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Cattle health, production and trade in Cambodia

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Cattle health, production and trade in Cambodia

Proceedings from three ACIAR-funded projects presented at an international workshop held in Phnom Penh, Cambodia, 7–8 June 2011

Editors: James Young, Luzia Rast, Suon Sothoeun and Peter Windsor

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Cover: Best-practice project staff measuring cattle girth at the Phnom Tamao Breeding Station in Takeo. (Photo: Peter Windsor)

Foreword

Cattle play an important role in rural Cambodian society, where smallholder farmers use them for draught, fertiliser, asset storage and beef. In the traditional smallholder system in Cambodia, cattle are typically fed for survival, and grazed communally in the dry season and through a labour- and time-intensive 'cut-and-carry' of native grasses when tethered during the wet season. Most of these animals have poor body condition and low reproductive performance, and are susceptible to trans-boundary infectious diseases such as foot-and-mouth disease and haemorrhagic septicaemia.

Demand for red meat is growing in South-East Asia, driven by a rising middle class and improved incomes in countries such as Vietnam and China. Cambodia is geographically well placed to capitalise on this growing demand by increasing its domestic beef productivity. Although multiple obstacles need to be addressed to achieve such a goal, the potential socioeconomic gains are far reaching—improving smallholder cattle productivity and profitability is a recognised pathway to help alleviate rural poverty.

These proceedings represent research outputs from three projects funded by the Australian Centre for International Agricultural Research (ACIAR) that operated predominantly in Cambodia between 2007 and 2012 (with some project collaboration and activities in Lao PDR). The three projects were on cattle health and husbandry, livestock movements and spread of trans-boundary diseases, and improved feeding systems. The projects were collaborative efforts between various Australian and Cambodian government and academic institutions. They shared the objective of improving cattle production and profitability through research on disease, nutrition, reproduction, trade, marketing and socioeconomics. In June 2011, project personnel came together in Phnom Penh at a workshop hosted by the Department of Animal Health and Production, Ministry of Agriculture, Forestry and Fisheries, Cambodia, to share research findings. These proceedings are a collection of those findings, with research updates included from the following 12 months as each project drew to a close in 2012.

The work described will be of interest to regional and international agencies, and to Cambodian domestic researchers and policymakers and their colleagues in other South-East Asian countries. Ultimately, it should also be of interest to Cambodian smallholder farmers who wish to improve cattle production and rural household profitability, and take advantage of potential gains such as increased export trade opportunities.

Nick Austin
Chief Executive Officer
ACIAR

Contents

Acknowledgments

The editors would like to thank all authors for preparing papers for these proceedings, and for sharing their knowledge, experiences and insights on cattle production, health, trade, marketing and capacity building in Cambodia. The three projects that contributed to this publication were:

- Improved feeding system for more efficient beef cattle production in Cambodia (F4B)—AH/2003/008
- Best practice health and husbandry of cattle, Cambodia (BPHH)—AH/2005/086
- Understanding livestock movement and risk of spread of trans-boundary animal diseases (ULM)—AH/2006/025.

These projects were supported and funded by the Australian Centre for International Agricultural Research (ACIAR), and this support is gratefully acknowledged. Thanks to Georgina Hickey of ACIAR, who provided support and information to meet the publication guidelines. Thanks are also due to the Ministry of Agriculture, Forestry and Fisheries, Cambodia, and staff of the Department of Animal Health and Production for hosting the workshop in Phnom Penh and contributing so much effort in this sometimes difficult but enjoyable work. Finally, a sincere thank you to everyone who participated at the workshop. Your enthusiasm, good will and wise counsel for shaping future directions in smallholder cattle production, development and extension is much appreciated.

Due to a delay in this manuscript being ready for publication, five summaries of research presented at the June 2011 workshop have been published elsewhere, including in peer-reviewed journals. To ensure these proceedings provide a complete record of the meeting, permissions to reprint the published materials were sought from either the original authors or the publisher (or both). The editors wish to acknowledge and thank those involved in providing their support and original articles.

Tribute to Ieng Savoeurn

The workshop participants were shocked to learn that Ieng Savoeurn died suddenly during the night following the first day of the workshop. He had just presented a summary of work from his PhD thesis with the Royal Academy of Cambodia, supervised by Dr Suon Sothoeun and supported with funds from ACIAR project AH/2005/086. Ieng Savoeurn was a very popular young trainee veterinary scientist with boundless enthusiasm and an ability to learn quickly. His English language skills were impressive and very useful to all in translating discussion during the first day of the workshop and in a number of previous meetings. He had a very promising future and his loss is felt deeply by all who knew and worked with him. The paper titled 'The epidemiology, diagnosis and control of haemorrhagic septicaemia of cattle and buffalo in Cambodia' attempts to capture important elements from his work with co-authorship by the project leaders as a tribute to his memory.

The late Ieng Savoeurn vaccinates a bull during fieldwork in 2010 (Photo: DAHP project team)

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Abbreviations

ACIAR	Australian Centre for International Agricultural Research
BCS	body condition score
BPHH	Best practice health and husbandry of cattle, Cambodia project
CI	confidence interval
CSF	classical swine fever
DAH	Department of Animal Health, Vietnam
DAHP	Department of Animal Health and Production, Cambodia
DLF	Department of Livestock and Fisheries, Lao PDR
DNA	deoxyribonucleic acid
DOAHP	District Office of Animal Health and Production, Cambodia
ELISA	enzyme-linked immunosorbent assay
EPG	eggs per gram
F4B	Improved feeding system for more efficient beef cattle production in Cambodia project
FEC	faecal egg count
FMD	foot-and-mouth disease
HI	high intervention
HPAI	highly pathogenic avian influenza
HS	haemorrhagic septicaemia
LI	low intervention
MAFF	Ministry of Agriculture, Forestry and Fisheries, Cambodia
NaVRI	National Veterinary Research Institute, Phnom Penh, Cambodia
OAHP	Office of Animal Health and Production, Phnom Penh, Cambodia
OIE	World Organisation for Animal Health
POAHP	Provincial Office of Animal Health and Production, Cambodia
SEACFMD	South-East Asia and China Foot-and-Mouth Disease Campaign
ULM	Understanding livestock movement and risk of spread of trans-boundary animal diseases project
VAHW	village animal health worker
VVW	village veterinary worker

Units

cm	centimetre	km	kilometre
g	gram	m^2	square metre
ha	hectare	mJ	megajoule
kg	kilogram	mL	millilitre

Workshop summary

Peter Windsor and James Young

Food security was defined at the 2009 World Food Summit in Rome as 'existing when all people at all times have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life'. Despite the recent economic development of several highly populated countries, including China and India, the Food and Agriculture Organization of the United Nations (FAO) estimates that the number of undernourished people worldwide increased from 925 million in 2009 to 1.023 billion in 2010. This increasing demand for food led to the 'GFC' or 'global food crisis' in 2009, with significant increases in prices of basic food commodities leading to panic buying and hoarding of food staples. Changes in dietary preferences, along with increasing demand, have led to consistent growth in the demand for red meat. Substantial price rises for cattle in Cambodia in 2011–12 suggest that regional demand in the Greater Mekong Subregion is currently outstripping the supply of large ruminants for human consumption.

Smallholder farmers make up a large proportion of global rural communities. In 2009, the International Fund for Agricultural Development (IFAD) estimated that more than two billion people depend on production of food from less than 500m^2. Around the world, 85% of farms are less than 2 ha and 97% of farms are less than 10 ha. This means that smallholder farmers currently engaged in subsistence activities or 'swidden' agriculture are an important potential resource for meeting the rapidly growing demand for protein and red meat. Through widespread uptake of knowledge interventions and technologies, smallholder farmers can move from being 'livestock keepers' to 'livestock producers'.

The research in this document aims to identify the best practices to improve smallholder livestock farming. We use a participatory approach that empowers farmers and their advisers to learn together and share experiences of the multiple interventions required for optimum large ruminant productivity. Efforts to improve nutrition, health, reproduction, marketing and trade of cattle are all required to optimise the efficiency of the smallholder livestock system in Cambodia. Information about the most successful interventions needs to be embedded in livestock development projects and used to influence policy. This includes systems that provide efficient feeding of cattle, address health and production issues, and facilitate marketing and trade, particularly through the control and eventual eradication of foot-and-mouth disease (FMD) in the region.

On 7–8 June 2011, a workshop was held in Phnom Penh to present and share research outcomes and recommendations from the three cattle research projects conducted in Cambodia between 2007 and 2012. These projects were funded by the Australian Centre for International Agricultural Research (ACIAR), and were nearing completion. The workshop was held at the Department of Animal Health and Production (DAHP), hosted by Dr Suon Sothoeun and Professor Peter Windsor, and was attended by 30 participants. Attendees were mostly researchers and extension workers involved in one of the three ACIAR cattle projects:

- Improved feeding system for more efficient beef cattle production in Cambodia (F4B)—AH/2003/008
- Best practice health and husbandry of cattle, Cambodia (BPHH)—AH/2005/086
- Understanding livestock movement and risk of spread of trans-boundary animal diseases (ULM)—AH/2006/025.

The workshop was structured around four main themes:

- Improving cattle production
- Improving cattle health
- Improving cattle trade
- Improving knowledge and capacity.

In Theme 1: Improving cattle production, six papers were presented that focused on critical constraining issues and solutions to improving cattle productivity. Improving cattle nutrition by feeding forage grass and legume species was discussed, and trial activities were presented that investigated preharvest productivity, forage chemical composition and growth rate response in both experimental and field conditions. The longitudinal survey undertaken by the BPHH project provided a mid-project update of the impact of the best-practice systems approach to improving productivity at the village level. As demonstrated by the F4B project, forage growing saves time for smallholder household members, which is clearly a strong driver for forage uptake. The F4B project also highlighted the importance of combining legumes with rice straw and tropical grass to increase dry matter intake. The combined data indicate a strong incentive for smallholder cattle farmers to adopt forage growing in addition to improving disease control. Further research is needed to determine whether improving cattle weights directly leads to higher household incomes, and to measure the effectiveness of extension delivery methods to ensure that farmers are equipped with the knowledge and skills to implement this technology. Two papers in this section have been published since the workshop, and are reprinted here with permission.

In Theme 2: Improving animal health, five papers were presented that covered a range of animal health issues of significance to Cambodia and the region. The papers included a review of the current status of livestock infectious diseases (focusing on large ruminants), drawing on national data provided by DAHP and surveillance conducted by the BPHH project. Haemorrhagic septicaemia was further explored, including a report of results from a post-vaccination serology study. Parasitic infections of large ruminants were reviewed in combination with faecal examination results from cattle in the BPHH project. Further information on liver fluke investigations from Lao PDR were included, highlighting the regional prevalence of this parasite and its potential human health risks. The ULM project described a case study of FMD vaccination from Kampong Cham, where it was identified that biosecurity knowledge and reporting were lacking, especially from the village animal health workers (VAHWs) that remain a largely underused resource for emergency disease reporting. Calculations of disease frequency showed that vaccination appeared to have a limited protective impact on villages that received donated FMD vaccine, which highlights the importance of planning and implementation of vaccine delivery, and showcases that vaccine can have a limited impact if not supported by appropriate epidemiological investigation and management.

In Theme 3: Improving animal trade, six papers were presented, including reprints of two previously published papers by the ULM project. Determining animal values at the point of sale from farmer to trader was investigated. Recent price increases in cattle were described from two trader surveys undertaken in 2009 and 2011 by the BPHH project. An analysis of the emerging cattle industry was provided, which investigated strengths, weaknesses, opportunities and threats faced by smallholder producers. The ULM project investigated livestock trading patterns and disease risk, and traders were surveyed to identify critical risk activities to direct extension needs and education in biosecurity. The final paper in this section detailed further in-depth information relating to three key trans-boundary trade routes involving Myanmar, Thailand, Cambodia, Laos, Vietnam and China by the ULM project. This research provides key insights into livestock market chains and market drivers for the Greater Mekong Subregion.

In Theme 4: Improving knowledge and capacity, four papers were presented that focused on farmer, trader and VAHW training and education. The BPHH project presented a reprinted paper from the journal Transboundary and Emerging Diseases that highlights improved farmer knowledge in participating villages where the best-practice program was conducted. A large-scale survey of VAHWs reported on the current activities of these paraveterinarians and the role they play in infectious disease control. A post-vaccination serology survey for FMD was presented and the delivery of veterinary services was discussed. Approaches to biosecurity education for traders were provided by the ULM project, including the development and use of digital stories, booklets and posters to increase awareness of trans-boundary disease risks.

A summary of questions and discussions raised during the focus group sessions in the workshop are presented in Appendix 1.

Improving cattle production

Forage-cutting demonstration and extension (Photo: Peter Windsor)

Introduced forage productivity and quality in the smallholder environment

Mong Seang Ngim, Kea Pha, Hout Savouth, James Young and Russell Bush

Abstract

Cambodian smallholder cattle farmers operating a traditional mixed farm system (underpinned by rice cultivation) provide limited quality feed to cattle due to year-round feed deficits and climatic seasonal impacts. This study has three primary aims: (1) to evaluate the preharvest productivity of targeted forage species; (2) to establish and evaluate the chemical composition and large ruminant digestibility of targeted forages; and (3) to evaluate the growth rate response of cattle that consumed targeted forages. Three experiments were conducted using established introduced forage plots and cattle at the Phnom Tamao Breeding Station, and involved split plot design and Weende analysis, a cattle feeding 4 × 4 Latin square experimental design with four forage species treatments, and a cattle feed and weight trial. Results showed that forages are typically ready for harvest 2 months after planting to yield 6.2–7.4 kg/m^2 for fresh grasses and 3.2 kg/m^2 for fresh legume. The crude protein ranged from 11.7% to 15.9% for the four grass forages, and the legume (Stylo 184) recorded the highest crude protein (as expected) of 17.8%. The digestibility of all forages was more than 60%. The average daily weight gain ranged from 0.33 kg to 0.52 kg; higher gains were achieved in cattle that were fed Mulato II and Terenos, with a daily consumption of approximately 21 kg of fresh forage. These results show that the forages provide improved nutrition for cattle. An additional benefit lies with the capacity to extend the fattening period through use of irrigation, and to conserve fodder as silage. This study provides evidence that introduced forage species can be used to increase the quantity and quality of nutrition available to feed cattle and result in increased cattle liveweight gains.

Introduction

In the traditional Cambodian rural smallholder cattle farming system, limited year-round nutrition is available to cattle and buffaloes. During the rainy season (typically from June to October), rice growing occupies a significant proportion of arable land, and animals are prevented from venturing onto rice paddies. This restricts the animals' nutrition to what is available on the roadside, levy banks and other non-cultivated areas. Although green and lush, these are typically native grasses and have limited nutritional value. In the dry season (typically from November to May), the primary source of nutrition is rice stubble, which requires animals to walk for long distances in search of feed, potentially using more energy than is gained from the stubble. Rice straw that is conserved post-harvest is also available but offers very little in the way of nutrients, and large ruminants potentially expend more energy through digestion than is gained. The end result from these feeding practices is that animals are traditionally fed for survival using low-quality feed. This results in the animals having a very low body condition score, and being susceptible to disease, poor reproduction and generally poor production levels. The consequences may include an extended calving interval (three or more years) for reproductive females, and reduced draught efficiency for males.

It is considered that the solution to these problems involves improving the quantity and quality of the nutrition offered to these animals. This is best achieved with introduced forage species, which provide higher yield and nutrients compared with local native grasses. Use of irrigation to extend the growing period for these forages, and making silage to provide better-quality feed during the dry season, provide additional opportunities for improvement.

Aim

The aims of the current study were to:

- evaluate the preharvest productivity of targeted forages
- evaluate the chemical composition and large ruminant digestibility of targeted forages
- evaluate the growth rate response of cattle that consumed targeted forages.

This provides a systematic approach to nutritional evaluation, with the objective to provide sound, evidence-supported recommendations for practical interventions for smallholder farmers. It is anticipated that this information will be especially of interest to farmers and their advisers who wish to increase the productivity and profitability of their enterprise and are currently unaware of the benefits of using introduced forage species.

Materials and methods

Three experiments were conducted using established introduced forage plots and cattle at the Phnom Tamao cattle breeding station, approximately 40 km south of Phnom Penh. The breeding station has established multiple forage species in a 1-ha plot and maintains a hybrid-breed cattle herd of more than 200 animals. Effective animal handling facilities are available, making this an ideal location for conducting research. The livestock included in the study were 16 male hybrid (local, Haryana and Brahman cross) cattle, aged 7 months and weighing 131 ± 1 kg.

The introduced forage species analysed for nutritional value included four grasses and one legume:

- grasses—*Panicum maximum* cv. Simuang; *Brachiaria* hybrid cv. Mulato II; *Brachiaria brizantha* cv. Marandu; *Paspalum atratum* cv. Terenos
- legume—*Stylosanthes guianensis* cv. Stylo 184.

Experiment 1

To evaluate the preharvest productivity of targeted forages, a split plot design was used and measurements were made on the forage growth height (in cm), the number of stems grown and the weight of forage yield (kg/m^2) over three time periods. In this paper, only yield is reported.

Experiment 2

To establish the chemical composition and hence nutritional value and large ruminant digestibility of forages, a combination of feeding trial and proximate (Weende) analysis was used. A 4 × 4 Latin square experimental design was used with four treatments (T1: fresh Simuang, T2: fresh Mulato II, T3: fresh Marandu, T4: fresh Terenos) and 4 × 12-day treatment periods (see Table 1). Four 7-month-old male hybrid cattle (local, Haryana and Brahman cross) were placed in individual pens. The animals were adjusted to the feed for 7 days before the experiment commenced.

During the first 7 days of each period, the feed offered to and feed refused by each animal was weighed daily. During the last 5 days of each period, feed samples were collected daily and divided into two parts. One part was analysed for dry matter, where approximately 5–10 g of sample was dried for 24 hours in an oven at 100–105 °C. The other part was kept and pooled at the end of each period for analysis of ash, crude protein, crude fibre (AOAC 1984), neutral detergent fibre and acid detergent fibre (Van Soest and Robertson 1985). Total faeces were collected and weighed during the last 5 days of each period. Faecal samples were collected at 5% of the fresh weight and divided into two parts: one part was analysed for dry matter as per the method above, and the other part was kept in a refrigerator and pooled at the end of each period for chemical analysis to calculate digestibility. Total urine was collected each day using plastic containers with a drop of 10% sulfuric acid to protect nitrogen loss. Approximately 10% of each urine sample was stored in a refrigerator

Table 1. Feeding treatments for four 7-month-old hybrid cattle for four 12-day periods

Period	Treatment designation			
1	T1	T2	T3	T4
2	T2	T3	T4	T1
3	T3	T4	T1	T2
4	T4	T1	T2	T3

T1 = fresh Simuang; T2 = fresh Mulato II; T3 = fresh Marandu; T4 = fresh Terenos and pooled at the end of each period to determine nitrogen balance (Beecher and Whitton 1970).

Experiment 3

To evaluate the growth rate response of cattle that consumed targeted forages, twelve 7-month-old male hybrid cattle (local, Haryana and Brahman cross) were placed in individual pens and allocated one of four treatments (T1: fresh Simuang, T2: fresh Mulato 2, T3: fresh Marandu, T4: fresh Terenos; see Figure 1). Cattle were allocated treatments based on the completely randomised design approach, with three replicates for each treatment. Cattle were weighed using electronic scales at the beginning of the study and at monthly intervals to provide a total of three weights. Data were analysed using one-way ANOVA in SPSS software (version 16.0).

Results

Experiment 1: Preharvest productivity (forage yield)

The yield (fresh, kg/m^2) of forage growth for five forage species was recorded at three time periods and is presented in Table 2.

Experiment 2: Forage chemical composition and digestibility

The chemical composition (%) of forage growth for five forage species was recorded 30 days after the first harvest and is presented in Table 3.

The digestibility of the grass forages (%) of forage growth for five forage species was recorded 30 days after the first harvest and is presented in Table 4.

Experiment 3: Animal growth rate trial

The initial and monthly liveweights (kg) of the cattle are presented in Table 5 and the daily weight gain and consumption of forages (kg) is presented in Table 6.

Discussion

This study demonstrated that use of introduced forage species increases the quantity and quality of nutrition available to feed animals. Forages are ready for harvest 2 months after planting to yield 6.2–7.4 kg/m^2 for fresh grasses and 3.2 kg/m^2 for fresh legumes. Stylo 184 is a legume and hence is lower yielding than the grasses. Dry matter composition of the forages ranged from 19.8% to 23.5% for the four grasses, and was 20.4% for the legume. The crude protein ranged from 11.7% to 15.9% for the four grass forages, and the legume recorded the highest crude protein (as expected) of 17.8%. Crude fibre ranged from 26.4% to 27.2% in the grasses and

Figure 1. Cattle enrolled in feeding trial to establish nutritional value of forages

Table 2. Fresh yield (kg/m^2) for five forage species

Time period		Simuang	Mulato II	Marandu	Terenos	Stylo 184
1	Mean	7.23^a	6.46^a	6.20^a	7.14^a	3.06^a
	SD	0.55	0.72	0.60	0.56	0.11
2	Mean	6.43^a	6.50^a	6.43^a	6.36^a	3.16^b
	SD	0.11	1.00	0.73	1.18	0.76
3	Mean	7.43^a	6.63^a	6.86^a	7.03^a	3.40^b
	SD	0.60	0.32	0.40	0.95	0.36
Average across three time periods	Mean	7.03^a	6.53^a	6.49^a	6.84^a	3.20^b
	SD	0.53	0.08	0.33	0.42	0.17

SD = standard deviation
Note: Means within columns with different superscripts are significantly different ($P < 0.05$).

Table 3. Chemical composition of forage species (%) 30 days after the first harvest

Forage		DM	Ash	OM	CP	CF	ADF	NDF
Simuang	Mean	21.50	7.03[bc]	92.97[ab]	11.7[c]	27.20[b]	42.40[b]	71.4[a]
	SD	1.20	0.20	0.20	0.32	2.01	1.05	0.96
Mulato II	Mean	21.60	7.46[b]	92.54[b]	15.90[b]	27.20[b]	46.60[a]	68.80[b]
	SD	4.49	0.19	0.19	1.27	0.66	1.88	0.90
Marandu	Mean	23.50	8.23[a]	91.77[c]	12.60[c]	26.40[b]	43.80[b]	66.70[c]
	SD	3.55	0.30	0.30	0.25	2.69	1.26	0.85
Terenos	Mean	19.80	6.85[c]	93.15[a]	12.60[c]	27.60[b]	44.00[b]	67.70[bc]
	SD	1.06	0.27	0.27	1.22	0.77	1.01	1.45
Stylo 184	Mean	20.40	7.21[bc]	92.79[ab]	17.80[a]	37.90[a]	44.60[ab]	69.50[ab]
	SD	0.79	0.08	0.08	0.70	1.68	0.95	1.20
P-value		0.54	0.00	0.00	0.00	0.00	0.02	0.00

ADF = acid detergent fibre; CF = crude fibre; CP = crude protein; DM = dry matter; NDF = neutral detergent fibre; OM = organic matter
SD = standard deviation
Note: Means within columns with different superscripts are significantly different ($P < 0.05$).

Table 4. Digestibility (%) of the grass forages

Parameter		Simuang	Mulato II	Marandu	Terenos
DMD	Mean	65.67[bc]	64.26[c]	66.65[b]	70.38[a]
	SD	1.57	1.28	0.93	1.46
ND	Mean	70.13[c]	74.65[a]	70.88[bc]	73.87[ab]
	SD	1.79	2.82	1.89	1.46
OMD	Mean	71.40[b]	66.25[c]	70.81[b]	75.21[a]
	SD	1.53	1.67	0.81	1.83
CFD	Mean	66.10[b]	66.73[b]	66.23[b]	71.72[a]
	SD	1.03	1.16	1.86	2.32
ADFD	Mean	65.01[c]	65.07[b]	66.92[b]	68.63[a]
	SD	1.14	1.01	1.09	0.93
NDFD	Mean	67.16[b]	66.13[b]	70.05[a]	71.17[a]
	SD	1.11	1.23	1.71	0.79

ADFD = acid detergent fibre digestibility; CFD = crude fibre digestibility; DMD = dry matter digestibility; ND = neutral detergent; NDFD = neutral detergent fibre digestibility; OMD = organic matter digestibility; SD = standard deviation
Note: Means within columns with different superscripts are significantly different ($P < 0.05$).

Table 5. Initial and monthly liveweights (kg) of cattle

Parameter		Simuang	Mulato II	Marandu	Terenos	*P*-value
Initial weight	Mean	132.30	132.00	131.80	132.10	0.91
	SD	0.51	0.71	0.81	0.35	
First month weight	Mean	142.77[b]	147.90[a]	142.50[b]	147.67[a]	0.00
	SD	0.66	1.27	0.50	0.83	
Second month weight	Mean	152.27[b]	163.10[a]	153.50[b]	163.43[a]	0.00
	SD	0.87	0.72	0.50	1.06	

SD = standard deviation
Note: Means within columns with different superscripts are significantly different ($P < 0.05$).

Table 6. Daily weight gain and consumption of forages (kg)

Parameter	Simuang	Mulato II	Marandu	Terenos
Daily weight gain	0.33	0.51	0.36	0.52
Daily consumption	21.19	21.09	21.23	21.26

was 37.9% for the legume. In comparison, rice straw contains between 4.0 and 6.5 MJ of metabolisable energy per kilogram of dry matter and has a very low crude protein concentration (2.0–6.0%). Rice straw contains large amounts of silica (12–16%), which has no nutritional value, affects its palatability and reduces the amount ruminants will eat (Nour 2003). The introduced forages examined in this study are therefore more appropriate for feeding animals to improve production.

The digestibility of all forages was more than 60%, which is comparable to actively growing young grass. Further research is needed to investigate if digestibility could be improved if the forages were harvested at an earlier stage. The average daily weight gain of the cattle ranged between 0.33 kg and 0.52 kg. Notably, cattle that were fed Mulato II and Terenos performed better, achieving 0.51 kg and 0.52 kg gains per day, respectively, from a daily consumption of approximately 21 kg of fresh forage. Cattle that were fed Simuang and Marandu achieved 0.33 kg and 0.36 kg weight gains per day, respectively. Possible reasons for these differences may include the higher crude protein of Mulato II (15.9%) and higher digestibility of Terenos (dry matter digestibility 70.38%), though this requires further investigation.

These results show that the forages provide improved nutrition for cattle. The intake and weight gain could be further improved if the forages were harvested at an earlier stage of maturity. Furthermore, it would also be useful to include a legume such as Stylo 184 in future weight gain studies to determine its contribution to animal growth and development, which would likely be beneficial due to its high crude protein content.

If farmers decide to 'target feed' animals to increase the value of individual animals and attract premium prices from traders, they will need high-yielding forages of good quality. This will require farmers to seek and grow introduced forage varieties. An additional benefit of introduced forages is the capacity to extend the fattening period through use of irrigation, as well as to conserve fodder as silage during the dry period. This study supports the use of introduced forage species to increase the quantity and quality of nutrition available to feed animals, and increase cattle liveweight gains.

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Cattle production of smallholder farmers in Kampong Cham province, Cambodia

Pen Miranda, Darryl Savage, Werner Stür and Seng Mom

Abstract

Almost all cattle raised in Cambodia are produced by smallholder farmers in rural areas, and the increasing demand for red meat means that cattle production represents an important opportunity for Cambodian farmers. Smallholder farmers commonly use native grasses and crop residues as feed for their animals. However, as the cattle population and the area cultivated with crops have increased, feed resources for cattle have become a constraint, resulting in low cattle productivity. Nutrition has been identified as the single most important constraint on cattle production in Cambodia. This study reports a survey that was conducted to identify constraints on cattle production of smallholder farmers in Cambodia. Sixty randomly selected households raising cattle in the Kang Meas and Tbong Khmum districts of Kampong Cham province were interviewed in late 2008. Most (80–90%) household income was derived from the farm and only 10–20% of income was from off-farm sources. Cattle production represented 20% of farm income, on average. The mean number of cattle per household was five. Overall cattle production was assessed as very low, with the average calving interval estimated at 18.6 months, and mean growth rates of non-lactating animals at less than 100 g/day. Farmers reported that cattle were mainly used for draught, breeding and selling. This is a significant shift from the traditional approach of using cattle for draught and breeding only, indicating that farmers were responding to market demands. Farmers rated feed availability as the most important constraint on cattle production, followed by diseases. In the surveyed villages, cattle production was severely constrained by the lack of feed resources that caused low animal productivity. Providing locally available feed (natural grasses and crop residues) for cattle is a major challenge for farmers, requiring high labour inputs. Planting alternative feeds such as forage grasses is an attractive opportunity for smallholder farmers to improve their cattle production.

Introduction

In Cambodia, livestock have an important role in rural areas, and smallholder farmers produce approximately 90% of all livestock in the country. Nearly all cattle are produced by smallholder farmers in rural areas using native grass and crop residue as the common feed for their animals. This practice is becoming a constraint as the number of animals and cultivated area increases, resulting in a shortage of feed resources (Stür and Horne 1999, 2001). Increasing cattle productivity provides a pathway for poverty reduction for smallholder farmers, and nutrition has been identified as the most important constraint on optimal cattle productivity in these systems.

Kampong Cham province accounts for 13% of Cambodia's cattle population and has great potential for cattle development with smallholder farmers. In 2003, the use of forage fodder banks was introduced by the International Center for Tropical Agriculture (CIAT) through the Livelihood and Livestock Systems Project in this province. Research to increase cattle productivity of smallholder farmers in Cambodia was carried out in the project 'Improved feeding systems for more efficient beef cattle production in Cambodia' (F4B), which was funded by the Australian Centre for International Agriculture Research from 2008 to 2012 (ACIAR 2008). This present study is part of that project.

Materials and methods

Two districts of Kampong Cham province were selected as the research sites for this study: Thmey Kor village located in Roka Koy commune in Kang Meas district (research site 1) and Chroy Ko village located in Chiro Pi commune in Tbong Khmum district (research site 2). A list of all households in each research site was assembled with the help of the village chief, showing which households raise cattle and which households have already planted forages. Sixty farmers were randomly selected from the list (30 from each village) to be interviewed in late 2008 using structured questionnaires.

Results and discussion

More land was available for the farmers in Tbong Khmum district than the farmers in Kang Meas district. As shown in Table 1, the farmers in Tbong Khmum had, on average, 2.9 ha of land per household, while the farmers in Kang Meas owned only 1.06 ha ($P = 0.001$). The annual income of the farmers was US$3,296 and US$1,912 in Tbong Khmum and Kang Meas, respectively ($P = 0.008$). More than 80% of household income was derived from farm activities, and cattle production represented almost 20% of the household income.

The cattle production of smallholder farmers was not found to be different in these two districts (Table 2). The mean number of cattle per household was 4.3 and 5.3 in Kang Meas and Tbong Khmum, respectively. Many farmers kept male and female cattle (1–3 per household). Most female cattle were kept for breeding, with the aim of producing progeny for sale. Cattle were also used for draught power and selling to market. More farmers in Kang Meas used their cattle for draught power (35% in Kang Meas compared with 22% in Tbong Khmum), while more farmers in Tbong Khmum kept their cattle for sale (32% in Tbong Khmum compared with 22% in Kang Meas).

The reproductive performance of cattle was very low in terms of age at first pregnancy and calving interval (Table 2). The heifers of smallholder farmers started the first calving at 3 years of age. The average calving interval of the cows was approximately 18.6 months. Poor nutritional status is the main factor prolonging the anoestrus period of the cow (Perry et al. 1991; Lalman et al. 1997).

Farmers rated the lack of feed and the presence of disease as the most important constraints to cattle production. The lack of feed occurred almost all year round as the grasses stopped growing in the dry season and the land was used for cultivation in the rainy season. Moreover, Kang Meas is flooded during most of the rainy season, which limits the available grazing land for animals. As a result, feeding cattle required a high labour input of more than 6 hours per day per household, on average. As shown in Table 3, members of the household, including children, spent an average of 4.5 hours per day raising their cattle. During months when there was increased availability of native grasses (rainy season), farmers spent an average of 2.5 hours per day collecting native grasses from the field. Farmers who planted forages around

Table 1. Descriptive characteristics of smallholder farms in Kampong Cham province

Variable	Kang Meas	Tbong Khmum	Average	*P*-value
Average land area (ha)	1.06	2.90	1.98	0.001
Average annual income (US$)	1,912	3,296	2,604	0.008
% of income from farm activities	80	87	83	0.295
% of income from off-farm activities	20	13	17	0.281
% of income from cattle	17	19	18	0.603

Table 2. Average cattle population and reproductive performance of smallholder farms in Kampong Cham province

Variable	Kang Meas	Tbong Khmum	Average	*P*-value
Number of cattle	4.3	5.3	4.8	0.230
Number of cows	1.6	2.3	1.9	0.037
Age at first calving (years)	2.8	3.1	2.9	0.155
Calving interval (months)	17.2	19.6	18.4	0.055

Table 3. Average time spent for cattle feeding and management (hours per day)

Variable	Kang Meas	Tbong Khmum	Average	*P*-value
Grazing	4.6	4.4	4.5	0.756
Collecting native grass	2.4	2.6	2.5	0.661
Cutting planted forage	0.3	0.4	0.3	0.169
Cleaning and watering	0.6	0.4	0.5	0.155
Manure management	0.4	1.0	0.7	0.345

or near their houses spent less than 30 minutes cutting and carrying those forages to their cattle. Besides these activities, farmers also spent almost one hour cleaning and watering their cattle and managing the manure. The lack of feed and presence of diseases were also the main constraints for cattle production of farmers in others provinces of Cambodia (Windsor 2008). During the identified 'feed gap' when feed resources for cattle are scarce, crop residues such as rice straw represent the majority of their diet. Rice straw is of low digestibility for cattle (approximately 40%) and this poor nutrition results in low growth rates (less than 100 g/day) and low reproductive performance (calving interval > 12 months).

