	<0.001
- Upland rice	0.63	0.95	0.23	0.26	0.00	<0.001	0.18	0.25	0.85	<0.001
- Forage	0.11	0.50	0.00	1.05	0.10	<0.001	0.55	0.26	0.30	0.001
- Others	0.87	1.04	0.28	1.09	0.83	<0.001	0.28	0.77	1.28	<0.001
B. No. Large ruminants(heads/hh)										
- Total	6.21	8.70	8.78	6.25	13.03	<0.001	10.49	8.79	6.37	<0.001
- Female	3.99	5.89	5.89	4.35	9.25	<0.001	7.07	5.78	4.75	<0.001
- Cattle	5.23	3.45	3.54	4.47	8.99	<0.001	5.95	6.26	3.14	<0.001
- Buffalo	0.98	5.25	5.25	1.64	4.08	<0.001	4.55	2.52	3.24	<0.001
- No. calf born	1.57	1.86	1.87	1.50	2.30	0.006	2.03	2.02	0.96	<0.001
- No. introduced	1.05	0.16	0.17	0.78	0.43	<0.001	0.47	0.38	0.72	0.004
- No. sold	0.49	0.78	1.62	1.82	1.02	0.019	1.51	1.45	0.64	<0.001
- No. died	0.14	0.23	2.00	0.04	1.14	<0.001	1.02	1.05	0.18	<0.001
C. Income and losses from large ruminants (US$/hh)										
- Income	142	369	760	558	450	<0.001	621	547	225	<0.001
- Loss	47	77	422	4	338	<0.001	248	252	44	0.001

[a] indicates significant different between the mean of each parameter ($p < 0.05$).

The on-farm fattening trial demonstrated that increased values of cattle and buffalo by US$ 78 and 123 per head respectively was achieved over a 4-6 month period. The results encouraged the participating farmers and others to continue or commence fattening activities, although this is not suitable for all smallholder famers as it requires investments in the planting forages and improved disease risk management through regular vaccination, parasite treatment and basic biosecurity practices. For farmers with available land and investment, higher returns from fattening can be used to further strengthening large ruminant production investments and obtain higher returns (Dorward et al., 2009).

Following ear tagging of animals enrolled in project villages, requests from farmers outside the project for ear tags occurred as farmers see benefits in individual animal ID for recording and theft reduction, plus ear-tagged and vaccinated animals are sought by traders who recognise their lower disease risk. Tagging also improves monitoring cattle/buffalo by individual owners when common grazing areas are used (Ban Naviang and Ban Nakud, Houaphan province).

Some evidence of farmers having commenced to use group bargaining with traders is emerging. This together with heavier cattle/buffalo and knowledge of animal weights is assisting in achieving higher sale prices for r cattle and buffalo in XG province where heavier animals are in demand for the live export market to Vietnam.

In Ban Nong, farmers have been building improved cattle and buffalo houses, being more careful about choosing a location that improves biosecurity measures to decrease risk of FMD, plus have added manure collection pits nearby or adjoining to these houses for better hygiene.

The financial benefit of vaccinating for FMD was documented in the FMD case study (Rast et al, 2010) and this paper has provided new approaches for assessing the socioeconomic impact of infectious disease control leading to work on establishing dynamic models of FMD management. Extension material for farmers (posters) on Biosecurity and the value of vaccination for FMD has been prepared. The financial impact of internal parasites (Liver fluke and *Toxocara vitulorum*) is being assessed as part of a PhD thesis, with final results of analysis expected in mid-2013.

8.3.2 Social impacts

Anecdotal evidence from interviews with farmers in the HI sites through the project consistently confirmed that smallholder farmers were empowered by their knowledge of animal production and particularly valued FMD & HS control, *Toxocara vitulorum* treatment plus forage technology. Similar interviews with farmers in the LI sites identified that farmers were aware that they should use such interventions but required assistance to implement them, as provided in the latter part of the project. Additional anecdotal information was that in HI sites other enterprises were developing as a result of increased incomes, including the purchase of trucks for animal trading.

8.3.3 Environmental impacts

Forage establishment, manure collection, more restraint and housing of cattle rather than free grazing are all likely to result in local environmental impacts, although analysis of this issue was not an objective of this project.

8.4 Communication and dissemination activities

8.4.1 Participation at meetings

See section 10

8.4.2 Conference presentations

See section 10

8.4.3 Scientific papers

See section 10

8.4.4 Project signs

Between 2 and 4 project signs were installed in all six project villages. Locations included by the roadside at village entry/exit, village meeting halls and schools.

8.4.5 Extension material

Posters on FMD, HS and *Toxocara vitulorum* were produced and displayed in villages in meeting halls and schools. Pamphlets were designed and presented to the in-country project leader for use in the LDP.

9 Conclusions and recommendations

9.1 Conclusions

This project has demonstrated that farmers are enthusiastic in their participation in knowledge based research projects that improve large ruminant health and productivity in northern Laos. Undertaking research projects on this scale presents a range of challenges, however as the primary aim is strongly focused on reducing poverty through improving large ruminant productivity, then incremental productivity gains, improvements in farmer knowledge and profitability should be celebrated. Farmers with greater knowledge have the ability to decide future activities and practices that help them.

The animal health knowledge intervention impacts that were achieved in a relatively short (3-4 year) time period provides significant potential for contributing to regional disease control, particularly in the SEACFMD campaign to control FMD in the Mekong region by 2020. The project has led to more timely disease reporting and increased occurrence of diagnostic confirmation; evidence that the project has successfully led to increased disease surveillance capacity in northern Laos. Disease response capacities have improved and although the current focus has been on FMD vaccination, efforts to build improved biosecurity practices are commencing. The nutritional interventions offer enormous potential for improving rural livelihoods but need greater effort for farmers to learn to target feed individually selected animas for predetermined production aims. A need for energy conservation in northern Laos due to risk of hypothermia and the delay required to achieve significant improvements in weight gain at the village-level due to high proportion of slow adopters of fattening, are of relevance.

The marketing interventions also show that although progress is slow, changes have commenced and with increasing demand and decreasing supplies of large ruminants, the drivers for increasing rates of change are in place. A major constraint to meeting this demand is the need to improve reproductive rates and northern Laos appears unique in that it is commencing to develop from such a very low base with almost no reproductive management at all. Attention to slaughterhouse standards is also an issue deserving attention.

An important feature of this research project was the co-location with a major livestock development project that enabled more effective capacity building through staff training and ‘real-time’ delivery of the research outcomes to other areas in the region. This has led to improved extension capacity with documented evidence of improved knowledge transfer to farmers. That this is occurred in a 4 year project is remarkable and shows the widespread receptivity that exists for knowledge in the region. Future projects should be made aware of the project ‘entry points’ for interventions that were identified, being FMD and HS management and potentially treatment of calves for Toxocariasis (compared to Cambodia where all year nutrition is a priority).

Future projects need to address FMD and HS risks through vaccination and biosecurity, encourage increased utilisation of forages to achieve more widespread fattening, recognise that parasitic infections are widespread and calf losses due to *Toxocara vitulorum* and adult underperformance due to *Fasciola gigantica is* common and manageable, that lack of breeding management is constraint that needs urgent address, plus intensive training programs can build extension capacities and change farmer practices quickly. This research demonstrates the importance of a systems approach with team members skilled in all aspects of the production system if improvement of large ruminant productivity is to be promoted as a development strategy for alleviating rural poverty in the Greater Mekong Subregion.

9.2 Recommendations

Reproduction

Farmers that have achieved improvements in cattle nutrition and disease control should be targeted for further reproduction improvement interventions. For reproduction to be successful, animals must be of a suitable body condition and plane of nutrition and free of infectious diseases. While improved animal restraint was practiced in this project, purpose built cattle crushes (with head locks) should be used in future studies to ensure advanced reproductive interventions can be conducted. Such interventions may include rectal pregnancy diagnosis, artificial insemination, bull evaluation and castration etc. that can be conducted in a safe manner for both animal and operator. Research project budgets should include such capital investments to ensure optimal productivity gains and enhance research potential.

Improving Market Information Systems

There is limited market information available in northern Laos. It is generally acknowledged that there is a significant and increasing demand for red meat in the GMS. A trend of improved farmer knowledge on market demands and value of animals was demonstrated from the KAP survey results (section 7.6.2.). Scaling out of the weigh band we developed should occur to further assist farmers in accurately gauging and assessing their animals' growth, weight gain and market value prior to sale. Farmers need marketing information that advises prices for types of animals demanded by the market to ensure they are able to plan and adapt to meet market demands and optimise profitability.

Forage suitability

As demonstrated in XK temperatures can drop below 0º Celsius between November and February and more work on suitable forages for that climate is needed, especially legumes. Continued farmer and extension staff training plus cost/benefit case studies on targeted feeding of cattle/buffalo for specific production objectives (i.e. reproduction or fattening of selected animals rather than spreading the feed resources across all animals owned) is required.

Biosecurity and vaccination programmes

The uptake of biosecurity practices including vaccination needs further research to establish the most suitable method for public education at the community level. For example, achieving FMD vaccination rates above 80% in villages has proved difficult due to the extensive management systems and turn-over of project animals.

Recording of animal husbandry and health at the farm and village level

Obtaining data from smallholders presents many challenges due to low literacy, the high numbers of smallholders and wide variation between farm systems and enterprises. Means of recording events need to be researched to improve both production and the management and control of trans-boundary animal diseases (TAD). High levels of trading within villages and to neighbouring communities as well as to traders, presents a high risk of TAD spread, and simple and effective methods of traceability should be examined.

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10.2 List of publications produced by project

10.2.1 Journal and ACIAR Publications

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10.2.2 Conference presentations and proceedings

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Bush RD, Khounsy S, Rast L, Henry LA, Nampanya S, Thomson PC, Windsor PA. (2010) Capacity building in northern Lao PDR for improved feeding and marketing of cattle and buffalo. Plenary paper, Proceedings, 14th Animal Science Congress of the Asian-Australasian Association of Animal Production Societies, Pingtung, Taiwan, Republic of China, August 23-26, pages 146-151

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Other publications

Several newsletter articles on project activities and progress were published in three UoS Newsletters: CNN (Camden Network News), Rumenations (publication by the Veterinary Science Foundation of the UoS) and VPHMgt newsletter.

11 Appendixes

11.1 Appendix 1: List of student projects and outcomes

Name / Degree	Title	Contribution / relationship to project goals and outputs
Luzia Rast PhD part-time, UoS, 2009-13 (by publication)	Financial and clinical impact of *Fasciola gigantica* and *Toxocara vitulorum* on large ruminants in northern Lao	Document the losses caused by endemic parasitism in northern Laos. Assess calf mortality rates and association with Toxocara or not. Initial results show Fasciola is common yet previously unknown in this region. Will improve disease diagnostic and control options and offers significant potential to avoid production losses, plus determine if there are zoonotic concerns. Also investigates Farmer Knowledge, practices and attitudes to parasite control and results will assist to provide drivers for sustainable parasite management. Research activities are assisted by DAFO, and local livestock section staff improving data collection/reporting and lab staff capacities.
Sonevilay Nampanya AVBSc Honours, UoS, 2009 PhD 2012-2015	Farmer knowledge and biosecurity in northern Lao .	PhD project intends to offer a 'bottom up' model approach to TAD control for the region; of highest priority if successful Very important initial measure of farmer knowledge gaps of health, production and biosecurity, for comparison with measures to be obtained that will document changes in practices after project interventions have been established.
James Young Masters VPHMgt, UoS, 2010-11	Data analysis of production data	Extremely important to obtain and document descriptive and quantitative analysis of productivity data from both the Cambodian and Lao projects and offer comparative interpretation of high versus low intervention strategies.
Shing Lee BVSc Honours, UoS, 2009	*Toxocara vitulorum* pilot studies, northern Lao	Important study that established initial prevalence data confirming both the need for a larger PhD project and that current investigative techniques were sufficiently robust.

Name / Degree	Title	Contribution / relationship to project goals and outputs
Verity Ambler BVSc Honours, UoS, 2009	*Fasciola gigantica* pilot studies, northern Lao	Important study that established that our initial opportunistic discovery of *Fasciola gigantica* reflected a high prevalence in the northern large ruminant population. Confirmed both the need for a larger PhD project and that current investigations were, in the main, sufficiently robust.
Jennifer Urwin BVSc Honours, UoS, 2011	Epidemiology of FMD and vaccine efficacy in Lao	Important work investigating outbreaks of FMD in new areas, including collection of material for molecular sero-typing, plus conduct post-vaccine serological assessments to determine vaccine efficacy. Extends work published in scientific paper and a conference paper.
Katy Kirby BVSc Honours, UoS, UoS, 2012	*Toxocara vitulorum*; Treatment trial	Initial analysis and summary of data from single pyrantel treatment of young calves
Laura Hodges BVSc Honours, UoS, 2013	Financial impact of FMD	Conduct of a financial impact survey of FMD on smallholder incomes in northern Laos, progresses a similar study done the team in Cambodia
Luke York AVBSc Honours, UoS, 2008	Farmer knowledge study, Lao/Cambodia	Initial studies established the low level of farmer knowledge of large ruminant production and their receptivity to project derived learning, enabling the projects to proceed with confidence.
Tara Macdonald AVBSc Honours, UoS, 2010	Weight data analysis for weight tape for Lao cattle and buffalo	Important outcome as provides a simple tool that if widely adopted offers farmers enormous empowerment in understanding growth and the value of animals.
Isabel McPhillamy BSc(Vet) project, UoS, 2013	Assessment of biosecurity awareness	Assisting in LDP FMD vaccination project with focus on determining effectiveness of delivery of biosecurity awareness information

Name / Degree	Title	Contribution / relationship to project goals and outputs
Rachel Bailey BVSc – RPP final year project, UoS, Sept 2010	Pilot slaughter point survey, Luang Prabang Lao	Additional data that supported the pilot *Fasciola* study but also established very high rate of pregnant female slaughtering and the need for compliance to reduce l decimation of the buffalo resource.
Clare Phillips BVSc – RPP final year project, UoS, Jan 2011	Parasitic studies,Lao	Assisted surveys of farmer knowledge and practices of parasite control to enable quantitative impact of interventions on farmer learning.
Lee Winer BVSc – RPP final year project, UoS, April/May 2011	Slaughterhouse survey. *Fasciola gigantica* extension material.	Assisted abattoir surveys and documented findings including high pregnancy rates in female slaughter cattle and buffalo.
Michaela Avery BVSc – RPP final year project, UoS, June-/July 2011	Cold exposure mortalities	Assisted in literature review and data collection/interview design prior to publication
Amy Howe; Bronwyn Bonette BVSc – RPP final year project, UoS, July/August Sep/Oct 2011	Facsiola Treatment trial	Assisted in field work with treatment trial and faecal sample analysis.
Jimmy Keep; Ilana Hoffman BVSc – RPP final year project, UoS, Jan 2012	Toxocara Treatment trial	Assisted in fieldwork with treatment trial and in faecal sample analysis
Debbie Burnet BVSc – RPP final year project, UoS, Jan 2012	Socioeconomic Survey of project farmers *Toxocara vitulorum* in calves	Assisted in developing KAP survey questionnaires. Initial analysis and summary of data from 3 project provinces
Laura Schmertmann BVSc – RPP final year project, UoS, Feb 2012	Trader survey analysis	Detailed report on analysis of trader surveys conducted by the project

Name / Degree	Title	Contribution / relationship to project goals and outputs
Varan Rajan BVSc – RPP final year project, UoS, Feb 2012	Haemoparasites in northern Lao	Small survey of Haemoparasites in northern Lao-very low prevalence of *Theilleria spp*.
Doraica Aponte BVSc – RPP final year project, UoS, March 2012	FMD review	Reviewed current relevant literature on FMD
Leah Weaver Max Tori BVSc – RPP final year project, UoS, April/May 2012	FMD vaccination programmes Fattening trial data summary	Assisted in LDP FMD vaccination project Contributed to report on fattening by forage feeding
Adam Robinson BVSc – RPP final year project, UoS, May/June 2012	FMD vaccination programmes	Assisted in LDP FMD vaccination project and socioeconomic impacts of FMD
Joyce Lau; Jennifer Zahrdadka BVSc – RPP final year project, UoS, Dec 2012	FMD vaccination programmes	Assisted in LDP FMD vaccination project and socioeconomic impacts of FMD
Emma Roffey BVSc – RPP final year project, UoS, Jan 2013	HS and FMD vaccination	Assisted and documented a field investigation of an outbreak of HS; assisted in LDP FMD vaccination project and socioeconomic impacts of FMD
Angeli Kaura BVSc – RPP final year project, UoS, March 2013	FMD vaccination program	Assisted in LDP FMD vaccination project and socioeconomic impacts of FMD

Name / Degree	Title	Contribution / relationship to project goals and outputs
Stephen Bailey BVSc – RPP final year project, UoS, April 2013	FMD vaccination program	Assisting LDP FMD vaccination project and biosecurity awareness initiatives
Peter Bartlet BVSc – RPP final year project, UoS, May 2012	FMD vaccination program	Will assist in LDP FMD vaccination project and biosecurity awareness initiatives

11.2 Data collection sheet for 3-year longitudinal production and health survey

Longitudinal baseline production and health of cattle and buffalo survey

Best Practice Cattle and Buffalo Health and Husbandry in Lao PDR ACIAR 2006/159

Farmer's information

1. Village name	**2. Farmer Name**	**3. House ID**
....	.... **- Age.......... (yrs)**	....

Large ruminant information

4. Ear-tag no.	**5. Sex**	**6. Species**	**7. Estimated date of birth (months/years**
....	Male.......... Female.......... Male Castrate	Cattle.......... Buffalo..........	....

8. Use for	**9. Original**
8.1. Draft.......... 8.2. Fattening..........	9.1 Born in the village.......... 9.2. Introduced/bought ....

8.3. Breeding.......... 8.4. Other..........	
10. Date of introduced/bought (month/year)	**11. If bought where from** 11.1. Province.......... 11.2. District.......... 11.3. Village..........

Data collection sheet (Collected every 3-4 months)

Date	Body condition			Coat condition		Last birth (month & year)	Bull selection (Yes/ No)	Date put with bull (month & year)	Weight (Kg)	Height (cm)	Girth (cm)	Width (cm)	Comments, observation (ie. injury, disease, external parasites) fate of animal if no loner present (dead or sold
	S	M	F	N	A								

Remark

Body codition: S = skinny, M= Medium, F = Fat

Coat condition: N = Normal smooth and shine, A = Abnormal (dull; rough faded etc..)

11.3 Farmer Knowledge survey questionnaire

Farmer Knowledge Survey of Cattle Farmer Participants ACIAR 2006/159 – Best Practice Cattle and Buffalo Health and Husbandry in Laos

Sampling Guidelines
All or a sample of farmers (~ 20%) of the farmers enrolled in the project in each village will be selected to complete the survey. The same farmers will be surveyed at the beginning (Nov/Dec2008), middle (Feb/Mar 2010) and end (Aug/Sep 2011) of the project.

Interviewer ……………………………………………………………………………….

Date …………………………………………………………………………………

A. Farmer Details

Province …………………………………………………………………………………

District …………………………………………………………………………………

Village …………………………………………………………………………………

Farmer name …………………………………………………………………………………

Farmer Gender………………………Farmer age:……………………………..

Forage Grower (Yes/No) ....

Number of cattle owned/managed by farmer ………………………………………………………..

Number of buffalo owned/managed by farmer…………………………

Area of total cultivated land owned/leased by farmer:………………square meters

Area of land used for forages:………………………square meters

Area of land used for other crops:………………………square meters

B. General Information

1. List the following, from 1 (most important) to 8 (least important), in order of importance to your livelihood?
   …… rice growing
   …… buffalo raising

…… pig raising
…… Poultry raising
…… Goat raising
…… non rice crop, vegetable or fruit growing
…… other: specify……………………………

2. Rate the following, from 1(most skills/knowledge) to 8 (least skills/knowledge), in order of the farming enterprises you think you have the most skills and knowledge in?
   …… rice growing
   …… buffalo raising
   …… pig raising
   …… Poultry raising
   …… Goat raising
   …… non rice crop, vegetable or fruit growing
   …… other: specify……………………………
3. How did you obtain your skills/knowledge in **cattle** raising? Indicate the following sources of knowledge in order of amount of knowledge you have gained from them: 1(source where most knowledge has been learned from) to 7 (source where least knowledge learned)
   …… From family/household member
   …… From other farmers in village
   …… From farmers from neighboring villages
   …… From Friends
   …… From government staff
   …… From project staff
   …… From schools
   …… From other- specify………………………………………

4. How did you obtain your skills/knowledge in **buffalo** raising? Indicate the following sources of knowledge in order of amount of knowledge you have gained from them: 1(source where most knowledge has been learned from) to 7 (source where least knowledge learned)
   …… From family/household member
   …… From other farmers in village
   …… From farmers from neighboring villages
   …… From friends
   …… From government staff
   …… From project staff
   …… From schools
   …… From other- specify………………………………………

5. What is your main reason for keeping **cattle**? List in order of priority (1 most important, 5 least important)
   …… For cash
   …… For draught power
   …… For breeding calves
   …… For fattening and sale for meat
   …… For other (specify)…..

6. What is your main reason for keeping **buffalo**? List in order of priority (1 most important, 5 least important)
   …… For cash
   …… For draught power
   …… For breeding calves
   …… For fattening and sale for meat
   …… For other (specify)…..

C. Marketing

7. Put the following in order, from 1 (most common) to 5 (least common), in terms of the most common reasons you normally sell your **cattle**?
   …… need the money
   …… good price available
   …… have too many cattle to care for
   …… a cow cannot have calves (ie culling)
   …… cattle are too old or sick

8. What age do you generally sell your **cattle**? *(circle which applies, can be several)*
   1) 0-1.9 years
   2) 2-3.9 years
   3) 4-10 years
   4) over 10 years
   5) whatever age they are when I need the money

9. Put the following in order, from 1 (most common) to 5 (least common), in terms of the most common reasons you normally sell your **buffalo**?
   …… need the money
   …… good price available
   …… have too many buffalo to care for
   …… a buffalo cow cannot have calves (ie culling)
   …… buffalo are too old or sick

10. What age do you generally sell your **buffalo**? *(circle which applies, can be several))*
    1) 0-1.9 years
    2) 2-3.9 years
    3) 4-10 years
    4) over 10 years
    5) whatever age they are when I need the money

11. Do you usually obtain a quote from more than one trader before you sell your cattle or buffalo?

    Yes No *(circle which applies)*

12. Do you know the market price of your cattle or buffalo before you decide to sell your animals?

    Yes No *(circle which applies)*

13. Do you know where your cattle are going to when you sell them?

Yes No *(circle which applies)*

If yes where? *(can circle more than one answer)*

a. other province
b. other country
c. for local slaughter
d. to Vientiane
e. other…………

14. How many **cattle** did you sell in the last 12 months? (circle)
    0-2 3-4 5-9 10<
    14a. What was the average price you received?
    …………………..Kip

15. How many **cattle** did you buy in the last 12 months? (circle)
    0-2 3-4 5-9 10<
    15a. What was the average price you paid
    …………………..Kip

16. How many **buffalo** did you sell in the last 12 months? (circle)
    0-2 3-4 5-9 10<
    16a. What was the average price you received?
    …………………..Kip

17. How many **buffalo** did you buy in the last 12 months? (circle)
    0-2 3-4 5-9 10<
    17a. What was the average price you received.
    …………………..Kip

D. Animal health: parasites

18. Liver fluke can infect cattle in my village. True- False- I do not know

19. Liver fluke can infect buffalo in my village True- False- I do not know

20. Liver fluke makes cattle and buffalo scour True- False- I do not know

21. Liver fluke can kill my cattle and/or buffalo True- False- I do not know

22. The intestinal worm, Toxacara can kill many buffalo calves True- False- I do not know

23. Liver fluke can be treated with medication if given one time per year to cattle or buffalo True- False- I do not know

24. Cattle and buffalo can become infected with worms or liver fluke when they graze True- False- I do not know

25. Toxacara can be treated by giving medication to calves once True- False- I do not know

26. Skin diseases (mange or fungal diseases) can be True- False- I do not know

treated with medication

E. Animal health: infectious diseases

27. What disease is this?
    Sores on mouth, tongue, feet or udder
    Loss of strength
    Many cows or buffalo affected at one time
    ……………. *(name the disease)* – I don't know

27. Do you know about FMD? (circle)
    Yes No
    If No go to question 30.
28. How does it spread?

29. How do you treat FMD?

30. How do you prevent FMD?

31. What disease is this?
    Swelling in neck area
    Quick and difficult breathing
    Death
    Many cattle or buffalo affected at one time
    ……………… *(name the disease)* – I don't know

32. Do you know about HS? (circle)
    Yes No
    If No go to question 34.

33. How does it spread?

34. How do you treat HS?

35. How do you prevent HS?

36. FMD and HS can be stopped by selling affected cattle or buffalo	True- False- I do not know
37. I can stop my cattle or buffalo getting FMD if they get A vaccination two times per year	True- False- I do not know
38. I can stop my cattle or buffalo getting HS if they get A vaccination two times per year	True- False- I do not know
39. Vaccination and antibiotic injection are the same	True- False- I do not know
40. My cattle or buffalo can get FMD or HS if I mix them with new cattle or buffalo.	True- False- I do not know

41. Giving an injection to pregnant cows or buffalos harms them True- False- I do not know

42. Keeping my sick cattle or buffalo away from other animals Helps to ensure other cattle or buffalo in the village do not get sick True- False- I do not know

43. Using the same food and water buckets for sick and healthy Cattle or buffalo is o.k. True- False- I do not know

44. If I buy cattle from a village where there are many sick Cattle and buffalo the bought cow or buffalo are likely to Bring disease to my village True- False- I do not know

F. Nutrition

45. A pregnant cow or buffalo needs more food than a cow or buffalo that is not pregnant True- False- I do not know

46. A cow or buffalo with a suckling calve needs more than Twice the amount of food than an animal without a calve True- False- I do not know

47. There is enough grass around the village and on my land to give enough food for my cattle or buffalo all year around True- False- I do not know

48. An adult cow or buffalo needs about 10 kg of fresh grass Each day to keep its weight True- False- I do not know

49. The condition score of cattle or buffalo can be used to assess Their nutritional status True- False- I do not know

50. Cattle or buffalo need about 20 liters of water once a day To drink True- False- I do not know

51. I can earn extra money if I buy skinny cattle and fatten them For three to four months and sell them again. True-False- I do not know

G. Reproduction

52. One calf every two years is all a cow or buffalo can Produce True- False- I do not know

53. A cow can have its first calve when it is two years old True- False- I do not know

54. All adult cows and bulls are good to breed with True- False- I do not know

55. Bull selection can produce better calves True- False- I do not know

56. The amount and type of food feed to cows or buffalo during pregnancy will affect the health of the calf when born. True- False- I do not know

57. If my cow is being mounted and is very vocal she is not yet ready for breeding True-False- I do not know

H. Extension

58. What source of information would you like best to provide you with more information about cattle and buffalo health and production? (rate the following from 1 would like best to 4 would like least)

…… TV or radio spots
…… Posters
…… Signboards
…… Leaflets/handouts
…… Meetings/discussion
…… Demonstrations
…… Learning by doing
…… Short courses
…… Farmer cross visits
…… Live speaker

THANK YOU FOR PARTICIPATING!

11.4 Farmer Knowledge, Attitudes and Practices survey questionnaire

Farmer KAP Survey ACIAR 2006/159

Lao Australian Large Ruminant Health & Husbandry Research Project

Aims to:

1. document level of large ruminant production in 25 households per village in 10 villages in 5 provinces of northern Lao PDR, Xieng Khoung, Luang Prabang and Hua Phan, Borkeo and Luangnamtha
2. identify the current knowledge, attitudes and practices of Lao farmers on biosecurity, risk of transmission of transboundary diseases and large ruminant health and production
3. determine the best methodologies and extension activities and assess their impact when applying a village-level biosecurity program to improve the large ruminant health and production system in the high intervention' communities, compared with control intervention' communities
4. investigate incentives for sustainable vaccination against FMD and HS in non project villages

Interviewer name:/ ………………………………………Date of interview ……………………

A. Farmer Details

Province ………………………………………District………………………………………

Village ……………………………………………………………………………………

Farmer name ……………………………………………………………………………………...

Farmer Gender:………………………Farmer age:……………………………………………

<u>PART 1</u>

B. Farmer economic data

1. Total cultivated areas owned

	Paddy field	Upland rice	Gardening	Forage (If grown)	Others	Total
Area in ha						

2. Number of large ruminant owned at present

	Cattle			Buffalo		
	Male	Female	Calf <6m	Male	Female	Calf <6m
Number (head)						
Number (head) fed forages						

3. Number of large ruminant introduced into herd in the last 12 months

	Cattle			Buffalo		
	Male	Female	Calf <6m	Male	Female	Calf <6m
Number (head)						
Average age (year)						
Average price (kip)						

4. Number of large ruminant sold in the last 12 months

	Cattle			Buffalo		
	Male	Female	Calf <6m	Male	Female	Calf <6m
Number (head)						
Average age (year)						
Average price (kip)						
Total (kip)						

5. Number of large ruminant slaughtered for family consumption or ceremony in the last 12 months

	Cattle			Buffalo		
	Male	Female	Calf	Male	Female	Calf
Number (head)						
Value of animal at the time (kip)						

6. Number of calves born in the last 12 months

	Cattle caves	Buffalo caves
Number		

7. Number of large ruminant died in the last 12 months

	Cattle			Buffalo		
	Male	Female	Calf	Male	Female	Calf
Number (head)						
Value of animal at the time (kip)						
Suspected disease if known						

C. Marketing

8. What is your main reason for keeping **large ruminants**? List in order of priority (1 most important, 5 least important)

…… For cash

…… For draught power

…… For breeding calves

…… For fattening and sale for meat

…… For replacing sold animals

……...For other (specify)…..

9. Put the following in order, from 1 (most common) to 6 (least common), in terms of the most common reasons you normally sell your **large ruminants**?

…… need the money

…… good price available

…… have too many cattle to care for

…… they cannot have calves (i.e. culling)

…… they are too old or sick

…… other reason (specify)…………………………………

10. Do you usually obtain a quote from more than one trader before you sell your cattle or buffalo?

Yes No *(circle which applies)*

11. Do you know the market price of your cattle or buffalo before you decide to sell your animals?

Yes No *(circle which applies)*

12. Do you know where your cattle or buffalo are going to when you sell them?

Yes No Don't care *(circle which applies)*

If yes, where? *(Can circle more than one answer)*

Cattle	*Buffalo*
a. other province	a. other province
b. other country	b. other country
c. for local slaughter	c. for local slaughter
d. to Luang Prabang	d. to Luang Prabang
e. to Vientiane	e. to Vientiane
f. other (specify) …..…………	f. other (specify)…………………

PART 2

D. Animal health: parasites *(circle which applies)*

13. Liver fluke can infect cattle and/or buffalo in my village. True- False- I do not know

14. Liver fluke can kill my cattle and/or buffalo True- False- I do not know

15. The intestinal worm, Toxocara, can kill many buffalo calves True- False- I do not know

16. Cattle and buffalo can become infected with worms or liver fluke when they graze True- False- I do not know

17. Toxocara can be treated by giving medication to calves once True- False- I do not know

18. Skin diseases (Mange or fungal diseases) can be treated with medication True- False- I do not know

E. Animal health: infectious diseases

19. What disease gives the signs of illness listed below to cattle or buffalo?

- Sores on mouth or
- Sores in tongue or
- Sores on feet or
- Sores on udder or
- Loss of strength or
- Many cows or buffalo affected at one time

……………. *(name the disease)* or I don't know (*circle*)

20. Do you know about FMD? (*Circle*)

Yes No *If No go to question 24*

21. How does FMD spread?

………

22. How do you treat FMD?

………

23. How do you prevent FMD?

………

24. What disease gives the signs of illness listed below to cattle or buffalo?

- Swelling in neck area
- Quick and difficult breathing
- Death
- Many cattle or buffalo affected at one time

……………… *(Name the disease)* – I don't know

25. Do you know about HS? (*circle)*

Yes No *If No go to question 29*

26. How does HS spread?

………

27. How do you treat HS?

………

28. How do you prevent HS?

………

For question 29 to 55 circle which applies)

29. FMD and HS can be stopped by selling affected cattle or buffalo — True- False- I do not know

30. Regular vaccination can stop my cattle or buffalo getting FMD & HS True- False- I do not know

31. Vaccination and antibiotic injection are the same — True- False- I do not know

32. My cattle or buffalo can get FMD or HS if I mix them with newly bought cattle or buffalo. — True- False- I do not know

33. Giving a vaccination to pregnant cows or buffalos harms them True- False- I do not know

34. Keeping my sick cattle or buffalo away from other animals helps to ensure other cattle or buffalo in the village do not get sick — True- False- I do not know

35. Using the same food and water buckets for sick and healthy Cattle or buffalo is o.k. — True- False- I do not know

36. If I buy cattle from a village where there are many sick Cattle and buffalo the bought cow or buffalo are likely to Bring disease to my village — True- False- I do not know

F. Nutrition

37. A pregnant cow or buffalo needs as much as twice as much feed as a cow or buffalo that is not pregnant — True- False- I do not know

38. A cow or buffalo with a suckling calve needs more than twice the amount of food than an animal without a calve — True- False- I do not know

39. There is enough grass around the village and on my land to give enough food for my cattle or buffalo all year around — True- False- I do not know

40. An adult cow or buffalo needs about 10 kg of fresh grass each day to keep its weight — True- False- I do not know

41. The condition score of cattle or buffalo can be used to assess their nutritional status — True- False- I do not know

42. Cattle or buffalo need at least 20 liters of water throughout the day to drink — True- False- I do not know

G. Reproduction

43. A cow can have its first calve when it is two years old — True- False- I do not know

44...A cow can have a calf every: year, 2 years, 3 years, don’t know (circle right answer)

45. All adult cows and bulls are good to breed with — True- False- I do not know

46. Bull selection can produce better calves — True- False- I do not know

47. The amount and type of food fed to cows or buffalo during pregnancy will effect the health of the calf when born. — True- False- I do not know

48. If my cow is being mounted and is very vocal she is not yet ready for breeding — True-False- I do not know

PART 3

H. Vaccination, biosecurity and current practices part

49. Were ALL your cattle over 6months vaccinated against HS and FMD (specific for XK)?

-For HS

Yes If yes, when was the last time vaccinated…………

No If no, when was the last time vaccinated……

If no, what numbers of cattle were vaccinated……

If no, provide the reason……

-For FMD

Yes If yes, when was the last time vaccinated…………

No If no, when was the last time vaccinated……

If no, what numbers of cattle were vaccinated……

If no, provide the reason……

50. Were ALL your buffalo over 6months vaccinated against HS and FMD (specific for XK)?

-For HS

Yes If yes, when was the last time vaccinated…………

No If no, when was the last time vaccinated……

If no, what numbers of buffalo were vaccinated……

If no, provide the reason……

-For FMD

Yes If yes, when was the last time vaccinated…………

No If no, when was the last time vaccinated……

If no, what numbers of buffalo were vaccinated……

If no, provide the reason……

51. Did any of your vaccinated cattle have signs of HS or FMD infection?

-For HS

Yes No

If No what is the proportion or number……

-For FMD

Yes No

If No what is the proportion or number……

Don't know

52. Did any of your vaccinated buffalo have signs of HS or FMD infection?

-For HS

Yes No

If No what is the proportion or number……

-For FMD

Yes No

If NO what is the proportion or number……

Don't know

53. Are you happy with the vaccination programs?

Yes No

If no please give reasons……………………….

54. Would you continue to vaccinate your large ruminants for HS if you have to pay for the cost yourself (3,000kip)?

Yes No

If no please give reasons………………………

If yes who will do for you

- I'll do it myself
- I'll ask other farmers to do it for me
- I'll ask VVW to do it for me
- Other Please Name: ……

55. Would you continue vaccinate your large ruminants for FMD if you have to pay for the cost yourself (10,000kip)?

Yes No

If no please give reasons……………………..

If yes who will do for you

- I'll do it myself
- I'll ask other farmers to do it for me
- I'll ask VVW to do it for me
- Other Please Name:

57. I isolate newly introduced animals for 2 weeks before introducing to the herd

Yes No

Give reasons for your decision………………………..