Conclusion

Cattle production contributed almost 20% to the household income of smallholder farmers in rural areas. Cattle productivity was severely constrained by the lack of feed resources available for cattle. This problem has a prolonged impact on the reproductive performance of cattle. Providing locally available feeds (natural grasses and crop residues) to cattle is a major challenge for farmers in rural areas, requiring high labour inputs. As a result, farmers spend more than 6 hours per day feeding and managing their cattle. Planting alternative feeds such as forage grasses is an attractive opportunity for smallholder farmers to improve their cattle production.

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Effect of *Stylosanthes guianensis* supplementation on intake and nitrogen metabolism of *Bos indicus* cattle offered a basal diet of mixed rice straw and tropical grass[1]

Pen Miranda, Darryl B. Savage, John V. Nolan and Seng Mom

Abstract

The effect of supplementing a mixed rice straw and tropical grass diet with legume as a nitrogen (N) source on intake, digestibility, rumen ammonia and microbial protein production was evaluated in *Bos indicus* cattle. Four rumen-cannulated steers were used in a crossover design with two diets and two periods. The diets were T1 = 40% rice (*Oryza sativa* L.) straw + 60% grass (*Brachiaria* spp. cv. Mulato II hybrid) and T2 = 40% rice straw + 30% grass + 30% legume (*Stylosanthes guianensis* cv. CIAT 184) on a dry matter (DM) basis. Supplementation with legume doubled ($P < 0.01$) rice straw and total N intake, and increased total DM intake by 32%. It did not affect the DM, organic matter, neutral detergent fibre and acid detergent fibre digestibility ($P > 0.05$) but did increase ($P < 0.05$) N digestibility. Faecal N and total N outputs from T2 cattle were higher ($P < 0.05$) than T1 cattle, but urinary N output did not differ between diets ($P > 0.05$). N retention in T2 cattle was improved by 83% ($P < 0.05$) compared to T1 cattle. Rumen ammonia concentration, microbial protein production and efficiency of microbial protein production were improved ($P < 0.05$) when the legume forage was included in the straw–grass diet. We conclude that when a mixed rice straw and fresh grass diet is supplemented with ~30% legume (DM basis), significant improvements in DM and N intake can be achieved.

Introduction

Cattle production in tropical areas is dependent on natural pastures and crop residues. However, the quality (digestible energy, nitrogen [N] and mineral concentrations) of pastures decreases, especially during dry seasons. Throughout Asia, rice (*Oryza sativa* L.) straw is used as the main diet during times of feed shortage. Rice straw has high silica and lignin content (Van Soest 2006) and is poorly digested and does not provide enough nutrients to sustain growth in ruminants (Doyle et al. 1986). Physical, chemical and biological treatments to improve the utilisation of rice straw were reviewed by Van Soest (2006) and Sarnklong et al. (2010), but are not sustainably adopted by smallholder farmers because of animal safety and cost concerns. At the farm level, it is more acceptable to use available supplementary forages (grasses or legumes). The supplementation of rice straw with only grass may not always provide sufficient nutrients, such as ruminal degradable nitrogen (RDN), particularly when the plants have reached a reproductive stage of maturity. When feeding poor-quality grasses, nitrogenous compounds and/or starch supplementation are needed to improve

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intake and digestibility (Sampaio et al. 2010; Souza et al. 2010). Legumes may be an ideal option for farmers as they can grow leguminous plants around their farm to improve the quality of soil and as supplemental feeds for ruminants. Tropical legumes contain higher concentrations of ruminally degradable N but less escape N than grasses (Brown and Pitman 1991). Feeding tropical grass alone may limit microbial synthesis so combination with legumes may be required for optimal animal performance (Brown and Pitman 1991).

While the available literature provides a strong case for legume supplementation of ruminants consuming low quality diets, comparisons that are relevant to the Asian context, in which fresh sources of legume are given as supplements with rice straw and fresh tropical grass are scarce. Our study aimed to test the hypothesis that inclusion of a fresh tropical legume in a mixed diet of rice straw and tropical grass fed to *Bos indicus* steers would increase feed intake and N balance such that animal production outcomes could shift from liveweight maintenance to growth.

Materials and methods

All procedures were approved by the University of New England Animal Ethics Committee.

Animals, experimental design, diets and feeding

The experiment was carried out at the Forage Station at the Royal University of Agriculture (RUA) in Phnom Penh, Cambodia. Four rumen-cannulated local yellow steers (*B. indicus*, 4 years old), mean liveweight 214 ± 20 kg (mean ± SD) at the beginning of the experiment, were randomly allocated in a crossover design to two treatments (two diets) and two periods. The total experimental period was 50 days (2 × 25 days), including 17 days' adaptation (7 days in individual pens and 10 days in metabolism crates) and an 8-day collection period (7 days total collection and 1 day when rumen fluid was sampled). Between periods, steers grazed ad libitum in a paddock of natural grass for one week.

The treatments used were T1 (40% rice straw + 60% fresh grass) and T2 (40% rice straw + 30% fresh grass + 30% fresh legume, dry matter [DM] basis). The amount of feed offered each day was based on liveweight (3% of liveweight) and adjusted according to intake from the previous day (previous day's intake plus 10%). The rice (*O. sativa L.*) straw was harvested from a local rice crop that was grown during the rainy season and was stored in a shed for 4 months after harvest.

The fresh grass (*Brachiaria ruziziensis* × *Brachiaria decumbens* × *Brachiaria brizantha* cv. Mulato II) was grown at the Forage Station of RUA. Mulato II is a hybrid of *Brachiaria*, which was developed for higher DM yield and better quality than earlier *Brachiaria* cultivars. This hybrid is tall vigorous grass that is suitable for 'cut-and-carry' systems (Cook et al. 2005). The fresh legume (*Stylosanthes guianensis* cv. CIAT 184) was also grown in plots adjacent to the grass. Stylo CIAT 184 is a short-lived perennial legume forage (2–3 years) that is adapted to infertile acid soil and is rich in protein [12–20% crude protein (CP)]. This legume forage is easily established from seed and has good growth habit for cut-and-carry systems and its leaves stay green well into the long dry season (Cook et al. 2005). The grass and legume plots were prepared and managed before the commencement of the animal study such that the plants were the same age at harvest throughout the study (16 weeks for grasses and 12 weeks for legumes). This was achieved by ensuring that the daily harvesting was arranged according to the rotation of previous harvest. Daily harvesting was undertaken every morning at 0700 h. Forages were cut at ~20 cm above ground level using a sickle. Fertiliser (NPK-based) and stored cow manure were applied to the field every 2 months and the field was watered every week. Water was available to all animals ad libitum. Animals were fed one-third of their daily allocation of each feed component at 0800, 1200 and 1600 h. The nutrient composition of each feed is given in Table 1.

Sampling procedure and measurements

During the collection periods, animals were housed in individual metabolism crates. Feed DM intake was measured daily and feed offered and refusals were retained for analysis. Faeces and urine outputs over the previous 24 h were recorded each morning before feeding during the total collection periods. Subsamples of feed and faeces (10%) were dried and stored. Urine output was collected into plastic buckets already containing 100 mL of 1.8 M sulfuric acid to maintain pH below 3 (Chen and Gomez 1995); subsamples (50 mL) were bulked and stored at –20 °C for each animal for a 7-day period for later N and allantoin analysis. On the final day of

Table 1. Nutrient composition (g/kg DM) of rice (*Oryza sativa* L.) straw, grass (*Brachiaria* spp. cv. Mulato II hybrid) and legume (*Stylosanthes guianensis* cv. CIAT 184) offered to *Bos indicus* steers

Parameters	Rice straw	Mulato II	Stylo CIAT 184
Dry matter (g/kg)	887.9	263.4	218.5
Organic matter	887.1	899.2	906.9
Crude protein	41.6	89.2	218.4
Crude fibre	353.0	261.3	230.8
Neutral detergent fibre	768.8	669.5	475.5
Acid detergent fibre	529.9	370.9	358.4
Hemicellulose	238.9	298.6	117.1

the collection period, rumen fluid samples were collected via a cannula in the dorsal sac, using a syringe to draw the fluid through a metal probe, at 0700, 1100, 1300, 1500 and 1900 h. Rumen fluid pH was determined immediately after sampling and 20 mL of sample was transferred into a McCartney bottle with 0.3 mL of 18 M sulfuric acid. The samples were stored at –20 °C pending analysis for ammonia concentration.

Chemical analyses

Subsamples of feed offered, feed refused and faeces were dried to a constant weight at 70 °C in a fan-forced drying oven for 48 hours to determine DM content and combusted in a muffle furnace at 550 °C for 4.5 h to determine organic matter (OM) content. Total N concentrations in feed, faeces and urine were determined using the Kjeldahl digestion procedure (AOAC 1990) before colourimetric measurement, using an improved method of Willis et al. (1996), of ammonia N concentration in a spectrophotometer at 685 nm (Genesys 10UV-Vis, Thermo Fisher Scientific, Sydney, Australia). Ammonia-N concentration in rumen fluid was also measured by the procedure of Willis et al. (1996). Crude fibre (CF), natural detergent fibre (NDF) and acid detergent fibre (ADF) were determined by using the filter paper method according to AOAC (1990) and Van Soest et al. (1991). Hemicellulose was calculated by subtracting ADF from NDF content. Allantoin concentration in urine samples was determined by the methods described by Chen and Gomez (1995) and IAEA (1997). Total purine derivatives and microbial crude protein (MCP) production were estimated from allantoin excretion in urine as in Chen and Gomez (1995). Urine and rumen fluid pH was measured using a pH meter (ECpH6, Eutech Instruments Pty Ltd, Singapore) calibrated with pH 4.01 and pH 7.00 buffer solutions.

Calculations and statistical analysis

Metabolisable energy (ME) content of diets [expressed as M/D (MJ/kg DM) or ME (MJ/kg DOM)] was estimated using the equations from Freer et al. (2007):

M/D = 0.169 OMD – 1.986; where M/D is ME content of diet and OMD is % organic matter digestibility.

ME (MJ/kg DOM) = 0.81 DE (MJ/kg DOM); where DE is digestible energy.

DE (MJ/kg DOM) = 17.33 + 0.0124 CP g/kg DM (Terry et al. 1974).

ME requirement for maintenance (ME_m) of cattle was estimated using the equations from Freer et al. (2007);

$ME_m = 1.2 \times 1 \times 1\ [0.26\ W^{0.75} \exp(-0.03A)]/k_m + 0.09$ MEI, where W is liveweight, A is age (with a maximum value of 6), k_m is the net efficiency of use of ME for maintenance and MEI total ME intake (MJ).

km = 0.02 M/D + 0.5.

The statistical significance of treatment effects were analysed using the statistical package SPSS 15.0 (SPSS for Windows, 2006, SPSS Inc., Chicago, IL, USA) using the General Linear Model procedure with terms for diet type (treatment), cattle and period. Pairwise differences between means were tested using the least significant difference procedure if the ANOVA test of the main effect was significant.

Results

Intake, digestibility, N retention and N outputs

Supplementation of a mixed-diet of rice straw and fresh grass with fresh legume forage increased DM intake of cattle ($P < 0.01$, Table 2) from 20.3 to 26.7 g/kg W.day. The inclusion of legume doubled rice straw intake ($P < 0.01$) from 5.9 to 12.0 g/kg W.day and

OM intake ($P = 0.051$) and DOM intake ($P = 0.056$) were increased by 25% and 27%, respectively. There was also an increase in intake of ADF ($P < 0.01$), but not in intake of NDF ($P > 0.05$, Table 2).

Intake of N and CP increased ($P < 0.01$) from 0.2 to 0.4 g/kg W.day and from 1.5 to 2.7 g/kg W.day. There was no difference in digestibility of DM, OM, NDF and ADF among the diets (Table 2). The digestibility of N was increased ($P < 0.05$) from 56.1% to 64.7%.

The daily faecal N output from cattle consuming legume was higher ($P < 0.05$) than from cattle without legume in their diet. There was a high variation in daily urinary N output between animals, and output was not different ($P > 0.05$) between the treatment groups. N retention was higher ($P < 0.05$) for cattle consuming the diet with legume (mean = 43.3 g/day) than for those not offered legume (mean = 23.7 g/day, Table 2).

Microbial protein production and rumen parameters

The efficiency of MCP (EMCP expressed as g MCP per kg DOMI) for cattle given a mixed rice straw and grass diet with supplementary legume was higher ($P < 0.05$) than for cattle offered the diet without legume (Table 3). The inclusion of legume did not affect ($P > 0.05$) rumen pH; however the concentration of NH_3-N in rumen was increased ($P < 0.05$). Cattle offered legume gained more weight (17.9 kg, $P < 0.05$) than cattle not offered legume, which lost weight (1.8 kg, Table 3).

Discussion

This study has demonstrated that inclusion of the legume *Stylosanthes guianensis* cv. CIAT 184 in a mixed rice straw and grass diet increased DM intake of the basal diet rather than substituting for it. This is particularly important in the context of ruminant livestock raising in Asia, where high quality feed resources are scarce and rice straw is widely used as a basal diet. This additive effect of supplement has been found in previous studies (Moran et al. 1983; Mosi and Butterworth 1985; Suriyajantratong and Wilaipon 1985; McMeniman et al. 1988; Alayon et al. 1998). The OM digestibility of the diet without legume (62%) was similar to that of another Cambodian-based study with the same breed of cattle fed rice straw and Para grass (*Brachiaria mutica*) (67.4%, Sath et al. 2012). However, improvement in OM digestibility (OMD) with increasing inclusion of tree legumes (*Gliricidia sepium* and *Leucaena leucocephala*) up to 26% has been found in a comparable study with Ongole cattle (*B. indicus*) in Indonesia (Syahniar et al. 2012). Importantly, the Syahniar et al. (2012) work was with a rice straw only-based diet with OMD of 53%. In the present study, the OMD of the diet with legume was not different due to relatively high digestibility of the grass and rice straw basal diet. It is accepted that there may be contributions of minor error in this study related to collection of faeces.

Increased rumen ammonia concentration in steers offered diets with legume was a consequence of degradation of RDP from the legume forage. The rumen ammonia concentration in cattle fed diets without legume (14.2 mg/L) was likely to be limiting for microbial growth, whereas the rumen ammonia concentration in cattle offered diets with legume (59.7 mg/L) was above the concentration (50 mg/L) considered necessary for optimal microbial growth (Satter and Slyter 1974). As a result, MCP outflow from the rumen was doubled.

For both diets, the EMCP production rates of cattle were lower (36.2 and 61.5 g MCP/kg DOMI for T1 and T2, respectively) than the MCP yield (130 g MCP/kg DOMI) expected in cattle ingesting adequate RDN (Freer et al. 2007), which suggests that intake of RDN or some other nutrient was still inadequate in cattle offered the legume-supplemented diet. EMCP production rates of cattle offered tropical grass were lower than rates in cattle given temperate forages that provided adequate RDN (Panjaitan et al. 2010) and, as rice straw was a major component of the total diet in the current study, the EMCP production was much improved when legume was included in the diet.

If MCP synthesis is inefficient, unused dietary protein is excreted in faeces and urine as was found in the present study. In North America and Europe, excreted N may be an environmental problem; however, smallholder farms in Asia are N-deficient environments and therefore N excretion from ruminants can be valuable as a source of fertilisers or for inclusion in bio-digesters to produce gas for household cooking and lighting.

In sheep given a low quality diet, DM intake and the level of fill in the alimentary tract is higher when N status of animals is improved (Egan 1965). The higher daily MCP production in the cattle offered the diet with legume would have substantially increased the amino acid availability in their small intestines relative to digestible energy (P : E), and this was likely to

Table 2. Mean intake (DM basis), digestibility and nitrogen (N) retention of *Bos indicus* steers fed a mixed-diet of rice (*Oryza sativa* L.) straw and grass (*Brachiaria* spp. cv. Mulato II hybrid) with and without legume (*Stylosanthes guianensis* cv. CIAT 184)

Parameters	Diet without Stylo 184	Diet with Stylo 184	s.e.d	*P*-value
Intake (g/kg W.day, except for ME intake)				
Mulato II hybrid	14.4	7.4	0.32	0.002
Stylo CIAT 184	–	7.3	0.76	0.011
Rice straw	5.9	12.0	0.53	0.007
DM	20.3	26.7	1.50	0.050
OM	18.3	24.0	1.35	0.051
DDM	11.9	16.1	0.98	0.050
DOM	11.3	15.2	0.94	0.056
Estimated ME[a]	0.17	0.23	0.01	0.052
NDF	14.2	18.5	1.67	0.124
ADF	8.5	11.7	0.61	0.035
N	0.2	0.4	0.02	0.028
CP	1.5	2.7	0.21	0.028
Digestibility (%)				
DM	58.3	60.1	0.79	0.161
OM	62.0	63.1	0.88	0.340
NDF	60.5	61.9	1.67	0.474
ADF	49.6	52.6	1.85	0.253
N	56.1	64.7	1.29	0.022
N retention (g/day)				
N intake	52.4	89.6	0.86	0.001
Faecal N output	22.9	31.4	0.63	0.005
Urinary N output	4.3	14.6	3.8	0.111
Total N output	28.7	46.3	3.4	0.036
N retention	23.7	43.3	3.8	0.035

ADF = acid detergent fibre; CF = crude fibre; CP = crude protein; DDM = digestible dry matter; DOM = digestible organic matter; ME = metabolisable energy; NDF = neutral detergent fibre; OM = organic matter

[a] Estimated MEI (MJ/kg W.day) according to equations from Freer et al. (2007).

Note: Values are means and s.e.d.

be the reason for their increased appetite and higher DDMI and DOMI (Egan and Moir 1965). The increase in P:E of absorbed substrates in this study, as a result of the higher EMCP production in the diet containing legume, could explain the difference in intake between the dietary treatments, as P:E is a factor that regulates feed intake (Egan 1977). The DOMI and DDMI are normally linearly correlated with MCP yield [see, for example, results of Liang et al. (1994) for Malaysian cattle and swamp buffalo]. So an increase in ME intake along with an increased amino acid supply from microbial protein explains the higher tissue growth and better performance of the legume-fed cattle.

Mean N retention of the legume-supplemented cattle (43 g/day) would be indicative of weight gains of up to 1 kg/day (Underwood and Suttle 1999) although N retention in tissues of these cattle could have been overestimated because of the more rapid losses of faecal and urinary N during collection of samples that are likely to occur in a hot climate. The mean liveweight change of cattle supplemented with legume forage in the present study was somewhat lower than predicted from N retention (~0.7 kg/day) but the cattle were a breed native to Cambodia that has not been selected for improved growth; these cattle were also cannulated and housed outdoors in individual pens. The cattle grew at rates that were greater than normally expected in Cambodia, although lower than rates reported for European breeds (Underwood and Suttle 1999).

Changes in liveweight of the cattle in this study need to be interpreted cautiously because of possible errors associated with gut fill in relatively

Table 3. Microbial crude protein (MCP) production, rumen chacteristics and liveweight change of *Bos indicus* steers fed a mixed-diet of rice (*Oryza sativa* L.) straw and grass (*Brachiaria* spp. cv. Mulato II hybrid) with and without legume (*Stylosanthes guianensis* cv. CIAT 184)

Parameters	Diet without Stylo 184	Diet with Stylo 184	s.e.d	*P*-value
Supply				
MCP supply (g/kg W.day)	0.41	0.84	0.11	0.057
MCP supply (g/day)	91.4	191.2	9.40	0.009
Efficiency of MCP				
EMCP (g MCP/kg DDMI)	34.6	58.1	5.61	0.052
EMCP (g MCP/kg DOMI)	36.2	61.5	5.77	0.048
Rumen parameters				
Rumen pH	6.73	6.69	0.01	0.117
Rumen NH_3-N (mg/L)	14.2	59.7	8.19	0.031
Liveweight				
Liveweight change (kg/period)	–1.76	17.9	3.4	0.028

DDMI = digestible dry matter intake; DOMI = digestible organic matter intake; EMCP = efficiency of microbial crude protein production
Note: Values are means and s.e.d.

short-term measurements. The cattle offered the diet without legume did not quite maintain liveweight (–70 g/day, Table 3) although the calculated ME intake (36 MJ/day; Table 2) was above the ME_m of these cattle predicted according to Freer et al. (2007) (26–29 MJ/day). The calculated ME_m could be underestimated using these predictions because the cattle were housed outdoors under tropical conditions and may have incurred additional energy costs to combat high temperatures and to repel insects. On the other hand, estimated ME intake from the diet with legume (46 MJ/day) was insufficient according to Freer et al. (2007) to support the measured level of tissue deposition (energy stored in protein and fat synthesis minus ME_m) in immature steers. The reasons for these discrepancies are not clear but could arise from several relatively small errors in various experimental measurements (liveweight gain as noted earlier, digestibility estimates which affect prediction of ME intake and uncertainty about the true ME_m). In addition, these animals had been subjected to undernutrition before the study commenced, and may have exhibited compensatory (more efficient) growth during the experimental period (Thornton et al. 1979).

Despite these uncertainties, it is clear that inclusion of *Stylosanthes guianensis* cv. CIAT 184 in a mixed-diet of rice straw and *Brachiaria* hybrid cv. Mulato II increased feed intake and N balance of *B. indicus* steers by providing extra fermentable energy and RDN and resulting in significantly improved performance. The study demonstrates the potential benefits of including legume forages in grass and rice straw-based diets for zebu cattle under tropical conditions.

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A longitudinal study on cattle health and production

James Young, Luzia Rast, Suon Sothoeun, Leoung Van Irng, Thong Samnang and Peter Windsor

Abstract

A 4-year longitudinal survey of cattle production was conducted in six villages from three provinces in Cambodia to determine the effectiveness of interventions that may improve the profitability of large ruminant production. Two villages in each province were 'paired' and designated as either high intervention (HI) or low intervention (LI). The HI villages experienced a 'best practice' program involving a series of interventions, including implementation of forage technology, education in husbandry, biosecurity and marketing aimed at developing skills and knowledge at the farmer and village level, and internal parasite control. Cattle in both HI and LI villages were vaccinated for foot-and-mouth disease and haemorrhagic septicaemia. Data were recorded every 3–4 months on animal health, production and reproduction. In the HI group, daily weight gains were an average of 30–80 g per day higher than the LI group for all ages in each weight gain period. This equated to 11–29 kg additional weight gain annually and demonstrated that improvements on a large scale are achievable with a multifaceted education-based program. A lower mean daily weight gain of 90 g (95% CI 0.080–0.092) was identified during the dry season, indicating farmers need solutions such as forage technology to meet seasonal feed deficits.

Introduction

The majority of Cambodian livestock producers are rural smallholder farmers living and working on a subsistence or semi-subsistence basis. Raising livestock is an important part of the rural economy because smallholders use animals as a source of protein, draught power and income, and as a cash asset store (Harding et al. 2007). Livestock production and income are limited by endemic diseases including foot-and-mouth disease (FMD), haemorrhagic septicaemia (HS) and blackleg, and by parasites such as *Fasciola gigantica* and potentially *Toxocara vitulorum*. Poor nutrition and knowledge of animal husbandry and breeding management are likely further factors limiting production (Windsor 2008). The climate in Cambodia is tropical, with the monsoon rainy season from May to November, and the dry season from December to April, with little seasonal temperature variation (21 to 35 °C). This paper provides a mid-project update on productivity data from the Australian Centre for International Agricultural Research (ACIAR)-funded project AH/2005/086: Best practice health and husbandry of cattle, Cambodia, jointly managed by the University of Sydney and the Department of Animal Health and Production in Cambodia (ACIAR 2011).

Aim

The aims of the project were to establish baseline production parameters for cattle productivity in the project villages, including mean daily body weight gain, body condition scores (BCSs), herd age and gender structure, breed type, animal use, and animal trade and other movement. The project also aimed to identify if any productivity differences (such as mean daily weight gain of cattle) accrued in villages where a series of production interventions were implemented.

Method

The 4-year longitudinal study commenced in March 2008, and repeated measures were taken from farmers and large ruminants in the project villages approximately every 3–4 months. Six project sites (villages) from three provinces were selected to participate in the project, with two villages in each province selected to provide three sets of geographically matched research sites. One of each of the matched villages was designated a high-intervention (HI) village and one as a low-intervention (LI) village, although the majority of cattle in both HI and LI villages were vaccinated against HS and FMD. HI villages received knowledge interventions in the form of workshops and on-farm training, plus resource support including supplying forage seeds, animal treatments, and disease and parasitic diagnostic testing. Workshops in animal health, nutrition, reproduction management and marketing were developed and introduced in the three HI villages. LI villages received advice only when requested during data collections. The six villages selected and their designated intervention type included No Mor (HI) of Tram Kok district and Dem Pdet (LI) of Trang district in Takeo province, Preak Por (HI) and Koh Kor (LI) of Saang district in Kandal province, and Senson Tbong (HI) and Veal (LI) of Prey Chhor district in Kampong Cham province. The three provinces of Kandal, Kampong Cham and Takeo each have high cattle populations and similar cattle breeds, and are representative of environment and husbandry practices in southern Cambodia.

Interventions

Project leaders delivered seven workshops to project and district staff. The topics of the workshops included reviewing livestock production and farmer knowledge, forage and silage production technology, large ruminant nutrition, husbandry, reproduction, infectious disease, parasite management and biosecurity. The practical interventions undertaken and implemented in HI villages included:

- vaccination for HS and FMD alternately at approximately 6-month intervals
- treatment with an anthelmintic three times during the study
- forage development with provision of seeds and cultivation techniques
- random selection for animal testing for brucellosis and faecal examination for evidence of internal parasites.

Data collection and management

Each episode of data collection (six in total at the time of analysis, with the sixth occurring during August and September 2010) included information on weight, condition, skin, use for draught, strength, calves born, use of bull selection, faecal and blood collection, movement (i.e. sale, death, no change) and treatments given (i.e. drench and vaccination). Cattle were identified using a tag hung on a rope around the neck. Weight collections were conducted using portable scales, and all additional information (e.g. pregnancy status) was collected by verbal survey of each farmer by the project staff. Information for farmers was entered manually onto an animal record card, and data collected for analysis were recorded onto a data collection sheet that was later entered into Microsoft Excel by one project staff member. The mean daily weight change for cattle was calculated and used as the outcome, and differences between HI and LI were assessed and confidence intervals recorded.

Results

A total of 1,516 cattle were enrolled in the study. Five villages exceeded the initial target of 250 animals, and one village (Dem Pdet) enrolled 247 animals. The first data collection began on 24 March 2008, and the sixth collection was completed on 6 September 2010, resulting in a total study time of 896 days (approximately 30 months). The mean duration of each data collection was 42.7 days to collect data from all six villages. A total of 370 animals remained in the study after six collections, which equated to a total attrition rate of 76%. Overall, 28.7% of farmers (188 farmers) owned one animal, 39.0% of farmers (255) owned two cattle, 17.3% (113) owned three cattle, 8.4% (55) owned four cattle, and 6.6% (43) farmers owned five or more cattle.

Two cattle breeds were represented in the study. Local breed accounted for 16.5% of the animals, and crossbred animals accounted for the remaining 83.5%. All of the cattle designated local breed came from one village (No Mor in Takeo province). Of the 1,516 animals enrolled in the study, 55.2% were females (837 animals) and 44.8% were males (678 animals). Of the males, 58% were castrated. The mean age of all animals was 3.5 years, ranging from 0.1 years to 13.0 years. Local and crossbreed mature cattle (more than 3 years old) had a mean weight of 220 kg and 294 kg, respectively. Body condition score was measured on a scale of 1 to 4 as follows: 1 = fat, 2 = medium, 3 = skinny and 4 = very skinny. The mean BCS for crossbred animals was 3.38 (n = 1,264) and for local breed 3.81 (n = 250). At the start of the project, 26.5% of all animals were designated as used for draught. The mean age of all animals used for draught was 4.9 years, and 97.5% of all draught animals were castrated males (bullocks).

Forage uptake

The following tables show the number of households that developed forage plots for livestock feeding between 2008 and 2009 (Table 1), and by 2010 (Table 2).

Mean daily growth rate analysis

Figure 1 shows graphical trends of daily weight gains (kg) of each of the two intervention groups. Weight gain period 1 refers to the mean daily gain

Table 1. Number of households that developed forage plots between 2008 and 2009

Village	No. of households	Land for planting (m^2)	Area per household (m^2)
Preak Por	6	4,450	742
Senson Tbong	25	12,940	518
No Mor	31	11,400	368
Total	62	28,790	464[a]

[a] Average total forage plot area developed per household

Table 2. Number of households that established forage plots by mid 2010

Province	No. of households	Land for planting (m^2)	Area per household (m^2)
Takeo	263	88,500	337
Kandal	15	14,000	933
Kampong Cham	148	81,338	550
Total	426	183,838	432[a]

[a] Average total forage plot area developed per household

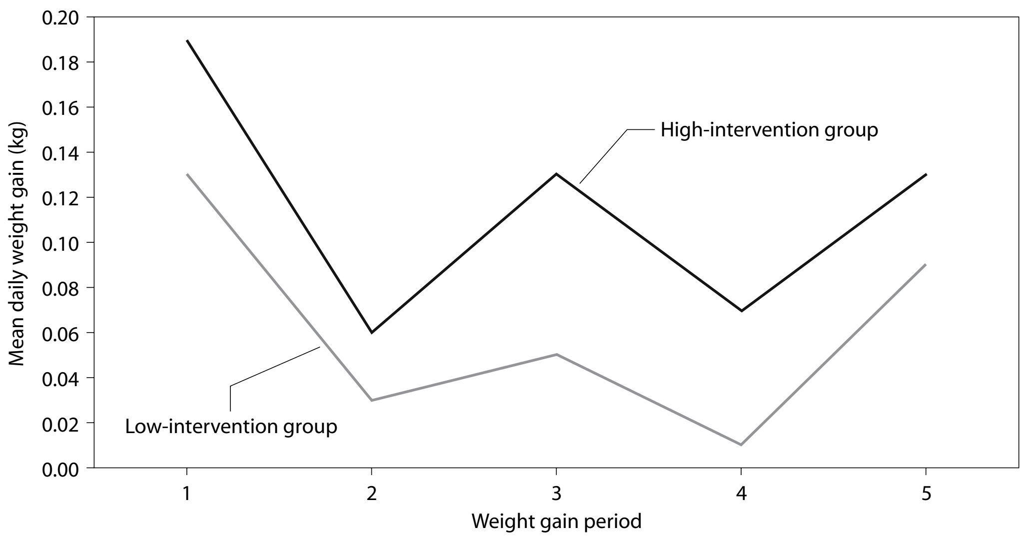

Figure 1. Mean daily weight gain (kg) of the intervention groups

Table 3. High and low-intervention group mean daily weight gain (kg)

Weight gain period	HI mean	LI mean	Difference	95% CI
All cattle				
1	0.19	0.13	0.06	0.044–0.076
2	0.06	0.03	0.03	0.020–0.040
3	0.13	0.05	0.08	0.071–0.089
4	0.07	0.01	0.06	0.051–0.069
5	0.13	0.09	0.04	0.030–0.050
Cattle ≤ 3 years				
1	0.21	0.15	0.06	0.044–0.083
2	0.07	0.05	0.02	0.011–0.033
3	0.15	0.06	0.09	0.078–0.100
4	0.09	0.02	0.08	0.068–0.088
5	0.13	0.09	0.04	0.030–0.055

CI = confidence interval; HI = high intervention; kg = kilogram; LI = low intervention

Table 4. Mean daily weight gains (kg) for each season

Season	Number of cattle	Mean	Difference	95% CI
Dry	1,328	0.04	0.09	0.080–0.092
Rainy	2,024	0.13		

CI = confidence interval

between the first and second data collection, weight gain period 2 refers to the interval between the second and third data collections, and so on.

The differences in mean daily weight gain in the HI group and the LI group for each weight gain period are presented in Table 3.

Seasonal weight gain analysis

Weight gain periods for each animal were assessed by date and grouped into either dry or rainy seasons. Table 4 shows the difference in mean daily weight gains for each season.

Discussion

Cambodian cattle are *Bos indicus* and consist of the local breed, Haryana and crossbred (local breed crossed with Haryana), and occasionally other breeds such as Brahman. Sath et al. (2008) reported the local breed as being yellow, having a small hump and a mature weight of about 250–300 kg. This was similar to the analysis in the current study, where local breed mature cattle (more than 3 years old) had a mean weight of 220 kg. Crossbred cattle had a mean weight of 294 kg. Haryana are tall and narrow framed with a hump, usually white in colour and are favoured due to their draught ability.

During the course of the project, 1,006 cattle were sold, accounting for 66.4% of project animals. This indicates that the sale market is highly active in these regions. A total of 104 cattle had an unknown exit or movement from the study.

During 2008–09, 2.88 ha of land in the project villages had been established with forages by 62 households. This equated to an average of 464 m^2 of land planted with forages per household. By mid 2010, more than 18.3 ha of land had been developed with forages in the three project provinces by 426 households, equating to an average of 432 m^2 of land planted by each household. These data show rapid uptake of forage technology.

Mean daily weight gains in each weight gain period were an average of 30–80 g per day higher in the HI groups compared with the LI groups for animals of all ages. Extrapolation of this data indicates that animals in HI villages would be gaining an additional 11–29 kg per year than animals in the LI villages. Increased weight gain has the potential to improve fertility, immunity and general health and welfare status of the HI cattle. Improved BCSs occurred as the project progressed, indicating that the effect of the interventions was cumulative as the transfer of skills and technology gathered momentum. This paper represents an update of the longitudinal study, and it is expected that the remaining data collections will demonstrate even greater weight gains.

Of note (and as expected), seasonal differences in the mean daily weight gains were identified. Cattle gained an extra 90 g per day on average during the rainy season compared with the dry season. This was not surprising because of the marked differences in rainfall; however, it does show that farmers should make further efforts to meet animal nutritional requirements during the dry season if animal weight gains are to be maintained.

Conclusion

Preliminary data analysis provides baseline production performance parameters for HI and LI project villages. The positive effect of the multifaceted interventions (including extension training) is supported by increased mean daily weight gains for project cattle in the HI sites compared with the LI project sites. This project has shown that a holistic approach to improving livestock productivity and animal health can be effectively implemented and managed, and it is suspected that the momentum of productivity gains will increase towards the end of the project as the interventions in technology and skills become established. To continue improvements, two potential areas of focus are targeted feeding of different stock classes to maximise production gains (including fattening to meet marketing requirements), and improved knowledge and skills in reproductive management to reduce calving intervals and improve reproductive rates.

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A field study of target feeding forages to *Bos indicus* beef cattle in southern Cambodia

Brianna Page, Suon Sothoeun, Kea Pha, Hout Savouth and Russell Bush

Abstract

The growing middle class and increase in wealth across Asia has led to a change in dietary preferences, resulting in an increased demand for red meat. This presents an opportunity for Cambodian smallholder cattle farmers to meet this demand and, in doing so, increase their annual income through improved cattle husbandry practices and profitability. Nutrition has previously been identified as the biggest limiting constraint on cattle production. A feeding trial in three southern Cambodian villages was conducted to examine the use of established forage plots for targeted feeding to improve the value of animals for sale. Twenty-two cattle owned by seven smallholder farmers were enrolled in a 3-month study to assess if targeted feeding principles applied in a field setting could lead to measurable increases in cattle weights and improve value. Restricted maximum likelihood (REML) linear mixed modelling indicated that weight gain was not significantly different between trial animals and control animals ($P = 0.057$). This was attributed to the inability of farmers to supply sufficient green fodder to the required target of 15% of body weight per day. On average, trial cattle were fed 8% of body weight in forage per day, and control cattle received 5% of body weight in forage per day. Using the REML model prediction function, the total weight gains in the trial cattle were 25.9 kg heavier than control cattle, and farmer assessment of cattle value was an additional US$61.29 in trial cattle than in control cattle at trial completion. Farmers indicated that they realised the benefits of growing forages and target feeding to fatten cattle, and planned to continue the practice to try to improve household income.

Introduction

The size of the middle class of many developing countries is increasing (Rask and Rask 2011). It is widely accepted that with an increase in wealth comes an associated change in diet, with the inclusion of more animal protein (FAO 2008). This change in dietary preference, combined with the need to feed an overall growing global population has led to an increased demand for animal protein production (Rask and Rask 2011). This trend is particularly apparent in Asia. As an example, Quirke et al. (2003) projected that from 2003 to 2023, China's per-person meat consumption is likely to increase by 68%. Hence, China and South-East Asian countries in various stages of development may become increasingly dependent on imports to meet their rising domestic demand for animal protein (Quirke et al. 2003). This is likely to provide an opportunity for smallholder beef cattle farmers in Cambodia to capitalise on this increased demand for beef in South-East Asia and China (FAO 2008).

Currently, smallholder farmers in Cambodia predominantly practise subsistence farming (Mund and Bunthan 2006), and approximately 90% of all livestock is produced by smallholder farmers (Pen et al. 2009). To take advantage of the emerging beef market, smallholder cattle farmers need to change from being cattle keepers to cattle producers, and increase their efficiency and level of production. This can be achieved by increasing knowledge and adopting more efficient management practices and technology (Nampanya et al. 2012; Young et al. 2013). The majority (84%) of the rural poor's income is generated from rice production and there is limited focus on the production of beef (Quirke et al. 2007). In Cambodia, cattle are viewed as assets to be sold when emergency funds are required or as a tool for rice production through draught power and manure (fertiliser), rather than a regular source of income (Nampanya et al. 2012). From a developmental perspective, this attitude towards beef production needs to change to capitalise on the opportunity to supply the burgeoning red meat demand.

Currently, cattle in Cambodia experience an almost year-round feed deficiency, due to seasonal climatic variability and an agricultural focus on rice production. There are distinct wet and dry seasons, with the wet monsoon season occurring from May to November, and the dry season from December to April. To avoid cattle eating and trampling the rice crop in the wet season, cattle are typically tethered close to the household and fed native grasses daily using a cut-and-carry method. During the dry season, cattle are often collected communally and tethered in the postharvested rice fields where they graze stubble (Nampanya et al. 2012). In both seasons, rice straw is fed to cattle (Devendra and Leng 2011), which provides roughage but is of limited nutritional value. These feeding regimes are low in protein (3–4%) and high in crude fibre (35–48%) (Devendra and Leng 2011). As a result, there is limited opportunity for cattle to gain weight and they therefore have low body condition scores (BCSs) (Young et al. 2013).

Over the past decade, developmental projects have implemented forage growing strategies for cattle consumption in Cambodia. For example, 426 Cambodian households introduced forage plots in 2010 as part of an Australian Centre for International Agricultural Research (ACIAR)-funded 'Best practice health and husbandry of cattle, Cambodia' (BPHH) research project (Young et al. 2013). Despite an increasing number of farmers growing forages, this is still an uncommon activity in Cambodia.

In addition to promoting the use of forage plots, education is needed to ensure appropriate feeding strategies are adopted. Currently, farmers who grow forages tend to feed cattle indiscriminately so that none 'miss out'. However, this approach is unlikely to optimise weight gain and sale value. Ideally, farmers should target one or two of their cattle to improve their nutritional status, and target feed these animals to achieve a desired outcome, such as achieving an appropriate market weight or improving reproductive performance. Best-practice fattening guides developed by the International Center for Tropical Agriculture (CIAT) for use in Lao PDR (Stür and Varney 2007) detail the recommended procedure to fatten cattle and buffaloes. They recommend tethering the animal in a feeding stall, and aiming to feed 15% of its body weight of fresh forage for 2–3 months. Key principles of this guide have been adapted for this study.

As part of the BPHH project, a new extension booklet titled 'Forages and forage cultivation techniques' has been prepared and published by the Department of Animal Health and Production (DAHP) extension office and project staff. This 51-page Khmer language publication guides farmers on the cultivation and development of forage plots, including information about site selection, feeding forages to cattle and supplement storage methods (i.e. silage production). The booklet is targeted at farmers and extension workers, and provides a reference as well as many pictures to illustrate forage technology implementation.

This study aims to determine if the principles for cattle fattening developed by Stür and Varney (2007) can be replicated and effective when applied in a participatory field environment with smallholder farmers in southern Cambodia. Previous studies in Cambodia have reported on cattle weight gains achieved in experimental environments, yet there is little documented evidence that these techniques can lead to measurable improvements when implemented by farmers in field situations.

Materials and methods

Site selection

The study was conducted in three villages in southern Cambodia: No Mor and Sen Ork (Takeo province) and Sensong Tbong (Kampong Cham province). All farmers from No Mor and Sensong Tbong have been involved in the BPHH and received training and support during the project (Nampanya et al. 2012; Young et al. 2013). One independent farmer from Sen Ork village also took part in the study. The Sen Ork farmer has been identified as a 'champion farmer' in the district, having independently sought out forage technology from the BPHH project staff, and has since helped over 100 smallholder farmers to establish their own forage plots. The villages were chosen because they were known to have farmers with established forage plots and who were familiar with participatory research, and were located within a reasonable distance from Phnom Penh to facilitate visits from DAHP project staff and Australian research team members.

Farmer and animal selection

A total of seven farmers (three from No Mor, one from Sen Ork, and three from Senson Tbong) were recruited through consultation with the village chief on the basis of the following desired selection criteria:

1. currently own two or more cattle
2. have approximately 800–1,000 m^2 of forage per animal enrolled in the trial in accordance with published feeding recommendations (Stür and Varney 2007)
3. have the facilities to feed the trial animals in individual feeding pens
4. have literacy levels appropriate for data recording
5. willing and enthusiastic about participating in the study.

The cattle enrolled in the study were selected by the participating farmers in accordance with their production goals, such as improved breeding, improved power for draught or improved liveweight and BCS for sale. They represent a range of ages, and include castrated males, bulls and females. The number of animals selected was dependent on the amount of available forage. A total of 22 cattle were enrolled: 14 as trial animals and 8 as controls.

Feeding trial protocol

The 3-month study took place from June to October 2012. These months were purposefully chosen (during the wet season) to allow for sufficient forage growth to meet the trial criteria. The duration was chosen to demonstrate that target feeding to fatten is effective and profitable if undertaken for 2–3 months (Stür and Varney 2007). Because liver fluke, foot-and-mouth disease (FMD) and haemorrhagic septicaemia (HS) are endemic in Cambodia (Suon et al. 2006; Nampanya et al. 2012; Suon et al. 2013), on the first day of the trial all cattle were given an anthelminitic treatment containing levamisole hydrochlroide 3.0% w/v and oxyclozanide 6.0% w/v (Levafas™) and vaccinated against FMD by project staff. All cattle were vaccinated for HS in February 2012 as part of the BPHH project interventions. All farmers completed a pre-trial survey, which captured baseline data including farmer name, number of cattle enrolled in the study, pre-trial cattle weights (weighed on a Tru-Test 2000, Tru-Test Group) and BCS, and estimated market value of the cattle. The interviews were conducted in Khmer by project staff, and later translated to English and entered into a Microsoft Excel (2007) spreadsheet for analysis by the lead author. Farmers were then briefed on the protocol of the feeding trial that was adapted from Stür and Varney's large ruminant fattening guide:

1. Trial cattle must be fed from individual troughs so that no other animals eat their ration.
2. Cattle must be kept in pens for the majority of the time to avoid unmonitored grazing.
3. Fresh water must always be available for the animals.
4. Every day, each type of feed presented to the animal (forage/rice straw/rice bran) must be weighed before being placed in the trough and the weight recorded on the daily record sheet.
5. Farmers should aim to feed 15% of the animal's body weight in fresh forage daily. This figure can be calculated by the farmer by consulting the 'Ideal daily forage ration' chart (a list of body weights in one column and 15% of those weights in a second column).
6. Rice straw may be provided ad libitum, but must be weighed.
7. When the animal has finished eating, residual feed must also be weighed and recorded.
8. Control animals are to be fed as per the usual feeding practices of the farmer.
9. Once a month, all cattle (trial and control) must be weighed by the project staff using electronic (Tru-Test) scales.
10. At trial completion, each farmer is to complete a post-trial survey capturing information such as perceived change in cattle value and BCS, and the farmer's attitude towards the target feeding technique.

Farmers were supplied with small, manual, kitchen-style scales to weigh the forage, 'daily record sheets' to record intake data and the 'Ideal daily forage ration' chart. The project team was responsible for visiting the villages once a month to record the weights of all the cattle and discuss any issues raised by the study participants. Body condition score was recorded by the project team on a 1–5-point scale, where 1 = fat and 5 = very skinny. The results were reversed to be consistent with conventional ascending BCS for analysis, where 1 = very skinny and 5 = fat.

Statistical analysis

Statistical analysis was performed using GenStat 12th edition (2009) (VSN International). The data were analysed using restricted maximum likelihood (REML) linear mixed modelling, with animal age, gender, trial/control classification and time included as fixed effects; and village, farmer and animal included as random effects. A P-value of < 0.05 was considered statistically significant.

Results

Study cattle

A total of 22 crossbreed cattle were enrolled in the study. This included one bull, two castrated males and 19 females. The age of the cattle ranged from 0.8 to 6.0 years, with a mean of 3.4 and median of 3.0. All cattle were available for the first three weight measurements; however, two cattle in Kampong Cham province had been sold before the final weighing. One farmer from Kampong Cham province was unavailable for the post-trial survey. Two cattle were used for draught for an estimated 60 days each during the trial.

At the completion of the trial, 12 trial animals had increased their BCS by 1 point, one animal had increased by 2 points and one animal, the bull, had decreased by 1 point after becoming sick (diarrhoea and lameness) during the final month of the study. Of the control animals, two increased in BCS by 1 point, three animals increased by 2 points, one had no change and one decreased by 1 point.

The average weight gains measured over the 3 months were 0.05 kg/day in Senson Tbong village and 0.24 kg/day in Takeo province.

Forage plots

The size of the forage plots owned by the farmers in the trial varied from 300 m^2 to 10,000 m^2; the average size was 2,514 m^2 and the median was 800 m^2. The forage plot size per animal ranged from 150 m^2 to 909 m^2. When asked in the post-trial survey if their forage growth this season had been poor, average or good, the six farmers available for interview all answered 'average'.

Animal value

Estimated value of the cattle was also assessed by the farmers pre and post-trial. On average, trial animals increased in value by US$137.43, while control animals increased in value by US$76.14 during the trial; indicating that target-fed animals, on average, increased their value by US$61.29 more than the control animals during the trial. These results are summarised in Table 1.

Forage intake

The daily forage intake varied for each animal. Although the aim was to feed 15% of the animals' body weight as fresh forage to the trial animals, the intake of each animal did not reach this targeted level. On average, trial animals received 8% (range 5–14%) of their body weight as fresh forage, while control animals received an average of 5% (range 2–10%). The sole farmer from Sen Ork village fed his cattle a supplement of rice bran.

Farmer attitude towards target feeding

All six farmers available for the post-trial survey answered 'yes' when asked if they would continue the technique, and all answered 'yes' when asked if the cattle they target fed were worth more than their control animals. When asked if target-feeding forages had time-saving benefits, five of the six farmers answered 'yes'.

Statistical analysis

A REML linear mixed model analysis was conducted, with animal age, gender, trial/control classification and time included as fixed effects; and village, farmer and animal included as random effects. One animal, the only bull in the trial, was excluded as an outlier due to illness. The results are summarised in Table 2.

The REML linear mixed model was used to generate a table of predicted means and estimated effects for the factors included. It found the mean weight of trial animals to be 248.0 kg, and the mean weight of control animals to be 222.1 kg. Therefore, trial animals are likely to weigh 25.9 kg more than control animals; representing the 'estimated effect' of target feeding in this trial (Table 3).

Table 1. Mean estimated value (US$) of cattle before and after the feeding trial period

Cattle classification	Pre-trial value	Post-trial value	Difference
Trial	882.50	1,019.93	137.43
Control	444.89	521.03	76.14

Table 2. REML linear mixed model analysis with weight as the outcome variable

Variable	*P*-value
Trial/control	0.057
Month	0.647
Gender	0.096
Age	< 0.001

Discussion

Cambodian farmers aiming to feed 15% of their animal's body weight as fresh forage, keeping the animals tethered in a feeding stall and target feeding for 3 months achieved higher weight gains in their animals than control animals ($P = 0.057$). Although the 0.05 level of significance was not met, this was not unexpected because the farmers did not meet the forage feeding target of 15% body weight. Cattle age was found to be a significant factor in the weight gain of the cattle ($P < 0.001$), which is to be expected as younger growing cattle were included in the trial. This study indicates that the underlying principles of Stür and Varney's fattening guide to target feed cattle can be applicable in Cambodia under field conditions.

Farmers struggled to meet the desired level of forage intake, with trial animals receiving 8% of their body weight in forage on average, and control animals receiving an average of 5% of their body weight in forage. It would be expected that, had trial cattle intake reached 15% body weight of forage, the difference would be more remarkable. It is likely that the inability of farmers to meet the 15% body weight target of forage intake was due to both a lack of available forage and the limited use of individual fattening pens. Target feeding for fattening is a specific technique where the best results are achieved by feeding the ideal amount of forage, tethering the animal in a feeding stall and continuing the practice for approximately 3 months. Failing to meet these simple requirements may compromise desired production outcomes. It should also be noted that animals require ad libitum access to fresh water, and the forage should be harvested at a stage of maturity that optimises both nutritional value and yield. Combined, these nutritional considerations contribute to digestibility and intake. The practice of feeding control cattle forages at a level only slightly lower than target-fed cattle indicates that farmers are keen to try and maintain body condition across all cattle owned rather than target feed individual cattle.

The weight gains measured over the 3 months were not as high in Senson Tbong village (0.05 kg/day) as in the villages in Takeo province (0.24 kg/day), possibly due to both drought and flood conditions experienced in Kampong Cham province leading up to and during the trial period. Although farmers still experienced 'average' forage growth, the adverse conditions affected the rice crop, resulting in farmers having less time to spend tending to their forages and cattle. This further demonstrates the importance of meeting the target feeding quantity in fresh forage to achieve optimal results.

The BCS measurements did not yield clear results in favour of the trial animals, and gains in body condition were approximately the same between the two groups. Reasons for this may include the small study sample size of 22 cattle, the relative short trial period, and that body condition scoring is a subjective assessment. Despite this, as traders and farmers use livestock appearance as a tool to establish sale values, further farmer training in using BCS as a tool for livestock assessment is recommended. It is expected that, if the target-fed animals had been fed a higher proportion of forage in individual fattening stalls, and had not been used for work (as two of the animals were), the differences in BCS between trial and control animals would have been clearer.

The average monetary value, as estimated by the farmers, of both trial and control cattle increased during the 3 months, and target-fed cattle were estimated to be worth US$61.29 more than the control cattle. Although this is a subjective and potentially biased assessment, it does indicate that these farmers see a financial benefit in using this practice. This is an important finding, as it shows that target feeding can have a financial motivation and has the potential

Table 3. REML linear mixed model analysis: predicted means and estimated effects

Cattle classification	Predicted mean	Standard error	Estimated effect	Standard error
Trial	248.0	26.0	25.9	13.6
Control	222.1	27.8	–	–

– = not applicable

to translate to direct economic benefits to the household. It is hoped that by selling these animals for profit, farmers will be encouraged to repeat the activity and increase household income. Indeed, the farmers indicated that they would continue to use this practice.

The ability of farmers in Cambodia to improve weight gain in their cattle has important implications for their ability to capitalise on increased regional demand for animal protein. Efficient fattening is required, whether the goal is to buy thin animals to fatten and sell for profit, to increase the BCS of breeding cattle to achieve more efficient reproduction or to have castrated males gain weight to be more powerful for draught. The practices of having breeding cows in calf as often as possible to grow and sell the young, and buying thin animals to fatten and sell need promotion in Cambodia, as it is currently common practice to sell animals only when the family needs cash, or when the animal is old or sick (which also has significant biosecurity implications).

Cambodian farmers have shown an encouraging level of initiative when it comes to growing forages. In 2008, the BPHH project established 52 forage plantations in three villages in southern Cambodia. By 2010, the total number of households with forage plantations in the project sites had risen to 426; more than eight times the original number set up by the project (Young et al. 2013). Also, forage plantations were found in villages outside the project sites (Young et al. 2013). This indicates that forage technology uptake and adoption has been actively sought by smallholder farmers, and demonstrates their enthusiasm to reap the benefits of the technology.

There is limited growth of forage in the dry season in Cambodia. The BPHH project initiated silage production workshops to assist in fodder conservation for use in times of poor growth. In addition, fattening guides suggest that the ideal amount of forage to grow per cow is 800–1,000 m^2 (Stür and Varney 2007), which may exceed the amount able to be grown on smallholder land sizes. In this trial, the size of the forage plots per animal owned ranged from 150 m^2 to 909 m^2. Only one farmer possessed the recommended amount of forage per animal owned (909 m^2/animal). Despite this, results from this study have shown that improved fattening can be achieved in field situations with less than the ideal amount of land dedicated to forage growing. Another recommendation is to promote the use of *Stylosanthes guianensis* (Stylo 184, a legume forage) because of its high protein content and proven benefits for fattening (Stür and Varney 2007), as well as its contribution in providing a source of nitrogen to surrounding grass forage species within the plot. The introduction of irrigation by building water storage capacity in the form of earthen dams will also extend the forage growing season and feed availability to animals.

The main objective of participatory research projects is to impart knowledge to the participants, and to influence sustainable improvements through attitudinal change. There is little benefit in administering interventions that are not understood or wanted by the community. The post-study survey requested farmers to indicate if they felt that their target-fed animals were worth more than their control animals, and if they would continue to use the technique. All six farmers present for the survey answered ‘yes’ to both questions. This is an encouraging response, and shows that despite the data being insufficient to demonstrate a statistically significant difference between trial and control animals, the farmers involved gained new skills and intended to continue to use the technique. Further studies are required to determine if these farmers become ‘champions’ of these techniques and assist other farmers in developing and implementing improved cattle feeding.

The study was restricted by the small sample size and limited number of control animals included. The vast majority of farmers in Cambodia own five or fewer cattle, and the farmers in this study were mostly willing to enrol two cattle in the study and have one as a control. To adequately control the experiment, control and trial animals should be of the same age, sex and number, and should be owned by the same farmer to ensure that all cattle are subjected to the same conditions. Design of field experiments is challenging because study objectives and methods do not readily align with the goals and daily practices of farmers. In this study, some participants simply did not have enough animals to allow the required level of replication.

This study has shown that, despite difficulties in implementation and target feeding according to the fattening guides, positive results can be achieved in the field by Cambodian cattle farmers by following the basic principles of target feeding. Although more research is needed, the encouraging results in this study should help promote the practice of forage feeding combined with preventive animal health.

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Improved cattle nutrition increases the time available for children of smallholder farmers in Cambodia to attend school[1]

Dimang Som, Pen Miranda, Lorn Sophal, Seng Mom, Werner Stür and Darryl Savage

Almost all cattle raising in Cambodia is done by smallholder farmers in rural areas. Smallholder farmers commonly use native grasses and crop residues as feed for their animals. Cattle in the study area of Kampong Cham province are always tethered and hand-fed (often referred to as the cut-and-carry system). Nutrition has been identified as the single most important constraint to cattle production in Cambodia. The increase in demand for red meat represents an important opportunity for Cambodian cattle farmers.

The time required to source feed for cattle and the labour involved limit beef production in Cambodia. The process of sourcing feed for cattle can take up to 8 hours per day and this task is often allocated to children. In an attempt to address the cattle feed shortage and associated labour demand, tropical forages (*Brachiaria* spp., *Panicum* spp. and *Stylo* spp.) were introduced to Kampong Cham province. This communication details some of the key findings of a study on the impact of the introduction of these forages on smallholder farmers.

A structured survey was conducted through on-farm face-to-face interviews with 143 smallholder farmers. Of those interviewed, 43 came from households that had adopted the use of forage as cattle feed, 50 came from households that had been exposed to the forages but chosen not to use them and 50 came from households that had never been exposed to the forages.

There was no difference in the average number of people (5.7) or cattle (4) per household between those that used the forages and those that did not. Households that used forages used less ($P < 0.05$) labour to feed cattle throughout the year (including the dry season, early wet season and the flood season) than those that did not use forages (Table 1). Importantly, the survey demonstrated that on average, the task of feeding cattle was shared evenly between the male head of the household (the father) and the children.

In systems such as those in this study, cattle feeding has to be undertaken during the daylight. When this task is allocated to children, it may reduce the time available for schooling. The introduction of forages for feeding cattle reduced the time children spent feeding cattle and increased the time available for them to attend school.

Table 1. Time spent feeding cattle (h/d)

	Adopters	Non-adopters	
		Exposed	Not exposed
Men	1.9^{a}	2.9^{b}	3.5^{b}
Women	0.7	0.7	1.2
Children (school age)	1.0^{a}	2.0^{b}	0.9^{a}

^{ab} Means within rows with different superscripts differ ($P < 0.05$).

[1] Originally published in 2009 in Recent Advances in Animal Nutrition 17, 192, and reproduced with permission.

Improving cattle health

Cow with calf (Photo: Peter Windsor)

Livestock infectious disease status in Cambodia

Suon Sothoeun, James Young and Peter Windsor

Abstract

With an estimated 80% of Cambodia's population living and working in rural areas, smallholder farm systems that integrate cash crops and livestock have a crucial role in rural society. Infectious diseases such as haemorrhagic septicaemia (HS) and foot-and-mouth disease (FMD) have significant impacts on large ruminant populations and smallholder farmers in Cambodia. Although recent reductions in national large ruminant and swine herd sizes are likely due to socioeconomic and climatic factors, interventions that use market drivers and enhance productivity are considered to offer opportunities to improve smallholder incomes and reduce rural poverty. Trans-boundary animal diseases remain a limiting constraint on expansion of this sector. This paper provides an overview of Cambodian livestock populations, current national disease surveillance, and findings from active disease surveillance conducted in the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project, including an FMD financial impact survey. The national large ruminant and swine livestock population decreased between 2009 and 2011, while the poultry population increased. Multiple factors are considered to have influenced this change, including feed costs, endemic infectious disease, market trends and demand for protein, climate and illegal trade. Data from the Department of Animal Health and Production indicate that FMD and HS are endemic and widespread. Vaccination coverage of the national large ruminant population in 2010 and 2011 has been estimated at 2.7% and 2.1% for FMD, and 43.8% and 41.0% for HS. The extremely low coverage for FMD is important because an assessment of the financial impacts of FMD on smallholder farmers indicates that severe losses can occur due to this disease. Preventing infectious diseases through biosecurity measures and reducing risk behaviours is also important, particularly when vaccine availability is limited and farmers are hesitant or resistant to pay for vaccination.

Introduction

Approximately 80% of Cambodia's population live in rural areas and make their livelihoods from agriculture. The Royal Government of Cambodia considers the agriculture sector a high priority for its national policy agenda. It promotes agriculture as a means to reduce poverty by enhancing agricultural productivity to improve food security, employment and family incomes (MAFF 2011). In 2010–11, the size of the national livestock herd decreased for cattle, buffaloes and pigs, and increased for poultry (MAFF 2011). Reasons for the changes in livestock populations are likely to be associated with climatic, marketing and social issues, and animal diseases. Foot-and-mouth disease (FMD), haemorrhagic septicaemia (HS), blackleg, highly pathogenic avian influenza (HPAI), Newcastle disease, fowl cholera, duck plague, classical swine fever, and porcine reproductive and respiratory syndrome are considered obstacles to growth of the livestock sector, as well as risks to human and animal health (MAFF 2011). This paper discusses the significant infectious diseases affecting large ruminants in southern Cambodia, and includes data on the national herd population statistics, passive surveillance (routine reporting) of infectious diseases reported by the Department of Animal Health and Production (DAHP), plus active surveillance (targeted disease investigation) conducted during the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project—a collaboration between DAHP and the University of Sydney that was developed to study these constraints (Windsor 2008). The impact of these diseases is discussed, including the financial impacts of FMD on smallholder livestock farmers.

Aim

The aim of this paper was to review currently available literature on livestock populations and large ruminant diseases in Cambodia, and provide details on cattle disease prevalence as determined by passive surveillance data and records compiled by DAHP, and active surveillance of infectious diseases undertaken within project village sites. In addition, a survey was conducted on the financial impacts of FMD on smallholder livestock farmers during an FMD epidemic in 2010.

Materials and methods

National livestock population

The Ministry of Agriculture, Fisheries and Forestry (MAFF) annual reports for 2010–11 and 2011–12 were examined to provide trends in the national herd populations for large ruminants (cattle and buffaloes), swine and poultry in Cambodia between 2009 and 2010, and 2010 and 2011, respectively.

National disease outbreak reports

Data on disease outbreak reports (or passive surveillance) collected between 2008 and 2011 were summarised and presented on three diseases affecting cattle, buffaloes and swine that are considered of high importance in Cambodia: FMD, HS and blackleg. Information on the number of cases reported and deaths was tabulated. A smallholder farmer can report disease cases to their village animal health worker, who may then disseminate this report through the district veterinarian, the provincial veterinarian and the National Veterinary Research Institute (NaVRI) of DAHP. Staff at NaVRI record the disease outbreaks in their disease information system and, in the case of an epidemic situation, conduct an investigation (including taking samples) depending on the suspected disease. The NaVRI reports to the World Animal Health Information System (WAHIS) and the Association of Southeast Asian Nations Regional Animal Health Information System (ARAHIS) on a monthly, quarterly and yearly basis, and also in the case of an emergency.

Targeted disease surveillance

Targeted (or active) disease surveillance was undertaken during the DAHP and University of Sydney collaboration with the BPHH project. A 4-year longitudinal study where cattle from six villages were repeatedly sampled for production parameters approximately every 6 months was undertaken, beginning in 2008. Two villages from each of the three provinces (Takeo, Kandal and Kampong Cham) were matched as either high intervention (HI) or low intervention (LI), where HI villages received a 'best practice' package involving a range of interventions, while the LI villages received vaccination only (see Young et al. 2013a). In an attempt to attain high levels of herd immunity, efforts were made to ensure that at least 70% of the cattle population was vaccinated for both diseases in all six villages. The six project villages were Senson Tbong and Veal in Prey Chhor district in Kampong Cham province, No Mor in Tram Kok district and Dem Pdet in Trang district in Takeo province, and Preak Por and Koh Kor in Saang district in Kandal province. In each village, at least 250 cattle of different sexes and age groups were selected to be included in the longitudinal production survey. During this study, blood and faecal samples were collected and screened for parasites and disease, with 120 blood samples randomly collected from cattle in the six project villages in April 2008 and tested for brucellosis by NaVRI using the bovine antibody rapid test and rose bengal tests. In addition to brucellosis, PhD students from the Royal Academy of Cambodia and the University of Sydney conducted post-vaccination serological testing for both FMD and HS; their studies are reported in these proceedings (Ieng et al. 2013; Taing and Stratton 2013).

Results

National livestock population

Table 1 shows the numbers of livestock in Cambodia between 2009 and 2011.

National disease outbreak reports

Data on reports of the infectious diseases FMD, HS and blackleg (presented in Tables 2–4) are collected by DAHP.

Table 5 shows the number of reported outbreaks of FMD and HS and the number of provinces that

Table 1. Cambodian livestock populations, 2009–11

Livestock	2009	2010	2011
Cattle	3,579,882	3,484,601	3,406,972
Buffaloes	739,646	702,074	692,611
Draught animals[a]	1,873,777	1,626,243	1,574,296
Pigs	2,126,304	2,057,431	2,099,332
Poultry	20,192,811	20,834,295	22,036,755

[a] Includes both cattle and buffaloes
Sources: MAFF (2011), DAHP (2012)

Table 2. Foot-and-mouth disease outbreak reports in cattle, buffaloes and swine, 2008–11

Year	Number of provinces affected	Number of cases	Number of deaths
2008	14	27,691	na
2009	12	3,427	1,008
2010	15	60,378	1,764
2011	19	11,664	329

na = not available
Source: Department of Animal Health and Production, Cambodia

Table 3. Haemorrhagic septicaemia outbreak reports in cattle and buffaloes, 2008–11

Year	Number of provinces affected	Number of cases	Number of deaths
2008	17	20,027	na
2009	15	4,477	634
2010	10	3,131	375
2011	12	1,912	201

na = not available
Source: Department of Animal Health and Production, Cambodia

Table 4. Blackleg outbreak reports in cattle and buffaloes, 2008–11

Year	Number of provinces affected	Number of cases	Number of deaths
2008	6	12	1
2009	1	7	7
2010	2	87	6
2011	1	38	2

Source: Department of Animal Health and Production, Cambodia

outbreaks were reported from. Data on the number of outbreaks of FMD and HS for 2008–11 are also shown in Figure 1.

Targeted surveillance of infectious and parasitic diseases

Brucellosis: All 120 blood samples collected from project cattle tested for presence of *Brucella abortus* were negative on both bovine antibody rapid test and rose bengal testing.

FMD and HS: The project initiated annual vaccination of all project animals against FMD and HS, and no cases of either disease were recorded during the study period in the HI villages, despite the common occurrence of both diseases in many villages in the three provinces during the project period (Nampanya et al. 2012). Foot-and-mouth disease was reported to have occurred in Veal, the LI village in Kampong Cham province (Nampanya et al. 2012). From July to November 2010, FMD affected about 20% of the cattle population in Veal (anecdotal reports suggest that these were mostly unvaccinated introduced cattle) compared with almost 100% of cattle affected in neighbouring villages, with the

Table 5. Number of outbreaks and provinces affected with foot-and-mouth disease, haemorrhagic septicaemia and blackleg

Disease	Year				
	2007	2008	2009	2010	2011
Foot-and-mouth disease					
No. of outbreaks	na	63	41	82	97
No. of provinces affected	13	14	12	15	19
Haemorrhagic septicaemia					
No. of outbreaks	na	67	82	52	64
No. of provinces affected	8	17	15	10	12
Blackleg					
No. of outbreaks	1	6	1	2	1
No. of provinces affected	1	6	1	2	1

na = not available
Source: Department of Animal Health and Production, Cambodia

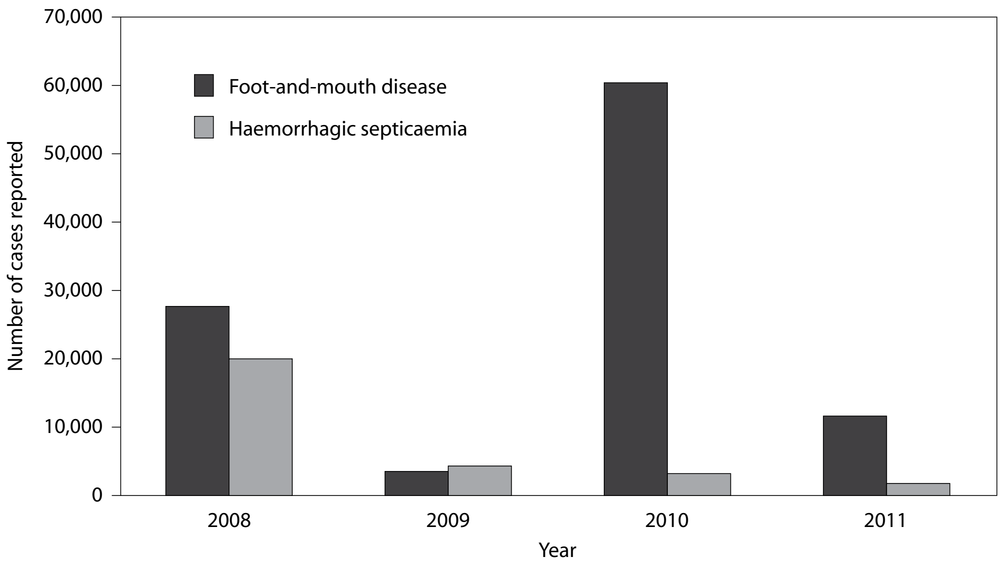

Figure 1. The number of cases of foot-and-mouth disease and haemorrhagic septicaemia from 2008 to 2011 reported to the Department of Animal Health and Production

exception of the HI village of Senson Tbong that remained uninfected (Nampanya et al. 2012). Further information on trans-boundary diseases conducted by the BPHH project, including reports on serological surveys of HS and FMD, can be found in these proceedings (Ieng et al. 2013; Taing and Stratton 2013).