58. Once any of my large ruminants becomes sick I separate it from the herd for treatment

    Yes No

59. I give treatment for Toxocara for my new born calf (less than 4 weeks)

    Yes No

    If yes, what kind of medicine…………………………..

60. I built fattening pens and do fattening activity

    Yes No

61. Do you remove manure from the fattening pen

    If yes, how often………

    No

62. Do you remove manure from the cattle house

    If yes, how often………

    No

63. Do you think that castration of unwanted male large ruminants for reproduction control

    Yes If yes, what age…..……

    No

64. Any comments on large ruminant health, disease outbreaks and vaccination programs

……

……

……

THANK YOU FOR PARTICIPATING!

11.5 Trader Survey Questionnaire

TRADER SURVEY, ACIAR PROJECT AH2006/159

Aim**:** Interview as many traders as possible from both the 6 project sites and other locations
Interviews are to be conducted with each trader individually.

Name of trader:

Address:

Contact details: (phone/email)

Operating location (villages/district/province)

Number of years trading:

Sole business: ☐ yes ☐ no

If no please list other businesses:

Interviewer:

Date:

1. Please fill in the following tables indicating the number of animals you bought in the last 12 months based on their breed (cattle (indigenous and other)/buffalo), age (years) and season (dry: Nov to April; wet: May to Oct).

Indigenous cattle:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Other cattle breeds:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Buffalo:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

2. Please indicate in the following tables the average price, in kip, you paid for the animals you bought in the last 12 months based on their breed (cattle(indigenous and other)/buffalo), age (years) and season (dry: Nov to April; wet: May to Oct) in meat weight.

Indigenous cattle:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Other cattle breeds:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Buffalo:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

3. What percentage of the animal do you sell as meat as compared to *offal*?

	Poor Condition (skinny) %	Medium Condition %	Good Condition (fat) %	Price (kip/kg
Meat/Muscle				
Bones				
Heart				
Intestine				
Kidney				
Liver				
Lungs				
Skin				
Stomach				
Other (specify)				

4. Do you purchase: (tick all which apply) and what percentage does each source represent of your total annual purchases?

☐ Directly from farmer Percentage…….…….

☐ Other trader Percentage…….…….

☐ Other (specify/explain) Percentage……….…

5. a) How do you establish contact with the farmer/s?

☐ Phone……………………………………………………………………

☐ SMS……………………………………………………………………

☐ Spotter……………………………………………………………………

☐ Other ……………………………………………………………………

b) Are you ever contacted by the farmers?

Yes ☐ ………………………………how often? ………………………

No ☐ ……………………………………………………………………………

6. Do you purchase cattle or buffalo from outside your district or province?

☐Yes ☐ No

If yes

a) from where?

b) What percentage?

7. Using the following codes please fill in the tables showing the destination of your cattle and buffalos, and indicate the number you sold in each of these markets in the last 12 months:

R sold for reuse for breeding or draft

X international

D sold for slaughter

C sold to meat company

Indigenous cattle:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Please provide details of the final destination of your indigenous cattle:

Provincial

Domestic (to other provinces)

International (eg to Thailand, Vietnam, China etc)

Slaughter Company

Meat Company

Other cattle breeds:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Please provide details of the final destination of your indigenous cattle:

Provincial

Domestic (to other provinces)

International (eg to Thailand, Vietnam, China etc)

Slaughter Company

Meat Company

Buffalo:

Bull	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Cow	Young animal aged under 2 years		Adult animal aged 2-8 years		Old animal aged over 8 years	
	Wet	Dry	Wet	Dry	Wet	Dry
Skinny condition						
Medium condition						
Fat condition						

Please provide details of the final destination of your indigenous cattle:

Provincial

Domestic (to other provinces)

International (eg to Thailand, Vietnam, China etc)

Slaughter Company

Meat Company

8. How do you transport your cattle or buffalo to their final destination? (Tick all that applies). Please indicate the percentage of animals transported that way in a year.

☐ Walk Percentage……………………

☐ Truck Percentage……………………

☐ Car/tuk-tuk Percentage……………………

☐Boat Percentage……………………

☐Other Percentage………………

9. What costs (in Kip) do you incur per head on average?

Transport ……………………………………………………………

Slaughter costs ……………………………………………………………

Marketing costs …………………………………………………

Levies ……………………………………………………………

Quarantine/health …………………………………………………

ᴓOther ……………………………………………………………

10. Do you own a slaughter house (partly or fully owned)?☐ yes ☐ no

If yes please fill in the following table providing details on throughput for the last 12 months

Month	Indigenous cattle breed			Other cattle breeds			Buffalo		
	Male	Female	Bulls	Male	Female	Bulls	Male	Female	Bulls
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

11. How do you assess/determine the value of the animals you are purchasing? Tick all that applies

☐ Meat Weight

what percentage do you use to determine this meat weight?

ສັດຈ່ອຍ Skinny……………………

ສັດປານກາງ Medium……………………

ສັດຕຸ້ຍ Fat……………………

☐ Live Weight

☐ Condition Score

☐ General Appearance (specify/explain)……………………………….…

…………………………………………………………………………………..……………………

……………………………………………………………..

☐ Other (specify/explain) ……………….……………………………..….

……………………………………………………………………………………..

……………………………………………………………………………………..

12. Would you prefer to buy vaccinated large ruminants (against FMD and HS)?

Yes ☐ Reason ………………………

No ☐ Reason………………………

13. Would you still continue buying cattle and buffalo from an areas where disease outbreak still happening?

Yes ☐…………………………………… Reason ………………………

No ☐……………………………………… Reason………………………

14. Would you able to buy cattle and buffalo as many as you would prefer all year-round

Yes ☐ …………… where is the most reliable source……………

No ☐……………… when it is the shortage ……………

15. What problems do you currently face relating to the purchase and sale of animals in the markets you are trading in?

Market	List of problems encountered: Purchase	List of problems encountered: Sale
Provincial		
Domestic (to other provinces)		
International (eg to Thailand, Vietnam, China etc)		

a) What do you think might help to overcome these problems?

b) Do you have any ideas that would assist for the future of marketing of cattle and buffalo in Lao PDR?

c) Do you have any other comments relating to the marketing of cattle and buffalo in Lao PDR?

Thank you so much for your participation

11.6 Final project workshop outcomes, July 2012

Participants were split into four groups (1) Health, (2) Production, (3) Marketing and economics, and (4) Capacity and skills and each addressed following questions:

a) What are the project recommendations?

b) How are project achievements best disseminated?

c) Gaps-What still needs to be done?

<u>Outcomes Group 1 Health</u>

a) FMD/HS / parasite/ incl. prevention/biosecurity studies/knowledge
b) Disseminate Project results through extension staff training and then training to farmers. Also use poster, radio, television to transfer knowledge
c) Need more project continuation to include: external parasite (esp. ticks)/sample collection-transport to lab, more disease knowledge esp. parasite live cycles

<u>Outcomes Group 2 Production</u>

a) Increased forage production, cattle fattening by increasing numbers of farmers, vaccination and parasite control

b) Cross-visits; poste/radio/TV/training/leaflets

c) Increase local breed production capacity; increase feed preservation/meat quality (slaughterhouse improving) improve/promote trader groups

<u>Outcomes Group 3 Marketing & Economics</u>

a) Transformation from farmers to traders. Both farmers and traders get benefit from disease free animals. Group establishment-farmers produce as group-but farmers still sell when need cash

b) Meeting with production groups-project need to promote group selling(production group) compared to individual selling

c) Study to provide Feedback to farmers what percentage of meat produced per animal; promotion of management amongst smallholder-selling individual vs group selling

<u>Outcomes Group 4 Capacity</u>

a) Animal health management skills; feeding management skills; reproduction management skills strengthening of PAFO/DAFO staff on how to improve production system; income generation for farmer

b) Need to share experience with non-target areas

c) Need to study other disease-external parasites and anthrax/blackleg by improved and longer training

11.7 Details of Weigh Tape for Lao cattle and buffalo

Buffalo Weigh Tape Sheet

Girth	**Weight**	Girth	Weight	Girth	**Weight**	Girth	**Weight**
Girth		100	71	140	174	180	366
61		101	73	141	178	181	372
62		102	75	142	181	182	376
63		103	77	143	185	183	381
64		104	79	144	188	184	386
65		105	82	145	192	185	391
66		106	84	146	196	186	395
67		107	86	147	199	187	400
68		108	89	148	203	188	405
69		109	91	149	207	189	409
70		110	94	150	211	190	414
71		111	96	151	216	191	418
72		112	98	152	220	192	423
73		113	101	153	224	193	427
74		114	103	154	229	194	432
75	31	115	106	155	233	195	436
76	33	116	108	156	238	196	440
77	34	117	111	157	243	197	445
78	35	118	113	158	247	198	449
79	36	119	116	159	252	199	453
80	38	120	118	160	257	200	458
81	39	121	121	161	263	201	462
82	40	122	123	162	268	202	466
83	42	123	126	163	273	203	471
84	43	124	128	164	279	204	475
85	45	125	131	165	284	205	480
86	46	126	133	166	290	206	484
87	48	127	136	167	295	207	488
88	49	128	139	168	301	208	493
89	51	129	141	169	307	209	497
90	52	130	144	170	312	210	502
91	54	131	147	171	318	211	506
92	56	132	150	172	323	212	510
93	57	133	153	173	329	213	515
94	59	134	155	174	335	214	519
95	61	135	159	175	340	215	524
96	63	136	162	176	345	216	528
97	65	137	165	177	351	217	533
98	67	138	168	178	356	218	537
99	69	139	171	179	361	219	542

220	546
221	551
222	555
223	560
224	564
225	569

Lao Cattle Weigh Tape Sheet

Girth	Weight	Girth	Weight	Girth	Weight	Girth	Weight
60	20	100	75	140	196	180	348
61	20	101	77	141	200	181	354
62	20	102	79	142	203	182	361
63	21	103	81	143	206	183	366
64	21	104	83	144	209	184	372
65	21	105	86	145	212	185	378
66	22	106	88	146	215	186	384
67	22	107	91	147	219	187	390
68	23	108	93	148	222	188	395
69	24	109	96	149	225	189	400
70	25	110	98	150	228	190	405
71	26	111	100	151	231	191	410
72	26	112	103	152	234	192	416
73	27	113	105	153	237	193	421
74	28	114	108	154	239	194	426
75	30	115	110	155	242	195	431
76	31	116	113	156	244	196	436
77	32	117	116	157	246	197	441
78	34	118	118	158	249	198	446
79	35	119	121	159	251	199	451
80	37	120	125	160	253	200	455
81	38	121	128	161	255	201	460
82	40	122	131	162	257	202	465
83	42	123	135	163	260	203	470
84	44	124	138	164	263	204	474
85	46	125	142	165	267	205	479
86	48	126	145	166	270	206	483
87	50	127	148	167	273	207	488
88	52	128	152	168	278	208	492
89	54	129	155	169	283	209	497
90	56	130	159	170	288	210	502
91	58	131	162	171	293	211	506
92	60	132	166	172	299	212	511
93	62	133	169	173	305	213	516
94	64	134	173	174	311	214	520
95	66	135	177	175	317	215	525
96	68	136	181	176	323	216	531

97	70	137	184	177	329	217	538
98	71	138	188	178	335	218	544
99	73	139	192	179	342	219	551
						220	557
						221	564
						222	571
						223	577
						224	584
						225	591

Analysis of Association between Girth and Weight for Cattle and Buffalo in Laos[1]

Model for Predictions

In this analysis, both seasons' data were used to develop a model to predict weight from girth. This was done separately for cattle and buffalo data (unlike the previous analyses), as it believed it is not the purpose to compare the morphometrics of cattle and buffalo (which would necessitate a combined analysis of both species). The major development is that unlike the previous analyses where a quadratic model of $\log_e$Girth was used to predict $\log_e$Weight, a cubic spline method was used were. This allows the data to be used to describe the relationship rather than the constraint imposed by a quadratic (or higher order) polynomial model. The specific form of the model fitted to each combined data set was

$$\log_e \text{Weight} = \beta_0 + \beta_1 \log_e \text{Girth} + \text{Season} + \text{Sex} + s(\log_e \text{Girth}) + \text{Village} + \varepsilon$$

where

Weight = weight of animal (kg);

Girth = girth of animal (cm);

Season = effect of season of data collection (first or second);

Sex = effect of male vs female;

Village = effect of village (random); and

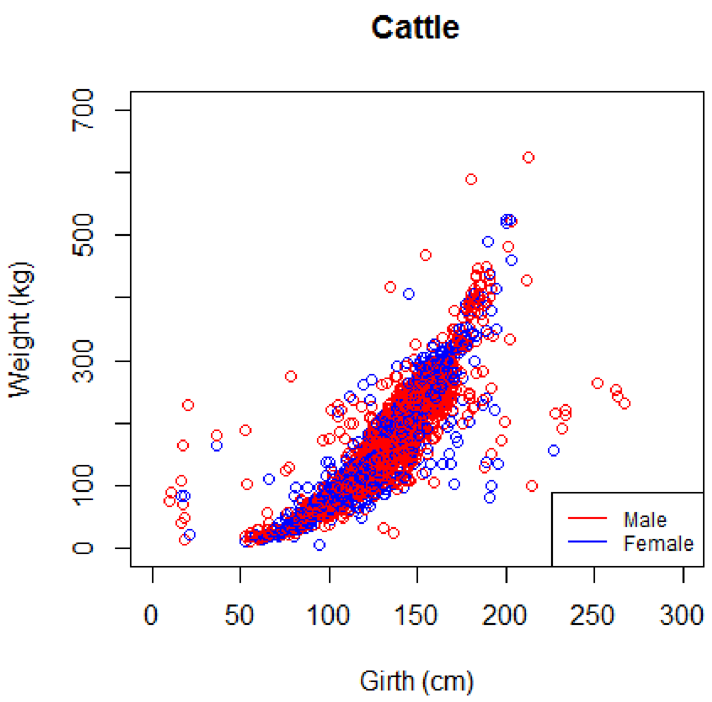
ε = random error.

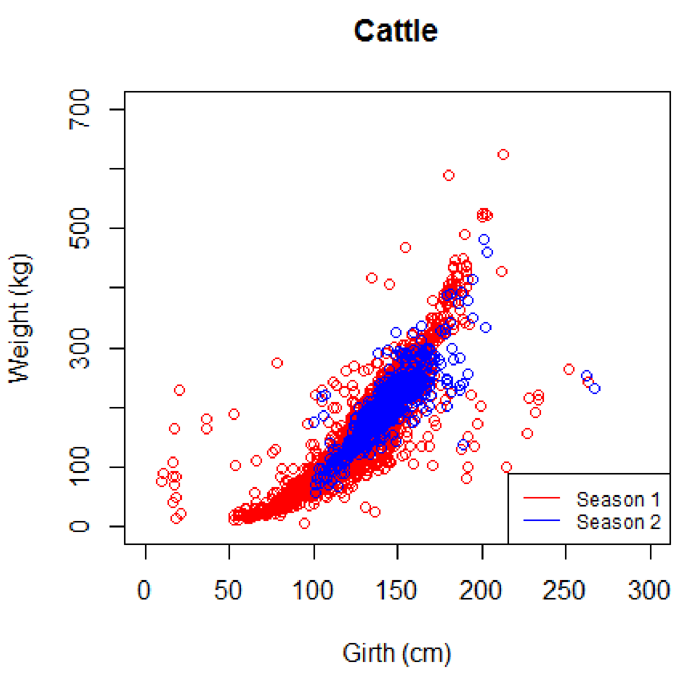
Here, $s(\cdot)$ represents a spline smoothing function, and the term $s(\log_e\text{Girth})$ incorporates the nonlinear departures from the overall linear trend of $\log_e$Girth (as specified by the $\beta_1\log_e$Girth term). Note that the log-transformation for both variables was included to satisfy approximate normality for $\log_e$Weight, the outcome variable, as well as approximate linearity between $\log_e$Weight and $\log_e$Girth. The models were fitted to the data using ASReml-R.

Note that there are many outliers, as shown in the accompanying plots. This was handled iteratively be eliminating observations with a standardised residual greater than 3.5 (in absolute value). This threshold was chosen as being the most extreme value expected if data were normally distributed for a sample of this size.

[1] *Peter Thomson, April 8, 2012*

Results - Cattle





There is no obvious difference in the girth-width relationships between the sexes, or between the two seasons. The above plots include the data prior to removal as extreme outliers.