Parasitic diseases: The results of the parasitic surveillance from the BPHH project are presented in these proceedings (Young et al. 2013b).

Discussion

There is a general lack of published information on large ruminant disease in Cambodia in the scientific literature. There are no reports of animal brucellosis occurring in Cambodia in the scientific literature, and no positive samples were detected in this study. No clinical cases of HS or FMD were officially reported in HI project animals or villages; however, an FMD outbreak was reported to have occurred in the LI village of Veal. This indicates that vaccination needs to be delivered with biosecurity information and education, and may not be effective if delivered in the absence of such education. Anecdotal reports of this outbreak suggest that the affected animals were recently introduced to the village, highlighting that a high level of animal movement and trading presents a significant biosecurity risk, and the delivery of disease control measures and education packages must allow consideration for this practice.

Generally, the project interventions involving vaccination (for both FMD and HS) were considered effective, despite the difficulties of maintaining a sufficient percentage of vaccinated large ruminants in the village populations due to the high rate of livestock turnover during the project.

Between 2009 and 2010, the combined national cattle and buffalo population decreased by 3.1%, and then again by a further 2.0% between 2010 and 2011. The total number of draught animals fell by 13.2% between 2009 and 2010, and then by a further 3.2% in 2011. Swine decreased by 3.2% from 2009 to 2010, but reversed this trend and increased by 2.0% in 2011. The estimated national poultry population increased in 2010 by 3.2%, and in 2011 by 5.8%.

The MAFF (2011) report cites a variety of reasons for the change in population sizes. Firstly, the increase in poultry is attributed primarily to a strongly developing market; however, an increased awareness and improvement of poultry-rearing techniques, as well as biosecurity management and control, and prevention of poultry diseases such as HPAI, have played a significant role. The reduction in the large ruminant populations is considered to be due to several reasons, including a high level of export and illegal movement into Vietnam, an increase in mechanisation by farmers (reducing the need for draught animals), changes in the production system, an increased demand for red meat, and climatic and seasonal conditions that impede adequate nutrition for livestock (MAFF 2011). The reduction in swine numbers was attributed to the high cost of swine production, particularly feed costs, occurrence of diseases and the importation of swine from Thailand.

Livestock diseases including FMD, HS, blackleg, HPAI, Newcastle disease, fowl cholera, duck plague, classical swine fever, and porcine reproductive and respiratory syndrome were all considered to be major constraining issues affecting livestock population growth. In 2010, 41,936 large ruminants were exported, and 106,408 cattle were transited through Cambodia (MAFF 2011). Illegal trading and transport of animals and animal products is recognised, and DAHP and the Office of Animal Health and Production (OAHP) cooperate to control and prevent this practice. Together in 2010, DAHP and OAHP intervened in 168 cases involving 386 large ruminants and 565 swine, in addition to cases involving multiple other species and animal products. It is considered that if substantial numbers of livestock are successfully being exported illegally, this is likely to impact on the national herd sustainability.

Trends from disease outbreak reports in large ruminants show that HS and FMD are endemic and widespread. In the four years from 2008 to 2011, the number of livestock cases of HS decreased, although the number of outbreaks ranged from 52 to 82. For FMD, a significant epizootic occurred in the 2010 wet season, with 82 outbreaks and more than 60,000 cattle cases reported from 15 provinces.

Although under-reporting of disease is recognised as an issue in some countries in the region (Nampanya et al. 2012), infectious disease surveillance information provided to DAHP highlights the increasing importance of FMD and HS in large ruminant production in Cambodia. Vaccination coverage of the national large ruminant population in 2010 and 2011 has been estimated at 2.7% and 2.1% for FMD, and 43.8% and 41.0% for HS. These differences relate to DAHP policy: public funds are made available for HS vaccination programs to prevent the high mortality rates attributed to this disease. However, public funding is scarce for FMD vaccination, and individual farmers usually meet the costs unless vaccination is delivered in a research or development aid project. Despite the widespread occurrence of severe FMD outbreaks in Cambodia, the impact of the disease is often underestimated because high mortality and morbidity rates attributed to FMD are rarely reported in cattle (OIE 2007).

Previously, there has been a lack of data on the financial impact of FMD and HS on smallholder farmers in Cambodia that could be used to support more rigorous disease prevention programs. Economic impact evaluations are considered difficult to perform due to a lack of data, or lack of data in an appropriate form for analysis (Perry et al. 1999). Case studies of recent outbreaks have provided useful information that indicates that losses due to FMD can be considerably greater than is often recognised, and that vaccination can have a major impact on these losses (Rast et al. 2010).

Recently, Young et al. (2013c) investigated the financial impact of an outbreak of FMD in 2010 on 62 smallholder cattle farmers in four villages in southern Cambodia. Financial losses associated with FMD infection were severe, with variation depending on whether the animal survived, died or was used for draught. The average post-FMD loss varied from US$216.32 (a 54% reduction from the pre-FMD value because of weight loss and treatment costs) to US$370.54 (a 92% reduction from pre-FMD values if the animal was treated, died and a rental draught replacement was required) (Young et al. 2013c). These results contradict the widely held view that smallholder farmers are not greatly affected by FMD, and show that affected farmers are likely to suffer significant financial shocks in the event of an FMD outbreak. In low-input production systems, the rate of weight gain would be considered low and a protracted time period would be expected for animals to regain pre-FMD body weights (Young et al. 2013a). This information should be used to support more vigorous disease prevention programs, and support educational materials for farmers to ensure they recognise the potential impact of FMD.

Young et al. (2013c) outlined a partial budget for FMD vaccination of cattle twice a year by smallholder farmers, using data from the impact study. In their analysis, the net benefit for farmers using FMD vaccination twice a year equated to US$31.48 per animal owned, using a predicted village incidence of 0.2 (i.e. a village outbreak every 5 years). This indicates that smallholder farmers have a strong financial incentive to vaccinate cattle to prevent FMD. Preventing infectious diseases through practical and cost-effective biosecurity measures and reducing risky behaviour is of high importance, particularly when vaccine availability is limited, and farmers are hesitant or resistant to pay for vaccination.

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The epidemiology, diagnosis and control of haemorrhagic septicaemia of cattle and buffaloes in Cambodia

Ieng Savoeurn, Suon Sothoeun and Peter Windsor

Abstract

As in many countries in South-East Asia, outbreaks of haemorrhagic septicaemia (HS) are common in Cambodia, with high morbidity and mortality rates reported. The Department of Animal Health and Production received reports of 82 outbreaks in 15 provinces in 2009, and 52 outbreaks in 10 provinces in 2010. Although buffaloes are generally considered to be more susceptible than cattle, both species are affected. In case studies of outbreaks conducted in Koh Pen and Kampong Reap in Kampong Cham province in 2010, morbidity in cattle was 59%, but 39% in buffaloes. Mortality rates were very high in both species (97% for cattle and 98% for buffaloes). Diagnostic investigations of these outbreaks led to isolation and confirmation by serology and polymerase chain reaction (PCR) that infections in both cattle and buffaloes were caused by *Pasteurella multocida* type B2. Widespread vaccination for HS occurs in Cambodia, with coverage currently considered to be approximately 50% of the large ruminant population, yet there is little information on the efficacy of the vaccine used. A post-vaccination serology study compared antibody titres of 60 cattle that had each been injected subcutaneously with 2 mL of killed HS vaccine in an aluminium hydroxide gel adjuvant with antibody titres from 20 control animals. Sera were collected at days 0, 21 and 180, and results confirmed a very strong serological response to vaccination. Serology at day 21 identified 100% of vaccinated animals with a titre > 1:320. At day 180, 100% of vaccinated animals had a titre > 1:160, and 95% had a titre > 1:320. This suggests that if post-vaccination antibody titres correlate with, or are a useful indicator of, protection against infection, HS vaccine efficacy as currently practised in this trial appears to be very good. This questions the recommendation of vaccinating against HS every 6 months. It is recommended that further work is done to determine if such high titres persist for longer than 180 days.

Introduction

In Cambodia, haemorrhagic septicaemia (HS) is one of the most important endemic infectious diseases. Vaccine coverage is estimated at 50% of the large ruminant population. Vaccination against HS is supported by government policy, yet cases of HS are still regularly reported from almost every province. The HS outbreaks reported from the three study provinces of Kampong Cham, Kandal and Takeo in 2008, 2009 and 2010 are presented in Table 1. Note that no outbreaks were reported in the six project villages where all animals were regularly vaccinated against HS in both the high-intervention (HI) and low-intervention (LI) sites.

Haemorrhagic septicaemia affects both cattle and buffaloes. Clinical symptoms include a high temperature (40–41 °C), loss of appetite, nasal discharge, salivation, and swellings in the neck and stomach associated with lymphadenopathy. Because detailed diagnostic investigations of these outbreaks are rarely performed, the causative organisms are rarely isolated and the efficacy of the vaccine is not well understood in Cambodia, studies were conducted in 2008–10 to address these knowledge gaps.

Table 1. Reports to the Department of Animal Health and Production of haemorrhagic septicaemia occurrence from all provinces over 3 years

Year	No. of provinces affected	Morbidity	Mortality
2008	17	20,027	na
2009	15	4,477	634
2010	10	3,131	375

na = not available

Method

Following field reports of two outbreaks of HS in 2010 in the villages of Koh Pen and Kampong Reap in Kampong Cham province, epidemiological investigations were conducted at both sites. The outbreak in Koh Pen involved 45 out of 81 cattle and 24 out of 97 buffaloes, and the outbreak in Kampong Reap involved 57 out of 93 cattle and 59 out of 118 buffaloes.

To investigate the bacteriological nature of HS in Cambodia, diagnostic investigations (including the collection of nasal swabs for laboratory culture) were conducted in Koh Pen village, Koh Sotin commune, Koh Sotin district of Kampong Cham province. The samples for culture were plated onto blood and MacConkey agar, and incubated at 37 °C for 24 hours. Two isolates were recovered and confirmed as gram-negative rods. They were submitted to catalase and oxidase tests for biochemical identification using a commercially available kit for API (Analytical Profile Index 20E). The isolates were then submitted to Heddleston's agar gel immunodiffusion test containing both antiserum 2 and 3 in the antibody wells. Bacterial DNA was isolated from the cultures and submitted to the commercially available multiplex capsular PCR typing test for molecular determination of the isolate type.

To assess the efficacy of vaccination, post-vaccination serology was conducted by collecting blood samples from the jugular vein of the large ruminants on three occasions (days 0 [day of vaccination], 21 and 180). The study included 20 cattle of different age groups in each of the three project villages. To enable comparison of serological profiles of vaccinated and unvaccinated animals, blood samples were taken from a control group of 20 unvaccinated animals (matched for age) from Taindaung village, Takeo province, at days 0, 21 and 180. The 60 vaccinated animals were injected subcutaneously on day 0 with 2 mL/animal of killed (formalin-treated) HS vaccine in an aluminium hydroxide gel adjuvant, manufactured in India (Brilliant Industries Pty Ltd).

Results

Analysis of the epidemiological features of the two outbreaks in Kampong Cham in 2010 found that the overall morbidity rate of HS in large ruminants was 48% (185 of 389 large ruminants were diagnosed with HS). This comprised 59% of cattle (102 out of 174) and 39% of buffaloes (83 out of 215). This apparent difference in susceptibility to infection between buffaloes and cattle was most notable in Koh Pen, where only 25% (24 out of 97) of buffaloes were affected, compared with 50% (59 out of 118) of buffaloes affected in Kampong Reap. The reason for the relatively lower risk of infection of buffaloes in Koh Pen was not determined. Of note is that the morbidity rates in cattle in the two villages were similar, with 56% (45 out of 81) in Koh Pen and 61% (57 out of 93) in Kampong Reap. A very high mortality rate of 97–98% occurred in HS-affected cattle and buffaloes in both villages.

The diagnostic investigations on the two isolates recovered from the nasal swabs of affected animals concluded that they were both *P. multocida*, with 91.7% accuracy in the API (considered an excellent level of identification). Somatic typing by the Heddleston's agar gel immunodiffusion method revealed that both isolates precipitated to antiserum type 2, and the multiplex capsular PCR typing test confirmed that they were both type B. These findings conclude that both isolates were *P. multocida* type B2.

Studies of the immune responses to vaccination using post-vaccination serology confirmed that at day 21, 100% of vaccinated animals had a titre > 1:320. At day 180, 100% of vaccinated animals had a titre > 1:160, and 95% had a titre > 1:320. The results are displayed in Figure 1.

Discussion

The current widespread use of a killed *P. multocida* type B2 adjuvanted vaccine that elicits high levels

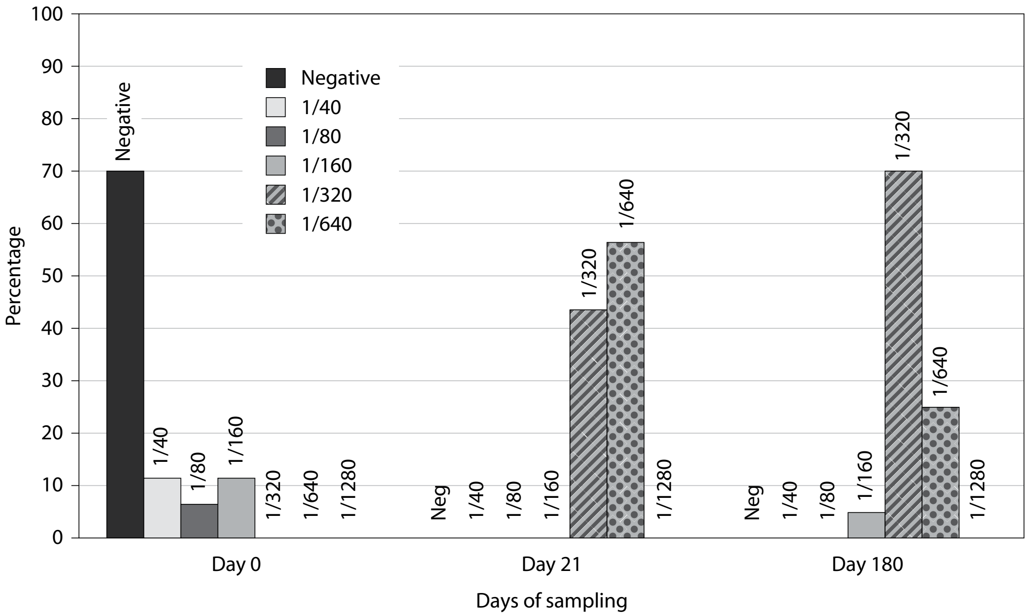

Figure 1. Percentage of animals and titre at three time points in relation to vaccination for HS

of antibody for at least 6 months post-vaccination is a powerful control intervention available for Cambodian large ruminant farmers. The current recommendation is to vaccinate animals every 6 months to maximise protection from HS infection. This report supports this as a sound approach. However, because twice-yearly vaccination of every susceptible animal in the country is impossible to achieve, two recommendations are offered:

1. Conduct a similar serological study to determine titres at 9 and 12 months post-vaccination, possibly including a challenge experiment. This may provide information about whether a single yearly vaccination would be sufficient to protect the majority of the large ruminant population, particularly if given just before a period of greater susceptibility (e.g. onset of wet season, movement etc.).
2. Conduct further work to improve animal movement controls through regulatory interventions (strengthening of the veterinary law and enforcement capacity) and—more importantly—conduct widespread education of smallholder farmers via extension programs to improve awareness at the village level and among traders about biosecurity and the need for HS vaccination.

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Parasitic infections of large ruminants in Cambodia

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Abstract

Gastrointestinal nematode and trematode infections in large ruminants are common in Cambodia because climatic conditions are favourable for their growth. These infections cause ill-thrift and production losses to smallholder-owned cattle because there is a general lack of awareness of the parasite and lack of knowledge of appropriate management strategies. This study identified parasitic genera and their prevalence within project cattle involved in the anthelmintic treatment regime used in the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) research project. Faecal samples from 1,080 cattle in six project villages (two villages located in each of Takeo, Kampong Cham and Kandal provinces) were collected during the dry and rainy seasons in 2008, and flotation and sedimentation analyses were performed. Three nematode and two trematode genera were identified. *Paramphistomum* spp. was found in nearly all cattle sampled, and *Fasciola gigantica* occurred in Kandal and Kampong Cham provinces, but not in Takeo province, in this study. Nematode genera identified were *Bunostomum* spp., *Cooperia* spp. and *Strongylus* spp. During the project, 859 anthelmintic treatments were administered to cattle in high-intervention villages over four occasions, and 56–77% of project cattle were treated each time. Stratification by age showed that cattle of different ages had evidence of helminth infection, indicating that production-limiting impacts may not be limited to young cattle in this environment.

Introduction

Year-round climatic conditions are favourable for many parasitic infections of large ruminants in South-East Asia, particularly gastrointestinal nematodes and trematodes (Holland et al. 2000; Tum et al. 2004). The clinical effects of helminth infections depend on the parasitic species involved and may include anaemia due to haematophagus activities, diarrhoea due to disruption of digestion and absorption, chronic weight loss and weakness due to the depression of appetite and reduced digestion of feed (Dorny et al. 2011), and calf mortality due to *Toxocara* spp. infection (Starke-Buzetti 2006). Parasitic infections are often subclinical, or at least not obvious, and are difficult for smallholder farmers to identify, even where poor body condition occurs. Ill-thrift in cattle is often multifactorial, involving poor nutrition, parasite infections and other potentially infectious diseases, all contributing to lowered productivity. It is recognised that to overcome the large impact that helminths have on livestock production, addressing parasite management cannot be separated from the larger problem of improving system productivity in the context of developing countries and smallholder systems (Gray et al. 2012). Furthermore, as livestock are completely integrated into the overall farming and livelihood systems of many developing countries (McDermott et al. 2010; World Bank 2010), innovation in livestock systems cannot be isolated from other economic and social developments (Gray et al. 2012).

The aim of this investigation was to determine the presence and level of gastrointestinal parasites in cattle enrolled in the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project (a collaboration between the Department of Animal Health and Production [DAHP], Cambodia, and the University of Sydney, Australia), and assess their impact and potential control methods available. In addition, this paper discusses significant parasitic diseases that affect large ruminants in southern Cambodia.

Materials and methods

Active disease surveillance was undertaken during the project, involving a 4-year longitudinal study where cattle from six villages were sampled for production parameters eight times, commencing in 2008. Two villages from each of three provinces (Takeo, Kandal and Kampong Cham) were matched as either high intervention (HI) or low intervention (LI). In the HI villages, a 'best practice' package of interventions aimed at improving cattle productivity was gradually introduced, while the LI villages received only vaccination against foot-and-mouth disease and haemorrhagic septicaemia (further details in Young et al. 2013). The six project villages were Senson Tbong and Veal in Prey Chhor district in Kampong Cham province, No Mor (Tram Kok district) and Dem Pdet (Trang district) in Takeo province, and Preak Por and Koh Kor in Saang district in Kandal province.

In each village, at least 250 cattle of different sex and age were selected for the longitudinal production survey. During this study, both blood and faecal samples were collected and screened for parasites and evidence of other infectious diseases. Faecal samples were collected in all six villages three times during the study period, with the first (n = 540) during the dry season in April 2008, the second during the rainy season in September 2008 (n = 540) and the third (n = 70) in April 2011. A convenience sampling method was used to collect faecal samples from project cattle that were made available by farmers during the BPHH longitudinal survey.

Samples of approximately 10 g of faeces were collected directly from the rectum by hand using latex gloves. Samples were placed in zip-lock plastic bags labelled with the animal identification number, date, village and farmer names, and stored in ice-cooled containers for transport to the National Veterinary Research Institute (NaVRI) on the day of collection. Samples were stored at the laboratory in the refrigerator at 4–6 °C until analysed by laboratory staff using a flotation or sedimentation method.

In the flotation test (National Veterinary Diagnostic Laboratory protocol LABP01) 4 g of faeces was mixed with 40 mL of water, strained and centrifuged at 1,700 revolutions per minute (RPM) for 1 minute. The supernatant was removed, and NaCl or sugar solution was added. A cover-glass was placed on top of the tube and left to stand for 10 minutes before microscopic examination. In the sedimentation test (NVDL protocol LABPA02), 10 g of faeces was mixed in 250 mL water, strained and left to stand for 20 minutes. The supernatant was removed, and a further 250 mL of water was added and left for 20 minutes. The supernatant was discarded except for the lower 10 mL, which was then centrifuged at 800 RPM for 5 minutes. The supernatant was removed and the residue was shaken with a vortex. One drop of the residue and one drop of methylene blue were combined on a slide for examination.

Cattle from the three HI villages (No Mor, Preak Por and Senson Tbong) were treated with either oxyclozanide/levamsiole (Nilzan®) or triclabendazole (Fasinex®) on four occasions (October–November 2009, February–March 2010, August–September 2010 and February–March 2011), at the same time as regular production data collections. At the fourth treatment in February–March 2011, 70 faecal samples were collected from the three HI villages only (23 in Senson Tbong, 19 in Preak Por and 28 in No Mor). The numbers of cattle treated at each visit are summarised in Table 1.

Results

Prevalence by region and sampling period

During the first sampling (s1) in April 2008, faecal samples were collected from cattle that had a mean age of 3.46 years (n = 535[1]). Of these, 261 (49%) were male and 274 (51%) were female. During the second sampling (s2) in September 2008, faecal samples were collected from cattle that had a mean age of 3.84 years (n = 506). Of these, 266 (53%) were male and 240 (47%) were female. The majority of cattle were crossbred (Haryana × local breed) (s1 = 445, s2 = 416); No Mor village in Takeo province had local breed cattle (s1 = 90, s2 = 90). Results of the faecal analysis are presented in Tables 2 and 3.

In the analysis of all cattle, two types of trematode eggs, *Paramphistomum* spp. and *F. gigantica,* were identified using the sedimentation technique. The cattle sampled in the six project villages all had very high prevalence of *Paramphistomum* spp.

[1] Not all 540 animals had a recorded age, therefore n were supplied.

Table 1. Cattle treated in each village at each treatment visit

Province and village	Total project cattle (Oct–Nov 2009)	No. of project cattle treated	Total project cattle (Feb–Mar 2010)	No. of project cattle treated	Total project cattle (Aug–Sep 2010)	No. of project cattle treated	Total project cattle (Feb–Mar 2011)	No. of project cattle treated
Takeo province								
No Mor (HI)	156	99 (63%)	124	94 (76%)	95	70 (74%)	81	60 (74%)
Dem Pdet (LI)	134		100		64		57	
Kandal province								
Preak Por (HI)	113	63 (56%)	94	58 (62%)	75	45 (60%)	72	45 (63%)
Koh Kor (LI)	114		81		51		44	
Kampong Cham province								
Senson Tbong (HI)	152	100 (66%)	125	90 (72%)	93	72 (77%)	86	63 (73%)
Veal (LI)	146		116		73		67	
Total	815	262	640	242	451	187	407	168

HI = high-intervention village; LI = low-intervention village
Note: Prevalence of trematode and nematode genera was assessed by region and sampling period, and by cattle age (≤1 year, 1–3 years, and 3+ years).

Table 2. Summary of positive sedimentation and flotation results from the six villages in Kampong Cham, Takeo and Kandal provinces in April 2008

Location		Number sampled	Nematode and trematode species identified and % of cattle positive				
Village	Province		*Fasciola gigantica* (%)	*Paramphistomum* spp. (%)	*Strongylus* spp. (%)	*Bunostomum* spp. (%)	*Cooperia* spp. (%)
Sensong Tbong	Kampong Cham	90	0.0	100.0	3.3	0.0	0.0
Veal		90	0.0	100.0	0.0	5.6	3.3
Preak Por	Kandal	90	42.2	75.6	22.2	0.0	0.0
Koh Kor		90	40.0	58.9	17.8	0.0	0.0
No Mor	Takeo	90	0.0	100.0	4.4	0.0	0.0
Dem Pdet		90	0.0	100.0	3.3	0.0	0.0

in both April and September 2008 (100% in cattle from Kampong Cham and Takeo provinces at both samplings, and 95.6% and 98.0% in Kandal province at each period). *Fasciola gigantica* was not identified in samples from Takeo province villages, but was present in Kandal province villages in 28.3% of cattle in April and 56.2% in September. In Kampong Cham, *F. gigantica* was identified in 13.3% of cattle in September only. No helminths were identified from the 70 samples obtained from cattle in April 2011.

Prevalence of trematode and nematode species by age

Table 4 shows the prevalence of helminth genera stratified by cattle age.

Production impacts

Specific production impacts were recorded in a range of studies during the project, including the longitudinal survey on cattle weights, growth rates and reproduction (Young et al. 2013).

Discussion

There is a general lack of published information on infectious diseases in large ruminants in Cambodia; however, several parasite surveys have been undertaken and reported. The main parasitic diseases in Cambodian cattle and buffaloes are fascioliasis, trypanosomiasis, toxocariasis, cysticercosis, strongyloidiasis, schistosomiasis, thelaziasis, oesophagostomiasis, and diseases caused by ticks and flies (Inoue et al. 2001; Tum et al. 2004; Sothoeun et al. 2006; Suon et al. 2006; Dorny et al. 2011).

In this study, the first faecal sampling occurred in April 2008, typically one of the warmest months during the dry season, with average monthly temperatures of 28.8 °C and 76.8 mm precipitation (World Bank 2012). The second sampling occurred in September 2008, in the middle of the wet season, with average monthly temperatures of 26.9 °C and 311.3 mm precipitation (World Bank 2012).

The genera of trematodes and nematodes identified were largely consistent with previous studies in Cambodia. A study of the prevalence and seasonal variations of helminth infections in cattle, involving nearly 2,400 faecal samples and examinations over 11 months from animals in four villages in western Cambodia, found that 52% of animals aged 1–6 months, 44% of animals aged 6–24 months and 37% of animals over 24 months old had faecal samples that were positive for gastrointestinal nematodes (Dorny et al. 2011). The geometric mean faecal egg counts (FECs) for each of these age categories were 125, 66 and 15 eggs per gram, respectively. Six genera of strongyles were found in faecal cultures; in descending order of occurrence, these were *Cooperia* spp., *Oesophagostomum* spp., *Haemonchus* spp., *Trichostrongylus* spp., *Mecistocirrus* spp. and *Bunostomum* spp. The prevalence of *F. gigantica* and *Paramphistomum* spp., estimated by coprological examination, varied between 5–20% and 45–95%, respectively. The study also found that low body condition score was associated with gastrointestinal nematode and liver fluke infections, and soft faecal consistency was associated with *Paramphistomum* spp. infections; however, other factors such as nutritional deficiencies and concurrent diseases are likely to increase the effects of parasites and should be considered when using these morbidity parameters as indicators of parasite infection.

In our study, *Paramphistomum* spp. were identified from 98.5% and 99.4% of cattle sampled in April and September, respectively, consistent with the above study (Dorny et al. 2011). The prevalence of *F. gigantica* was 9.5% in April and 21.5% in September. This variation in prevalence is probably attributable to the seasonal differences of the sampling periods, and is consistent with previous findings (Suon et al. 2006) that *F. gigantica* infection in cattle in riverbank villages is acquired from about August until November (originating from metacercariae on herbage, and water in irrigation canals and dams on the riverbank), and that the progressively increasing monthly incidence from December to April developed from herbage and water in recently harvested rice fields and lakes adjacent to the riverbank. The abrupt cessation of new infection in riverbank villages in May coincided with flooding of low-lying land, the movement of cattle to land above flood height on the riverbank, and a change of diet to dryland crop residues, stored dry rice stalks, and herbage and water that were unlikely to contain metacercariae. Snails in dams and canals on the riverbank became infected with *F. gigantica* after cattle were moved to the riverbank in May, and metacercariae shed from these snails provided the new infections that occurred in cattle in August and September.

In the village located away from the river, infection of cattle between September and March coincided with the rice harvest, supporting the conclusion that feeding of fresh rice stalks and stubble after the rice was harvested was the main source of infection.

Table 3. Summary of positive sedimentation and flotation results from the six villages in Kampong Cham, Takeo and Kandal provinces in September 2008

Location		Number sampled	Nematode and trematode species identified and % of cattle positive (September)				
Village	Province		*Fasciola gigantica* (%)	*Paramphistomum* spp. (%)	*Strongylus* spp. (%)	*Bunostomum* spp. (%)	*Cooperia* spp. (%)
Sensong Tbong	Kampong Cham	90	25.8	100.0	3.4	0.0	0.0
Veal		90	0.0	100.0	2.4	2.4	0.0
Preak Por	Kandal	90	49.3	100.0	12.7	0.0	0.0
Koh Kor		90	62.2	96.3	19.5	0.0	0.0
No Mor	Takeo	90	0.0	100.0	1.1	0.0	0.0
Dem Pdet		90	0.0	100.0	0.0	0.0	0.0

Table 4. Prevalence of trematode and nematode species by cattle age group

Cattle age (April 2008)	n	*Paramphistomum* spp. (%)	*Fasciola gigantica* (%)	*Strongylus* spp. (%)	*Bunostomum* spp. (%)	*Cooperia* spp. (%)
≤ 1 year	88	96.6	14.8	15.9	0.0	0.0
1–3 years	208	98.1	6.3	9.6	1.0	0.0
3+ years	236	99.6	10.6	5.1	1.3	1.3
Cattle age (September 2008)	n	*Paramphistomum* spp. (%)	*Fasciola gigantica* (%)	*Strongylus* spp. (%)	*Bunostomum* spp. (%)	*Cooperia* spp. (%)
≤ 1 year	22	95.5	13.6	13.6	0.0	0.0
1–3 years	192	100.0	21.4	6.8	0.0	0.0
3+ years	292	99.3	22.3	5.1	0.7	0.0

Between April and August, there was no opportunity for new infection because cattle were fed forage from around houses and headlands, dryland crop residues and stored, dry rice stalks.

Based on these findings, control of fascioliasis was proposed using a single treatment of cattle with triclabendazole in riverbank villages in May, when cattle were moved to the riverbank, and after harvest of the last rice fields in villages located away from the river (Suon et al. 2006). Fascioliasis occurs in wet areas where water lies continuously throughout the year, whereas hot and dry weather minimises spread because both the intermediate snail host and the metacercariae are susceptible to desiccation. Consistent with Suon (2007), the current study found that prevalence of fascioliasis in cattle and buffaloes is high in some parts (wet areas) of Kandal, Prey Veng, Svay Rieng, Kampong Cham and Kampong Thom provinces. Varied presence of *F. gigantica* across a region is most likely due to geographical features that affect the ecology of *F. gigantica*. Features associated with the presence of *F. gigantica* were also found in our study where *F. gigantica* was identified in project villages in Kandal and Kampong Cham provinces, but not in Takeo province. Tum et al. (2004) developed a geographic information system (GIS) model for mapping the risk of fascioliasis in cattle and buffaloes in Cambodia, estimating that 28% of Cambodia is potentially at risk of fascioliasis, with areas of high and moderate risk concentrated in southern and central Cambodia.

Consistent with Dorny et al. (2011), the current study did not identify *Toxocara* spp. infections. This may be due to the small number of samples taken from young calves < 90 days old, which is the age when *Toxocara* spp. infection is apparent (Roberts 1993).

Helminth species were identified in cattle in all three age groups in this study. Without FECs, it is difficult to consider the burden of disease; however, it could be hypothesised that cattle involved in traditional husbandry can be affected at all ages, possibly due to generally poor nutrition leading to low body condition scores and contributing to lowered immunity.

Where the prevalence of fascioliasis is higher than 30%, impacts on cattle include reduced weight gain (21.3 kg/animal in female cattle and 41.0 kg/animal in male cattle), 10% reduction in pregnancy rates in infected compared with non-infected females, insufficient strength for draught (reduction in strength of 40%), liver damage and subsequent reduced product quality and weight by 2.5 kg, reduced sale price and increased mortality rate (Suon 2007). Although the specific impacts of parasites on production were not directly recorded in this study, this project delivered a range of best-practice interventions at the village level, and parasite control and anthelmintic treatment are considered highly likely to contribute to improved productivity gains seen in cattle in HI villages.

Parasite control

Smallholders have limited access to anthelmintics such as triclabendazole, so extension methods should focus on biological control and grazing management to prevent or minimise parasite infection. There are three types of control options for fascioliasis in large ruminants: biological control involving collection and storage of cattle and buffalo faeces, scheduled treatment with flukicide anthelmintics and grazing management. The main restriction on the use of anthelmintics is their lack of availability, high cost and the lack of knowledge about their use among farmers and extension workers (Sani et al. 2004; Gray et al. 2012). The use of chemical control has been refined in these scenarios to include targeted deworming (with dramatically positive effects in the case of *Toxocara vitulorum*) and strategic drenches to increase growth rates (Gray et al. 2012). To avoid transmission of *F. gigantica* infection to cattle or buffaloes from water supplies, underground water sources (e.g. wells) or water from a flowing river should be used. Grazing management to avoid possible fascioliasis infection involves avoiding feed from locations where infection is known to occur, and cutting grasses for forage at least 5 cm above the water level to reduce the risk of harvesting metacercariae in the grasses, water plants and rice stalks near the water surface. Improving feeding to control parasite infections is also effective, although it is stressed that the reason for the improved feeding was to save labour and increase growth, and improved resistance to parasites is a consequence of this (Gray et al. 2012).

Although scientific knowledge about parasite control is available, farmer knowledge about appropriate parasite management is lacking. Appropriate management recommendations require timely prevalence data, knowledge of epidemiology, evidence from treatment trials and, importantly, knowledge about the local drivers for parasite control, especially at the farmer level.