Following outlier removal, the following analysis was obtained:

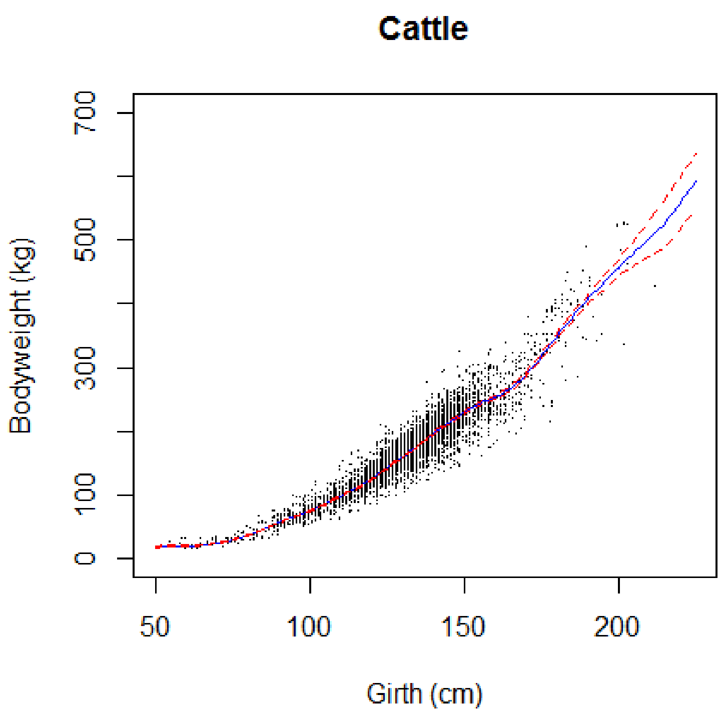
```
$Wald
              Df  denDF     F.inc     F.con Margin        Pr
(Intercept)    1 1336.0 2.110e+05  4668.000        0.0000000
logGirth       1 1152.8 1.265e+04 12650.000      A 0.0000000
Sex            1 4724.9 2.419e+00     2.433      A 0.1188519
Season         1    9.4 3.370e-01     0.337      A 0.5758243
```

- Highly significant effect of $\log_e$Grith as expected ($P < 0.0001$)
- No significant effect of sex ($P = 0.119$)
- No significant effect of season ($P = 0.576$)

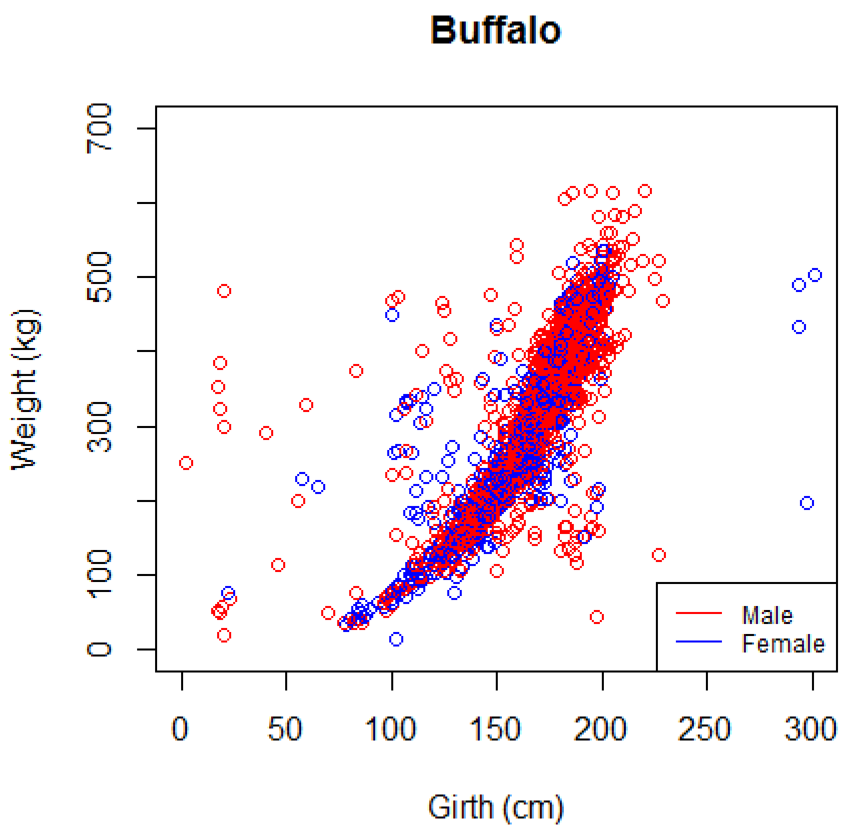
```
> summary(lao.asr)$varcomp
                           gamma    component    std.error   z.ratio constraint
Village!Village.var 0.04497812 0.0006720868 0.0003473684  1.934796   Positive
spl(logGirth)       0.01862257 0.0002782683 0.0001247147  2.231239   Positive
R!variance          1.00000000 0.0149425290 0.0003079630 48.520534   Positive
```

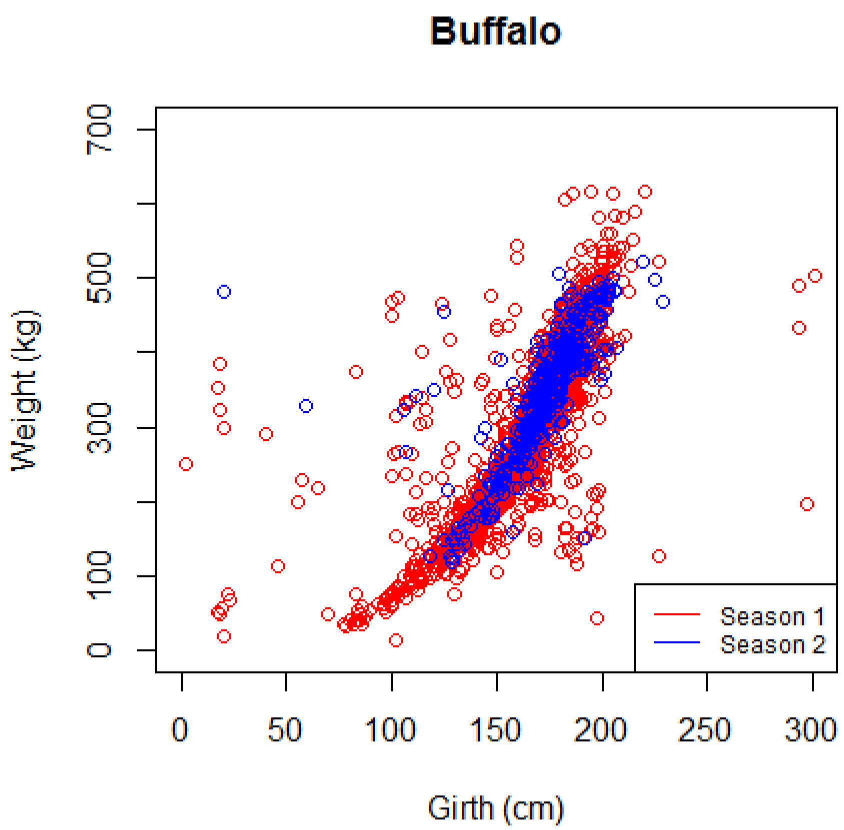
```
> summary(lao.asr, all=T)$coef.fixed
                solution   std error     z ratio
Season      -0.009529234 0.016415687  -0.5804956
Sex_Female   0.000000000          NA          NA
Sex_Male     0.006192921 0.003970087   1.5598956
logGirth     2.617127738 0.023268247 112.4763612
(Intercept) -7.729786229 0.113113834 -68.3363473
```

The model was re-fitted dropping the non-significant Sex and Season terms. The following plot shows the fitted model (mean weight for a given girth) along with the standard errors of the mean (red dashed lines). Note that predictions have been restricted to **60 to 225 cm girth**; outside that range predictions are not reliable. Details are shown in **Cattle_pred.xlsx**.



Results - Buffalo





There is no obvious difference in the girth-width relationships between the sexes, or between the two seasons. The above plots include the data prior to removal as extreme outliers.

Following outlier removal, the following analysis was obtained:

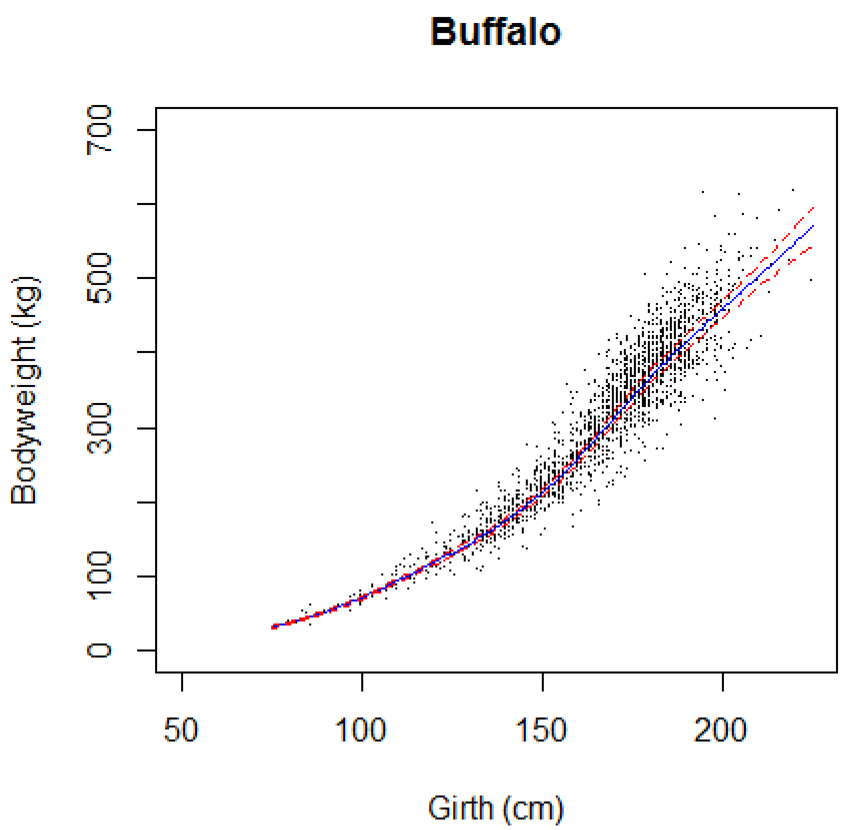
```
$Wald
            Df  denDF     F.inc     F.con Margin           Pr
(Intercept)  1  896.6 3.945e+04 2.713e+03        1.845304e-273
logGirth     1  860.3 1.027e+04 1.012e+04      A  0.000000e+00
Sex          1 2196.9 2.430e+00 2.454e+00      A  1.174016e-01
Season       1    7.6 8.954e-01 8.954e-01      A  3.717273e-01
```

- Highly significant effect of $\log_e$Grith as expected ($P < 0.0001$)
- No significant effect of sex ($P = 0.117$)
- No significant effect of season ($P = 0.372$)

```
> summary(lao.asr)$varcomp
                          gamma    component    std.error   z.ratio constraint
Village!Village.var 0.738874401 8.309002e-03 4.418341e-03  1.880570   Positive
spl(logGirth)       0.002125296 2.389999e-05 1.433819e-05  1.666877   Positive
R!variance          1.000000000 1.124549e-02 3.398981e-04 33.084880   Positive
```

```
> summary(lao.asr, all=T)$coef.fixed
                 solution   std error     z ratio
Season        0.050988076 0.053877465   0.9463711
Sex_Female    0.000000000          NA          NA
Sex_Male     -0.007967537 0.005086656  -1.5663605
logGirth      2.702569223 0.026863877 100.6023508
(Intercept) -8.261522975 0.159829332 -51.6896547
```

The model was re-fitted dropping the non-significant Sex and Season terms. The following plot shows the fitted model (mean weight for a given girth) along with the standard errors of the mean (red dashed lines). Note that predictions have been restricted to **75 to 225 cm girth**; outside that range predictions are not reliable. Details are shown in **Buffalo_pred.xlsx**.



11.8 Fasciola treatment trial

Control of *Fasciola gigantica* infection in smallholder large ruminant farming systems in developing countries: a case study from Lao PDR (to be submitted shortly when all author inputs finalised)

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[4] Novartis, Sydney, NSW, Australia

Abstract

F. gigantica is endemic in domestic large ruminants in many developing countries in the tropics. Estimated costs due to Fasciolosis are high and in recent years the disease also been recognised as a human health risk. Research investment on *F. gigantica* in SE Asia in previous years has been significant, but for many areas in the region there is little information on the prevalence and impact of the disease on large ruminant production and management of the parasite is rare. Using faecal egg count analysis we found a prevalence of 17.2% in cattle and buffalo in northern Laos, with infection in 73.3% of the villages where animals were tested. Smallholder farmer knowledge attitudes and practices of *F. gigantica* in cattle and buffalo were assessed (n = 306) and showed an almost complete lack of knowledge on Fasciolosis. We identified that 93.1% of farmers had no knowledge and 6.9% minimal knowledge, with 95.4% indicating a desire to learn more of the disease. As the surveyed farmers had been regularly visited by livestock extension staff for 2-3 years prior to this survey, knowledge of Fasciolosis amongst extension staff was considered to be poor or their ability to transfer this knowledge transfer was deficient. A field treatment trial on *F. gigantica* during a period of declining nutrition and using imported triclabendazole and a locally available triclabendazole/albendazole combination, identified that both anthelmintics were effective, with >90% faecal egg count reduction at 4, 8 and 12 weeks post treatment in both cattle and buffalo, although no significant treatment effect on weight was determined (p=0.6) between the treatment and control groups over the 12 week trial period. With predictions of increasing demand for large ruminant red meat demand in the region over the next decade, opportunities exist for poor smallholder farmers to supply this market and increasing their income. However this requires increased productivity and eventually quality and addressing the identified knowledge gaps of Fasciolosis in our studies is recommended to assist this process to address both regional rural poverty and food security.

Keywords

Fasciola gigantica, smallholder farming systems, farmer knowledge, treatment trial, cattle, buffalo

Introduction

Fasciolosis is a global parasitic infection caused by *Fasciola hepatica* in temperate and *F. gigantica* in tropical climates, with overlapping of their geographical distribution in some Asian and African countries (Mas-Comas et al 2005). The parasite mostly affects domesticated ruminants but can also occur in other species including horses, pigs and humans. Fasciolosis is considered one of the most important diseases of cattle and buffalo in humid tropical regions (Copeman and Copland, 2008) and has recently been recognised as an important zoonosis in developing countries (Mas-Comas et al., 2005; Soliman, 2008; Torgerson and Macpherson, 2011).

In large ruminants Fasciolosis is associated with chronic production losses, decreased carcass quality and yield, and less commonly, overt clinical disease and death. As it causes mainly chronic symptoms and does not affect transboundary trade, Fasciolosis is often neglected by owners and livestock workers in developing countries where animal health inputs are low (Gray and Copland, 2008). In much of South East (SE) Asia, high rates of Fasciolosis are associated with areas where the intermediate snail hosts thrive and sustain the parasites life cycle, including areas of rice cultivation, where animals graze recently harvested crops and in low lying areas close to rivers and lakes (Suhardono & Copeman 2008). Large areas of SE Asia are mountainous upland areas where rain fed agriculture is practiced including growing of dry land rice. There is a paucity of published information on the occurrence and prevalence of Fasciolosis in upland SE Asia, although the climate in these areas is conducive for the maintenance of *F.gigantica*. For example in northern Laos annual rainfall is around 1500mm, many small rivers, lakes or dams exist near villages and smallholder farmers co-graze their cattle and buffalo near villages. A prevalence survey in late 2010 in 5 northern provinces of Laos using faecal egg count analysis of 1262 cattle and buffalo, identified an overall prevalence of 17.2% (CI 13.5-20.9%) with 73.3 % of villages (n=75) having at least one positive result. In addition, slaughterhouse surveys conducted in March to June 2011 in the same 5 northern provinces identified 95.6 % and 40% of slaughtered buffalo and cattle respectively with gross hepatic lesions consistent with liver fluke infection. The prevalence as determined by faecal egg count analysis of this slaughterhouse population was 34.1% (CI 26.0-42.2%) (Rast et al, 2013). In southern Lao in 2004 a survey of a number of slaughterhouses in the two cities of Vientiane and Savannakhet found a prevalence of 17-57% of *F. gigantica* in cattle and buffalo, with a survey of 6 villages indicating a prevalence in humans of 2.4% (by faecal examination) and 13.8% (serology) (Duong Quang et al., 2008). These findings suggest that *F. gigantica* infection in the upland and potentially the lowlands of Laos and similar environments in other countries in the region, is widespread and common. Fasciolosis is likely to contribute significantly to suboptimal large ruminant production and is potentially a serious human health risk in the region.

The geographical location of Lao PDR in SE Asia makes it an increasingly important contributor to meeting the increasing demand for livestock and red meat in the region, driven by the growing economies and urbanisation in the more developed countries in the region (Delgado, 1999; Steinfeld et al., 2006). Lao PDR is a poor country with the majority of agricultural outputs produced by smallholder farmers contributing 31% of GDP (World Bank, 2011). As in other parts of the region, smallholder farms are mostly mixed enterprises with farmers using traditional low input farming methods and operating at subsistence levels. Large ruminants are used for draft power, a source of meat and manure as fertilizer, plus kept as an asset store and sold when the household needs larger amounts of cash, rather than for optimal returns. In the north of Lao the farming population is very poor, with villages mostly remote due to poor road infrastructure, ensuring market access is limited and access to modern technologies in agriculture and livestock production is lacking (Millar and Photakoun, 2008). However the increased demand for red meat and livestock products provides opportunities for smallholder farmers to improve their incomes by providing animals to this market as access improves, although improved productivity is required. Increasing large ruminant production requires that the many constraints that currently inhibit optimal production be addressed. These include endemic transboundary and production limiting diseases, limited farmer knowledge and access to information on modern production practices, as well as difficulties of market access and other deficiencies in market chains.

This study had the objective to assess: (1) farmer knowledge of Fasciolosis in cattle and buffalo; (2) the impact of *F.gigantica* on cattle and buffalo in northern Lao; and (3) the effectiveness of chemical treatments used in the field for reducing *F.gigantica* egg output in faeces of cattle and buffalo and improving weight gain. It is expected that these findings may contribute to understanding of the drivers for sustainable parasite control that can lead to improved and large ruminant productivity in the regional smallholder farming systems.

Materials and Methods

Farmer Interviews

Face to face interviews were conducted in January and February 2011 with a sample (n = 240) of smallholder farmers that had previously had their large ruminants tested in a study on *F. gigantica* prevalence one to 5 months earlier in the villages of the 5 northern Lao provinces of Bokeo, Houaphan, Luang Namtha, Luang Prabang and Xieng Khouang. All villages included in the earlier prevalence study and this study were enrolled in a large livestock development project (ADB, 2007) and in a smaller research project on large ruminant health and production (Windsor, 2006; Windsor, 2011). Department of Livestock and Fisheries (DLF) staff involved in both of these projects provided authority to access the villages and assisted in data collection. A two stage sampling method was used to randomly select 35 villages from the list of 79 villages where animals had previously been sampled for *F.gigantica,*with 8 households randomly selected from the list that had participated in the prevalence survey. The interviews were conducted by DLF district staff that had been trained and implemented similar interviews for a *T. vitulorum* study 6 months earlier (Rast et al., 2013). Interviews took an hour per farmer to complete and responses were recorded in Lao.

Questionnaire

The questionnaire was designed in English, translated into Lao, tested for clarity and modified with assistance from two DLF district extension staff. The final questionnaire contained 15 open and closed questions to capture data on the location of the household, number of household members, number, age, gender, species, weight and monetary value of large ruminants owned, large ruminant morbidity and mortality over the last 12 months, plus knowledge, practices and attitude of farmers of *F. gigantica*.

Numbers of large ruminants per household and farmer knowledge on *F.gigantica* were open questions and answers were categorised for analysis (Table 1). Farmer knowledge was categorised as: 0 (no knowledge) if the answer indicated the farmer had heard about liver fluke but had no further knowledge; as 1 (minimal knowledge) if the answer indicated that the farmer knew that it was a parasite of cattle or buffalo, or that it affected the liver, or caused chronic disease or could list some of the clinical signs (including oedema, weight loss, anorexia, anaemia, jaundice); or as 2 (good knowledge) if the answer indicated that the farmer had basic knowledge about the aetiology, epidemiology, impact (clinical signs) and control or management options of liver fluke.

Field treatment trial procedure

The trial was located in the rural village of Ban Nong in Paek district in Xieng Khouang province in northern Laos, a research project examining interventions to increase cattle and buffalo productivity through improved health, nutrition, husbandry, reproduction and marketing (Windsor, 2006; Windsor, 2011). Interventions included vaccination for Foot and Mouth Disease and Haemorrhagic Septicaemia once or twice a year, anthelminthic treatment of young calves with pyrantel against *T. vitulorum* infection, forage plots in a small number of households to provide supplementary nutrition for large ruminants, and participatory training of farmers in large ruminant production techniques (Nampanya et al., 2010). In addition, targeted disease surveys were conducted and included faecal sample collection and analysis from 30 randomly selected cattle and buffalo per village in April 2009 and October 2010 for *F. gigantica*. Ban Nong was selected for the treatment trial as 50% of the faecal samples were positive for *F. gigantica* eggs.

The treatment trial commenced in July 2011 with 26 cattle and 27 buffalo randomly selected and allocated to two treatment groups and a control group (Table 2). Each of the selected animals was weighed using electronic scales (EC2000B, TruTest, New Zealand) and a faecal sample collected. Treated animals were administered with either triclabendazole (TCB) oral drench (Fasinex®, Novartis, Animal Health Australia Inc.) imported for the trial as is not commercially available in Laos, or triclabendazole/albendazole (TCBA) tablets (Han-Detril-B, Hanvet, Vietnam) purchased commercially in Laos. The animals were dosed according to their live weight and manufacturer's recommendation with TCB for buffalo dosed at 24mg/kg bodyweight as recommended (Sanyal and Gupta, 1996). Both anthelmintics were applied orally using a calibrated drench gun with the TCBA tablets first dissolved in 20 ml of water.

Weighing and faecal sample collection was repeated on all animals presented at weeks 4, 8 and 12 (August to October 2011) of the trial, with data recorded including animal identification, species, age, gender, weight and owner details at each collection. After the final faecal sample collection all animals were treated with triclabendazole. Faecal samples were taken per rectum from each animal and put in small individually labelled zip-lock plastic bags, and 5ml of 3% formalin was added for sample preservation (as analysis at the veterinary laboratory in Luang Prabang could not be completed within 24 hours). The sedimentation technique was used to detect Fasciola eggs using microscopy and the number of *F.gigantica* eggs per gram of faeces (EPG) was determined using the technique described (Happich and Boray, 1969). Owners assisted with drench application and weighing but were not given records of type and dose of drench applied and lab staff were not aware of the anthelmintic treatment status of the animals for which faecal samples were analysed. All trial animals remained in the care of their owners during the trial period and were managed using the locally established practices, mostly free-grazing in and around the village on common natural grazing land, around paddy fields or in forested areas with minimal supplementary feeding. During the night some animals were brought back to the village and stabled in shelters or tethered in their owner's house yard, with cattle and buffalo often together.

Cattle and buffalo included in the trial were chosen from farmers who had established forage plots as part of the large ruminant productivity research project to ensure the animals were as well fed as possible to reduce the likelihood of poor nutrition as a cause of poor weight gain. Reproductive management of large ruminants is not practised in northern Lao, with no castration of the male animals that run together with females throughout the year, resulting in all year calving with a natural peak between September and February. Pregnancy testing is not practiced and calves are weaned naturally, so the reproductive status could not be accounted for in the weight analyses.

2.3. Data entry and management

Completed interviews were translated into English by an independent translator and the data was entered into a customised database in Microsoft access 2003 (Microsoft cooperation, Redmond, WA, USA) by the senior author. Basic data manipulations were conducted in this database and excel (Microsoft 2003 and 2010). Data record sheets from the treatment trial were sent to a central office at Luang Prabang and translated into English and entered into a database created in Excel (Microsoft, 2010).

2.4. Statistical analysis

Statistical analysis was conducted using SAS version 9.3 (SAS 2002-2010 by SAS Institute Inc., Cary, NC, USA). For the farmer interviews descriptive analysis was performed on each investigated variable (Table 1) using frequency tables and charts. Univariable logistic regression with the binary outcome variable of household *F. gigantica* status (positive/negative) was used to determine the association with the explanatory variables and from the likelihood ratio chi-square analysis, the odds ratios of significant explanatory variables were examined to determine the extent as well as positive or negative association with the presence of *F. gigantica* infection at household level. Subsequently, explanatory variables with a p-value of < 0.25, <10% missing values and Spearman rank coefficient of <0.7 (when variables checked for collinearity in pairs) were included in the multivariable logistic regression model and tested using a stepwise approach. Variables with likelihood ratio chi-square p-values < 0.05 were retained in the final multivariable model.

For the treatment trial, analysis was performed on data of 43 animals that were present at all four collection points and that had a positive FEC at the commencement of the trial. Of the 10 excluded animals, 5 were not present at one of the data collection points and 5 had a negative

FEC at the commencement of the trial. Weight differences between the groups and the sampling points were evaluated using the Proc MIXED of SAS (2003), with treatment group, species and data collection date (week 0, 4, 8 and 12) as fixed effect and animal as random effect. Prior to statistical analysis weight was log- transformed for stabilising variance.

The anthelmintic efficacy was calculated from faecal egg count reduction (FECR) at week 4, 8 and 12 for each treatment group and for cattle and buffalo separately using the method described by Dash et al (1988). The formula used was:

FECR= 100 x (1-[Tx/T0] [C0/Cx])

where Tx and Cx = arithmetic mean eggs per gram (EPG) of faeces count of each treatment and control group at week 4, 8 and 12 and T0 and C0 = arithmetic mean count of EPG of faeces of each treatment or control group at week 0 .

Results

Farmer interviews

Farmers (n=306) from 37 villages in 20 districts were interviewed across the 5 northern provinces of Bokeo, Luang Namtha, Luang Prabang, Houaphan and Xiengkhuang. The interviewed farmers reported morbidity in 39 (5.7%) adult (>12 months) buffalo and 93 (8.4%) adult cattle with a mean duration of illness of 25.9 days (SD 23.3). The mean age of sick animals was 52.9 months (SD 33.2) and clinical signs and frequency that farmers reported for cattle and buffalo are listed (Table 3). The treatment rate of sick animals was 66.4% and medications used included traditional medicines (51 animals), salt (6), antibiotics (6; penicillin/streptomycin or oxytetracycline), anthelmintics (5; ivermectin or levamisole), human antidiarrheal medication (1), petrol (1) and uncertain (2; owners unsure what medication was used). Of the 110 sick animals where the outcome was reported, 96.4% recovered (106), 2.7% died (3) and one was sold. Of the farmers (n=306) interviewed, 91.2% (279) had never heard of or knew anything about liver fluke, with 8.8% (27) farmers having minimal knowledge of Fasciolosis in large ruminants. Farmers were asked if they had seen leaf shaped worms in cattle or buffalo livers when animals were slaughtered in the past, with 18.4% (56) and 17.7% (54) having seen some in cattle and buffalo livers respectively. Farmers were also asked if they thought their own cattle or buffalo had liver fluke, with 73.4% (174) and 78.1% (157) unsure of their cattle and buffalo liver fluke status respectively, with the remaining either classifying their animals as infected or uninfected. The majority of farmers expressed a desire to learn more about liver fluke with 95.4% (292) wanting to know more about liver fluke including its aetiology, epidemiology, lifecycle, control and prevention. Only 1 farmer wanted to know about its economic impact and 14 farmers did not respond to this question.

The result of the final multivariable logistic regression model is presented (Table 4). Province (Houaphan) was the only explanatory variable significantly (p=0.003) associated with positive *F. gigantica* status of the household large ruminant herd.

Field treatment trial

Of the 43 animals presented at all four data collection points and having a positive FEC for *F. gigantica* at the trial start, 19 were buffalo (18 female and 1 male) and 24 cattle (22 female and 2 male). The age of cattle ranged from 3 to 8 years with a mean age of 6.0 years (SD 1.6) and of buffalo from 3 to 11 years with a mean age of 6.1 years (SD 2.3). FECR of the two treatment groups is presented (Table 2), with efficacies ranging between 95.4% to 100.0% in cattle and 90.2% to 100.0% in buffalo for either treatment between weeks 4 and 12 post treatment. Mean weights for each group and species at weeks 0, 4, 8 and 12 of the trial are presented (Figure 1), showing a trend of increased weight gain in treatment groups especially buffalo. Weight was not significantly different between the trial groups over the 12 week trial period (p=0.6).

Discussion

Farmer knowledge

There has been significant past investment into *F. gigantica* research in SE Asia yet there is little evidence that the widespread knowledge amongst livestock development industry stakeholders has led to widespread and sustained control and management of the parasite (Gray et al., 2012; Gray et al., 2008). Our study confirmed the almost complete lack of knowledge of farmers in northern Laos about *F. gigantica* in large ruminants and the impact of Fasciolosis on large ruminant production, despite the interviewed farmers having been part of a prevalence survey for liver fluke and having some of their animals sampled a few months earlier for faecal egg count analysis as well as having been regularly visited by 'trained' DLF extension staff since early 2009. The lack of knowledge by farmers probably reflects lack of knowledge transfer and may be due to a number of reasons, including cultural and communication challenges (i.e. different ethnic groups and languages), remoteness of many villages from DLF district centres in larger towns where some training and information is more readily available, plus the low capacity in and minimal resources of the Lao animal health and production extension system. Lack of knowledge and information transfer was possible a reason for a large proportion of interviewed farmers not being aware of the *F.gigantica* FEC status of their herd, despite the results being made available to the relevant district DLF offices after faecal samples were analysed for the prevalence survey prior to this study. The desire of farmers for more information on the topic was evident with 95.4% of the interviewed farmers wanting more information on liver fluke especially on its epidemiology, clinical signs, control and prevention.

Only one of the interviewed farmers wanted to know about the economic impact of Fasciolosis in cattle and buffalo, probably reflecting that large ruminant smallholder farming in northern Lao is predominantly at subsistence levels and that economic considerations are not yet a driver for farmers to use parasite control in their mixed farming enterprises.

The need for education of farmers and their having access to relevant information is evident from the observations that interviewed farmers reported seeing leaf shaped structures in the livers of slaughtered cattle (18.4%) and buffalo (17.7%) respectively, despite that having no knowledge on Fasciolosis. This indicates that smallholder farmers did not associate the presence of parasite in livers of cattle and buffalo with any adverse effect on large ruminant health and production. Although it is possible that the leaf shaped structures farmers reported having seen were not *F.gigantica,* we consider this unlikely as extensive slaughterhouse surveys at the same time in the same areas did not reveal the frequent presence of any other trematode or similar looking parasites in the examined livers (Rast et al., 2013 in print).

Our study did not allow determination of the aetiology of morbidity as reported in adult cattle and buffalo by the interviewed farmers as the clinical signs described were of a general nature (not considered pathognomonic for any diseases other than for FMD) and diagnostic investigation of sick animals with submission of samples or investigation by a qualified veterinarian did not occur. Fasciolosis mostly leads to chronic production losses rather than overt clinical disease and this was supported by the results of our statistical analysis where we found no significant ($p=0.4$) association of household herd liver fluke status and observed morbidity of large ruminants by farmers.

Treatment rates of sick animals were considered high with 66.4% of ill animal treated mostly using traditional medicines or plants but also some anthelminthic, antibiotics and human medication. This is of potential concern for food safety and sustainability as development of resistant to antibiotics and anthelmintics due to uncontrolled use of therapeutics is possible and with the widespread unavailability of weight scales suited for adult large ruminants in villages, it is probable that animals are regularly dosed incorrectly.

Field treatment trial

Although there is no global accepted standard, generally an anthelmintic is considered effective if there is ≥ 90 % reduction of faecal eggs 14 days post treatment (Fairweather, 2011). FECR

>90% were achieved in our field trial for both anthelmintics used in both cattle and buffalo (Table 2). The FECR results for TCBA were slightly higher and both anthelmintics showed higher efficacy in cattle than in buffalo. This is consistent with previous research that showed lower anthelmintic efficacies at the recommended rates for cattle of triclabendazole when dosed at 12mg/kg in buffalo, due to more rapid clearance of triclabendazole in buffalo than in cattle. Further, dose rates of 24mg/kg and 36mg/kg triclabendazole given by intra-ruminal injection were 100% effective in buffalo (Sanyal and Gupta, 1996). In our trial 100% efficacy for triclabendazole in buffalo using a dose rate of 24mg/kg was not achieved, although as an oral application was used, it is possible that not all buffalo swallowed the full dose of the anthelmintic due to difficulties of restraining baffalo compared to the much smaller local indigenous cattle. The lowered FECR at week 8 compared to week 4 and then again higher at week 12 post treatment for buffalo treated with TCBA and cattle treated with TCB, could be due to maturation of young flukes or possibly, that fluke eggs were stored in the gall bladder for some time after treatment and flukes were killed and expelled around the time of the faecal collection at week 8.

In cattle the trends in weight gain were similar in treatments and the control group with an initial increase and then loss over the last four weeks of the trial (Figure 1). However in buffalo both treatment groups showed a trend of higher weight gain compared to the control group up to week 8 and then weight loss in all groups over the last four weeks of the trial (Figure 1). Weight differences of the groups were not statistically significant (p=0.6) over the trial period probably due to inadequate nutrition. Weight loss observed in all groups between week 8 and 12 (October) is likely to be the result of insufficient nutrition to maintain weight at the beginning of the dry season when available grazing feed is of declining quality and quantity, including the available forages grown by some farmers. Although the trial identified successful reduction of the *F. gigantica* egg burden using anthelmintics, for this to improve production at a time of declining pasture quality requires sufficient supplementation of nutrition beyond what is currently available in northern Lao. Resolving nutritional constraints through further experimental research and extension on forages technology in particular may then enable assessment of whether treatment for Fasciolosis is able to provide production benefits in the infected animals in the region.

Despite the limitations, this field trial provided evidence that triclabendazole and albendazole/triclabendazole are effective options for management of Fasciolosis in smallholder farming systems as they showed high efficacy against *F. gigantica* and were used and accepted by farmers and local government extension staff. However sustainable control of Fasciolosis needs to be context appropriate and consider farming systems, knowledge, practices and attitudes of farmers and other large ruminant production stakeholders, plus identify drivers for uptake of control strategies. Sustained widespread internal parasite control is currently not practiced in Lao PDR and many other tropical developing countries for a variety of reasons, including low availability, high cost and low knowledge of farmer and extension workers (Sani et al.,2004) plus the lack of a sound understanding of farmer needs and requirements within the many farming systems (Gray et al., 2012). Parasite management in livestock usually involves a combination of anthelmintics, grazing and husbandry management that is underpinned by good knowledge about the ecology and epidemiology of the parasite. For farmers, knowledge of the epidemiology, diagnosis, impact and control methods of the parasite, including correct dosage and application, are important. Whilst the drivers for sustained *F.gigantica* control in smallholder farming systems are likely to be complex and require adaptation to different regions and farming systems, awareness of the parasite and knowledge of control amongst stakeholders especially the producers is an essential driver for sustained and widespread control and management. This appears to require continued training of animal health extension staff, farmers and other livestock production stakeholders.

Conflict of interest

None

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11.9 KAP Survey paper

Promoting transboundary disease risk management through multiple large ruminant husbandry interventions may improve smallholder farmer incomes: a case study in Lao PDR (to be submitted shortly when financial impact data included)

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Abstract

To address rural poverty and food security in the Mekong region, research projects have been initiated that aim to understand how best to increase the supply and value of smallholder large ruminant productivity, providing knowledge of pathways for sustainable rural development. Surveys of smallholder farmer incomes and knowledge, attitude and practice (KAP) were conducted in 2011 and 2012 in five northern provinces of Lao PDR, involving 200 smallholders from either a livestock research or a livelihood development project (LV). The study progressed work published in 2010 that identified knowledge gaps to be addressed in the research project, using multiple interventions to improve large ruminant husbandry practices, including nutrition, biosecurity and disease risk management for foot and mouth disease (FMD). Villages in the research project were classified as either 'high intervention' (HI) where training plus a suite of health and productivity interventions was implemented, or 'low intervention' (LI) where only vaccination occurred. Some interventions for large ruminant production were also introduced to villages in the LV. Farmers participating in the projects were randomly selected for interviews, with survey questions on socioeconomic variables and KAP of large ruminant health and disease risk management, enabling determination of quantitative and dichotomous qualitative traits and comparison of results from HI, LI and LV villages. The average farmer income from selling large ruminants in HI, LI and LV was US$621, 547 and 225 respectively ($p<0.001$). The prediction means of total knowledge scores (/42) in HI, LI and LV villages in the 2012 survey were 27.74, 21.83 and 17.19 respectively ($p <0.001$). The results showed that improved KAP of large ruminant health and production can be achieved by intensive training, with some farmers yet to apply their knowledge on husbandry and biosecurity practices, ongoing learning support for smallholders, close linkage of research and development projects to improve extension capacity is recommended. This multiple intervention participatory approach that promotes biosecurity in addition to vaccination may provide a more sustainable pathway for the advancement of Lao PDR and other developing countries on the progressive control pathway for FMD control and eventual eradication.

Keywords:
Large ruminant health and production; FMD; transboundary diseases; biosecurity; socioeconomics; KAP surveys.

Introduction

Lao People's Democratic Republic (Lao PDR or Laos) is one of the least developed countries in the world, ranked at 138 out of 187 countries (United Nation Development programs, 2011). A large proportion of the Lao rural population is still poor, with 74% living on USD 2 per day (World Bank, 2007). Agriculture and in particular livestock production, is one of the most important economic sectors that can provide sustainable growth of the Lao economy and reduce rural poverty (Khounsy and Conlan, 2008). Development of the livestock industry is important in progressing the wealth of the country where 16% of GDP has been attributed to the livestock sector (Wilson, 2007). Buffalo and cattle raising in particular, are crucial livelihood activities for smallholder farmers in rural areas, providing up to 50% of household annual cash income (Asian Development Bank, 2005) with smallholders producing more than 94% of all livestock products. Despite its importance, this sector is still under-developed with the majority of smallholder farmers owning about 5-10 cattle and buffalo, using them mainly as a cash reserve (Nampanya et al., 2010; Wilson, 2007). As large ruminant farmers are currently best considered as livestock keepers rather than livestock producers, improving their knowledge, attitude and practices in large ruminant productivity is an opportunity to potentially increase smallholder household incomes, contributing to the alleviation of rural poverty in northern Lao PDR.