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Liver fluke in large ruminants in northern Lao PDR

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Abstract

Slaughterhouse and field surveys for evidence of *Fasciola gigantica* infection were conducted in five northern provinces of Laos during 2010 and 2011, providing prevalence estimates of 34.1% (95% CI 26.0–42.2) in 2010 and 17.2% (95% CI 13.5–20.9) in 2011. The field survey examined for *Fasciola* sp. eggs using a sedimentation method in single faecal samples from 1,262 cattle and buffaloes over 12 months old from 75 randomly selected villages. This survey identified widespread infection, with 73.3% of villages having at least one faecal egg count–positive animal. The slaughterhouse survey of 123 livers found that 70.7% of livers had gross liver and bile duct lesions consistent with *F. gigantica* infection that were characterised as mild (22.8%), moderate (17.9%) or severe (30.1%). Higher rates of gross cholangiohepatopathy were observed in buffaloes (95.6%) compared with cattle (40.0%). Regression analysis showed that province was significantly associated with *F. gigantica* infection status ($P < 0.05$), suggesting geographical differences in the prevalence of *F. gigantica* in northern Laos. Similarly, a geographical pattern of *F. gigantica* infection in Cambodia in association with the Tonle Sap is well described. Although suboptimal production is caused by a multitude of factors, our findings suggest that *F. gigantica* is a major parasitic pathogen in northern Laos. Control strategies for fascioliasis should be considered because the high prevalence of infection is likely to result in substantial production losses, as well as pose a potential human health risk through continued and widespread contamination of the environment with *F. gigantica* eggs and consumption of contaminated products.

Introduction

Fasciola gigantica is considered to be a major production-limiting disease in ruminants in tropical countries, and has also been identified as an important human health risk and disease burden (Mas-Coma et al. 2005; Torgerson and Macpherson 2011). Significant research on this parasite has been conducted in South-East Asia, including in Cambodia (Gray et al. 2008), but sustained and effective management remains elusive, and the benefit to cost of the research has been questioned (Windsor 2011). Fascioliasis is a chronic disease and its impact on production is rarely recognised by producers. Despite continued evidence that fascioliasis is endemic in the South-East Asian region, improved knowledge about the impacts on large ruminant production and increasing evidence of the human health risk it poses, the question remains why the large amount of research about *F. gigantica* in South-East Asia has not had a more widespread impact on its control and management.

Anecdotal reports of the occurrence of *F. gigantica* exist in northern Laos. As part of the 'Best practice health and husbandry of cattle and buffalo in Lao PDR' project (Windsor 2006), a study including field and slaughterhouse surveys was conducted to determine the presence, prevalence and clinical impact of *F. gigantica* in cattle and buffaloes. The results of this study have implications for developing countries in the region where the disease situation, production systems and level of animal health capacities are similar.

Materials and methods

Study design, village and animal selection

Field survey: The sample size was calculated assuming a 95% level of confidence, an error of 0.075 and an expected prevalence of 10–30% (based on results of a small pilot survey) using Survey Toolbox software (Cameron 1999), and resulted in a sample size of 68 villages and 10 animals per village. A two-stage sampling technique was used to select villages and animals. The sampling frame for random selection of 2–4 villages per district (n = 18) was a list of the 198 villages that had more than 10 cows and buffaloes, were enrolled in a large livestock development project (ADB 2007) and were located in the northern provinces of Bokeo, Houaphan, Luang Namtha, Luang Prabang and Xieng Khuang. In addition, all six 'best practice' project villages (two villages each in Luang Prabang, Houaphan and Xieng Khuang provinces) were selected. Department of Livestock and Fisheries district staff organised visits to the selected villages with local authorities and the village headmen between August and December 2010, and collected faecal samples from animals over 12 months old that were presented by farmers on the days of the visit until 10–20 faecal samples per village were obtained. All large ruminants sampled were either Asiatic water buffalo (*Bubalis bubalis*) or local indigenous cattle (*Bos indicus*). Data collected with the samples included owner and village name, age and monetary value of the animal provided by the owner, and species, sex, body condition, coat condition, morbidity (including symptoms) and faecal consistency assessed or observed by the researchers.

Slaughterhouse survey: In northern Laos, slaughter of large ruminants occurs in small, basic, privately owned slaughter facilities during the night for sale of meat products at local wet markets a few hours later. Between March and June 2011, the main slaughterhouse in each provincial capital of Bokeo (Huaxay), Houaphan (Sam Nua), Luang Namtha (Luang Namtha), Luang Prabang (Luang Prabang) and Xieng Khuang (Phonsavanh) provinces were visited for 3–5 consecutive nights. In all facilities visited, 5–10 large ruminants were killed and processed each night by different trader and butcher teams who had purchased the animals.

Animals were examined before and after slaughter, and findings were recorded. Species, sex, body condition score (BCS), coat condition and any obvious abnormalities were determined or observed and recorded at the pre-slaughter examination. The source (province and district) of the animal was ascertained when possible from the slaughterhouse owners or trader. Body condition was scored according to a five-point scale (1 = emaciated to 5 = obese). During necropsy examination, the animal's age was determined according to dentition (FAO 2002), and the liver and some other internal organs were examined for any gross abnormalities. Livers were grossly assessed as normal or with mild, moderate or severe liver lesions based on categories adapted from Molina et al. (2006). Although livers were also examined for liver fluke, minimal dissection of liver and bile ducts was possible, as both are highly valued commodities.

Faecal sample collection and analysis

Approximately 10 g of faeces were collected per rectum using a latex glove and placed in a small zip-lock plastic bag, labelled with the animal identification, village name and date of collection. When samples could not be analysed within 24 hours of collection at the laboratory in Luang Prabang, 5 mL of 3% formalin was added to each sample to preserve them. Faecal egg counts (FECs) were performed using the simple sedimentation method described by Happich and Boray (1969), but only 0.25 mL of sediment per sample was analysed rather than the whole sediment because of resource constraints. *Fasciola gigantica* eggs were differentiated from *Paramphistomum* spp. eggs using microscopy (*F. gigantica* eggs are oval, operculated, golden brown and have a more homogeneous and darker content than *Paramphistomum* spp. eggs). More sensitive testing methods that can detect immature or prepatent infections (such as copro-antigen ELISA or indirect serum ELISA) were considered for use, but these require more resources and capacity than were available in Laos.

Statistical analysis

Apparent prevalence of *F. gigantica* infection and confidence intervals were calculated for the field and slaughterhouse surveys using EpiTools epidemiological calculators (Sergeant 2009). Univariate and multivariate logistic regression analyses were performed to investigate the association between outcome variables and the explanatory variables using SAS macros for statistical modelling (Dhand 2009) and SAS statistical software SAS Institute Inc., Cary, United States). Variables with a P-value ≤ 0.05 were considered statistically significant and retained in the final model.

Field survey outcomes were infection status determined by faecal sedimentation (positive or negative) and egg counts, and the slaughterhouse survey also used the amount of liver damage (normal, mild, moderate, severe). *Fasciola gigantica* infection status was defined as positive if an animal had a positive faecal sedimentation or if flukes were found in the liver. For all outcomes, explanatory variables investigated were animal origin (province), species (cattle/buffalo), sex (male/female), coat condition (normal/abnormal), diarrhoea (yes/no), general illness at time of sampling (yes/no), age, BCS and monetary value. Age in years reported by owners was analysed as both a continuous and a categorical variable (< 3 years; 3–5 years, > 5 years) to determine any differences in statistical significance. Body condition score was re-categorised from 1 (emaciated) to 4 (fat).

Results

Prevalence estimates: The apparent prevalence estimate for the field survey was 17.2% (95% CI 13.5–20.9) and the slaughterhouse survey was 34.1% (95% CI 26.0–42.2).

Field survey: A total of 1,268 large ruminants over 12 months old were sampled, comprising 462 buffaloes 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 Houaphan province. At the time of sampling, 32 (2.5%) animals were reported as sick and 15 (46.9%) of these had positive FECs. Average FECs were 132.6 eggs per g (EPG) in cattle and 158.9 EPG in buffaloes. Multivariate analysis showed that province, being sick, sex (female) and species (buffalo) were significantly ($P < 0.005$) associated with *F. gigantica* infection status (Table 1). The final linear regression model for severity of infection (expressed through EPG of faeces level) among positive cattle and buffaloes indicated that being sick was the only variable that was significantly associated with EPG levels ($P = 0.0001$), with not-sick animals having a β value of –0.59 (intercept β value = 5.17).

Slaughterhouse survey: The slaughterhouse survey examined and sampled 125 animals. The majority (66.3%) of animals slaughtered were more than 5 years old. Of the 123 livers examined, 87 (70.7%) had gross liver lesions that were mild (22.8%), moderate (17.9%) or severe (30.1%). Buffaloes had

Table 1. Logistic regression model for *Fasciola gigantica* infection status in cattle and buffaloes in the field survey

Variable category	Regression coefficient estimate	Standard error of regression coefficient estimate	Odds ratio	95% confidence interval	*P*-value
Intercept	–1.49	0.27			
Province					< 0.0001
Bokeo			1.00		
Houaphan	0.65	0.27	1.93	1.15–3.40	
Luang Namtha	–0.06	0.33	0.95	0.49–1.83	
Luang Prabang	–0.12	0.30	0.89	0.50–1.62	
Xieng Khuang	0.05	0.35	1.06	0.53–2.11	
Is animal sick?					< 0.0001
No			1.00		
Yes	1.43	0.38	4.17	1.98–8.73	
Species					0.023
Buffalo			1.00		
Cattle	-0.36	0.16	0.70	0.51–0.95	
Sex					0.006
Female			1.00		
Male	0.50	0.18	0.61	0.42–0.86	

higher rates of hepatic and biliary tract pathology: 95.6% (n = 68) had grossly abnormal livers compared with 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; 29 (78.4%) of these were from buffaloes and 8 (21.6%) were from cattle. Interestingly, of the 79 animals that were not infected with *F. gigantica*, 50 (63.3%) had hepatic and biliary tract pathology; 36 (72.0%) of these were from buffaloes and 14 (28.0%) were from 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 tested that were significantly ($P < 0.05$) associated 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 (Table 2). Linear regression results indicated that none of the factors investigated were associated with *F. gigantica* FECs.

Discussion

Prevalence estimates of *F. gigantica* infection in this study were 17.2% in the field survey and 34.1% in the slaughterhouse survey. These fall within the range of results from a small number of studies in the bordering countries of Cambodia, Vietnam, Thailand and China that reported prevalence between 12% and 76% (Copeman and Copland 2008). A survey of the main slaughterhouses in the cities of Vientiane and Savannakhet in southern Laos in 2004 by Duong Quang et al. (2008) reported prevalence of 17–57%, also within the range of our prevalence estimates. Different study methodologies used, season of surveys and possibly host differences among animals surveyed in these studies make comparisons difficult.

The prevalence estimates from our study are likely to be an underestimate because testing for *F. gigantica* infection by analysing a single faecal sample has a sensitivity of 43–64% depending on the quantity of faeces used (Charlier et al. 2008). This can be improved to 90% sensitivity when two or three serial samples are examined (Rapsch et al. 2006); however, this option was not available due to transport and resource constraints. Limited resources at the local laboratory may have further contributed to underestimation of prevalence.

The limitations of faecal sedimentation for diagnosing *F. gigantica* infection are particularly evident in the slaughterhouse surveys, where 64.2% of animals classed as uninfected had hepatic and biliary tract pathology consistent with *Fasciola* spp. infection. Faecal egg identification and fluke identification in liver may have missed a significant number of infected animals because flukes do not enter the bile ducts until 8 weeks post-infection, and eggs are produced 13–14 weeks after initial infection, when there is intermittent shedding. A method involving cutting and macerating the liver through a sieve and collecting the gall bladder contents would enable both immature and mature flukes to be counted (Molina et al. 2005a; Wiedosari et al. 2006). This could not be done in our study because liver and bile are highly valued products. Even where pathology was present, the liver was never condemned and resource constraints prevented their purchase for study. Infection with immature *F. gigantica* has been reported to cause significant liver pathology, resulting in poor production (Sothoeun et al. 2006).

Table 2. Logistic regression model for gross liver pathology of cattle and buffaloes in the slaughterhouse survey

Variable category	Regression coefficient estimate	Standard error of regression coefficient estimate	Odds ratio	95% confidence interval	*P*-value
Species					< 0.0001
Buffalo			1.00		
Cattle	–4.14	0.98	0.02	0.00–0.09	
Fasciola gigantica infection status					< 0.0001
Negative			1.00		
Positive	1.43	0.42	4.16	1.81–9.96	
Age					< 0.0001
≤ 3 years			1.00		
3–5 years	1.71	0.91	5.52	1.16–33.70	
≥ 5 years	1.26	0.58	3.53	1.16–11.03	

It is important to note that 73.3% of survey villages (n = 75) had at least one *F. gigantica*–positive large ruminant, indicating widespread infection across northern Laos.

The slaughterhouse prevalence estimates in our surveys are higher than the field survey prevalence estimates. It is probable that the slaughterhouse study population is biased, reflecting the farmers' culling or selling practices and transport limitations rather than being representative of the general large ruminant population in northern Laos. Smallholder farmers tend to sell animals when there is a sudden need for cash for the household rather than for maximum profit when the animal is in good condition. They may choose older, 'sick' or 'poorer' animals to sell, despite it being discouraged by authorities. Some evidence of this practice was apparent, with 65.3% of animals at the main slaughterhouse surveys being over 5 years old; some were likely to be much older than 5 years as they could not be aged using dentition because of extensive tooth wear.

Identification of risk factors for *F. gigantica* infection may help in developing control strategies. Some previous studies have hypothesised that buffaloes may have greater resistance to infection than cattle, and suggest that techniques to manage the parasite in buffaloes may be less important (Wiedosari et al. 2006). Our study found that cattle were less likely to be infected (odds ratio 0.7) in the field survey, and less likely to have cholangiohepatopathy (odds ratio 0.02) in the slaughterhouse survey. The average FEC in cattle was lower (132.6 EPG) than buffaloes (158.9 EPG). These results contrast with previous studies that found a significantly higher prevalence of fluke infection but lower fluke burden per animal in buffaloes compared with cattle (Molina et al. 2005a, 2005b), and significantly lower FEC and fluke counts (mature and immature) in buffaloes than cattle (Wiedosari et al. 2006). It is likely that host–parasite relationships differ significantly between different countries and animal species sampled in these studies. Although a significant difference between species was found in our study (with cattle apparently less susceptible), comparison of the amount of cholangiohepatopathy observed at necropsy showed that, regardless of infection status, buffaloes were more likely to have hepatobiliary lesions than cattle and, for that, pathology to be more severe (Table 2). This may indicate that buffaloes in this study were more susceptible to infection, that they experience greater infective doses because of their preference for swampy areas, or that damage from past infections is cumulative and tissue regeneration is poor. Alternatively, it may be possible that another aetiology causes similar gross liver lesions in buffaloes, particularly as 92.3% of buffaloes classed as not infected with *F. gigantica* had hepatobiliary lesions. Nevertheless, our study suggests that *F. gigantica* control is important for both species because buffaloes may suffer greater growth and production losses from the increased severity of hepatobiliary pathology, and especially because farmers in Laos keep both species in close contact and keep their animals until they are quite old before selling them.

The age of the host is an important consideration in *F. gigantica* infection. Previous studies indicate that young animals can suffer very poor growth if they are infected with high doses (Mehra et al. 1999) and significant performance losses occur in the pre-patent period of infection. This means that, to reduce production losses most effectively, treatment is required as early in the infection as possible (Sothoeun et al. 2006; Ganga et al. 2007). In our field survey, 17.8% (66) of sampled animals under 3 years old were positive for *F. gigantica*, and infection was highest in animals over 5 years old in both the field and slaughterhouse surveys. Hepatobiliary pathology was also highest in animals over 5 years old. These findings suggest that, in northern Laos, large ruminants can become infected with *F. gigantica* at a young age and that infection and liver pathology accumulate with increasing age, indicating that control of *F. gigantica* should commence in animals under 3 years old.

Being sick was significantly ($P < 0.0001$) associated with *F. gigantica* infection in the field survey, and lower BCS was significantly associated with *F. gigantica* infection in the slaughterhouse survey. Clinical signs for fascioliasis are non-specific, including weight loss, oedema, inappetance, lethargy, anaemia and jaundice, and are poor indicators for diagnosis or treatment decisions. Body condition score is a fairly subjective assessment of weight, and weighing and measuring animals would increase accuracy in future studies but requires better handling facilities, weight scales or weight tapes.

In our field survey analysis, male animals were less likely to be infected (Table 1). It is possible that bulls have an increased level of resistance to parasite infection because they have better body condition and nutrition levels compared with females. This probably reflects the impact of lactation during the extensive period of the dry season when energy is limited. In addition, male animals (particularly draught animals) are considered to be more valuable and often receive more of the limited feed resources available.

Conclusion

Our study confirmed that *F. gigantica* is an important parasite in Laos. It is widespread (73.3% of tested villages infected), has significant prevalence (17.3% using a test with low sensitivity) and causes severe liver pathology, suggesting that *F. gigantica* control should be considered. If not controlled, *F. gigantica* is likely to cause substantial production losses, and also pose a potential human health risk through continued and widespread contamination of the environment with *F. gigantica* eggs and consumption of infected livers. Faecal analysis is likely to continue to be the main diagnostic method available for live animals in countries with low animal health capacities, and methods of increasing test sensitivity (e.g. serial faecal sampling) need to be considered.

Analysis of factors associated with *F. gigantica* infection indicated that it is important to target both cattle and buffaloes of all ages in control strategies. Hepatic and biliary tract pathology found in both cattle and buffaloes (but with higher prevalence and severity in buffaloes) suggests that early intervention to control *F. gigantica* may have significant benefits in increasing large ruminant production.

The slaughterhouse survey is a practical method for collecting regional or provincial disease information in areas with limited animal health capacities. This surveillance method could easily be implemented regularly, and be expanded geographically and for other diseases (e.g. clinical foot-and-mouth disease, other internal parasites) and production benchmarks such as weight, body condition and reproductive status. The possible bias of the slaughterhouse population should be considered before making policy decisions based on information obtained from slaughterhouse surveys. Slaughterhouse surveillance could also provide an opportunity for implementing a system of quality control.

Further studies are required to determine the best parasite control strategies throughout an animal's life, including determining the appropriate age and time to begin treatment and control. This may vary across regions and production systems, and with farmer knowledge, attitudes and practices.

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An investigation of vaccination effectiveness in two Cambodian villages facing an outbreak of foot-and-mouth disease

Socheat Sieng and James Kerr

Abstract

An outbreak of foot-and-mouth disease (FMD) in Cambodia in 2010 provided an opportunity to investigate the effectiveness of FMD vaccination in the face of an outbreak. A limited vaccination program using donated FMD vaccine was managed by local veterinary authorities in Kampong Cham province. Because the vaccination program was not supervised by the central veterinary authorities and did not take place in the controlled environment of a research project, results provide a ‘real world’ indication of vaccination effectiveness in Cambodia. Investigations of livestock movements and the spread of FMD were conducted in seven villages in Kampong Cham province that were affected by the 2010 FMD outbreak, two of which had received a quantity of donated FMD vaccine to use as a protective measure against the advancing outbreak. In Chrey Vien village, there was a statistically significant difference ($P < 0.001$) between the proportion of vaccinated (51.4%) and unvaccinated (71.5%) animals showing signs of FMD. In Tropeang Ampil village, the difference in FMD attack rates between vaccinated (57.2%) and unvaccinated (61.5%) animals was not statistically significant ($P = 0.524$). Likely reasons for the poor results included inadequate vaccination coverage to produce herd immunity, uncontrolled movement of sick animals during the outbreak, overwhelming infection challenge created by roadside tethering and communal grazing of livestock, and weaknesses in planning and carrying out the vaccination process. Implications for the management of donated FMD vaccine in Cambodia are discussed, with recommendations that future vaccine donations allow for an observer to monitor planning, storage, handling, vaccine quality and administration of donated vaccine in response to an FMD outbreak. In addition, disease control measures including movement restrictions, alternative feeding strategies to communal grazing, controlling trade of sick animals, and biosecurity education for village animal health workers and farmers are proposed.

Introduction

An outbreak of FMD was first reported in Cambodia’s Kampong Cham province in late July 2010. Kampong Cham province is located in the south-east of Cambodia, adjacent to the border with Vietnam. A limited amount of type O foot-and-mouth disease (FMD) vaccine had been donated by the Vietnamese Government to provincial authorities in Kampong Cham before the outbreak to help with FMD control in this border area. The District Office of Animal Health and Production (DOAHP) administered 375 donated doses to cattle and buffaloes in Prey Chhor district for protective use in selected villages that were not yet affected by the outbreak in early August 2010.

The Australian Centre for International Agricultural Research (ACIAR) funded a research project in Cambodia and Lao PDR titled ‘Understanding livestock movement and the risk of spread of trans-boundary animal diseases’ (ACIAR project AH/2006/025). With the assistance of the Cambodian Department of Animal Health and Production (DAHP), project personnel gathered information from seven villages in Kampong Cham province that were affected during the outbreak. The aim was to record information about the introduction, progress and outcome of the outbreak for affected livestock and their owners.

Vaccination in Tropeang Ampil village took place on 2 August 2010 and 147 animals (35% of the cattle and buffalo population) were vaccinated. In Chrey Vien village, vaccination occurred on 3 August 2010 and 140 animals (47% of the cattle and buffalo population) were vaccinated. Both villages had very small pig populations and none of the donated vaccine was used in pigs. The first report of FMD in Chrey Vien village occurred on 25 August (23 days after vaccination) and in Tropeang Ampil village on 27 August (25 days after vaccination).

Materials and methods

Researchers from ACIAR project AH/2006/025 made several visits to seven villages in Kampong Cham province during and in the months following the widespread 2010 FMD outbreak. The Cambodian DAHP and the Provincial Office of Animal Health and Production (POAHP) in Kampong Cham facilitated the visits. Data were obtained from the records of village animal health workers (VAHWs), district and provincial veterinary authorities, and interviews with VAHWs, villagers, village chiefs, and district and provincial veterinary officers. In the two study villages (Tropeang Ampil and Chrey Vien) that had received donated FMD vaccine to use as a protective measure against the advancing FMD outbreak, FMD morbidity was recorded between August and November 2010 in the vaccinated and unvaccinated livestock. Disease frequency tables were used to assess the vaccination effort in each village by calculating the attack rate (morbidity), relative risk, risk difference (also known as the attributable risk) and attributable fraction.

Results

Summaries of the results of the FMD investigation in cattle and buffaloes are presented in Tables 1, 2 and 3.

In Chrey Vien village there was a statistically significant difference ($P = 0.000565$) between the proportion of vaccinated (51.4%) and unvaccinated (71.5%) animals that showed signs of FMD. The unvaccinated animals were approximately 1.4 times

Table 1. Disease frequency table for Chrey Vien village

	FMD disease status		Total
	Positive	Negative	
Exposed (unvaccinated)	113	45	158
Non-exposed (vaccinated)	72	68	140
Total	185	113	298

Table 2. Disease frequency table for Tropeang Ampil village

	FMD disease status		Total
	Positive	Negative	
Exposed (unvaccinated)	168	105	273
Non-exposed (vaccinated)	85	62	147
Total	253	167	420

Table 3. Measures of disease frequency for Chrey Vien and Tropeang Ampil villages

Measure of disease frequency		Village	
		Chrey Vien	Tropeang Ampil
Attack rate (%)	Exposed (unvaccinated)	71.5	61.5
	Non-exposed (vaccinated)	51.4	57.8
Relative risk		1.39	1.06
Risk difference		0.20	0.04
Attributable fraction		0.28	0.06

more likely to show clinical signs of FMD than the vaccinated animals. The risk difference associated with lack of vaccination was 0.20, representing the increased probability of FMD in the unvaccinated group (i.e. 20% of FMD cases could be attributed to lack of vaccination). The attributable fraction among the unvaccinated animals in this village, which is commonly calculated as an estimate of vaccine effectiveness, was 0.28, meaning that only 28% of FMD cases among the unvaccinated animals would have been prevented by vaccination.

In Tropeang Ampil village, the difference in FMD attack rates between vaccinated (57.8%) and unvaccinated (61.5%) animals was not statistically significant ($P = 0.524$). The relative risk of disease in this village (1.06) was not significantly different (95% CI 0.901–1.258) between unvaccinated and vaccinated animals. Likewise, the risk difference was small (0.0372), and the 95% confidence interval for the risk difference (–6.66 to 14.09) spans zero, indicating that there is no significant difference in morbidity between the vaccinated and unvaccinated groups. The attributable fraction for unvaccinated animals in Tropeang Ampil was 0.06, suggesting that only 6% of FMD cases among the unvaccinated livestock would have been prevented by vaccination in the way that vaccination was carried out in this village.

Other significant findings

Several factors were identified as being important in the rapid spread of the disease during the outbreak, including:

- communal grazing of livestock throughout the outbreak
- uncontrolled movement, trade and slaughter of sick animals during the outbreak
- inadequate understanding and application of biosecurity measures by the paraveterinary workers responsible for examining and treating sick animals (VAHWs)
- lack of urgency and a standardised approach to the reporting and investigation of disease (including sample submission) at village, district and provincial levels, which is crucial for an effective response.

Discussion

This simple comparison of morbidity in vaccinated and unvaccinated animals cannot be considered to be a formal trial of vaccine efficacy, but it does provide some 'real world' assessment. The attributable fraction (28% and 6% for Chrey Vien and Tropean Ampil villages, respectively) is commonly calculated as an indicator of vaccine efficacy. However, the diagnosis, reporting and recording of FMD cases in the villages were likely to have been imperfect and subject to recall and misclassification bias, and were not supported by laboratory testing. Less than half the cattle and buffalo population in each village were vaccinated, meaning that effective herd immunity was not reached (this would require 80% of the population to be effectively vaccinated) (Chamnanpood et al. 1993; Jori et al. 2009).

A period of 23 days (Chrey Vien) and 25 days (Tropeang Ampil) elapsed between vaccination and FMD index case dates in each village, meaning that the vaccinated animals in each village had 2–3 weeks to develop an immune response prior to challenge. Disease reporting and recording is not always accurate in Cambodia, and the vaccinated animals may have faced infection challenge sooner than the recorded index case dates suggest. There were no attempts to determine the age of the lesions in order to calculate the likely date of disease introduction.

The infection challenge facing the vaccinated animals may have been continual and overwhelming due to the practices of roadside tethering of livestock and communal grazing. These two practices, which represent significant opportunity for FMD spread between households within villages, and between villages, continued throughout the outbreak and probably explain why the outbreak seems to have erupted simultaneously throughout the villages, rather than exhibiting any directional spread from a starting point. Reports from the VAHWs suggest that the clinical signs in vaccinated animals were generally milder than those in unvaccinated animals. Although the validity of our results may be affected because accurate and timely data were unavailable, the results of our study provide a crude assessment of the effectiveness of FMD vaccination and are of value to planning FMD response measures in Cambodia.

The lack of apparent protection offered by FMD vaccination in Tropeang Ampil village, and the minimal advantage offered by vaccination in Chrey Vien village, may reflect failures in the vaccination process that was applied in Kampong Cham province in August 2010, rather than questioning the value of vaccination as a means of controlling FMD outbreaks in general. Possible reasons for the poor results include:

- poor planning in determining where and when the donated vaccine would be used, which was further

hampered by inadequate surveillance data and poor understanding of FMD epidemiology. As a result, the populations chosen for vaccination may have been too close to the margin of the advancing outbreak, particularly as no movement controls were attempted within or between villages
- poor execution, including cold chain weaknesses and poor vaccination technique. Anecdotal reports suggest that people who administer the vaccine sometimes reduce the individual dose to vaccinate more animals, because they are paid a vaccination fee per animal.

It is important to address these weaknesses for future vaccination campaigns in the face of an outbreak to ensure the campaigns are effective and make best use of limited vaccine availability.

The results presented in this report provide 'real world' information and balance to the impressive level of protection reported in some other FMD vaccination trials in the Mekong region. It is possible that the disappointing results recorded in Kampong Cham demonstrate what can happen in situations where FMD vaccination is not applied in the controlled environment of a research project. This highlights the need for monitoring (as opposed to managing) the future application of vaccine in Cambodia to identify the weaknesses in the vaccination process. The importance of vaccination failures should not be underestimated, as they are likely to discourage farmer cooperation in future FMD vaccination programs. Although FMD vaccination is not fully subsidised and farmers are required to pay a fee for administration of FMD vaccine, they are unlikely to participate in future vaccination programs if past vaccination programs have failed to protect their livestock.

Achieving adequate vaccination coverage to produce herd immunity within villages is likely to become the major challenge for effective FMD vaccination programs in Cambodia. In addition, Cambodian farmers may perceive FMD as being far less important than highly fatal diseases such as haemorrhagic septicaemia (HS), which also needs to be addressed. In Cambodia, FMD vaccine is currently far more costly and less readily available than HS vaccine. If it is also viewed as less effective, farmer cooperation with FMD vaccination programs will suffer.

The 2010 FMD outbreak in Cambodia emphasised that disease reporting and investigation in Cambodia remains a critical weakness in any disease control efforts. Our research in Prey Chhor district discovered that district animal health authorities had collected and collated outbreak data in a report dated 3 August 2010, but the report had still not been forwarded to the POAHP by 31 August. This lack of urgency in FMD reporting suggests that either FMD is not viewed as a serious disease by many stakeholders, including animal health staff, or that reporting disease is considered to be unlikely to achieve a useful response from the authorities further along the reporting pathway.

Kampong Cham province is located on a major livestock trade route running from Thailand (and possibly Myanmar) to Vietnam. Considering that a serotype A FMD outbreak was recorded in Myanmar in September 2010, it was possible that the 2010 FMD outbreak in Cambodia may not have turned out to be serotype O, in which case the donated type O vaccine used in Kampong Cham would have been inappropriate. Sampling of FMD cases for serotyping should have been a priority. To obtain good value for donor money, urgent sampling and submission should precede the distribution of donated vaccine, if possible.

Unfortunately, outbreak samples were not received by the regional reference laboratory for FMD in Bangkok until 24 September 2010, and it was a further 18 days (12 October 2010) before the results of that serotyping (serotype O) were available. Given that Vietnamese-donated FMD vaccine was used in the two study villages on 2 and 3 August, it is concerning that a delay of more than 2 months occurred before laboratory confirmation of serotype was obtained. It therefore seems reasonable to suggest that a proportion of the funds donated for FMD control in the Greater Mekong Subregion should be directed towards understanding and addressing fundamental flaws in disease reporting and investigation before allocating them to ad hoc vaccination response efforts that may have serious weaknesses.

Recommendations

Further research is required to monitor and record the planning, storage, handling and administration of donated vaccine in response to an FMD outbreak to determine if our study results represent an isolated incident or the norm. This research could be attempted by attaching an observer (but not an adviser) to future consignments of donated vaccine, to record the planning and use of the vaccine, as well as farmer/VAHW/DOAHP/POAHP attitudes and willingness to cooperate. The quality of vaccine at various points along the supply chain, including at the time of actual administration (crush-side sampling), should also be monitored by laboratory examination of samples.

Surveillance information is crucial in planning effective and justifiable response measures. Research is required to record the timeliness and quality of disease investigation (including sampling) and reporting, as well as ongoing monitoring of outbreak progress by district and provincial authorities.

Village animal health workers require training in biosecurity measures that should be applied in the course of their work. Unfortunately, the existing instruction booklet supplied to Cambodian VAHWs for investigation and treatment of FMD and classical swine fever cases lacks adequate advice about personal biosecurity responsibilities. The ACIAR project AH/2006/025 is therefore developing generic biosecurity education materials for VAHWs, but improved biosecurity training for VAHWs will be a nationwide undertaking that requires input from government and development organisations.

Cambodian custom dictates that neighbours, friends and relatives typically help in the restraint and treatment of sick livestock. This means that the risk of vector-borne and fomite-borne disease spread (via humans, clothing and equipment) to livestock in other households is considerable. Biosecurity education for VAHWs is therefore particularly important so that they, in turn, can educate other villagers, especially those who help them handle affected animals.

The feasibility of potential disease control measures depends on the cooperation of villagers. This means that a significant educational component would be required to explain the benefits they would derive from such measures. The following disease control measures should be investigated for feasibility:

- movement restrictions during disease outbreaks, particularly as many villagers tether their cattle along the roadsides before walking them to communal grazing areas each day. This means that animals from other areas that walk through the village have an opportunity to introduce diseases such as FMD
- alternative feeding strategies to communal grazing (especially at times of disease outbreaks), including promoting household forage plots and pen-feeding systems (such as those trialled by 'Improved feeding systems for more efficient beef cattle production in Cambodia', ACIAR project AH/2003/008)
- control of trade in sick animals, including preventing traders from tethering and grazing sick animals (purchased cheaply for slaughter or recovery and re-sale) close to other village livestock
- education of traders and villagers about the disease risk associated with slaughtering infected animals and distributing the slaughter products, promoting
  - quarantine/isolation of sick animals purchased for slaughter
  - avoidance of slaughter in areas where livestock walk and graze
  - the need to clean equipment, hands, shoes and clothing after handling infected animals and animal products
  - the particular risk of disease spread that is posed by feeding infected slaughter products to pigs.

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Improving cattle trade

Buffaloes entering an unofficial mountain pathway from Xieng Khouang province, Laos, into Vietnam. (Photo: Ben Madin)

Understanding the market chain: trader survey and determining animal values

Lynn Henry and Russell Bush

Abstract

Changing dietary patterns have resulted in increased demand for beef and buffalo meat in South-East Asia. With improvements in animal health and production through interventions at the village level, farmers responded to this demand by producing heavier animals with better body condition, and we investigated if this resulted in higher prices for cattle and buffaloes. A trader survey was conducted to describe the supply chain and the relationship between the farmer and trader or 'middleman'. The ability of farmers and traders to describe animals based on visual assessment of their body weight and body condition scores, and comparing this with weights from electronic scales and girth weight tapes, was assessed. The study identified a need for farmers to target feed animals to increase the value of individual animals and attract premium prices from traders. Additional data on girth measurements and their correlation to weight is necessary to develop a girth weight tape based on local cattle because commercially available tapes overestimated the weight and were not useful for farmers and traders.

Introduction

There have been considerable changes in dietary patterns in South-East Asia, with meat consumption more than doubling in the last 20 years (Pingali 2007). Cambodia is strategically placed to capitalise on the growing demand for beef and buffalo meat by increasing large ruminant production by smallholder farmers. This has the added potential benefit of addressing rural poverty by improving household incomes.