The research project 'Best Practice Health and Husbandry of Cattle and Buffalo in Lao PDR' was commenced implementation in 2008, funded by the Australian Centre for International Agriculture Research (ACIAR). The project is an agreement between the Australian and Lao governments, delivered through the Lao Department of Livestock and Fisheries (DLF) in collaboration with the University of Sydney (UoS). This 4-year project has played an increasingly important role in providing research for development of large ruminant production in Laos. The project has been working in six villages in the three northern provinces of Huaphan (HP), Luang Prabang (LPB) and Xiengkhoung (XK), with two villages located in each province. Three of the six villages were classified as 'high intervention villages (HI)', where a best practice health and production package has been gradually implemented between 2008 and 2012. The package included animal health (vaccination, parasite management and biosecurity), nutrition (forage establishment and conservation, plus fattening), reproductive management (breeding husbandry including introduction of castration) and marketing interventions. The remaining three villages were classified as 'low intervention or control villages (LI)' where only the vaccination program was implemented, enabling objective longitudinal measurement of the changes in productivity attributable to knowledge interventions, rather than a simple 'before and after' measure of progress (Windsor et al., 2008).

The project has closely collaborated with the Northern Region Sustainable Livelihood through Livestock Development Project (LDP)', a large development project in northern Lao PDR working in 18 priority poor districts in the five provinces of Luang Namtha (LNT), Bokeo (BK), HP, LPB and XK. This project involves 312 villages and 17000 households, with about 4900 households expected to benefit from increased incomes due to improvements in rearing and marketing livestock (cattle, buffalo and pigs), and about 7,000 households expected to benefit from improvements in rearing poultry and goats (Khounsy, 2012). The collaboration between the research and development projects has enabled the outcomes from the research project to be immediately extended as development interventions by the LDP. This was facilitated by a series of seven training programs on large ruminant health and production conducted between 2008 and 2010 that was led by the UoS team, involving 28 LDP staff from 20 districts (Table 1). This training aimed to build livestock extension capacity in the region. After the completion of the training, the district livestock extension staff engaged in participatory research and extension activities including training of large ruminant smallholder farmers in their district.

This study progresses the initial farmer knowledge survey conducted in 2009 that identified the knowledge gaps in the research project sites (Nampanya et al., 2010), plus expansion of the study areas from three to five provinces across northern Laos. The aim was to measure the progress of the mainly knowledge-based interventions in delivering, through participatory research and extension practices, potentially positive benefits to participating farmers. Surveys of the smallholder farmer income from selling large ruminant and knowledge, attitude and practice (KAP) of participating farmers in the five provinces of LNT, BK, HP, LPB and XK were conducted in 2011 and again in 2012 to assess the sustainability of any observed respondents. The aim was to record changes in smallholder farmer awareness of biosecurity and risk of transmission of transboundary diseases such as FMD and HS, knowledge of parasitic diseases, and adoption of husbandry practices, plus identify trends in practices associated with large ruminant productivity and socioeconomic progress in the region.

Methodology

District livestock extension staff training

With funding supported by the Australian Crawford Fund, a series of seven 2-3 day workshops covering large ruminant health and production topics was developed and delivered by the UoS research team between September 2008 and December 2010. All workshops were attended by the same group of district livestock extension workers from 20 districts (22-25 staff) and provincial level (3 staff) as well as a teacher of the Northern Agriculture and Forestry College situated just north of LPB involved in the research project and the LDP. Only one participant had a veterinary degree and the remaining had agriculture college training. After the training, these extension workers then trained large ruminant smallholders in the two projects' target areas. At the completion of the training series, workshop assessment was conducted with 26 out of 28 participants providing evidence of learning (two participants missed the final workshop). The structure and numbers of questions were similar to those used in the farmer knowledge assessments, although higher assessment criteria were used in assembling the results.

Large ruminant smallholder farmer training

The knowledge-based interventions introduced to the HI villages by the research project consisted of three components, using a similar approach as reported from Cambodia (Nampanya et al., 2011), being: participatory 'applied field research', 'on-the-job' training, and 'formal' training with farmer group meetings and cross visits. Only the 'applied field research' component was introduced to the LI villages. Nevertheless, informal discussions on various large ruminant health topics between district staff and participating farmers in LI sites did occur. Two extension staff in each of the research project sites were assigned to work with the HI and LI villages throughout the project operations period between December 2008 and June 2012. The three training components are described as follows:

1. Participatory 'applied field research' consisted of the project-enrolled farmers presenting their cattle and buffalo on 10 occasions over a 3 year period for weighing, vaccination, sample collection (e.g. faeces for internal parasites) and recording of additional health and production information. As the farmers and project team worked closely together and there was general discussion on the aims and progress of the project, farmers were able to develop relationships with project staff and 'informally' learn new information and skills.

2. The 'on-the-job' training consisted of extension staff working with small groups of farmers to improve large ruminant health and production through 'best practice' interventions. These included regular vaccination and anthelmintic treatments (when required) plus importantly, substantial improvements to nutrient availability through implementation of forages technology.

3. The 'formal training' was conducted between June 2011 and April 2012 for village animal health workers and 25 - 35 farmers in each of the three HI villages. Training was conducted by a trained district livestock extension team and involved 2 days of training with a half day group discussion, plus a numbers of farmer 'cross visits' and meetings. The training consisted of five modules including:

I. Prophylaxis for controlling major animal diseases

- Good husbandry practices
  1. Nutrition
  2. Vaccination
  3. Basic biosecurity measures (quarantine and separation of sick animals..etc)

II. Infectious diseases in cattle and buffaloes

1. Haemorrhagic septicaemia (HS)
2. Foot and mouth disease (FMD)

III. Basic information on parasitic disease in cattle and buffaloes

- Toxocariasis
- Fascioliasis

IV. Forage cultivation and management

- Importance of the forage and nutrition
- Selection site for cultivation
- Land preparation and planting techniques
- Forage management

V. Farmer group meetings and cross visits

- Group discussions and village meeting on large ruminant health
- Cross visits to share experience of champion farmers within and outside the village

For the LDP, one extension staff member was assigned to be responsible for 5-6 villages and involved in on-the-job training and public awareness as well as farmer group meeting and cross visits for livestock and rural development. Posters on FMD, HS and Toxocariasis were displayed in the meeting hall, temple and primary school in each of the observed villages.

Surveyed sites and farmer selection

This study progresses the initial farmer knowledge survey conducted in 2009 that identified the knowledge gaps in the research project sites (Nampanya et al., 2010), plus expansion of the study areas from three to five provinces across northern Laos of LNT, BK, LPB, HP and XK covering the research and development projects' areas of 10 villages (two villages/ province). The two villages in each province of LPB, HP and XK were selected for the research project based on criteria established by consultation between local and national authorities and the UoS team. As described, three of the six villages were classified as the high intervention villages (HI) and the remaining three villages were classified as low intervention (LI) (Nampanya et al., 2010). The farmers targeted for enrolment in the research project sites were selected through participatory consultation between project staff and village headman, with decisions for inclusion including the requirement that they owned at least one head of cattle and displayed a high level of receptivity to possible introduction of new technologies (Windsor et al., 2008).

Of the 312 LDP target villages (LV), 2 villages in each of LNT and BK province were selected for interviews, being located 70 and 80 Km from the capital district of each province, respectively. The LDP selected its target sites based on the following criteria: (1) ethnicity, (2) poor village and (3) year round access (Khounsy, 2012). The participating farmers were selected based on their own decision to participate and their level of receptivity to possible introduction of new technologies. Of the targeted farmers in the ten villages of both the research and development projects, 20 famers in each village were randomly selected for interviews (200 in total) in May 2011 and May 2012. The selection process for interviews involved discussions with the village chief and veterinary worker in addition to farmer availability during the interview period. The majority of the farmers participated in both interviews.

Farmer socioeconomic factors and knowledge, attitude and practice (KAP) surveys

The survey team consisted of district livestock extension workers and the senior author; being the same team that worked on previously reported surveys (Nampanya et al., 2010; Rast et al., 2010; Khounsy et al., 2011). The team interviewed the head of each household or the person who takes care of the family livestock, using the local dialect. Each interview took about 1 hour and the survey involved about 2-3 days per village. The interviews were informal, offering open questions about the topic, followed by probing questions to clarify the answers to fill in the information needed in the questionnaire. Questions covered farmers' socioeconomic parameters (farm land areas, total large ruminant per household, number of large ruminant sold, introduced, died and born) and KAP on large ruminant health, biosecurity and disease risk management for FMD and HS.

Examination of records of FMD and HS records
Information on disease occurrence in the 10 surveyed villages was collected monthly by district extension staff and sent to the DLF regional office in LBP. The disease records for 2009 and 2012 were reviewed for this paper.

Data management and data analysis
The survey data was transcribed into spreadsheets in Microsoft Excel 2010. For socioeconomic data of each farmer such as income from selling large ruminants were calculated based on total number of large ruminant sold and average price. The annual total loss due to mortalities was calculated from the total number of large ruminants died in the 12 months prior to the survey (either from diseases or misadventure) and average price that farmers would get if they sold that stock. For the knowledge questions, responses were assessed based on answer guidelines developed by the research team. A correct answer was given one mark, and an incorrect or an 'I-do-not-know' answer was given a zero mark. Scores for each section and the entire interview were added to obtain knowledge scores for each interviewed farmer. The knowledge scores were used for data analysis, with farmer attitude and practice answers (yes or no responses) on large ruminant health and market summarised in frequency tables.

Quantitative traits and dichotomous qualitative traits were analysed by restricted maximum livelihood (*REML*) and *Chi-square* test in the GenStat 14th Edition statistical package program. Linearity, homoscedasticity and normality assumptions were checked by viewing standardised residues graphics of the quantitative traits on model checking options of *REML*. Comparisons across the observed provinces and villages were made with a *p*-value of <0.05 indicating significant differences between the observed traits.

Results
The number of farmers interviewed in each target village and province and an outline of data analysis were tabulated (Table 1).

Table 1. Number of interviewed farmers, a survey data analysis outline

	Across province					**Across village**		
	LNT	**BK**	**HP**	**LPB**	**XK**	**HI**	**LI**	**LV**
2011 Survey Farmer interview								
- Total	40	40	39	40	40	60	59	80
- Female	18	2	3	3	13	10	9	20
- Mean age (yrs)	42.20	49.20	45.20	43.30	50.60	45.70	47.90	45.70
2012 Survey Farmer interview								
- Total	40	40	35	40	40	55	60	80
- Female	4	10	2	3	3	4	4	14
- Mean age (yrs)	40.00	49.90	43.50	40.80	52.60	47.20	45.40	45.10
Mean from each parameter in the survey was compared between province and across the village								

LNT,Luang Namtha, BK, Bokeo, HP, Huaphan, LPB, Luangprabang and XK, Xiengkhoung. LI, low-intervention village; HI, high-intervention village, LV, Livestock development project village

Socioeconomic data of large ruminant smallholder farmers

There were significant differences in farmer socioeconomic factors, including total cultivated areas, number of large ruminants per household and income from selling their large ruminants across the observed provinces and villages (Table 2). The prediction mean of the total cultivated areas per household ranged from 1.27 ha in HP to 3.38 ha in LPB (p<0.001). The prediction mean of number of large ruminant per household was 6.25 heads in LPB and 13.03 heads in XK (p<0.001) and number of large ruminant in HI, LI and LV villages were 10.49, 8.79 and 6.37 respectively (p<0.001).

The average income from selling large ruminants across the province ranged from US$ 142 and 760 in LNT and HP, respectively (p< 0.001) and across the village were US$621, 547 and 225 in HI, LI and LV villages respectively (p<0.001). The average loss due to mortalities were US$248, 252 and 44 in HI, LV and LI respectively (p= 0.001).

Table 2. Smallholder farmer income from large ruminants across the observed provinces and villages been 2011 and 2012

	Across province						Across village			
	LNT	**BK**	**HP**	**LPB**	**XK**	***p***	**HI**	**LI**	**LV**	***p***
A. Cultivated areas (ha/hh)										
- Total	1.92	3.32	1.27	3.38	2.15	<0.001	1.67	1.74	3.62	0.020
- Paddy field	0.24	0.78	0.78	0.93	1.22	<0.001	0.85	0.69	0.83	<0.001
- Upland rice	0.63	0.95	0.23	0.26	0.00	<0.001	0.18	0.25	0.85	<0.001
- Forage	0.11	0.50	0.00	1.05	0.10	<0.001	0.55	0.26	0.30	0.001
- Others	0.87	1.04	0.28	1.09	0.83	<0.001	0.28	0.77	1.28	<0.001
B. No. Large ruminants(heads/hh)										
- Total	6.21	8.70	8.78	6.25	13.03	<0.001	10.49	8.79	6.37	<0.001
- Female	3.99	5.89	5.89	4.35	9.25	<0.001	7.07	5.78	4.75	<0.001
- Cattle	5.23	3.45	3.54	4.47	8.99	<0.001	5.95	6.26	3.14	<0.001
- Buffalo	0.98	5.25	5.25	1.64	4.08	<0.001	4.55	2.52	3.24	<0.001
- No. calf born	1.57	1.86	1.87	1.50	2.30	0.006	2.03	2.02	0.96	<0.001
- No. animal introduced	1.05	0.16	0.17	0.78	0.43	<0.001	0.47	0.38	0.72	0.004
- No. animal sold	0.49	0.78	1.62	1.82	1.02	0.019	1.51	1.45	0.64	<0.001
- No. animal died	0.14	0.23	2.00	0.04	1.14	<0.001	1.02	1.05	0.18	<0.001
C. Income and losses from large ruminants (US$/hh)										
- Income	142	369	760	558	450	<0.001	621	547	225	<0.001
- Loss	47	77	422	4	338	<0.001	248	252	44	0.001

[a] indicates significant different between the mean of each parameter ($p < 0.05$).

Staff workshop training and farmer KAP assessment

The assessment of knowledge of district livestock extension staff showed very positive gains. There were no significant difference in the knowledge scores of the trained staff between provinces, with the prediction means of total knowledge scores (/42) ranged between 31.80 and 33.25 (p= 0.745).

The 2012 survey showed that there were significant differences in the farmer knowledge scores across both villages and provinces, with prediction means of total farmer scores (/42) of 27.74, 21.83 and 17.19 in the HI, LI and LV villages, respectively (p<0.001, table 2). The farmer knowledge scores on infectious disease questions (/24) in HI villages was 13.72 and was significant higher than other sites (p<0.001). Total farmer knowledge scores in XK were significant higher than in other observed provinces (p<0.001).

The comparison of the total farmer knowledge scores in HI, LI and LV villages between 2011 and 2012 was not statistically different. The prediction means of total knowledge scores (/42) in HI, LI and LV villages in the 2011 survey were 28.87, 23.88 and 16.36 and in 2012 survey were 28.28, 22.51 and 16.38, respectively (*p*=0.53, *p*=0.20 and *p*=0.98, respectively). The comparison of total farmer knowledge scores between each individual province across the two surveys indicated no significant difference. The prediction means of total knowledge scores (/42) in LNT, BK, HP, LPB and XK in the 2011 survey were 17.61,15.08, 23.64, 25.26 and 29.18; and in the 2012 survey were 16.47, 16.28, 24.29, 27.71 and 28.45, respectively (*p*=0.420, *p* =0.320, *p*=0.623, *p*=0.074 and *p*=0.504, respectively).

Table 3. Knowledge scores in the 2012 surveys across the observed provinces and villages

	Across province						**Across village**			
	LNT	**BK**	**HP**	**LPB**	**XK**	***p*** [a]	**HI**	**LI**	**LV**	***p*** [a]
Parasitic disease questions(/6) - Prediction mean - Standard errors	4.49 0.27	3.89 0.15	3.90 0.16	3.33 0.22	4.35 0.22	<0.001	5.13 0.18	4.05 0.19	2.79 0.19	<0.001
Infectious disease questions(/24) - Prediction mean - Standard errors	8.55 0.73	10.92 0.52	10.92 0.52	12.05 0.73	14.26 0.73	<0.001	13.72 0.61	10.25 0.65	10.26 0.64	<0.001
Nutrition questions (/6) - Prediction mean - Standard errors	5.06 0.25	3.64 0.14	3.65 0.14	2.89 0.19	4.09 0.19	<0.001	5.51 0.16	4.44 0.17	1.65 0.17	<0.001
Reproduction questions (/6) - Prediction mean - Standard errors	3.42 0.21	2.87 0.12	2.87 0.12	2.88 0.17	2.87 0.17	0.104	3.37 0.14	3.09 0.15	2.48 0.15	0.001
Total (/42) - Prediction mean - Standard errors	21.53 0.64	21.33 0.64	21.33 0.64	21.15 0.90	25.92 0.90	<0.001	27.74 0.75	21.83 0.80	17.19 0.78	<0.001

[a] indicates significant different between the mean of each parameter ($p < 0.05$).

There was a significant difference in the proportion of the farmers in their response to husbandry practice questions with respect to having their livestock vaccinated for FMD in the 2012 surveys across the provinces and villages (Table 4). 98, 100 and 42% of the respondents in the HI, LI and LV respectively reported that their livestock were vaccinated for FMD (*p*<0.001) and 98, 96 and 97% of the interviewed farmers respectively, advised they would like to continue vaccinating their livestock for FMD (*p*<0.789). 98% of the farmers in HI sites advised that they treated their newborn calves for Toxocariasis, with the proportions significantly different when compared to LI and LV (*p*<0.001). Further, there were significant differences in the proportion of farmers indicating they had practiced basic biosecurity measures. This included quarantine of newly introduced animals for two weeks and separation of sick animals, across the village sites (*p*=0.001 and *p*=0.043, respectively).