Animal health and production improvements were facilitated at a village level through interventions as part of the 'Best practice health and husbandry of cattle, Cambodia' (ACIAR project AH/2005/086) research project. The aim was to identify whether farmers and traders were able to recoup gains in improved animal weight and body condition score (BCS) by asking a higher price for their animals, in line with current and future market requirements. We wanted to describe the supply chain (from village to end user) and identify how farmers and traders would benefit from improvements in animal health and production. Of particular interest was the role of the trader as a 'middleman' and their ability to source cattle for each of the markets they supplied. We also wanted to assess the ability of farmers and traders to determine the value of an animal based on visual assessment, including body weight and BCSs. To assist with this subjective measurement, a commercially available girth weight tape was introduced to determine its accuracy and usefulness.

Aim

The aim of this paper was to report on the initial understanding of marketing strategies in Cambodia, and outline the role of a girth weight tape to determine animal value by estimating body weight of sale animals.

Materials and methods

Trader survey

A face-to-face survey of 55 traders from five districts was conducted in 2009 by project staff based at the Department of Animal Health and Production office in Phnom Penh. The districts surveyed were in the provinces of Kampong Cham, Kampot, Kandal, Takeo and Phnom Penh. Due to differences in the Takeo market (i.e. type [sex and age] and breed of animals), results were recorded separately for the markets in this province (Tram Kok and Trang markets). Survey questions related to the type, breed and age of the cattle and buffaloes purchased by the traders, the condition of the animals (poor, medium and good), the destination of the animals (domestic or export), prices paid and whether trade occurred during the wet or dry season. The development of the survey followed a series of provincial meetings held between the Australian economic specialist, traders and slaughterhouse managers in February 2008. The traders were also asked their opinions for the future development of marketing cattle and buffaloes in Cambodia.

Determining animal value

During the survey the traders admitted that, although they used BCS as a means of assessing animal weight, they had difficulty determining the actual body weight of animals. In response to this information, a field visit was organised in June 2010 to provide an opportunity for farmers, traders, and village and provincial staff to visually assess five cattle at the Tameo Breeding Station and estimate BCS, weight and animal value. Following the visual assessment, a girth weight tape was used to estimate the animal's weight. Animals were then weighed on electronic scales and comparisons made between the estimated and actual weights. Any differences between estimated and actual were then discussed in relation to the impact on animal value.

Results

Trader survey

The main concern raised by the traders was the high prices they had to pay for livestock relative to how much they received for the meat. To help counter this, traders would like to see the establishment of three main markets: a domestic market for cattle and buffaloes, a market on the Cambodian–Vietnamese border and a market for hides. Traders also wanted to prevent the importation of cattle, obtain tax discounts for slaughterhouses and prevent the illegal export of livestock. Traders from Kampong Cham, Kampot, Kandal and Phnom Penh purchased animals from outside their districts, although the majority of traders bought their cattle locally. The traders would like to see a consistent supply of better-quality animals.

Heavier cattle received a higher price in all districts, and the prices for local breed were less than for crossbred cattle. An example of the increasing price trend for heavier animals is illustrated in Figure 1. Different prices were paid for different animals across all districts, reflecting the market that each trader bought for. In most districts, prices paid by individual buyers were consistent, but in some cases there was a large difference. For example, in Kampong Cham, the price for 4–10-year-old fat cattle ranged from US$250 to US$500. Skinny cattle in some districts had a large price differential, but this could reflect that the animals were either sick or of poor quality.

Some traders purchased cattle mainly for resale. One trader in Kampot's Kompongtrach market purchased 80% of his female cattle and 50% of his male cattle for resale, with the rest of his purchases exported. Other traders resold around 10–15% of all their cattle.

Major costs borne by the traders related to transportation, slaughter charges and (in the case of Phnom Penh) police fees. Kandal traders were the only ones consistently paying marketing fees of US$0.25 per animal, although one trader indicated his fees were as high as US$1.50 per animal. Additional levies were paid in all districts except Phnom Penh.

Determining animal value

The five animals chosen for the visual and objective assessment activity were selected from the cattle on display during the field visit in June 2010. For some of the animals, the trader's estimate of body weight was only marginally (3–4%) different to the electronic scales, but for other animals the trader underestimated the weight of the animal by as much as 24%, which equated to 50–60 kg. The flow-on implications of this error may translate to a potential loss of income for the farmer (or gain if the trader overestimated the weight). It appeared that the lighter the animal, the more likely that a higher variance would occur.

The farmers and village and provincial staff in attendance also estimated the animals' value. In some cases the participants were 75% accurate in placing the animal within a weight range based on 25 kg increments. However, for the animal in

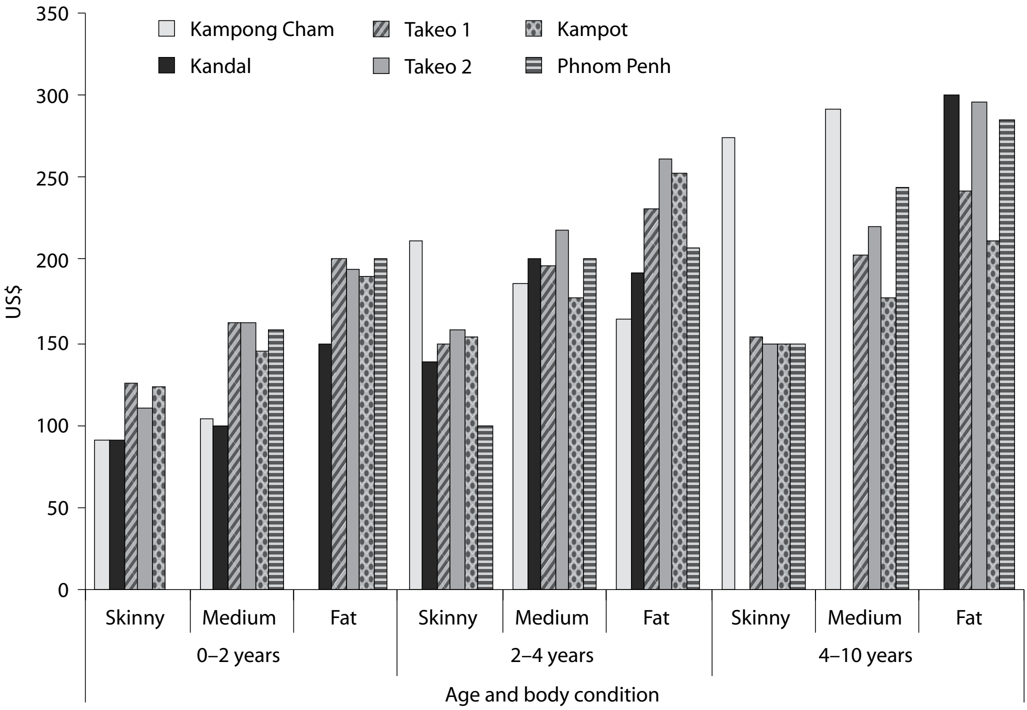

Figure 1. Average price of male cattle (local breed), all districts

Figure 2, which weighed 131 kg, all participants underestimated the weight. Eleven of the 14 participants assessed the animal in the same weight range (90–100 kg) as the trader.

When assessing the animal in Figure 3, which weighed 350 kg, 16 of the 26 participants (62%) assessed the animal in the same weight range (325–350 kg) as the trader.

Predicting body weight from girth measurements

When predicting weight from girth, morphometric measurements often show a power relationship between one variable and another, which is revealed as a linear association when both are plotted on a log scale. This is illustrated in Figure 4 from data obtained from the 'Best practice health and husbandry of cattle and buffalo in Lao PDR' project (ACIAR 2013), where the two regression coefficients (intercept and slope) for breed were significant ($P < 0.05$), and reflected in the separate lines. However, the effect in reality is not substantial, despite the statistical significance. There was no sex effect for this relationship. Due to the large number of outliers in the raw data, an iterative algorithm was used to reject observations with a standardised residual of more than four in absolute value. The value of four was selected as it is reasonable to assume the

Figure 2. Both the trader and the field visit participants underestimated this animal's body weight by 40–50 kg

most extreme standardised residual would be about 3.5 for approximately 6,500 observations in normally distributed data. The girth weight tape developed from this data was designed for use in northern Lao PDR; the next step will be to develop weight tapes based on girth measurements from Cambodian cattle and buffaloes.

Figure 3. The trader and 62% of the field visit participants estimated the correct body weight for this animal

Discussion

The traders wanted a marketing system to monitor the number of animals being bought and sold, and also wanted to see improvements in cattle fattening. In general, they were demanding better-quality animals, especially to supply the Vietnamese export market.

One of the main issues that emerged from the trader survey and trial to determine animal values was that farmers and traders are currently using different grading systems and methods to value the animals they buy and sell.

The first stage in establishing marketing interventions is to ensure that all parties are aware of market information and can grade the animal in the same way. The use of a standardised grading system for both farmers and traders not only helps to improve the flow of information through all sections of the market chain, but can reduce the costs of marketing and lead to increased prices.

Recommendations

There is a need for farmers to 'target feed' animals to increase the value of individual animals and attract premium prices from traders. This will require

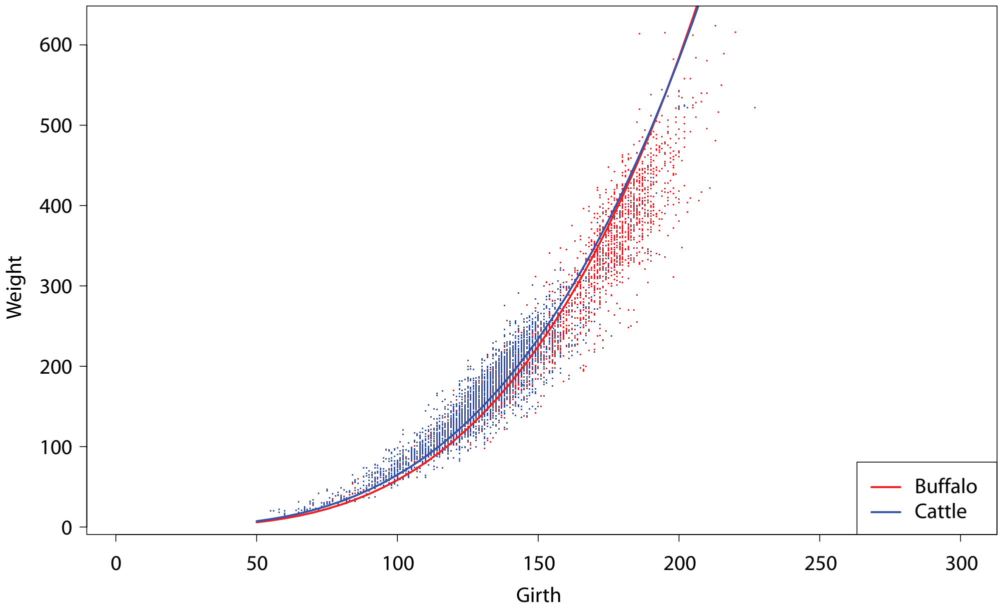

Figure 4. Association between girth (cm) and body weight (kg) for approximately 6,500 observations from cattle and buffaloes in northern Lao PDR.

farmers to identify animals for sale that are superior quality. To satisfy trader requirements, as well as maximise returns for the farmer, it would be beneficial to determine the demand for animals throughout the year and adjust management to deliver suitable animals at peak periods.

A further survey is planned within the same five districts to measure any economic gains occurring from improvements in both the health and nutrition of the animals from our project villages, based on the prices paid by traders. It is also hoped that additional data on girth measurements and the correlation to weight can be collected to develop a girth weight tape based on local cattle. Commercially available tapes currently overestimate the weight and are not a helpful guide for farmers and traders. The development of a local girth weight tape will be a handy tool for farmers and traders to estimate weight without the use of electronic scales.

Conclusions

Traders are seeking a constant supply of good-quality animals and a more formalised marketing system for local and export markets. Farmers can capitalise on this demand for quality animals by fattening superior animals. The ability of both the trader and farmer to accurately determine the value of an animal based on estimated body weight and BCS may be assisted with access to a girth weight tape following further research and development. An additional trader survey is planned to measure the economic gains resulting from improvements in animal health and nutrition.

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An analysis of the emerging smallholder cattle industry of Cambodia

Hugh Stahel, James Young and Russell Bush

Abstract

Cattle productivity in Cambodia is limited by a number of factors, including poor feeding and animal health practices. With a growing demand for meat in the South-East Asia region there is an opportunity for smallholder farmers to meet this demand and help reduce rural poverty. This report investigates the current position of the cattle market, and specifically smallholder farmers within that market, through the development of a strengths, weaknesses, opportunities and threats (SWOT) assessment, followed by an analytic hierarchy process analysis. The aim was to determine key factors that affect the current state of the smallholder cattle industry, and identify and direct attention to the most important factors. Key factors identified include growing forages to target feed cattle, controlling endemic diseases, improving the accessibility and cost of vaccines, addressing the risks of extreme climate events and the lack of mitigation strategies, and responding to the demand from local traders for cattle of higher body condition and quality. The two most important factors are the uptake and adoption of forage growing and training in target-feeding strategies to improve the value of cattle (strength), and the risk of endemic and trans-boundary diseases to smallholder cattle producers (threat). The identification of these factors will assist in the development of the smallholder cattle industry by prioritising resource allocation to areas that are critical to the success of the industry. Although identifying factors for prioritisation can be used for resource allocation, this analysis is not exhaustive, and other factors such as the lack of a market information system that is accessible to farmers may become key market development constraints.

Introduction

Cambodia is bordered by Thailand to the north-west, Lao PDR to the north and Vietnam to the east. The population of Cambodia is 14.9 million (Population Reference Bureau 2012) and more than 80% of these people live in rural areas (Mund 2010). Despite improvements during the last two decades, in 2007 an estimated 30% of Cambodians remain living below the national poverty line (2,473 riel or US$0.61 per day) (UNDP 2012). Approximately 90% of the country's poor reside in rural areas (Zimmer 2008; Mund 2010). Because rural populations rely on agriculture as a primary source of income, there is an opportunity to alleviate rural poverty by improving agricultural practices (Windsor et al. 2008).

Livestock, particularly cattle, are an extremely important asset to farmers in Cambodia, acting as a primary store of rural wealth or 'asset bank', draught power for tillage and transport, and as a source of fertiliser (Thomas et al. 2002; Huyen et al. 2010). There are more than 3.5 million cattle in Cambodia (Bunthoeun et al. 2011), and smallholder farmers typically own 2–5 cattle each (Sath et al. 2008). At present, farmers do not focus on producing cattle for meat production. This is despite rapidly growing demand for animal protein in the South-East Asia region (Pingali 2007; Windsor et al. 2008; Nampanya et al. 2012). Because more than 90% of the livestock market is contributed by smallholder farmers (Windsor 2011a), improving cattle profitability through better health and production management can significantly improve the livelihoods of smallholder farmers and their families. Cattle production is currently limited by very basic animal husbandry, poor feeding practices, poor reproductive performance and almost non-existent herd health practices (Windsor 2011a; Nampanya et al. 2012).

A 5-year project funded by the Australian Centre for International Agricultural Research (ACIAR) has sought to address limitations to cattle production in Cambodia by introducing interventions in the areas of animal health, nutrition, husbandry, reproductive management and marketing to improve the health and production of cattle owned by smallholder farmers. The 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project (Windsor 2011b) has been facilitated by a research team from the University of Sydney in collaboration with the Cambodian Department of Animal Health and Production (DAHP) extension office.

This paper reports on an investigation of the current state of, and factors that affect, the Cambodian smallholder cattle industry. A strengths, weaknesses, opportunities and threats (SWOT) analysis was used to critically assess current factors that affect the smallholder cattle market. The SWOT analysis is a useful business tool to critically analyse an industry, providing a comprehensive overview of all contributing factors (Ho 2008). This type of analysis has been previously used for livestock industries, including sheep production in developed countries (Madai et al. 2009) and cattle production in developing countries (Wasike et al. 2011). The most important factors identified from the SWOT analysis were prioritised using an analytical hierarchy process (AHP) analysis (Peterson et al. 1994; Ho 2008). This approach provides a critical assessment of factors that are most likely to be influential in future decision-making to improve the emerging smallholder cattle industry in Cambodia.

Materials and methods

Study sample

The BPHH project was conducted in six villages located in Kampong Cham, Takeo and Kandal provinces in Cambodia between 2007 and 2012. The selection criteria for the six project villages included willingness of the village authorities and farmers to participate, more than 250 cattle and all-year road access (Windsor 2011b). Each province had one low-intervention (LI) and one high-intervention (HI) village participating in the survey. Smallholder producers in HI villages received a suite of best-practice interventions including extensive education, materials and support from the project team, while LI villages were only supplied with vaccinations for foot-and-mouth disease and haemorrhagic septicaemia as a project participatory incentive.

Data collection

Following a literature search to identify and define factors influencing the smallholder cattle industry, the lead author visited Cambodia in July 2012 to investigate the smallholder production system and interview stakeholders (farmers, project researchers, government officials and DAHP staff) with the aim of gaining insights into the current state of the smallholder cattle industry.

Data from a knowledge, attitudes and practices (KAP) survey conducted in January 2012 were used to identify factors that affect the smallholder industry. The KAP survey interviewed 20 farmers per project village (n = 120), and asked questions specific to disease and feeding management, labour inputs and the incoming and outgoing expenses of each farm.

Strengths, weaknesses, opportunities and threats

Factors emerging from the data collection were grouped into strengths, weaknesses, opportunities and threats. Strengths and weaknesses constitute factors that enable or hinder the system from achieving further goals, while opportunities and threats reflect external factors that facilitate or limit the emerging industry (Wasike et al. 2011).

Analytic hierarchy process analysis

Factors identified in the SWOT analysis were subjected to an AHP analysis. The AHP allows factors in complex decision-making processes to be prioritised (Peterson et al. 1994; Ho 2008) using a pairwise comparison matrix (see Kurtilla et al. 2000 for method details). Factors are compared according to two questions: which of the two factors being compared is of greater importance, and to what extent is it more important. A scale of absolute numbers (1–9) as described by Saaty (2005) is used to answer these questions (Table 1). Factors were ranked on a numerical basis, with a higher score implying increased importance. Final priority scores were calculated by adding the scores from the rows of each factor from the matrix. Factors with a score of more than 10 were considered significant to the Cambodian smallholder cattle industry.

A collective SWOT–AHP analysis was undertaken in the manner described above, using the two highest scoring factors emerging from each individual SWOT–AHP analysis. Recommendations were made based on this final group analysis.

Results

The identified SWOT factors are presented in Table 2, and the pairwise comparison matrix of group SWOT factors are shown in Table 3.

The final priority scores from the group SWOT–AHP analysis are presented in Table 4. Factors that had a priority score of more than 10 were considered significant to the smallholder industry. These were growing forages to target feed cattle, the prevalence of disease, inaccessibility and cost of vaccines, climate extremes and local traders expressing demand for higher-quality cattle of acceptable body condition. The two most important factors are target forage growing to improve the value of cattle (strength), and the prevalence and associated risk of disease to smallholder cattle producers (threat).

Table 1. Analytical hierarchy process fundamental scale of absolute numbers

Fundamental score	Scale of absolute numbers	
	Description	Comments
1 2	Equal importance Weak or slight	Equal contribution to objective
3 4	Moderate importance Moderate plus	Experience and judgment slightly favour one activity
5	Strong importance	Experience and judgment strongly favour one activity over another
6 7 8	Strong plus Very strong or demonstrated Very, very strong importance	Activity favoured very strongly; dominance demonstrated in practice
9	Extreme importance	

Source: Adapted from Saaty (2005)

Table 2. Strengths, weaknesses, opportunities and threats for smallholder cattle farmers in Cambodia, 2012

Strengths	Weaknesses	Opportunities	Threats
• Base product (cattle) suited for tropical conditions; 90% of cattle owned by smallholders • Willingness among champion farmers to adopt new technologies • Technologies available are suitable for extension • Target forage growing can be implemented to increase the value of cattle • 80% of population from rural areas; comfortable and involved with rural practices	• Cattle not traditionally seen as source of protein • Cattle typically have low productivity • Low levels of education and literacy • Cattle underfed using low-quality forages • Vaccinations and health care expensive and not readily available • Producers are 'price-takers' rather than 'price-makers', and unaware of market trends • Social prestige associated with number of cattle owned, affecting willingness to sell	• Demand for animal products (especially meat) increasing in region • Domestic and international export avenues • Local traders expressing demand for higher-quality product (incentive to improve cattle) • International aid available for expansion of agriculture • Global push to eradicate foot-and-mouth disease • Alleviate rural poverty by increasing ruminant production • Adoption of silage to cope with 'climate shocks' (drought, flood etc.) • Increased mechanisation of agriculture shifting importance of cattle as sources of draught power	• No market information system • Transport and access to markets limited • High occurrence of illegal cattle movement (and trans-boundary disease) • Climate extremes • Other cattle-producing countries seizing markets before Cambodian producers • Endemic disease (foot-and-mouth disease and haemorrhagic septicaemia)

Table 3. Pairwise comparison matrix of group SWOT factors comparison

Factor of interest	Target forage growing to improve cattle	Cattle adapted to local conditions, 90% of livestock owned by smallholders	Cattle chronically underfed	Vaccinations/ health care expensive and not readily available	Demand for animal products increasing	Local traders expressing demand for acceptable body condition	Climate extremes	Endemic diseases	Total score
Target forage growing and feeding to improve cattle production	1	6	1	4	4	5	4	4	29
Cattle suited to local conditions, > 90% of livestock owned by smallholders	1/6	1	1/3	1/4	1/4	1/5	1/6	1/7	1
Cattle underfed using low-quality forages	1	3	1	1/6	4	1/5	1/6	1/7	9
Vaccinations/health care expensive and not readily available	1/4	4	6	1	4	3	3	2	23
Demand for animal products increasing in region	1/4	4	1/4	1/4	1	1/5	1/5	1/7	5
Local traders expressing demand for higher-quality products	1/5	5	5	1/3	5	1	3	1/4	19
Climate extremes	1/4	6	6	1/3	5	1/3	1	1/3	18
Endemic diseases	1/4	7	7	1/2	7	4	3	1	29

SWOT = strengths, weaknesses, opportunities and threats

Table 4. Final priority scores emerging from the group SWOT–AHP analysis

Factors	Priority score	Category
Target forage growing and feeding to improve cattle production	29	Strength
Cattle suited to local conditions and > 90% of livestock owned by smallholders	1	Strength
Cattle underfed using low-quality forages	9	Weakness
Vaccinations and health care expensive and not readily available	23	Weakness
Demand for animal products (especially meat) increasing in region	5	Opportunity
Local traders expressing demand for higher-quality products	19	Opportunity
Climate extremes	18	Threat
Endemic disease	29	Threat

SWOT–AHP = strengths, weaknesses, opportunities and threats – analytical hierarchy process

Discussion

The adoption of forage growing to target feed cattle has been identified as a key strength for smallholder cattle producers within Cambodia. By improving cattle nutrition through forage growing and feeding, farmers are better positioned to cope with feed shortages that occur in the dry season. An introduced nutritious fodder source can improve cattle productivity through increased draught power output and better meat and milk production (Mureithi 1998; Windsor 2011b).

Traditional nutritional management of cattle consists of a combination of tethered and cut-and-carry feeding supplemented by rice straw (Nampanya et al. 2012). Tethered cattle may only access rice stubble within the range of the tether (observed to not exceed 3–4 m). Cut-and-carry feeding involves farmers and family members spending up to 8 hours a day collecting grasses and weeds (Maxwell et al. 2012). Feed collected is usually not of sufficient quantity or quality to meet the nutritional needs of cattle.

The effect of climate extremes such as droughts or flooding can be alleviated with the adoption of forage conservation techniques such as silage practices. As demand for animal protein in the region continues to rise, traders will continue to demand a high-quality product from farmers. Assuming the prices received for these higher-quality products are appropriate to cover any increased costs of production, farmers are well positioned to improve their livelihoods by increasing cattle production from a subsidence to a commercial level.

Growing improved grass forage species as an alternative fodder source for cattle has achieved positive results (Stür et al. 2002); however, this practice is not widespread. Grasses grown include guinea grass (*Panicum maximum*), atratum (*P. atratum*) and *Brachiara* spp., which have moderate protein levels (Hare et al. 2009). Improving nutritional management of cattle has emerged as one of the key focuses of the BPHH project. Enthusiastic ‘champion farmers’ who sought out aid and willingly adopted new technologies and practices were identified as one of the key drivers to encourage the adoption of new technologies and practices by the wider farming community. Smallholder farmers may be sceptical about the merit of adopting new technologies. Once the benefits of these technologies are apparent, they are generally more willing to adopt them (Stür et al. 2002; Windsor et al. 2008).

The prevalence of endemic and trans-boundary diseases was identified as not only the strongest threat to the emerging industry, but a significant factor to the overall success of the industry. This includes illegal movement of cattle resulting in trans-boundary disease outbreaks, and poor disease management practices within villages. An associated factor identified in the SWOT analysis was the high costs and relative inaccessibility of appropriate vaccines. The prevalence of key diseases (especially foot-and-mouth disease) is most likely due to uncontrolled mixing of cattle from different herds, especially at the point of sale where disease may be introduced to healthy animals (Bronsvoort et al. 2004). The influence of wild cattle and buffalo stocks acting as reservoirs of disease may also affect disease prevalence, as seen in outbreaks of diseases carried by ticks in Zimbabwe (Latif et al. 2002). The relative inaccessibility and high cost of vaccines is associated with inferior disease control, and therefore higher disease prevalence. As a result, continued support is required from agencies such as DAHP to assist in biosecurity education and the distribution of vaccines.

The fact that traders are demanding cattle of higher body condition is a key opportunity for advancing the smallholder cattle industry in Cambodia. If traders are actively seeking cattle of acceptable body condition, and necessarily offering a higher return for these animals, farmers are more likely to improve their cattle. These benefits can be realised through better productivity of cattle, reduced mortality and morbidity from disease, better body condition scores and (if farmers adopt target forage growing) increased time savings for farmers (Maxwell et al. 2012). The benefits of time savings may be realised through expansion of agricultural or other income-generating activities, and potentially increased school attendance by children as they are no longer needed to assist with farming activities.

Further work is required to gauge what factors stakeholders see as most significant to the success and continued expansion of the cattle industry in Cambodia. Questionnaires that require stakeholders to rank the factors that affect the smallholder industry should be distributed, with the responses further serving to guide the allocation of resources. This method has been employed in similar smallholder cattle production systems in developing countries (Latif et al. 2002; Bronsvoort et al. 2004; Wasike et al. 2011). Identifying factors that are important to stakeholders can assist with long-term planning to improve the smallholder cattle industry in Cambodia, and enables strategies to be developed to address these factors. These include offensive strategies (where strengths are maximised and available opportunities are seized) and defensive strategies (where weaknesses are alleviated and threats are evaded).

Progressing from a subsistence to commercial level of production presents new challenges that can be difficult to overcome for smallholder farmers. The most important factors influencing the success of the industry have been identified using this SWOT–AHP analysis. The identification of these factors will provide valuable information to decision-makers shaping the successful future direction for the emerging smallholder cattle industry. While factors identified in the SWOT analysis may be considered as individual components that affect the industry, they are by no means independent. In almost every case, improving one factor will have a direct effect on one or more other factors.

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Assessment of current trends in smallholder cattle trade in Cambodia

John O'Connell, James Young, Lynn Henry, Luzia Rast, Suon Sothoeun, Russell Bush and Peter Windsor

Abstract

With increasing demand for beef in South-East Asia driven by growing regional economies, there is a significant opportunity for Cambodian smallholder cattle farmers to improve production of large ruminants and increase household income. Improvements in smallholder productivity can play a role in ensuring regional food security and addressing rural poverty. In addition to the limitations on cattle production imposed by disease and poor husbandry, a lack of formal information relating to trading and marketing systems has been identified as a further constraint on cattle production. Two surveys of traders of large ruminants were conducted as part of the 'Best practice health and husbandry of cattle, Cambodia' project to improve knowledge of the cattle market chain. In addition, a pilot study was undertaken to assess the viability of using a commercial *Bos indicus* weight tape to estimate cattle weights in the absence of liveweight scales. Trader surveys were conducted in August and September 2009, involving 55 traders from five provinces, and in December 2011 and January 2012, involving 100 traders from six provinces. Survey questions focused on the transaction process, including method of farmer contact and price determination, stock price, condition and age of stock, method of transport, destination of stock and costs incurred by the trader. As expected, average prices of cattle age, sex and body condition score show a trend of higher prices for older and better conditioned cattle. The pilot study investigating the use of a weight tape shows that accurate weights can be determined; however, further research and farmer training is needed. This study reinforces that there are significant opportunities for smallholder farmers, and continued research, training and extension should be conducted to ensure smallholder farmers are positioned to capitalise on these opportunities.

Introduction

The last decade has seen increasing demand for beef in South-East Asia. The regional powerhouse economies such as Thailand, Malaysia, Vietnam and China, and, to a lesser extent, urban growth within Cambodia, have resulted in burgeoning regional demand for livestock products, characterised as the 'livestock revolution' (Shanker et al. 2012). Income and population growth in these countries, which is driving the increased red meat demand, is expected to continue to grow over the coming decades (Harding et al. 2007). This has been recognised as an opportunity for Cambodia because there is a latent supply potential in Cambodia's relative land abundance and in the smallholder systems that dominate its cattle production (Shanker 2012). Improvements in smallholder productivity may contribute significantly to ensuring regional food security and in addressing rural poverty (Windsor 2011).

In 2011, Cambodia had an estimated population of 14.3 million people (World Bank 2012), 80% of whom live in rural areas (MAFF 2011). Cambodia's poverty rate was estimated at 25.8% in 2010 (WFP 2012). The estimated cattle population in 2011 was around 3.41 million, with 99.8% being raised on smallholder farms (Sar Chetra, pers. comm.). Agriculture contributes 28.4% of Cambodia's GDP, and livestock production contributes 4.2% (Sar Chetra, pers. comm.). Cattle support the livelihoods of the poor in multiple ways, including as a source of cash income and storage of wealth, draught power for tillage and transport, a source of food, energy (through biogas) and fertiliser.

In addition to the limitations on cattle production imposed by endemic disease and poor husbandry (Maclean 1998; Windsor 2008; Young et al. 2013a), a lack of information about the trading and marketing system has been identified as a further constraint (Windsor 2008). Cattle trading has been described as a system in which there are no formal markets, with usually just one licensed trader visiting a circuit of villages infrequently, purchasing cull animals that are no longer fit for draught or animals that a farmer needs to sell to pay a bill (Sar Chetra, unpublished data). In this system, smallholder farmers are 'price-takers'. Despite traders being an integral link in the cattle marketing chain in Cambodia, there is limited knowledge of the trader system and its role in livestock pricing and distribution. Knowledge about local trade and marketing systems and trends is important to ensure that improvements in on-farm productivity are recouped in farm-gate returns, and returns are maximised for farmers and traders.

Two surveys of traders operating in project and non-project areas were conducted as part of the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project in 2009 and 2011, to improve knowledge of the cattle market chain. This followed a series of interviews in both project and non-project areas with traders, governmental officials and farmers in 2008 by the BPHH research team. This report presents selected preliminary descriptive analysis based on the two surveys. In addition, a pilot study was undertaken to assess the viability of using a commercial *B. indicus* weight tape to estimate cattle weights in the absence of liveweight scales during the final longitudinal data collection of the BPHH project in February 2012 (Henry and Bush 2013).

Aim

The three specific aims of the trader surveys were to identify patterns in trading practices, obstacles to trade as perceived by traders and any marketing opportunities for smallholder farmers. The aim of the weight tape pilot study was to assess the potential for a commercial weight tape to be used to assess cattle weights, and hence improve the valuation of livestock and price determination at the point of sale.

The intended outcome is a better understanding of the Cambodian cattle trading and marketing system, recognition of potential opportunities that could be capitalised on by smallholder farmers and identification of areas for further research and/or policy interventions.

Materials and methods

Trader surveys

Trader surveys were conducted in August and September 2009, involving 55 traders from five provinces, and in December 2011 and January 2012, involving 100 traders from six provinces. The five provinces in 2009 were Kandal, Kampong Cham, Kampot, Takeo and Phnom Penh. In 2011, traders from Kompong Thom were also surveyed due to its proximity and supply of cattle to Phnom Penh.

The survey questionnaires were designed by the project team and included questions about the trader's practices, including their operating location, number of years trading, numbers of large ruminants bought and the prices paid in the previous 12 months. Livestock numbers were recorded and categorised by species (buffalo or cattle), breed in the case of cattle (local or crossbreed), age group in years (0–2, 2–4, 4–10 or over 10) and body condition score (BCS) (with three categories: skinny, medium and fat). Questions were asked regarding the transaction process, how contact was made with the farmer, price determination, method of transport, destination of stock and costs incurred by the trader. At the end of the survey, traders were asked to comment on what problems or issues they might have. In addition to the 2009 survey, traders in 2011 were also asked for details on the source of purchased cattle, transport methods to slaughterhouse and markets, and market locations.

Traders known to regional official Department of Animal Health and Production (DAHP) staff were invited to the district veterinarians' offices in 2009 and to provincial veterinarians' offices in 2011. Staff from DAHP carried out the surveys in face-to-face interviews with the traders. Answers to the questions were hand-written in Khmer in the space provided on the questionnaires. The data were translated and entered into Microsoft Excel spreadsheets by DAHP project staff, and analysed.

Pilot weight tape assessment

During the eighth and final data collection of the BPHH longitudinal production survey (conducted in February 2012), 258 project cattle were weighed with electronic scales and were also measured using a weight tape (Beef Cattle Coburn Tape, USA). The tape had metric units (centimetres and kilograms) on one side and empirical units (inches and pounds) on the other.

This particular tape is divided into four categories (thin, moderate, fleshy and very fleshy), which were interpreted to correspond to the 4-point BCS (1 = very skinny, 2 = skinny, 3 = medium and 4 = fat) used during the BPHH project. The initial intention was for staff to record the girth in centimetres; however, only the weight in kilograms was recorded.