Table 4. Statistical analysis of farmer attitude and practice in the 2012 surveys across the observed provinces and villages

	Across province						**Across village**			
	LNT	**BK**	**HP**	**LPB**	**XK**	***p*** [a]	**HI**	**LI**	**LV**	***p*** [a]
Vaccinate all cattle for FMD a) Yes(%) b) No(%)	78 22	0 100	96 4	100 0	100 0	<0.001	98 2	100 0	42 58	<0.001
Vaccinate all buffalo for FMD a) Yes(%) b) No(%)	100 0	0 100	97 3	100 0	100 0	<0.001	98 2	100 0	38 62	<0.001
Would continue to vaccinate livestock for FMD. a) Yes(%) b) No(%)	97 3	97 3	94 6	97 3	100 0	0.655	98 2	96 4	97 3	0.799
Treat young calf for toxocara a) Yes(%) b) No(%)	47 53	57 43	66 34	67 33	77 23	0.069	95 5	44 56	53 48	<0.001
Plant forages a) Yes(%) b) No(%)	47 53	60 40	0 100	87 13	30 70	<0.001	53 47	27 73	54 46	0.04
Provide night shelter and clean regularly. a) Yes(%) b) No(%)	63 37	0 100	9 91	58 43	83 17	<0.001	57 33	35 65	31 69	<0.001
Separation new introduced for 2 weeks a) Yes(%) b) No(%)	67 33	82 18	82 18	82 18	72 28	0.055	95 5	70 30	73 27	0.001
Separation sick animals for treatment a) Yes(%) b) No(%)	92 8	89 11	91 9	90 10	95 5	0.814	97 3	85 15	90 10	0.043

[a] indicates significant different between the mean of each parameter ($p < 0.05$).

Information on infectious diseases

Both the 2011 and 2012 surveys indicated that no major outbreaks of HS and FMD occurred in the surveyed villages. However, between 2009 and 2011 inclusive, official reports of outbreaks of FMD in most northern provinces were recorded across the northern Laos. Almost all the villages in Paek district of XK were affected during the 2010 FMD outbreaks (Rast et al., 2010) and eight districts in three northern provinces were affected by FMD in 2 of 3 years between 2009 and 2011 (Nampanya et al., 2012). Official reports of HS outbreaks were not observed in the surveyed areas although there were unofficial reports of HS outbreaks in a few villages in HP involving several deaths of buffalo and cattle. Further, an extreme cold exposure was recorded in March 2011affecting many villages across northern Laos including the survey areas in HP and XK, where losses of 2-4 large ruminants per household were reported (Khounsy et al. 2011)

Discussion

This smallholder farmer income and KAP survey in 10 villages in five northern provinces of Lao PDR builds on a baseline farmer knowledge survey conducted in 2009 (Nampanya et al., 2010) and provides evidence of the positive impact of multiple interventions and farmer learning on large ruminant health and production. The expansion of surveyed villages, provides very interesting results enabling comparisons of approaches to improving farmer knowledge, attitudes and practices on large ruminant health and production and in particular, risk management and biosecurity measures for FMD and HS in targeted areas of these livestock research and development projects.

Farmers' household economic data

Total cultivated areas of 1.27 in HP and 3.38 ha per household in XK was in accord with the baseline survey (Nampanya et al., 2010) and previous study that determined that upland farmers utilised 1.5-2 ha of land per household (Steering Committee for the Agricultural Census, 2000). The significant difference in forage areas of 1.05 and 0.55 ha per household in LPB and HI villages ($p<0.001$ and 0.001, respectively) reflected in higher uptake of the forage plantation interventions and pressures for farmers to better utilise their available land particular in a place like LPB where the majority of land ownership has been allocated (Thongmanivong and Fujita, 2006). It was worthy to note that many farmers in BK and LNT utilise their available land of 0.87 and 1.04 ha per house for cash crops such as rubber and maize boosted by high demand in China (Thongmanivong and Fujita, 2006).

The significant differences in number of large ruminants per household of 13.03 and 10.49 in XK and HI sites reflected an increase from 10.30 and 9.17 from the baseline survey (Nampanya et al., 2010). Overall increase in number of cattle per household was more dominant than in buffalo. Literatures showed that local cattle breed may have higher reproductive performance than local buffalo (Stür et al., 2002, Wilson, 2007). The average number of large ruminant death per household and financial loss incurred in the research sites in HP and XK province is likely due to the impact of cold exposure in March 2011, where losses of 2- 4 large ruminants per household with the mean value of the livestock before death of US$250 – 450 was reported (Khounsy et al., 2011). The financial loss is an indication that in addition to prevention of FMD and HS, smallholder famers need to improve husbandry and nutritional management, to enable preparation for managing the risks of climatic shocks in the future (Khounsy et al., 2011).

The survey revealed that farmers in the HI villages had significant higher income from selling livestock of US$ 621 per household compared to US$ 547 and 225 in LI and LV villages. A separate interview of 10 farmers in the HI village in LPB showed an increase of annual income of US$ 2600 in 2012, compared to US$1200 in 2008 which about a third of the income comes from selling large ruminant (unpublished). When asked what their income was used for, many farmers reported that it was used to pay their children's education, saving for an emergency, buying a new hand tractor or purchasing new bulls and cows. These are examples of using large ruminant activities as 'step up and step out strategy' to alleviate poverty (Dorward et al., 2009). The high income from large ruminants encourage some farmers in the research HI villages in LPB and XK to improve product quality through planting forages and fattening activities and risk management through regular vaccinations that can increase values of cattle and buffalo of USD$ 78 and 123 per head over a period of 4-6 months respectively (unpublished). The higher returns can then be used to further strengthen large ruminant production investment to obtain higher returns in a 'stepping up' approach (Dorward et al., 2009).

Farmer knowledge improvement of infectious disease outbreak risks

The results show a significant difference in farmer knowledge scores across the provinces and observed villages, with farmers in XK province and in HI villages having higher knowledge scores. When compared with findings from the baseline survey (Nampanya et al., 2010), the survey results showed that significant improvement of knowledge was achieved. The comparison of the observed traits between the 2011 and 2012 surveys showed insignificant difference, although this can be explained by several reasons. Firstly, the time gap between each survey and the training programs may have been insufficient to show a significant difference. Secondly, applied field research and general disease awareness through posters and passive information transfer is likely to improve farmer knowledge as is shown in the results from the LI and LV villages. Further, insignificance of the total farmer knowledge scores in the HI villages between the 2011 and 2012 probably reflects retention of knowledge and supports the notion that such learning is potentially sustainable. The results suggested that achieving high levels of farmer knowledge as occurred in the HI sites, requires a combination of on-the-job training and specific training programs, as demonstrated in southern Cambodia (Nampanya et al., 2011). Although the overall total knowledge scores of farmers in HI villages were considerably improved, their knowledge scores on the infectious disease questions were considered insufficient to manage their risk of incursions of FMD or HS. Ongoing knowledge interventions are recommended to continue the improvement of farmer knowledge and risk management practices for these important diseases.

Despite there being no reports of FMD in the 10 villages during the survey periods, the risk of FMD remains high as there were numerous outbreaks reported in northern Lao PDR and beyond (Rast et al., 2010, Nampanya et al., 2012). Improved knowledge and practices of large ruminant health, biosecurity and risk of transboundary diseases as well as the introduction of FMD vaccination programs in the research project and parts of the LDP areas, are likely to have been important in preventing FMD in cattle and buffalo in the observed areas. FMD control provides a number of positive benefits for smallholders. These include healthier animals to provide a stable source of draught power, reduced vulnerability to other diseases, and the greater likelihood of adoption of more efficient production practices based on sound agro-ecological and economic principles, such as forage plantation and fattening stalls (Perry and Rich, 2007).

Changes in farmer attitude and practices

The study indicated that the interviewed farmers had very good perceptions of the benefits of FMD vaccines, with more than 95% of the farmers in the 2012 survey villages indicating they would want to continue vaccinating their cattle and buffalo for FMD. However sourcing FMD vaccines and implementing vaccination programs in northern Lao PDR currently involves many stakeholders, including donors, the management team, the implementation teams and farmers. In the research project areas, the vaccines were provided by the project for large ruminant in the project areas, explaining why a high proportion of the farmers in the HI and LI sites said they had their livestock vaccinated. There were limited FMD vaccines available in the LDP areas and allocation of vaccines had to be managed carefully. Through the recent support from South-East Asia and China Foot and Mouth Disease (SEACFMD) initiative and other major donors, the DLF received several hundred thousand doses of FMD vaccines for use across the northern provinces and in particular in the recently identified hotspot areas in XK and Xayyabouli province (Nampanya et al., 2012).

The study observed improved husbandry practices. More than half of the interviewed farmers in the HI and LV villages said they had planted forages and treated their new born calves for *Toxocara vitulorum*, indicating that farmers have gradually seen the importance of planting forages and taking care of livestock at a very young age as crucial factors to increase the value and health of their animals. Improving large ruminant productivity by enhancing farmer knowledge of nutrition, husbandry and disease prevention practices is an important village-level activity that can encourage smallholder farmers to use large ruminant activities as a strategy to alleviate poverty (Dorward et al., 2009; Windsor, 2011).

Although the 2011 and 2012 surveys showed that the majority of the interviewed farmers practiced basic biosecurity measures for newly introduced and sick animals, most of the farmers also mentioned that they do not have an appropriate quarantine area. They often tether new or sick cattle and buffalo near their home or in a corner of their paddy fields. During disease outbreaks, some farmers take their stock far away from the village and main roads, but many others still allow their healthy animals to graze on the community land and paddy fields (Nampanya et al., 2012). These basic biosecurity practices need wider adoption and refinement as current practices are not sufficient to prevent infectious disease outbreaks in cattle and buffalo. FMD is a particularly serious risk in the region and improving quarantine and animal movement control are the priority strategic tools for FMD control (Rweyemamu et al., 2008; Windsor et al., 2011).

Implications for FMD controls

This study shows an improvement in knowledge of smallholders and livestock extension staff on large ruminant health and FMD risk management. This suggests improved public awareness and enhances disease reporting and surveillance, two of the four FMD control strategies implemented successfully in the Bicol FMD surveillance zone in the Philippines (Windsor et al., 2011b). Improved public awareness for FMD control is very important in Lao PDR where the disease reporting and communications are passive, relying on the awareness of the importance disease by local villagers and authorities (Khounsy and Conlan, 2008). This is reflected in the 2011 FMD outbreaks in some villages near the research HI villages in LPB (Nampanya et al., 2012). As soon as the headman and village veterinary workers were aware of the outbreak, prompt reporting to district staff and senior veterinary officers via mobile phone had been made, followed by a swift disease emergency response through the use of strategic vaccination and animal movement control. Had the reporting of FMD not been made, many more villages and livestock would have been affected. This example shows that with the improvement of smallholder awareness of FMD as well as the use of a mobile phone, the current reporting system will provide timely information for FMD outbreak emergency responses, provided FMD vaccines, budget and human resources are made available. The use of a negative disease reporting system for important diseases including FMD, HS, Classical Swine Fever, Fowl Cholera and Rabies has commenced to improve the disease response in the 18 districts across the five northern provinces of the LDP project areas. Training of livestock extension staff and improvement in farmer knowledge on large ruminant health and disease emergency response is crucial in ensuring accurate field reporting of these diseases.

Currently, Laos is still on the early stage of the 5 stage progressive control pathway (PCP) for FMD control (FAO, 2012). The PCP is based on risk reduction of FMD in the context of improvement in market access of livestock commodities and livelihood of livestock dependent communities in the FMD endemic areas (Rweyemamu et al., 2007, FAO-EuFMD-OIE, 2011). The results of this study support the PCP and indicate the importance of the interactions between improved nutrition, husbandry practices and FMD risk management strategies. Should Lao PDR be able to move onto a higher stage on the PCP and have success in control of FMD by following the road map from the SEACFMD campaign for FMD freedom with vaccination by 2020 (OIE Sub-Regional Representation for South East Asia, 2011), it is clear that improvement in public awareness and disease reporting and surveillance should be high priority strategies alongside animal movement control and strategic vaccination (Windsor et al., 2011). Further FMD control strategies can be enhanced through knowledge improvement of smallholder farmers, livestock traders and livestock extension staff on large ruminant health and FMD risk management.

Entry points intervention for knowledge improvement and introduction of biosecurity

The study indicated that knowledge interventions through applied research and specific training programs on village-level biosecurity, plus FMD and HS vaccination programs, forage plantation and parasite control, are key entry points for working with large ruminant small holders. In northern Laos where FMD is endemic, disease prevention and control has been shown to be very important to retain participation in research and development programs. The comparison of FMD vaccination operation cost and hypothetical financial impact of FMD at village level proves that the programmes are very cost effective with a high level of protection as shown in a recent case study in the same study areas (Nampanya et al., 2012; Rast et al., 2010). The introduction of vaccination programs with farmer knowledge training is considered an important priority intervention, followed by forage plantation and nutritional management and parasite control. Interventions need to be introduced at an appropriate pace using a participatory approach to ensure the acceptance and sustainability of the programs (Windsor 2011; Gray et al., 2012). In addition, introduction of interventions requires extensive training of livestock extension staff as a priority as they and smallholders are the key to any success of the program.

The significance of farmer knowledge and practice across the research and development project areas probably reflects the scope of human resources available between the research and development projects. In the research project, two staff worked as a team in two villages and had regular visits focusing on large ruminant health in the target villages, whereas the LDP extension staff had to work in more than 5-6 villages with less regular visits focusing on rural and livestock development. The LDP has introduced, adapted an applied some of the 'scaling up' techniques to expand learning and organisational or community capacities, include identification and solving of new and emerging problems with adaption to changing situations (Millar and Cornell, 2008). This study highlights the need to continue the support through training programs of extension staff, providing a link between research and development projects in order to create a supportive environment for both extension staff and large ruminant smallholders, working together to enhance capacity for improving their large ruminant husbandry practices, biosecurity and FMD risk management leading to improved productivity and better income from cattle and buffalo production.

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11.10 Trader survey analysis and report

Rural Public Practice Rotation Report on Trader Surveys

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Method:

Participants - from the 23/01/2011 to the 27/02/2011, 32 large ruminant livestock traders and slaughterhouse owners operating in the northern Lao PDR were surveyed. The project sites in the provinces of Luang Prabang (LP), Xieng Khouang (XK) and Houaphan (HP) were targeted, however any opportunity to interview a trader was taken, and as a result some traders operated outside of the project areas. Human research ethics approval was granted by the University of Sydney under the protocol number 11382. Participants were sourced by spending 3 to 4 days in each target province at the local market and approaching traders.

Interview - the interview was semi-structured, involving categorical, quantitative, qualitative, open, closed and semi-closed questions. Participants were interviewed individually, with the process taking approximately 1-2 hours per trader. The questions targeted trading habits such as the number and types of large ruminant livestock purchased within the year preceding the interview, purchase and sale prices, attitudes to disease, numbers of animals slaughtered per month, destination of the livestock and their products and the costs and logistics of trading large ruminants in Lao PDR. The final section of the survey allowed open input from the traders regarding any comments on livestock production, trading and marketing in Lao PDR and suggestions for any improvements.

The body conditions of livestock were recorded as skinny, medium and fat based on the subjective assessment by the traders. Dry season was defined as November to April and wet season as May to October. All prices were given in Lao kip (LAK). As of February 2012, 10 000 LAK was approximately $1.20 Australian. The surveys were written in English, conducted in Lao and the answers were recorded in English. The surveys were primarily conducted by Sonevilay Nampanya, with assistance from other project staff. Suitable data was analysed using Microsoft Excel.

Results:

Provinces - Of the 32 traders surveyed, all operated (purchased and sold large ruminant livestock) in one or more of four provinces: LP, XK, HP and/or Xayyabouli (XB). Twenty seven traders operated in only one province while 4 operated in two provinces and 1 in three provinces. Table 1 illustrates the numbers of traders working in each province.

Table 1: Number of traders operating by province (displays those in 1&/or2 provinces)

Province	Luang Prabang	Xieng Khouang	Xayyabouli	Houaphan
Luang Prabang	7	-	3	-
Xieng Khouang	-	8	1	-
Xayyabouli	3	1	-	-
Houaphan	-	-	-	12

Note: 1 trader was excluded as operated in the LP, XK and HP provinces.

Most traders operating in HP only worked from this province, with only 1 trader operating in HP and other provinces. Of the 11 traders who specified operating in LP, 4 also worked in other provinces. Of the 10 traders working in XK, 2 worked in other provinces. All traders operating in XB operated in another province.

Numbers of livestock – 30 of 32 traders offered data on the number and type of large ruminant livestock purchased in the past year. A total of 8860 animals (buffalo and cattle) were accounted for. The mean number purchased per trader was 295.33 (standard deviation 392.78, range 16-1440) (Table 4).

Table 4: Total numbers of large ruminant livestock displayed by different factors

Factor		**Total**	**% of Total animals (n=8860)**
Species	Cattle	3249	36.67
	Buffalo	5601	63.22
Sex	Male	4231	47.75
	Female	4629	52.25
Body condition	Skinny	56	0.63
	Medium	5475	61.79
	Fat	3345	37.75
Age	<2 years	252	2.84
	2-8 years	7341	82.86
	>8 years	1267	14.30
Season of Purchase	Wet	4089	46.15
	Dry	4697	53.01

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Valuation of livestock - 30 of 32 traders responded when asked how they determined the value of livestock for purchase. 18 of the 30 responded that the price paid was based on meat weight; 12 of the 18 paid roughly 40000 LAK/kg while 2 of the 12 said prices can increase up to 450000 LAK/kg during high demand. Another 4 of the 18 traders specified a range of 38000-40000 LAK/kg based on meat weight, and 2 named meat weight as the determining factor but gave no price.

Of the 12 remaining traders, 7 based prices on the general appearance (body condition), while 5 primarily negotiated the price based on past experiences with livestock pricing and farmers or other traders.

Purchase prices - Traders were asked the typical price paid for particular livestock based on species, sex and body condition. Most traders offered a small range for each response, hence the mean was taken to use for descriptive statistics.

The results are displayed in Table 2. The “skinny” body condition score was excluded from Table 2 as no responses were obtained for skinny buffalo prices and only 1 and 3 responses for skinny cow and bull indigenous cattle respectively; hence it was considered unlikely to be a representative sample.