Results

Trader surveys

In 2009, the 55 traders interviewed reported 14,230 cattle transactions. Surveyed traders did not report any buffalo transactions in 2009. More results for this survey are reported in these proceedings (Henry and Bush 2013).

In 2011, the 100 traders reported 22,746 large ruminant transactions consisting of 441 Asiatic water buffalo and 22,305 cattle. The breed of cattle traded included 15,406 local breed and 6,899 crossbreed. In 2011, 48.4% of traders purchased animals outside of their regular operating area (district or province).

Data from the 2011 survey indicated that the traders purchased large ruminants directly from the farmer, from a broker (who takes a commission on the transaction), or from a store farmer (who may purchase cattle from individual farmers and keep them for varying periods of time). Traders sourced large ruminants directly from a farmer (94%), from a store farmer (35%) and from a broker (6%). Two traders sourced large ruminants from the Thailand border: one sent stock directly to a slaughterhouse in Phnom Penh, and the other transported cattle to the Vietnam border to sell live. Many of the surveyed traders operating in Takeo and Kampot provinces sold live large ruminants at the Vietnam border.

The breed and BCS of animals traded are presented in Tables 1 and 2.

No traders currently weigh cattle at the time of purchase, and the price of the animal is determined by general appearance and BCS. The average purchase price and percentage change between 2009 and 2011 for local breed cattle are presented in Table 3, stratified by cattle age and BCS.

Table 1. Percentage of cattle traded by breed in 2009 and 2011

Province	2009		2011	
	Local	Crossbreed	Local	Crossbreed
Kampong Cham	95.8	4.2	92.7	7.3
Kandal	44.1	55.9	0.0	100.0
Takeo	29.6	70.4	49.1	50.9
Kampot	79.5	20.5	49.7	50.3
Phnom Penh	100.0	0.0	97.4	2.6
Kampong Thom	–	–	100.0	0.0
Mean of 6 provinces	49.4	50.6	69.1	30.9

– = Kampong Thom was not included in the project in 2009

Table 2. Percentage of large ruminants traded by body condition score

Province	2009			2011		
	Skinny	Medium	Fat	Skinny	Medium	Fat
Kampong Cham	19.2	67.2	13.6	7.9	86.3	5.8
Kandal	35.6	28.4	36.0	0.0	21.5	78.5
Takeo	7.0	39.2	53.8	0.0	47.2	52.8
Kampot	13.2	56.1	30.7	0.0	72.5	27.5
Phnom Penh	2.3	22.5	75.2	0.0	75.7	24.3
Kampong Thom	–	–	0.0	0.0	56.3	43.7
Mean of 6 provinces	10.7	37.6	51.7	0.9	62.2	36.9

– = Kampong Thom was not included in the project in 2009

Table 3. Average purchase price of local breed cattle (US$), and the percentage change in prices between 2009 and 2011 by sex, age and body condition score

Year	Sex	Age and body condition of cattle								
		0–2 years			2–4 years			4–10 years		
		Skinny	Medium	Fat	Skinny	Medium	Fat	Skinny	Medium	Fat
Mean price (US$)										
2009	Female	$98	$135	$191	$149	$196	$240	$176	$227	$280
	Male	$112	$145	$190	$153	$202	$231	$163	$220	$260
2011	Female	–	$301	$432	$173	$390	$516	$247	$490	$570
	Male	–	$341	$493	$198	$444	$595	$296	$585	$672
Mean price change (%)										
2009	Female	–	123%	126%	16%	99%	115%	40%	116%	104%
2011	Male	–	135%	159%	29%	120%	158%	82%	166%	158%

– = not applicable (no animals sold in this category)

There were large price ranges for the same cattle breed, sex, BCS and age groups between and within provinces. For example, prices for local breed females in the fat BCS group ranged from US$296 to US$914 for a 2–4-year-old, and US$296 to US$815 for a 4–10-year-old. Prices for local breed males categorised as medium BCS ranged from US$296 to US$864 for a 4–10-year-old.

The average purchase price and percentage change between 2009 and 2011 for crossbreed cattle are presented in Table 4, stratified by cattle age and BCS.

Table 5 shows the average price of meat per kilogram at the market in 2011 from each province. Phnom Penh and Kandal had the highest price for both cattle and buffalo meat. On average, cattle meat was valued US$0.20 higher than buffalo meat per kilogram.

Major costs borne by traders included transport costs and slaughter fees. Transport costs ranged from US$1.00 to US$30.00 in 2009, and US$1.50 to US$66.70 in 2011. Slaughter fees ranged from US$1.00 to US$13.00 per animal in 2009 (for 29 of the 55 traders), and US$3.21 to US$4.94 per animal in 2011 (57 of the 100 traders); some traders did not pay slaughter fees.

The destination of purchase stock is presented in Table 6.

Pilot weight tape assessment

Data from 257 cattle that were measured using the weight tape and electronic scale were recorded and analysed for variation between the two weight assessment methods. One outlier with a variation of more

Table 4. Average purchase price of crossbreed cattle (US$), and the percentage change in purchase prices between 2009 and 2011 by sex, age and body condition score

Year	Sex	Age and body condition of cattle								
		0–2 years			2–4 years			4–10 years		
		Skinny	Medium	Fat	Skinny	Medium	Fat	Skinny	Medium	Fat
Mean price (US$)										
2009	Female	$134	$176	$250	$191	$258	$331	$232	$296	$335
	Male	$135	$184	$257	$203	$236	$317	$231	$292	$384
2011	Female	–	$617	–	–	$560	$663	–	$673	$864
	Male	–	$617	$790	–	$646	$811	–	$818	$976
Mean price change										
2009	Female	–	251%	–	–	117%	100%	–	127%	158%
2011	Male	–	235%	207%	–	174%	156%	–	180%	154%

– = not applicable (no recorded animal sales in this category)

Table 5. Average price (US$) of meat per kg at market in 2011

Province	Cattle	Buffalo
Kandal	6.86	6.37
Kampong Thom	5.39	5.39
Takeo	5.64	5.39
Kampot	5.39	5.39
Phnom Penh	6.86	6.37
Kampong Cham	5.64	5.64
Average of all provinces	5.96	5.76

than 100 kg was excluded from the analysis. The mean age of cattle was 5.8 years (range: 3.1–11.0). The mean cattle weight using the electronic scales was 332.5 kg, and 333.0 kg using the weight tape. The mean variance between the weight scale and weight tape was 3.4 kg, equivalent to only 1% of the actual (scale) liveweight.

Discussion

The initial aim of the survey as drawn up by the research team was to interview as many traders as possible associated with the six project villages, in the hope that trader and market data could be linked to BPHH project interventions. Because of the limited number of traders in some districts, selection was expanded to include traders that were not associated with the project villages. Without a robust livestock identification system, and a BPHH total project cattle population of 2,123 cattle, there were no records to link project cattle to the trader data, despite project cattle wearing an identification tag around their necks. Despite the requirement for traders to be licensed to trade large ruminants, a central database that can be used to establish a sampling frame is not known to be available; therefore, results should be interpreted with care.

The percentage of cattle traded by breed varied between region and year of the survey. Phnom Penh and Kampong Cham were dominated by local breed cattle in both 2009 and 2011. In Kandal and Takeo provinces, crossbreed cattle sales dominated over local breed sales; however, the proportion of local breed cattle traded in Takeo increased in 2011, while the proportion of crossbreed sales rose to 100% in Kandal. In 2011, Kampot reversed its 2009 dominant trend of local breed sales to just over 50% of sales being crossbreed. Overall across all provinces, approximately 50% of sales were crossbreed and 50% were local breed. The local breed in 2011 accounted for approximately 69% of sales, although this may have been heavily influenced by the addition of Kampong Thom to the survey, where trades of only local breed cattle were reported.

The BCS of cattle traded varied substantially between provinces. Across all provinces in 2009, the majority (nearly 52%) of cattle traded were in a ‘fat’ condition, with the remaining 38% ‘medium’ condition and 11% ‘skinny’. In 2011, the proportion of skinny cattle traded dropped markedly from 11% to 1%, and medium increased from 38% to 62%. The proportion of sales of fat cattle dropped from 52% to 37%. Despite the proportion of both skinny and fat cattle falling, it was positive to see a stronger demand for cattle in a medium condition. However, this is a lost opportunity for farmers in selling medium rather than fat animals for slaughter.

Average prices of cattle based on age, sex and BCS showed a trend of higher prices for older and better conditioned cattle, as expected. Younger cattle with

Table 6. Final market destination in percentage of total animals traded from each province in 2009 and 2011

Province	2009			2011		
	Domestic	Re-use	Export	Domestic	Re-use	Export
Kampong Cham	97.0	3.0	0.0	90.5	9.5	0.0
Kandal	97.1	1.0	1.9	95.3	4.7	0.0[a]
Takeo	56.0	0.1	43.9	13.4	32.1	54.5
Kampot	51.4	23.2	25.4	24.6	3.4	72.0
Phnom Penh	100.0	0.0	0.0	100.0	0.0	0.0
Kampong Thom	–	–	–	98.7	1.3	0.0
Mean of 6 provinces	69.7	2.0	28.1*	72.3	7.0	20.7

[a] No traders interviewed exported cattle, despite a large export market operating.
Note: Percentages for all provinces in 2009 do not equal 100% because some animals were traded to an unknown destination. Kampong Thom was not included in the project in 2009.

a higher BCS fetched higher prices on average than older cattle in poorer body condition.

Price increases in local breed cattle were observed for all groups of sex, age and BCS. These increases ranged from 16% in skinny females aged 2–4 years, up to a 166% increase in average prices of males in medium BCS aged 4–10 years. Overall, substantial increases were seen in prices between 2009 and 2011, with 11 of the 16 groups reported as increasing by more than 100% or doubling in average price.

As was the case with local breed cattle, crossbreed average sale prices increased from 2009 to 2011, with some younger cattle of a higher BCS fetching higher prices than older cattle in poorer BCS. Overall, crossbreed cattle achieved substantially higher prices than local breed, with males in 2011 of 4–10 years of age in fat BCS achieving an average price close to US$1,000. In crossbreed cattle, the minimum increase in price from 2009 to 2011 was 100%, indicating that doubling of prices was the lower limit, and prices increased by more than 200% in young cattle aged 0–2 years.

Increase in prices between the two surveys may have resulted from a number of factors, including the potential latent market lack of supply of cattle (Shanker et al. 2012). This was supported in the 2011 survey where traders travelled outside their base locations to source animals.

Major costs borne by traders included transport costs and slaughter fees. Transport costs ranged from US$1.00 to US$30.00 in 2009, and in 2011 from US$1.50 to US$66.70. Variations would be expected with the type of transport used and distance covered, as well as the size of the animal being transported. In 2009, 29 traders paid slaughter fees ranging from US$1.00 to US$13.00 per animal. In 2011, 57 traders paid slaughter fees ranging from US$3.21 to US$4.94 per animal, and some traders did not pay slaughter fees. This may have been because they also owned the slaughterhouse.

Takeo and Kampot provinces appeared to be the major export provinces. DAHP staff report anecdotally that Kandal does export cattle, although these data were not captured in this group of surveyed traders. In 2009, re-use of cattle was not of a high proportion in most provinces, with the exception of Kampot where it reached 23.2% and declined to 3.4% in 2011. In Takeo, re-use increased from 0.1% in 2009 to 32.1% in 2011. The majority of traders surveyed identified domestic slaughter as the most common reason for purchasing cattle (69.7% in 2009 and 72.3% in 2011). Re-use accounted for 2.0% in 2009 and increased to 7.0% in 2011. The proportion of cattle exported fell from 28.1% in 2009 to 20.7% in 2011, with this possibly reflecting the growing demand for meat within the region and a smaller national herd size.

In the 2009 survey, the traders' major concerns related to the high prices they had to pay for livestock compared with the amount received from the sale of meat. They were keen on the establishment of a domestic market for cattle, a market on the Cambodian–Vietnamese border and a market for hides. They were also keen to have access to better-quality animals, tax discounts for slaughterhouses, and prevent the importation of cattle. They also admitted that they had difficulty in assessing animals' body weight (Henry and Bush 2013).

In the 2011 survey, the traders commented again that cattle prices were high in relation to how much they received for the meat at the market, and that they had difficulty obtaining stock during the last 12 months, reflected in the distance some travelled outside of their usual operating locations to source stock. Some stated that the increase in large ruminant prices was due to a shortage of animals as a result of the foot-and-mouth disease outbreak of 2010–11, widespread flooding and limited feed available in 2011. Multiple traders would still like the establishment of a domestic market or saleyard system to provide better access to cattle, and expand training to farmers to continually produce high-quality animals.

Use of a weight tape

The two methods of cattle weight measures showed remarkably similar measures, so much so that it is likely that the project staff referred to the weight scales for confirmation of the closest fitting BCS to the weight tape. This would result in systematic bias and affect the validity of any results and conclusions. Further studies involving blind assessment and the inclusion of training of farmers, traders and extension staff in BCS assessment are needed to validate the accuracy and agreement of the two weight measurement methods, as previously reported by Henry and Bush (2013) in Laos. However, this pilot weight tape study did show the potential for accurate weight assessment using this method.

Conclusions

Major price variations reported by traders for a particular animal class at both the provincial and district levels may indicate a significant lost opportunity for farmers aiming to maximise their returns from large ruminant sales. The lack of a readily accessible market information system, combined with farmer behaviour of selling in times of need as opposed to fattening for sale for maximum returns, are likely major contributing factors.

Strategies for farmers to improve knowledge of the market value of their large ruminants should be further investigated. Weight tapes could offer one potential solution, although further research is needed, combined with training of farmers, traders and extension staff in their appropriate use. Village or commune investment in weigh scales could be further supported by cost–benefit studies. The development of village or commune cattle yards could be used for both marketing and animal health activities. However, this should be considered carefully in the context of biosecurity and disease management, and would be more appropriate following improved control of foot-and-mouth disease.

With evidence of substantial market price increases driven by a rising demand, cattle should be targeted for beef production and considered as a primary income source. More focus is warranted on increasing productivity from these multipurpose livestock. Crossbreed cattle obtain substantially higher prices than local breed cattle, therefore farmers of local breed cattle should consider changing, provided they have the feed resources to meet the greater needs of the larger crossbreed animals.

Recommendations

- Extension staff should reinforce the need for farmers to 'target feed' large ruminants to increase weight, condition and value of individual animals. The BPHH project has identified a range of interventions that can be implemented to achieve this (Mong et al. 2013; Rast et al. 2013; Young et al. 2013b).
- Smallholder farmers should adopt forage growing and fattening practices to improve cattle weight and BCS to maximise profit at sale.
- Smallholder farmers should seek education and methods to improve valuation of large ruminants, including the use of weight tapes to promote accurate monitoring of weight gain and knowledge regarding animal value at different weights.
- Smallholder farmers should determine the demand for animals throughout the year and adjust management to deliver suitable animals at peak periods (e.g. Khmer New Year).
- Smallholder farmers should identify individual market requirements within their province and produce animals to meet the targeted market to maximise returns.
- Smallholder farmers, together with extension workers, should consider the feasibility of establishing district or provincial markets (saleyards) and a market information system informing farmers of current prices, once foot-and-mouth disease is better controlled.

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Livestock trading and foot-and-mouth disease risk[1]

Chris Hawkins, Socheat Sieng and James Kerr

While the movement of people, equipment and animal products such as meat and milk pose a real risk of transferring foot-and-mouth disease (FMD), movement of live animals poses probably the greatest risk. In the greater Mekong area, cattle move over large distances in short periods, with few stops or health checks between departure and destination. Further, checking to see if an animal has FMD will only detect those with active or recent infection. It will not detect those incubating the disease, nor will it detect those carrying the virus post-infection. As part of an ACIAR project,[2] we have interviewed traders and observed them trading livestock across borders. Information collected in this study has been used to examine the impacts of prevalence, inspection effectiveness and potential for infection in transit on moving FMD across international borders.

Trading pattern

Cambodian traders intent on selling into the Vietnamese market will often source stock from Thailand markets near the Cambodian border. These stock are inspected and, if considered satisfactory by the trader, incorporated into a shipment or consignment of about 50 animals. Transport is by truck, and vehicles travel more-or-less diagonally across Cambodia, terminating near the Vietnamese border. Two main routes may be taken (Kerr et al. 2012). The journey usually takes less than 24 hours, and any inspections along the way are for shipment integrity purposes—that is, to ensure that the number and type of stock on the truck corresponds to that listed on the transport permit. On arrival near the Vietnamese border, stock are unloaded and placed in a holding facility. These facilities may allow contact between different shipments. At this point, Vietnamese buyers may inspect the consignment and could reject any animals showing signs of disease or the whole consignment. Stock are then walked across the Cambodian–Vietnamese border, before completing their onward journey by truck to an abattoir, or occasionally a feedlot. About 700 such journeys occur each year. During the walk across the border, cattle may come in contact with domestic cattle tethered nearby.

Assessing the risk

A scenario tree was constructed using Microsoft Excel®, and a risk or probability assigned to each branch of the tree. Each probability was entered as a range of possibilities, assigned empirically from best-guess information, using @Risk (©Palisade Corporation, New York). This software enables an evaluation of the importance of each component of the scenario tree and, in this case, indicates where the ‘weak links’ are and where more information is needed. The same data in the scenario tree were used to construct a discrete quantitative model to predict the number of infected shipments likely to enter Vietnam, as a cross-check to assist in the validation of model outcomes.

Results

The scenario tree itemises the conceptual events in the transport of stock from Thailand to Vietnam in a stepwise manner. This is outlined in Figures 1 and 2. Each step is assigned a likelihood value, obtained primarily from discussion with traders, with inputs from provincial and district offices, and Department

1 Originally published in 2012 in ACIAR Proceedings No. 137, 73–79, and reproduced with permission.

2 AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal diseases

of Animal Health and Production staff. These likelihood values are expert opinion and best guesses. They are not researched or confirmed by reference to collated data. Such data, though highly desirable, is not available. The scenario tree takes into account the possible prevalence at the market in Thailand, the ability of traders to remove animals that may be affected with FMD, and the chances of reinfection during stopovers or when walking across the border into Vietnam.

Simulation using the model

The likelihood of an infected shipment entering Vietnam was calculated using @Risk as described above. The model was recalculated 1,000 times, and yielded the following data (Table 1).

The model indicates that with the given estimates, the chance of a shipment arriving in Vietnam with infected cattle is about 6 in 1,000 by this trade route. Since there are about 60 shipments a month, or about 700 a year, then 4 could be infected. This value is an average that lies somewhere between about 3 in 2,000, and 2 in 100. The very wide spread around the average indicates that there is a need to further research this data. Information is being sought on FMD in Vietnam associated with this trade route.

One of the very valuable outcomes of this approach to risk is that we can gain an indication of the important components of each of the output calculations along the way, sometimes referred to as sensitivity analysis.

The first output of interest is the likelihood that infected cattle will make their way to the final destination in Cambodia, a holding facility just before the border with Vietnam. The tornado diagram (Figure 3) indicates that the biggest contributors to this are the prevalence in the cattle when purchased initially, and the ability of traders to exclude animals affected with FMD.

Secondly, it is helpful to know the key determinants for an infected shipment entering Vietnam. This is given in Figure 4; the analysis shows that the two key factors are the likelihood of a shipment becoming infected in the holding facility (secondary prevalence), and the ability to exclude infected stock at this stage. Cattle could become infected in a number of ways during their time in the holding facility: by using an area recently vacated by an infected consignment, by mixing an uninfected consignment with an infected one, or by contact between pens at feed or water points. Each of these possibilities is included in the model. Earlier factors, the original prevalence and capacity to remove infected animals prior to the holding facility, although still present, play an insignificant role at this stage of the transport chain.

Discrete quantitative modelling approach

A discrete quantitative shipment model was constructed using information from traders; they indicated that there were about 50 animals in a shipment, with about 50–60 shipments each month, contributing to about 36,000 cattle moving into Vietnam annually by this trade route. While there is some seasonality to livestock movements, this was not modelled due to lack of detailed information. Such variations may influence the timing of infected cattle moving, but in a model of this nature would not affect the final numbers in the outcomes. Onto this movement information, the probabilities used in the scenario tree were applied to determine the number of infected animals entering Vietnam. Being a discrete model, only whole shipments and whole numbers of animals were ‘allowed’ to move. This influences the output, and adds a level of realism that the scenario-tree approach lacks.

The model was run for 1,000 iterations, each iteration representing a month of trading. Outcomes were much as expected: there were 46–59 shipments per month, resulting in 2,303–3,461 cattle shipped monthly, and the number of infected animals was 0–4 per month, with averages of less than 1 per month and about 8 per year. This is a little higher than the scenario-tree approach, and reflects the nature of the model, which only deals with whole animals, rather than probabilities, as described earlier.

What do not seem to make a big difference to the risk outcomes are inspections in transit, and the possibility of becoming infected by contacting

Table 1. Simulation output of the likelihood of an infected shipment arriving in Vietnam

Number per thousand shipments						
Minimum	Mean	Maximum	5%	95%	Iterations	Variance
5.68E-04	5.65E-03	1.78E-02	1.55E-03	1.17E-02	1,000	9.87E-06

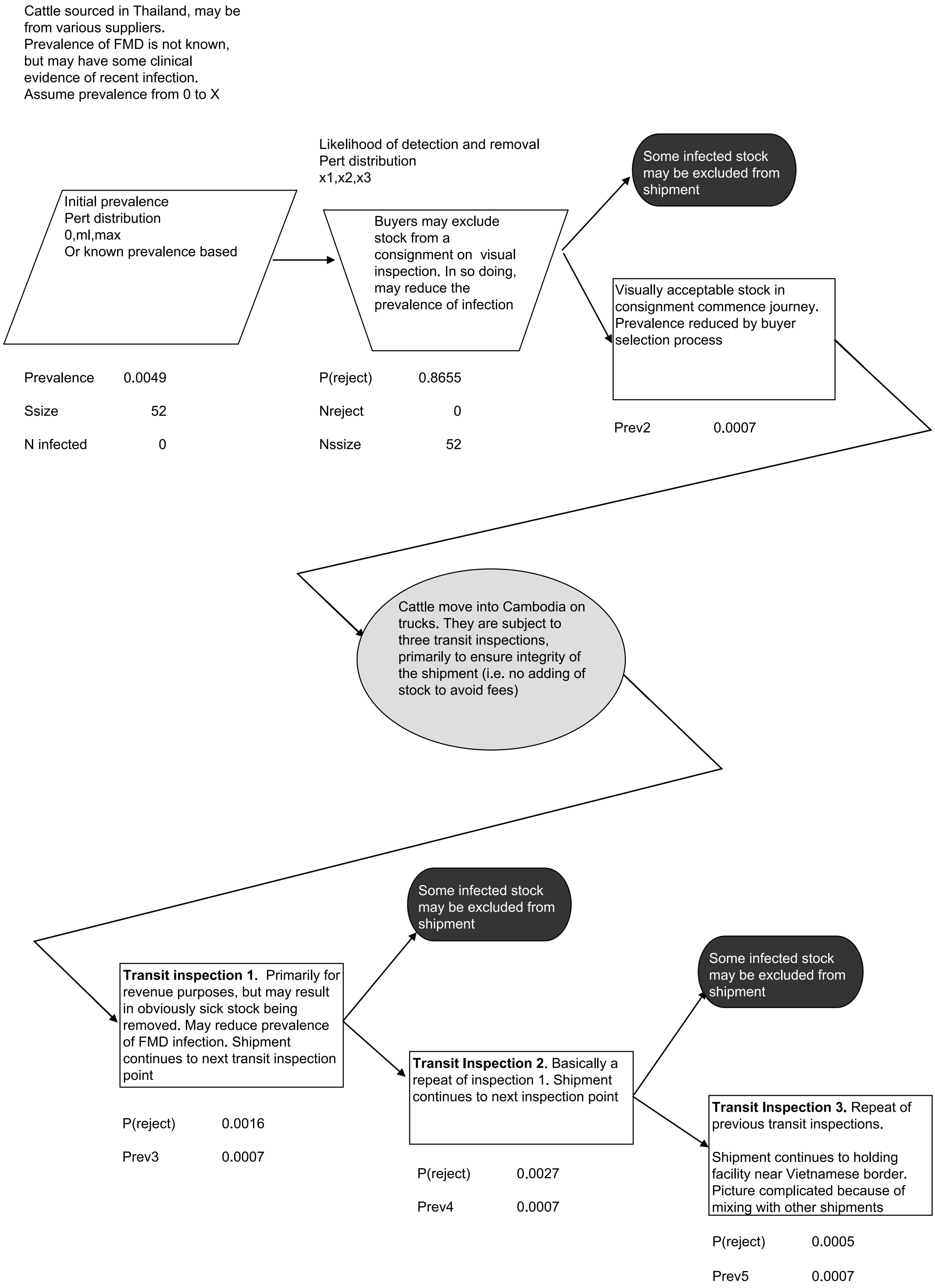

Figure 1. Scenario tree for the transport of stock from Thailand to Vietnam—Thailand to final transit inspection

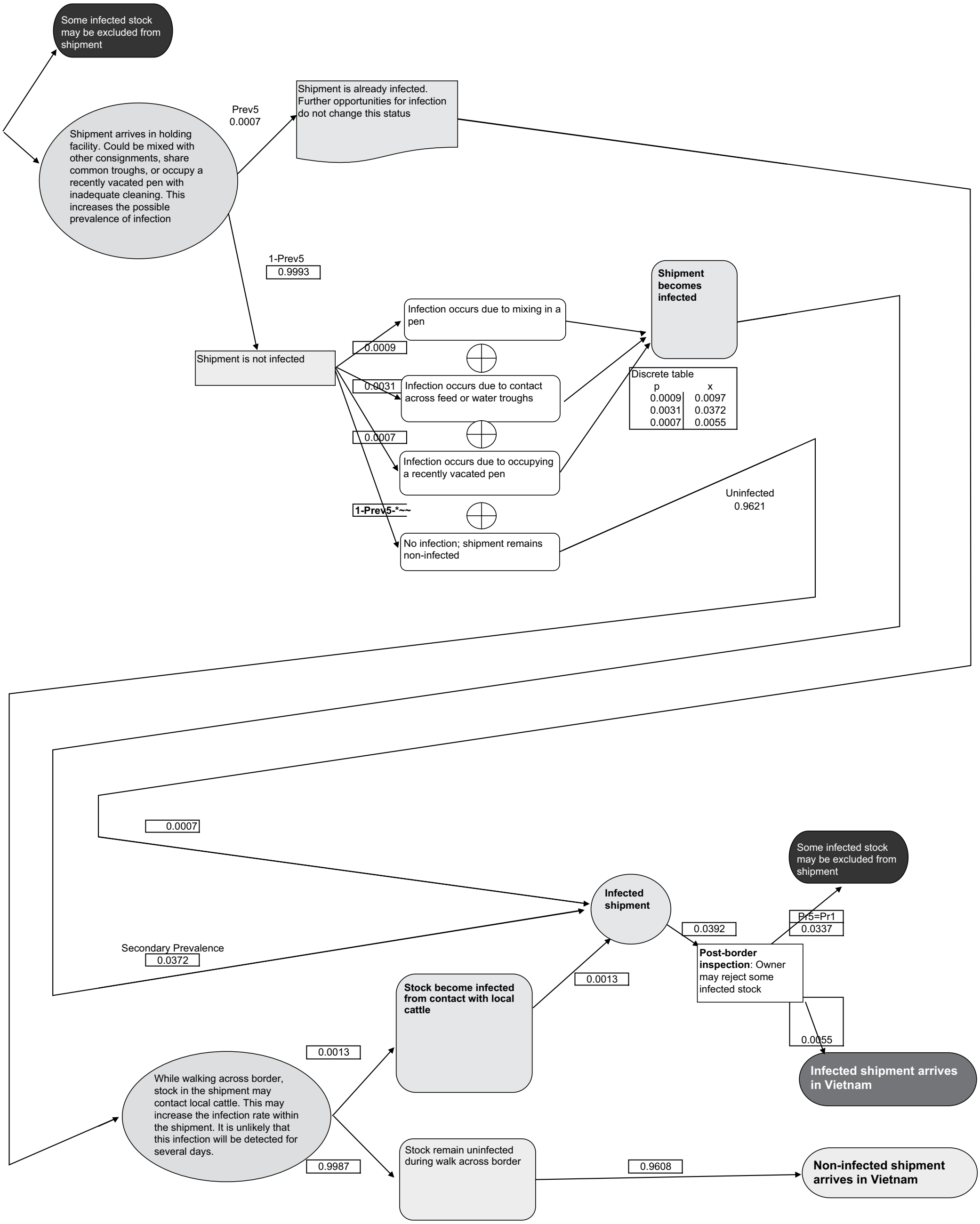

Figure 2. Scenario tree for the transport of stock from Thailand to Vietnam—final transit inspection to arrival in Vietnam

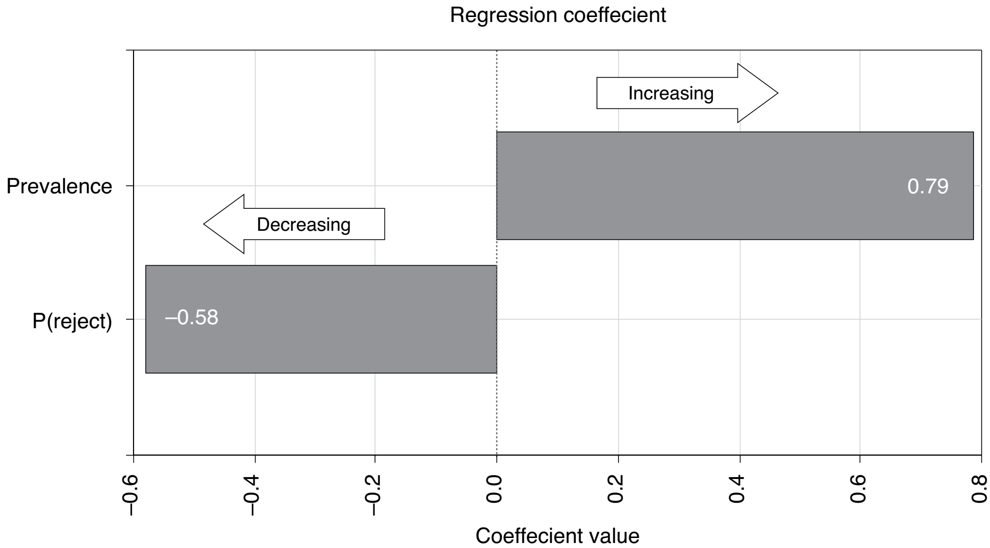

Figure 3. Tornado diagram indicating main contributors to the prevalence of foot-and-mouth disease after the last in-country inspection and when the shipment enters the holding facility near the Vietnamese border. 'Prevalence' is the disease frequency at the point of purchase; P(reject) is the likelihood that infected cattle will be rejected.

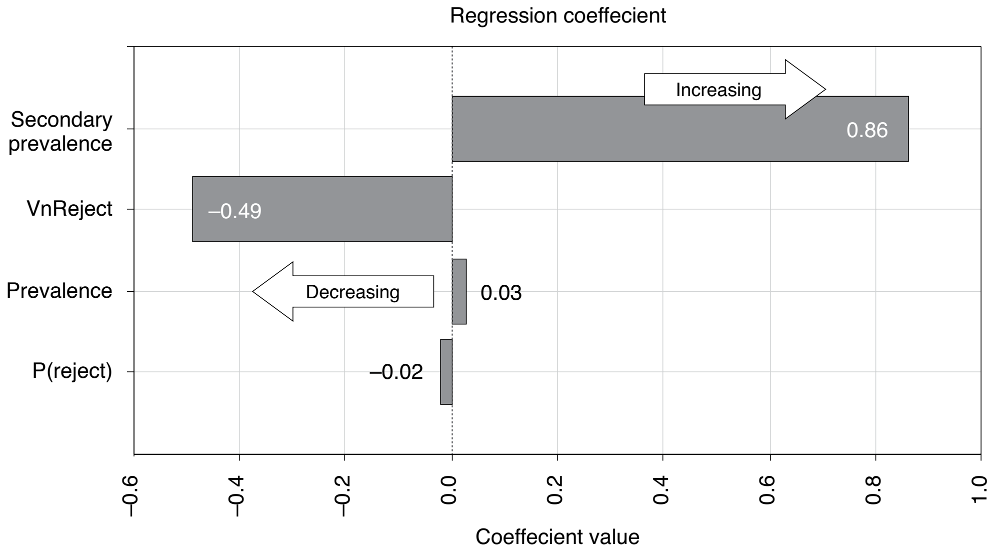

Figure 4. Tornado diagram of key factors determining whether an infected shipment enters Vietnam. Secondary prevalence is the likelihood of infection during a stopover in a holding facility, and VnReject is the likelihood of being rejected by Vietnamese traders.

local cattle while walking across the border from Cambodia into Vietnam. This is probably because transit inspections are intended to count the animals to ensure that the number on the truck corresponds to that on the trade movement permit (i.e. no biosecurity activities are undertaken) and that shipments tend to travel at night when visual appraisal of the stock is difficult. Walking stock across the border allows for very minimal contact with stock that may be tethered on the roadside, and any sick stock are more likely to be retained in the village for extra care rather than be walked to the roadside for feeding.

Understanding and interpreting the models

It is always wise to remember that a model is only a representation of the world, not the real world. However, such models do give a level of clarity that may not otherwise be apparent, and may identify areas where information is lacking.

Overall, the models indicate a number of areas where further investigation is needed:

- Prevalence at the source of cattle—it is important to know whether cattle are infected in the markets from where they are purchased by the traders.
- Ability of traders to exclude infected animals—how effectively can buyers identify and remove animals carrying FMD?
- Potential for new infections before reaching the destination—how likely is it that cattle will become infected in holding facilities near the border to Vietnam?
- Ability of the trader from Vietnam to exclude infected animals—how well can a trader from Vietnam recognise and remove infected stock from a shipment?