Table 2: Prices paid by traders for livestock

<table>
<tr><td>Species</td><td>Sex</td><td>Body condition</td></tr>
<tr><td rowspan="4">Indigenous Cattle
2.49 (0.86, 0.70–5.50)</td><td rowspan="2">Bulls
2.90 (0.91, 0.80–5.50)</td><td>Medium
2.59 (0.62, 0.80-4.00)</td></tr>
<tr><td>Fat
3.84 (0.81, 1.30-6.00)</td></tr>
<tr><td rowspan="2">Cows
2.04 (0.53, 0.70-3.25)</td><td>Medium
1.95 (0.50, 0.70-3.20)</td></tr>
<tr><td>Fat
2.46 (0.56, 1.80-3.50)</td></tr>
<tr><td rowspan="4">Buffalo
4.32 (1.11, 1.70 – 6.50)</td><td rowspan="2">Bulls
4.87 (1.01, 3.00-6.50)</td><td>Medium
4.44 (0.85, 2.50-6.50)</td></tr>
<tr><td>Fat
5.61 (0.85, 3.80-7.00)</td></tr>
<tr><td rowspan="2">Cows
3.73 (0.89, 1.70-5.50)</td><td>Medium
3.49 (0.88, 1.70-5.00)</td></tr>
<tr><td>Fat
4.22 (0.71, 3.00-5.50)</td></tr>
</table>

Table shows [mean (standard deviation, minimum–maximum)] in millions of LAK. 1.00 million LAK = approximately $120 Australian in February 2012.

Sales prices – the prices for different components of the large ruminants are displayed in Table 3. Other organs were reportedly sold by traders, but muscle, bone, heart, kidney, liver and stomach were selected for inclusion as they had the highest apparent value.

Table 3: Sale prices in LAK/kg for different components of large ruminants.

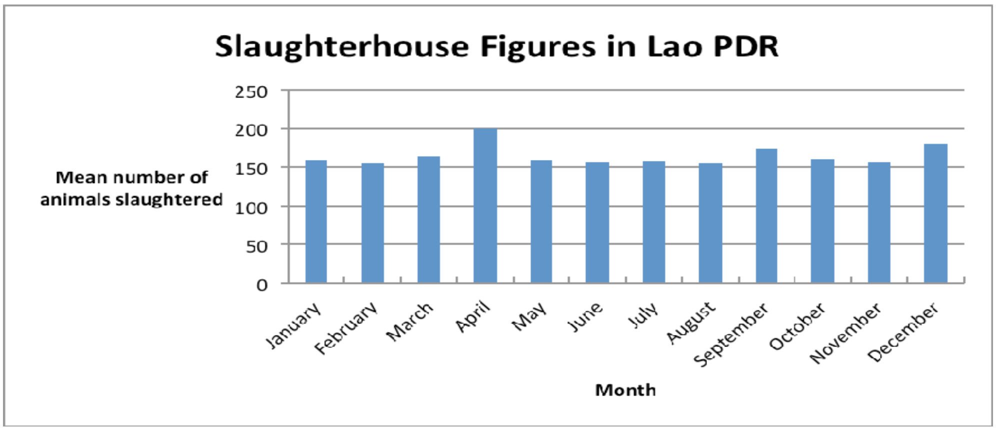
	Muscle	**Bone**	**Heart**	**Kidney**	**Liver**	**Stomach**
Mean	30000	15000	27000	26000	27000	24000
Standard Deviation	2000	5000	4500	4500	4500	6000
Minimum	27500	6500	19000	19000	19000	15000
Maximum	33500	22000	34000	30000	35000*	31000

Note: Values are rounded to the nearest 500 LAK. 1000 LAK=approximately $1.20 Australian in February 2012. * indicates that one figure was left out of this calculation: one trader specified a normal price range of 32000-35000 LAK/kg, but for good, untainted livers (no lesions or scars) prices of up to 50000 LAK/kg had been obtained.

Slaughter figures - 10 of the 32 traders surveyed responded that they slaughter, as well as trade livestock. 5 of these 10 slaughter a few animals, generally two per month, in or around their home due to a lack of a nearby slaughter point in the district. The remaining 5 own and operate slaughterhouses, with 2 of the 5 only working only as slaughterhouse owners.

Figure 1 illustrates the mean number of large ruminant livestock slaughtered each month in the 12 months preceding the survey at a slaughter point in northern Lao PDR, based on responses from the 5 owners of slaughterhouses.

Figure 1: Mean number of large ruminant livestock slaughtered per month based on data from 5 slaughterhouses in northern Lao PDR.



Source of livestock - The average percentage obtained directly from farmers was 51.33% (standard deviation 38.93, range 0 to 100) compared to 48.67% (standard deviation 38.93, range 0 to 100) directly from other traders.

Destination of purchased livestock - 31 of 32 traders responded regarding the destination of the livestock they purchased. 9 of 31 answered that some of their stock were bound for export, while the remainder only traded for domestic supply. 8 of these 9 named the export destination as Vietnam, the remaining 1 trader did not respond to the question. Both buffalo and cattle were exported to Vietnam and all were in medium to fat condition and most commonly 2-8 years old. However, livestock from all age groups (<2 years, 2-8 years and >8 years) were exported. No bulls >8 years of age were exported. Some traders specifically stated that their "Grade A" product or fatter, well-conditioned livestock were selected for export.

Fees and costs – traders were asked to summarise the costs encountered from transport, marketing, slaughter and sale of stock, including various fees and taxes. These varied greatly between traders, making them difficult to summarise. They were often expressed in different units (e.g. some traders specified transport costs per head, some per trip and some per month), or sometimes the unit was not mentioned resulting in difficult, and some cases impossible, comparisons. However, some general trends were noted and a mostly qualitative analysis was conducted.

HP – similarities between traders included animal health checks prior to slaughter (generally 13000 LAK/head), slaughter fees (92000 LAK/head cattle, 112000 LAK/head buffalo), marketing fees (generally 15000 LAK/day for rental of sale points) and taxes were commonly 30000 LAK/month, but reports varied considerably. Some traders claimed 30000 LAK/head in taxes, which is vastly different to 30000 LAK/month in the same province. Transport costs varied considerably, reportedly from 100000-400000 LAK/trip and 80000-200000/head.

XK – transport costs varied from 100000-200000 LAK/trip. All traders declared 6000 LAK/head as the price for an animal health check. Slaughter was 30000 LAK/head. Marketing costs were generally 4000 LAK/day. Taxes were typically approximately 300000 LAK/month, but ranged from 100000-850000 LAK/month.

LP – transport costs varied from 150000-400000 LAK/trip to apparently 100000 LAK/head. Animal movement fees were around 10000 LAK/head. Health check and slaughter prices were not declared by many traders, but the few results indicated that health checks are 10000-15000 LAK/head, and slaughter prices vary from 200000 LAK/day to 3-5 million LAK/month.

Extra costs mentioned by some traders included days of care for animals if sale or slaughter was delayed (10000/head/day)

Opinions on vaccination and disease - 29 traders responded when asked if they would prefer vaccinated livestock (HS, FMD); 26 of 29 answered yes and 3 of 29 answered no. The majority of traders cited the reason for preferring vaccinated stock as investment security. However, very few traders would actually check if stock were vaccinated. All said they would not buy stock from areas with an outbreak due to investment security but also government regulations.

Shortages - No trader felt they had reliable access to as many animals as they would like to purchase. Of 29 traders that responded when asked to name the period of greatest shortage, 16 said wet season, 7 said dry season, 1 said constantly, 1 said Vietnamese new year, 3 said rice season and 1 said rice season and festival season. The conditional probability of trading in HP and time of the greatest shortage being wet season was 100%.

Problems and comments – at the conclusion of the survey, the traders were given the opportunity to discuss the main problems they faced in trading and any comments or suggestions they had for improving large ruminant production and trading in Lao PDR. The following themes were encountered in the responses:

- *Taxes and transport permission* – too much variation between different provinces. Too complex, time consuming and expensive.
- *Shortages* – constant undersupply of large ruminant livestock.
- *Slaughter and selling points* – another common theme was concerns over food safety.
- *Disease* – outbreaks restricting trade areas and decreasing livestock value. Also, meat with lesions (e.g. liver lesions from fascioliasis) is less valuable.
- *Grazing and forage planting zones* – specific grazing and forage plantation areas should be allocated by the government.
- *Infrastructure* – poor roads cut off by flooding or destroyed in wet season.
- *Export* – control illegal foreign trading to countries such as Vietnam to keep prices fair.
- *Value* – fair value assessment procedure for livestock should be implemented by the government.

Discussion:

Provinces – HP is the most remote province in this study which is likely to be a contributing cause as to why most traders operating in HP operate in no other province. As a poorer province, HP traders also face logistical constraints related to poor infrastructure. The traders operating in HP tended to purchase smaller numbers of livestock than other provinces, therefore these traders may generate less profit which results in insufficient resources and finances to operate outside their home province. All traders operating in XB also traded in other provinces, however this is simply related to the fact that XB was not targeted in this survey as it is not a province involved in the ACIAR project at this stage. Therefore, any traders working in XB were encountered whilst in another province (LP or XK). Traders in LP were more likely to operate in greater than one province, which may be related to LP being a more populous province with better infrastructure and communication.

Purchase patterns – Buffalo were more commonly purchased than cattle, which may simply be related to the greater prevalence of buffalo over cattle in Lao PDR. Buffalo are also more

valuable than cattle, as demonstrated by the higher prices paid by traders. The majority of livestock were classed as of medium condition, while a large proportion was also classed as fat and a very small proportion skinny. Fat conditioned livestock are more profitable and desirable for export markets. However, fat livestock may be harder to source and expensive to purchase, meaning traders may not be able to purchase them as frequently. The vast majority of animals purchased were from 2-8 years of age. This is likely to be largely related to the greater availability of animals in this age range, but also this age is more desirable for meat sales. Younger animals may fetch poorer prices due to decreased muscle mass and fat hence lower weights, while older animals may be less desirable in terms of body condition and disease status.
A slightly higher number of livestock was purchased in dry season compared to wet season. This could be related to a number of reasons:

1. In the dry season, less feed is available for livestock. As a result, the livestock will lose condition. Therefore, farmers may elect to sell livestock in the dry season before too much condition is lost to increase profits.
2. In the dry season, it is difficult to grow crops and produce income from other forms of agriculture, therefore selling livestock during this time may boost farmer income.
3. In the wet season, it is more difficult to access villages and transport animals, therefore fewer may be purchased during this time.
4.

Prices – in Lao PDR, pricing is based heavily on negotiation. The final amount paid may be related to prices traders have paid, or sellers have received, in the past, or established relationships between farmers and traders. A number of traders suggested that the large amount of variation in pricing can make trading difficult. Sometimes, prices for which people are willing to buy or sell livestock are not considered fair, and traders must wait and care for animals until a suitable price can be obtained. Some encouraged the government to implement a fair valuing scheme for livestock. However, in Lao PDR, negotiation is an ingrained part of the economy and such a scheme may not be well received.

The purchase prices indicated by traders show that a buffalo bull of 2-8 years in fat condition is the most valuable large ruminant. Buffalo are worth more than cattle, fat conditioned livestock are worth more than medium conditioned and males are worth more than females. These may all simply be related to the greater muscle mass and hence weight of buffalo, males and fat livestock.

The sale prices for different components of the livestock varied greatly. For example, bones were reportedly sold for 6500-22000 LAK/kg. This large variation could be related to regional demand for different components, error in translation or traders not entirely understanding the question and for example, supplying 6500 LAK as the price for a certain bone, as opposed to per kilogram. One trader responded that liver, while normally 30000-35000 LAK/kg, could fetch as high as 50000 LAK/kg if high quality and free of lesions. Although this is only reported by one trader, if it can be validated it could assist in emphasising the importance of disease control to farmers.

Slaughter – peaks in slaughter figures corresponded with Laos new year (April), just before international (Chinese or Vietnamese) new year (January; peak occurs in December and tapers off over January) and the boat racing festival (September; peak in September tapering off over October) in Lao PDR. This is consistent with reports from traders of these being times of high demand, and as demand often exceeds supply in Lao PDR, shortages occur at these times.

Many traders raised concerns about the slaughter of livestock, suggesting that standardised slaughter points should be built with staff trained by the government, while regulations regarding hygiene and points of sale should also be created and enforced in order to improve food safety.

Export – it was of note that most of the traders exporting to Vietnam operated out of the XK province. XK shares a long border with Vietnam, however, HP also shares a significant border but no traders in HP claimed to export cattle. This may be related to poorer infrastructure in HP, fewer border crossings or the terrain in this area making export unfeasible. There is also the possibility that export does occur illegally and HP traders chose not to acknowledge this in the survey. This should be investigated further, however, on the surface it appears that there is room to develop export trade from HP by improving infrastructure and communication with Vietnamese traders. This could help alleviate poverty in this especially poor and remote province of Lao PDR. By improving the cash flow, farmers in HP may be more open to higher intervention work from the ACIAR project and acknowledge the benefits of disease prevention and fattening livestock.

Many traders expressed concern over illegal trading to Vietnam resulting in unfair prices. They suggested that the government be lobbied to better regulate this trading and to introduce quotas of livestock permitted to be exported.

Costs – the information supplied by the traders was difficult to analyse, as it was often given in different units (e.g., per trip, per head, per month, per year). It would be ideal to have a standardised unit for each category or asking traders for their total expenditure per year as a result of trading (excluding amounts paid for the purchase of cattle), the total number of animals purchased per year and then calculating costs per head. It was clear that the different provinces paid sometimes vastly different amounts for taxes, marketing and slaughter fees. HP appears to be a very expensive province for a trader, with higher costs of slaughtering, transport and marketing compared to other provinces. This could again be related to poor infrastructure increasing transport and slaughter costs. Taxes appeared to be fairly similar across the provinces, although some traders claimed to pay 'animal movement fees' while others did not.

It may also be possible to obtain more accurate information about taxes and animal movement fees, as well as pre slaughter health inspections, from the relevant government departments in each province. Many traders complained about the high costs of trading large ruminant livestock in terms of fees and taxes, and also insisted that they should be standardised between provinces to avoid the complex, time consuming procedure they are at present. If the various provincial governments were lobbied to standardise these fees nation-wide, it would be important to have accurate information regarding the specific amounts.

It is unclear why such a large variation was encountered in taxes in some provinces. It was considered possibly due to traders operating in more than one province paying taxes in multiple provinces, but there did not appear to be an association between trading in two or more provinces and a greater amount of taxes. This may again be a result of translational error or misunderstanding during the interview.

Disease – little was asked in the surveys regarding disease and biosecurity. While most traders declared that they would prefer vaccinated stock, none answered that they would proactively seek such animals, and some admitted that they definitely would not. This may be due to such a small number of vaccinated animals being available in Lao PDR. All traders declared that they would not purchase livestock from areas with current disease outbreaks and attributed this primarily to government regulations but also fear over investment security.

It may also be useful to assess trader knowledge of FMD, HS and other diseases. There could potentially be room to incorporate traders into biosecurity education. If traders could be made to better appreciate the benefits of vaccinated livestock, they may preferentially purchase such animals, which would aid disease control and eradication programs. Several traders mentioned occasional losses of animals due to disease while on route to slaughter points or while waiting for slaughter. If the costs of these losses could be quantified this could also be beneficial in convincing traders of the importance of disease control.

Shortages – all traders were in agreement that shortages occurred constantly. However, particular times of greater shortage were named and these varied between provinces and traders. In dry season, traders blamed insufficient feed for shortages. This may result in animals losing condition and farmers opting not to sell until more feed was available, the animals improved in condition and more money could be obtained upon their sale. Also, in dry season, livestock are generally left to roam and forage for themselves due to food shortages. This makes it more difficult for farmers to access their livestock. Wet season also caused shortages, particularly in HP province. It was believed that this was related primarily to its remoteness and poor infrastructure and as a result access to animals is often cut off by a lack of, or impassable roads. If the government could be lobbied to improve rural infrastructure, particularly in remote provinces such as HP, then trading may continue at a greater volume throughout the year. Chinese/Vietnamese New Year, Laos New Year and the boat racing festival were also times of shortage, mainly related to increased demand. Rice growing season was also named as a time of shortage. This may be related to farmers being absorbed by the importance of growing rice and less concerned about livestock.

Some traders also expressed problems such as farmers keeping animals too far from infrastructure or not being willing to sell their livestock until the money was required for other expenses. Many suggested the need for the numbers of large ruminant livestock in Lao PDR to be boosted. Increasing and improving the forage available was named as a strategy for increasing numbers, however, this raised the issue of conflict between livestock farmers and farmers of other plant crops for land. Therefore, it was suggested that the government allocate specific areas for grazing or forage plantation to avoid this conflict. There are also concerns in Lao PDR over unexploded ordinances (UXOs) in rural land preventing farmers from grazing certain areas. If more areas could be declared cleared of UXOs, farmers may be able to take advantage of greater tracts of land.

Summary of recommendations:

It is recommended that this initial trader survey be expanded to include more traders and to more specifically evaluate how effective the ACIAR project has been in high and low intervention areas from the perspective of traders. The traders also raised a number of points regarding problems and limitations faced and suggested government lobbying as a means of improving these issues. The following are points that could be expanded on in future trader survey analysis:

- Compile a list of the official details of the fees and taxes imposed on livestock sale and movement in Lao PDR in each province, specifically project provinces (LP, XK, HP).
- Survey more traders and develop a more consistent format to collect information regarding expenditure by ensuring the same units are used to allow data to be analysed more effectively.
- Assess the knowledge levels of traders regarding biosecurity and disease.
- Ask traders specifically about ACIAR project villages and their general impressions of the livestock and farmers, as well as quantitative data regarding the average price of livestock from project villages as opposed to non-project villages.
- Investigate the plausibility of lobbying for improved infrastructure, standardised valuing systems, standardised slaughter points and food safety regulation, increased control over illegal export, designated forage plantation areas and clearing areas of UXOs to allow for more forage area.

Conclusion:

The trader surveys have indicated substantial room for growth in the large ruminant livestock industry in Laos PDR, as all traders declared issues with shortages of animals. This shows that there is ample room for projects to expand and continue to alleviate poverty in Lao PDR, as if more livestock can be produced year-round to better meet demand from traders, more farmers can benefit from the profits. In particular, the province of HP could be targeted as this is the most remote and poor province and has great room for growth, potentially in lucrative international export, if improvements can be made.

The surveys have also indicated a large number of problems faced by traders in Lao PDR. If conditions can be improved for traders by standardising and simplifying taxes, implementing fair valuing schemes and improving access to farmers and villagers, the benefits are likely to trickle on throughout communities.

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