Addressing these issues first and foremost requires a genuine commitment to surveillance for FMD, and an effective strategy to keep infected animals out of markets. This is probably the biggest challenge facing an export livestock industry seeking to minimise the threat of FMD.

Secondly, the ability to identify and remove animals infected (or carrying) FMD is problematic. Stock showing signs of active disease would be relatively easy to exclude, as would those with suggestive lesions, or lesions that are healing after active infection. Visual appraisal is unlikely to detect convalescent carriers, or cattle incubating FMD. The transit time for livestock from Thailand to Vietnam is approximately 24 hours, which is sufficient for the virus to spread, but may not always be sufficient for clinical disease to become apparent. A rapid test to determine whether stock are infected (a cow-side test) is needed to ensure that all stock are free from the FMD virus.

Thirdly, the potential to spread between consignments in holding facilities requires very high-level biosecurity practices—the ability to keep shipments strictly separate, so that there is no physical contact, movement of aerosols or other body products between shipments. Staff engaged to feed, water and tend to stock in holding facilities would need to maintain strict biosecurity standards.

Clearly, some of these strategies are not practical at present, and some alternative methods would need to be considered. In the short term, the following could be worthwhile:

- Ensure every animal coming into the market has been effectively vaccinated with the most commonly occurring strains of FMD, at a time before market that enables protective antibodies to develop. This would markedly reduce the effective prevalence of infection in trading cattle at markets. However, it would still be wise for traders to inspect stock carefully, and exclude any that show active or recent signs of infection with FMD.
- Make better use of the official checkpoints along the journey—increase the benefits of stopping to examine livestock on trucks. Any signs of FMD in the stock should warrant biosecurity action. Confirming or excluding FMD in the shipment will have long-term benefits to transporters and buyers.
- Minimise time in holding facilities, and implement a management system for these facilities that includes thorough cleaning of holding areas between shipments; construction of an isolation area for suspect consignments, away from the main holding area; development of a rapid communications process that alerts traders to the presence of FMD when or if it occurs; and application of total quarantine of a holding facility if FMD is detected.
- For traders in Vietnam buying stock, ensure a minimum time from purchase to slaughter. In other words, as soon as an animal is purchased, consign it to the abattoir. If stock are to be kept for any length of time (e.g. in a feedlot), arrange these as a special consignment, ensure they were vaccinated ahead of time, and keep them isolated from other stock from the time of vaccination.
- Routinely clean trucks carrying livestock after every shipment. There is no way round this—trucks become contaminated, and can be very efficient spreaders of FMD.

- Promote the importance of these strategies through effective media and educational campaigns.

Again, these suggestions may sound impractical. However, we are dealing with a highly infectious disease that nobody anywhere in the world wants. Only with long-term commitment from all stakeholders (traders, buyers, cattle growers, governments, non-government organisations and private companies) can advances in FMD control be achieved.

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Kerr J., Socheat Sieng and Scoizec A. 2012. Working with traders to understand livestock movements and spread of animal diseases in Cambodia and Lao PDR. In 'Animal biosecurity in the Mekong: future directions for research and development', ed. by L.B. Adams, G.D. Gray and G. Murray. ACIAR Proceedings No. 137, 59–64. Australian Centre for International Agricultural Research: Canberra. [Reproduced in these proceedings, pp. 101–106]

Working with traders to understand livestock movements and spread of animal diseases in Cambodia and Lao PDR[1]

James Kerr, Socheat Sieng and Axelle Scoizec

This paper describes some outputs and insights from a project[2] designed to better understand livestock movements in Cambodia and Lao PDR to better assess and predict the risk of trans-boundary animal disease spread throughout the Greater Mekong Subregion (GMS). The project focused on movements of cattle, buffaloes and pigs and the associated occurrence of foot-and-mouth disease (FMD) and classical swine fever (CSF). Information collected from livestock traders was crucial in understanding movement drivers, trading practices that influence disease risk and the significant unofficial livestock trade across country borders. This information was collected by Socheat Sieng and the original study is published elsewhere in these proceedings (see Socheat Sieng et al. 2012).

An initial approach was to compile and analyse government permits to describe livestock movement patterns in Cambodia and Laos. Although these official records were useful in identifying and helping to quantify seasonal and longer term changes in movement patterns, they failed to capture important information about movement drivers, trading practices that influence disease risk and the significant unofficial livestock trade that accounts for the majority of cross-border livestock movements in the GMS.

Consequently, the project consulted extensively with livestock traders throughout Cambodia and Laos to determine:

- important trade routes for cattle, buffaloes and pigs
- quantitative movement data for those trade pathways
- sociological background information for livestock movements, including
  - trading practices
  - trader networks
  - trader knowledge of disease and biosecurity
  - movement drivers and trade impediments (official and unofficial).

Our research was also intended to develop a relationship with traders in these countries for ongoing consultation, research and education.

Method

A project consultant managed data collection from traders in each country. The Cambodian Department of Animal Health and Production (DAHP) and Lao PDR Department of Livestock and Fisheries (DLF) facilitated the process.

In Cambodia, a team of trained researchers used questionnaires to collect qualitative and quantitative data in one-on-one interviews with traders. The DAHP was excluded from these interviews to ensure confidentiality and encourage honest responses. Data collection in Laos followed a less structured checklist approach, with DLF staff present as translators.

Traders were interviewed throughout each country, with an increased focus on those provinces that featured significantly in long-distance and cross-border livestock trade. Data was collected in important border provinces in collaboration with the Food and Agriculture Organization of the United Nations, the Asian Development Bank and the World Organisation for Animal Health South-East Asia Foot-and-Mouth Disease Campaign (SEAFMD)

1 Originally published in 2012 in ACIAR Proceedings No. 137, 59–64, and reproduced with permission.

2 ACIAR project AH/2006/025: Understanding livestock movement and the risk of spread of trans-boundary animal diseases

study on cross-border movement and market chains of large ruminants and pigs in the Greater Mekong Subregion.[3]

'Snowball sampling' was undertaken when following trader networks, whereby interviews with key traders (primary respondents) identified suppliers and buyers in their trading networks for follow-up interviews (secondary respondents). This technique presented time, cost and logistical challenges when investigating trading networks that operate on a national and international scale.

Results

The major trade routes for cattle, buffaloes and pigs in Cambodia and Laos were described, particularly transnational pathways that represent the greatest risk of spreading trans-boundary animal diseases rapidly between countries (Figure 1). Trade volumes across these major routes between 2008 and 2009 were quantified (Figure 2).

Some of the more significant livestock trading and movement patterns in Cambodia and Laos during the study period are described below. Although these patterns may already be changing, the research also generated less ephemeral information about trader networks, trading practices and the trading environment (including geographical, seasonal, political and regulatory influences). This information will guide interventions aimed at reducing the disease risk associated with livestock trading.

Livestock movements in Cambodia

Cambodian cattle and buffaloes are directed to different slaughter markets according to body condition and quality. Vietnam appears to be the market for the best-quality animals, followed by Phnom Penh, with Cambodian provincial slaughterhouses the destination for animals of a lower standard. The poorest-quality animals, including the injured and diseased, are slaughtered locally.

Much of the movement of cattle and buffaloes from Cambodia into Vietnam is unofficial with some village-level trade in the vicinity of the border. Larger numbers of cattle and buffaloes move through export depots in an organised trading system facilitated by a small number of Cambodian trading companies. Livestock producers in Cambodia aiming to supply the Vietnamese market must be aware that the importation protocols may vary.

Cambodia also acts as a conduit for cattle and buffaloes moving from Thailand to Vietnam. During 2009, this transit trade involved the movement of 200–300 truckloads of cattle and buffaloes per month, representing up to 150,000 animals for the year. In mid 2010, this trade was100 truckloads per month, highlighting the variability of movement patterns. Further research is required to determine whether a proportion of these transit cattle originated in Myanmar, as this factor might influence the risk pathways for trans-boundary livestock diseases across the region.

Transit movements through Cambodia are rapid, with most animals taking less than 1 day to get from the Thai border to export depots located close to the Vietnamese border in the south-eastern Cambodian provinces of Kampot, Takeo, Svay Rieng and Kampong Cham (Figure 3). Once the transit livestock arrive in the Cambodian export depots, however, they may wait between several hours and several days before being walked into Vietnam. Contact between various livestock consignments in these depots may be a significant feature of the disease-risk pathways. Consequently, improved biosecurity practices or other interventions at these depots may represent an opportunity to significantly reduce (or at least assess) the disease risk associated with the livestock trade into Vietnam.

Cambodia is an importer of pigs, with Vietnam and Thailand the main suppliers. In recent years, however, Cambodia has imposed importation bans on pigs from Vietnam due to concerns about disease incursions. These import bans significantly altered movement patterns and pig population dynamics within Cambodia during 2008, with pig populations in some provinces greatly depleted in the attempt to meet market demand in Phnom Penh. Pigs are still imported from Thailand to meet the slaughter market demand in Phnom Penh and Siem Reap.

Livestock movements in Lao PDR

Laos is an importer and exporter of cattle and buffaloes, and a transit country for livestock destined for Vietnam and (more recently) China. Quotas of Thai cattle are imported through various provinces to satisfy the slaughter demand in Vientiane, which is also serviced by livestock from northern Lao provinces including Sayabuli, Luang Prabang and Xieng Khouang.

3 This report can be found at the project website: http://ulm.animalhealthresearch.asia.

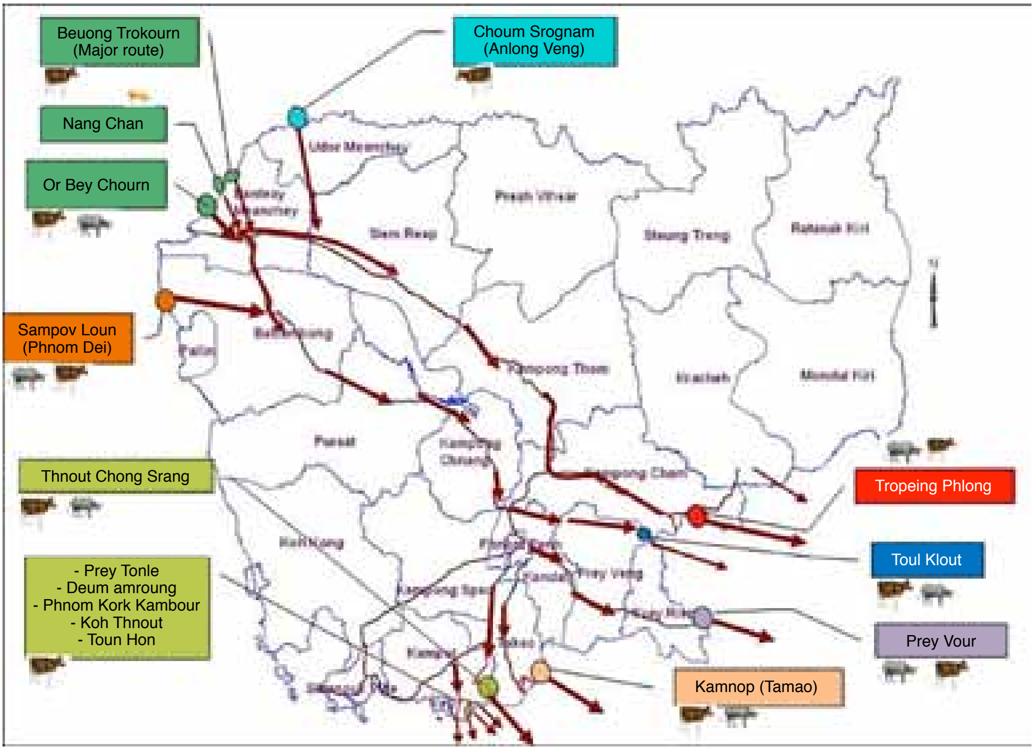

Figure 1. Transit routes for cattle and buffaloes moving from Thailand through Cambodia into Vietnam

The north-eastern province of Xieng Khouang is important as a production area for cattle and buffaloes and also as an export pathway for Lao and imported livestock moving into Vietnam. Most of the cattle and buffalo (and horse and goat) trade into Vietnam through Xieng Khouang is unofficial. This trade pathway was estimated to represent 2,500–3,000 head of cattle (60%) and buffaloes (40%) per month during 2008–09, of which 10% were thought to have originated in Thailand. Some of the livestock movement pathways that exit Laos through Xieng Khouang stretch from the southern, western and northern provinces of Laos, and feature a number of transaction and storage locations along their length. As with the Cambodian export depots, these locations represent both high-risk points for disease transmission and potential opportunities for applying risk-reduction strategies.

Significant transit movements of cattle were reported through southern Laos from Thailand into Vietnam, particularly the movement of up to 15,000 head of cattle per month through Savannakhet province during 2008–09 (see Figure 2). This particular movement reportedly had official approval from the Thai and Lao authorities, but required unofficial entry into Vietnam, highlighting the difficulty of understanding regional livestock movements by examining official records.

Early in 2010, increased rapid movement of cattle from Thailand through north-western Laos into China was reported as an increasing trend.

As with the transit cattle exported through Cambodia into Vietnam, further research is required to determine what proportion of the cattle and buffaloes entering Laos from Thailand originate in Myanmar.

Like Cambodia, Laos is a net importer of pigs. A limited number of fattened pigs are imported from Thailand for slaughter, but imports from Thailand mainly take the form of piglets for fattening on Lao farms. The locations of highest demand for pig meat in Laos are Vientiane, Luang Prabang in the north and Pakse in the south.

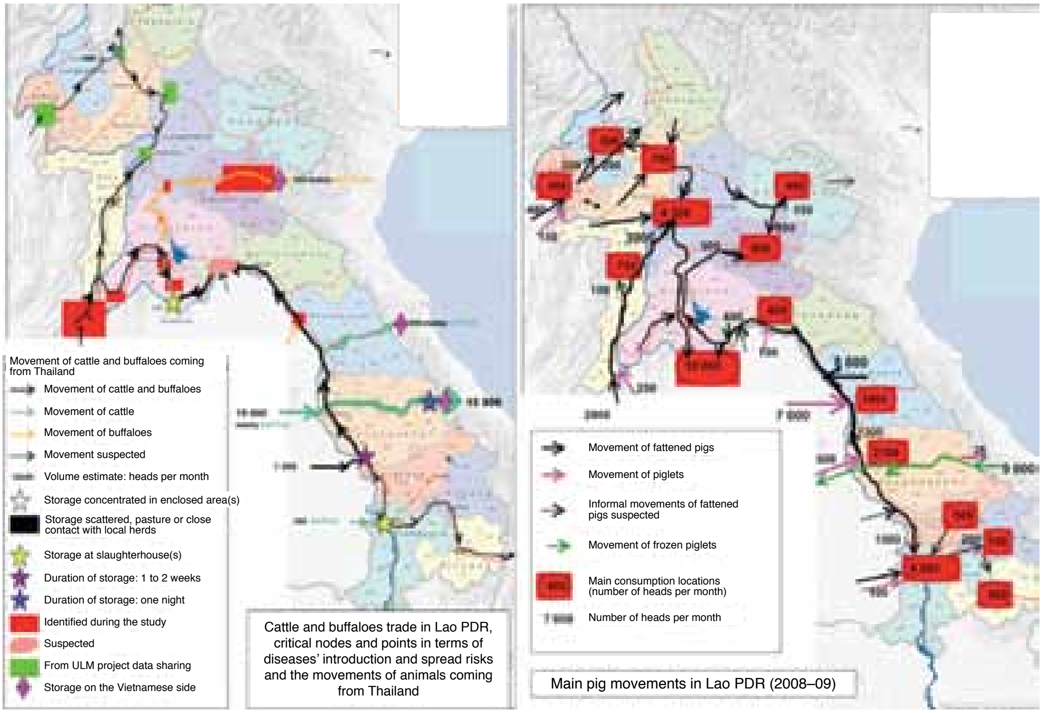

Figure 2. Trade routes and volumes through Lao PDR for cattle and buffaloes (left) and pigs (right), 2008–09

Market chains and trader networks

Market chains and trader networks were described in both countries (Figures 3 and 4). One-on-one interviews in Cambodia identified trading practices that carry a high risk of spreading disease. Of the Cambodian traders interviewed, 45% admitted to having traded in livestock affected with FMD, as the low prices accepted by farmers for sick animals can make them a profitable commodity for traders. Whether these sick animals are kept for recovery and resale or intended for local slaughter, they represent an important feature of the risk pathway for FMD, given the common trader practice of housing them after purchase with other livestock in the trader's village before resale or slaughter.

Fortunately, many livestock traders were keen to receive information about disease transmission and biosecurity, offering hope that trader education might be able to modify high-risk practices engaged in through ignorance.

Discussion and conclusions

Research with traders identified a number of critical points along the trade pathways where interventions might be attempted to reduce the risk of disease spread. These critical points included:

- physical features of the trade pathways, such as the small number of livestock depots located in south-eastern Cambodia, through which all transit cattle from Thailand must pass before entering Vietnam
- important stakeholders with the ability to influence the trade (risk) pathways, such as the small number of Cambodian trading companies that facilitate most livestock trade across Cambodia's borders
- trading practices used by livestock traders that carry a high risk of spreading livestock diseases.

This information will contribute significantly to risk pathway analysis for FMD and CSF in the GMS, which is intended to assist the development of animal movement policy in the region. A risk analysis of several major trade routes in Cambodia and Laos is planned in 2010–11, to identify future research

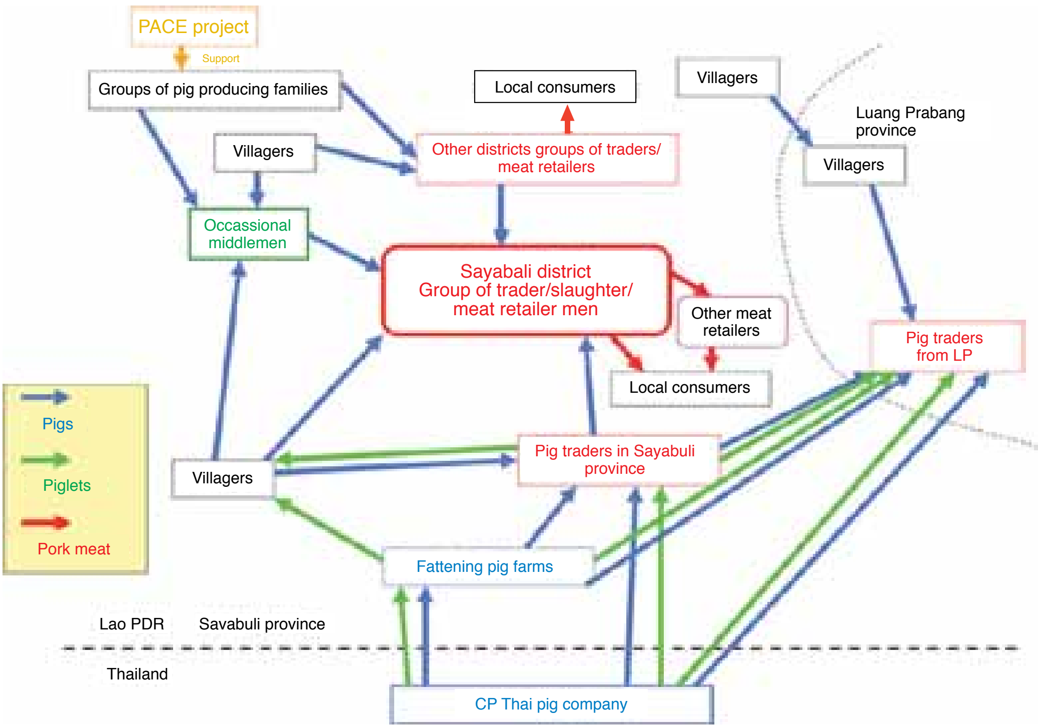

Figure 3. An example of a market chain for pigs, Sayabuli province, Lao PDR. The diagram cannot be fully explained because of a confidentiality agreement between the researchers and traders.

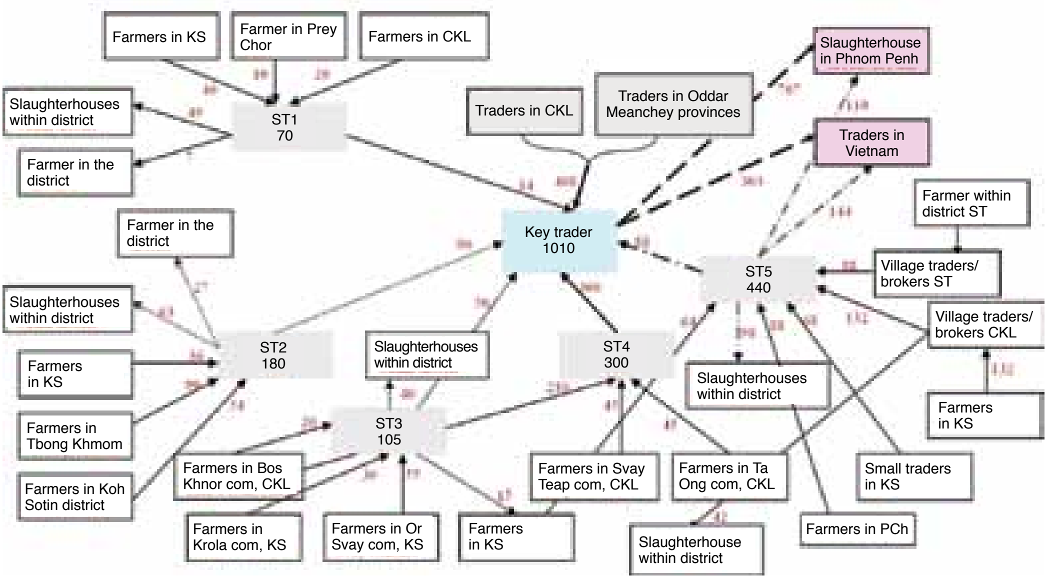

Figure 4. An example of a trader network in Kampong Cham province, Cambodia. The diagram cannot be fully explained because of a confidentiality agreement between the researchers and traders.

priorities. An initial risk analysis has been completed (Hawkins et al. 2012).

Opportunities have been identified for improved biosecurity practices and risk-reduction interventions at various points along the risk pathways for these diseases. Ongoing work with livestock traders is fundamental to these proposed interventions, and feedback meetings have already been conducted throughout both countries for that purpose.

The project is already developing and trialling educational materials in various formats to improve trader understanding of disease transmission and basic biosecurity.

The information collected by this project is not available from official sources. It has emphasised the importance of continuing to work with important industry stakeholders in developing animal movement and disease control strategies.

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Investigating trans-boundary livestock trade and associated disease risk in the Greater Mekong Subregion

James Kerr, Nancy Bourgeois Lüthi, Socheat Sieng, Phouth Inthavong, Ben Madin and Chris Hawkins

Introduction

This paper describes research conducted during 2010–12 as part of the 'Understanding livestock movement and risk of spread of trans-boundary animal diseases' project (Australian Centre for International Agricultural Research [ACIAR] project AH/2006/025). Information collected from livestock traders throughout Lao PDR and Cambodia from 2008 to 2010 identified important trade routes running through Cambodia and Laos, and across their borders (Kerr et al. 2012). Some of these trade routes were primarily transit pathways used to transport cattle and buffaloes from Thailand and Myanmar across Cambodia and Laos to destination markets in Vietnam and China. Three transit pathways were selected for further research because of their potential to rapidly move livestock and associated livestock disease across several countries in as little as 24 hours:

- the transit routes delivering Thai cattle and buffaloes to southern Vietnam via Cambodia
- the route transporting cattle and buffaloes from Thailand to central Vietnam via Savannakhet province in Laos
- the 'fast-track' route delivering cattle from Thailand (and reportedly Myanmar) to China through Laos' north-western provinces of Bokeo and Luang Namtha (reported for the first time early in 2010).

We aimed to investigate whether these movement pathways posed a risk of introducing disease to local livestock populations in Cambodia and Laos and, conversely, whether local livestock populations in Cambodia and Laos had the opportunity to contribute a disease risk to the transiting livestock.

Methods

Our research between 2008 and 2010 demonstrated that traders were a far better source of trade information than official records. Applying methodology that had previously been successful in the project, independent consultants were engaged to manage the research in each country. The work of the consultants were facilitated by the Department of Livestock and Fisheries (DLF) in Laos, the Department of Animal Health and Production in Cambodia and the Department of Animal Health (DAH) in Vietnam. To take advantage of established contacts and existing knowledge, the consultants chosen had already collected information from traders for both our project and the study on cross-border movement and market chains of large ruminants and pigs in the Greater Mekong Subregion by the Food and Agriculture Organization of the United Nations, the Asian Development Bank and the World Organisation for Animal Health South-East Asia Foot-and-Mouth Disease campaign (Cocks et al. 2009).

In addition to the pathways listed above, the project also attempted to gather quantitative data about the important trade pathway for cattle and buffaloes (and horses and goats) that enter northern Vietnam through the Lao province of Xieng Khouang. This trade route moves cattle and buffaloes from Thailand (and probably Myanmar) into northern Vietnam, but also delivers a significant number of homebred livestock from various Lao provinces into Vietnam.

Consequently, it cannot be considered merely a 'transit' route, and is a complex pathway to analyse for disease risk. Our efforts to record trade volumes across this unofficial border pathway over a 12-month period were unrewarding, despite paying official road checkpoints and village 'smugglers' to do so.

Most of the project's risk assessment work was attempted at a qualitative level, and was intended to identify opportunities to reduce the disease risk associated with these trans-boundary trade pathways.

Results

Trade route delivering cattle and buffaloes from Cambodia to southern Vietnam

Our research of movement patterns suggested that Vietnam was the destination for most trans-boundary cattle and buffalo movements that involve Cambodia and Laos. Vietnam was therefore the main recipient of the associated disease risk. We shared these findings with Vietnam's DAH at a risk pathway workshop conducted by the project at the 2009 Meeting of the Lower Mekong Working Group on Foot-and-mouth Disease Control, held in Ho Chi Minh City on 25 November 2009.

Two research trips were subsequently undertaken by the project in collaboration with Vietnam's DAH in February and June 2011 to investigate the Vietnamese end of the livestock market chains (and associated risk pathways) that run through Cambodia into Vietnam.

This research was expected to complement similar research conducted for the study on cross-border movement and market chains of large ruminants and pigs in the Greater Mekong Subregion (Cocks et al. 2009) in northern Vietnam in 2009, which described the Vietnamese end of the livestock market chains entering Vietnam through Laos.

Cambodian section of the trans-boundary risk pathway

Cambodian livestock depot operations: A significant research finding was that each of the important trade routes delivering cattle and buffaloes from Cambodia into southern Vietnam features an 'export depot' in Cambodia close to the border with Vietnam.

In these depots, animals from different consignments can have close contact or share troughs and pens recently vacated by previous consignments, representing a critical point for disease spread (and possibly control) in the trans-boundary risk pathways for various contagious diseases, including foot-and-mouth disease (FMD).

The cattle and buffaloes that are delivered to these Cambodian depots originate in Thailand, Myanmar and various parts of Cambodia. Animals that enter Cambodia from Thailand are walked across the Thailand–Cambodia border after being selected for purchase by Cambodian and Vietnamese traders at Thai markets and farms located close to the border. The animals are then loaded onto trucks in the north-western Cambodian provinces of Banteay Meanchey, Battambang and Oddar Meanchey and transported across Cambodia in a single journey of less than 24 hours. There is usually a single stop at a midway point for the purpose of inspection by animal health authorities, which involves checking paperwork rather than animal health. The animals are not unloaded, so these inspections appear to have little bearing on the disease risk posed by the consignment.

The transit trade routes run diagonally across Cambodia from the north-west to the south-east and terminate in export depots located in five Cambodian border provinces: Kampong Cham, Prey Veng, Svay Rieng, Takeo and Kampot. The depots are used as staging points for the final, unofficial movement of livestock across the border into Vietnam. The animals are generally delivered to the depots by truck, and are then walked or swum across the border into Vietnam, depending on the location of the depot and time of year.

The transit routes through Cambodia are shown in Figure 1, including entry points from Thailand and exit points into Vietnam

The first of these export depots was established in 2006–07, and most have only existed since 2008. The majority of the livestock moving through them were originally Thai cattle that were permitted entry into Cambodia only for transit to Vietnam (i.e. these animals were not permitted to remain in Cambodia). This transit trade peaked in 2008, when as many as 45,000 animals per month reportedly moved from Thailand into Cambodia via Or Bey Chourn in the Cambodian province of Banteay Meanchey, destined for Vietnam (see Figure 1). Project research at the Vietnamese end of this market chain suggests that a proportion of these 'Thai' animals originated in Myanmar, but that the majority were genuinely of Thai origin.

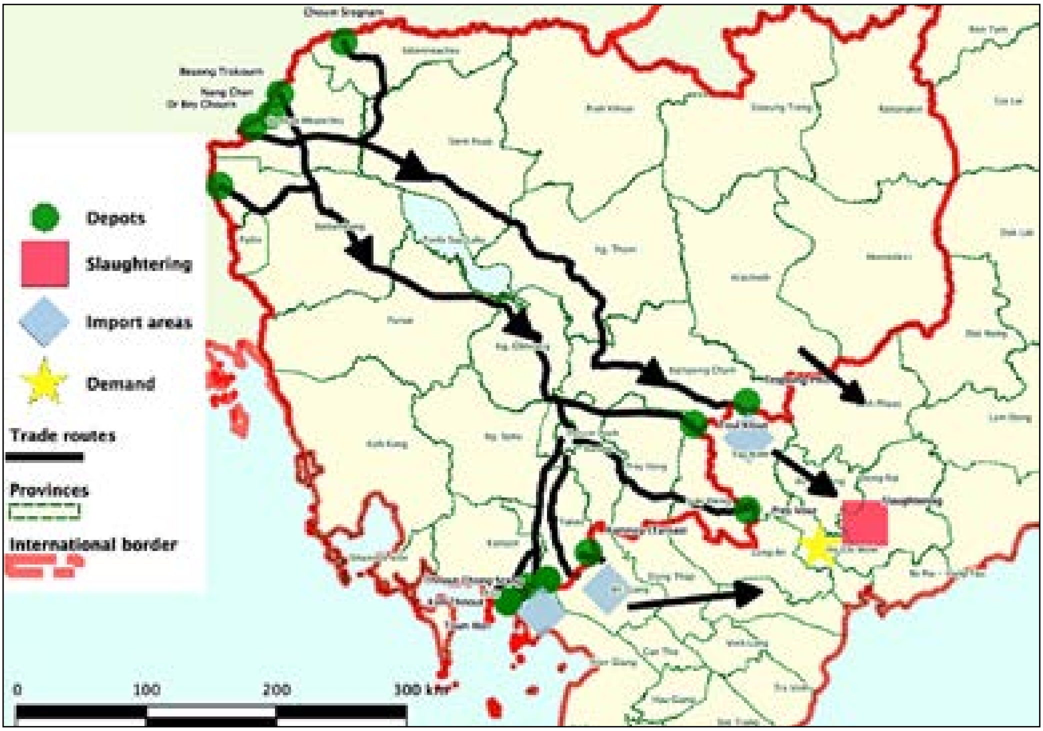

Figure 1. Trans-boundary trade routes passing through Cambodia in 2007–11, demonstrating the location of Cambodian and Vietnamese border provinces and depots featured in the cross-border movement of cattle and buffaloes to service major markets for beef in southern Vietnam

The vast majority of livestock handled by some of the Cambodian export depots during the peak of the transit trade in 2007–08 was made up of transit cattle and buffaloes from Thailand. Other depots featured a regular throughput of Cambodian livestock, representing an additional risk factor for introduction of disease into the market chain. Since the volume of Thai cattle has declined, however, all of the depots for which we have obtained information now include Cambodian-bred cattle in their export operations. Given that FMD vaccination of livestock in Cambodia is practised far less commonly than in Thailand, the increasing volume of Cambodian livestock being imported into Vietnam presumably adds to the trans-boundary disease risk.

Other risk factors identified in the operations of the Cambodian livestock depots include the following:

- The mechanisms of disease spread and biosecurity measures for disease control are poorly understood by depot managers and staff.
- Animals from different consignments or owners are sometimes mixed in the same pen.
- Even when kept in separate pens, livestock from different consignments have the opportunity for nose-to-nose contact.
- Although consignments of Thai transit cattle are generally kept separate from consignments of local Cambodian cattle, they are sometimes mixed if they are owned by the same trader.
- There is no effort to clean water troughs, discard partially eaten feed, or clean or spell pens between consignments.
- Trucks delivering livestock to depots sometimes have to drive through livestock holding areas to reach the unloading ramp, offering an opportunity for contamination of trucks (or contamination by trucks) in the process.
- Cleaning of trucks is dependent on how dirty they have become, and is never accompanied by disinfection.

- Although traders aim to limit costs by keeping the time spent by livestock in depots to a minimum, consignments sometimes spend more than 4 days in the depot.
- Many depot staff have their own livestock at home, but have no understanding of biosecurity. They rarely make any effort to clean themselves before returning home after working at the depot, creating an opportunity for transmission of disease from transit consignments to local livestock populations. The reverse risk also exists: depot workers who arrive at work after handling sick local livestock may introduce disease into transit consignments.
- Cambodian farmers sometimes use the export depots as a 'market' to purchase replacement breeding and draught animals.
- Foot-and-mouth disease is reported to have occurred in some depots, and is well known and recognised by all depot staff interviewed.
- Sick livestock in the depots (including FMD-affected animals) are sold to local traders to partially recoup losses. Occasionally, Vietnamese traders buy these animals cheaply for slaughter in Vietnam.
- Local livestock populations have the opportunity for contact with export consignments in some depots.
- Local livestock populations that are close to some depots have the opportunity for contact with export consignments as they are moved across local grazing areas during their walk to the Vietnamese border.
- Vietnamese traders generally have no particular animal health requirements, such as a preference for vaccinated animals or vaccination certificates.

The depots are critical points in the disease risk pathway associated with the regional livestock trade. Because a limited number of these depots are in operation, it seems feasible that non-regulatory risk-reduction interventions might be attempted with this small stakeholder group. Although the feedback from depot managers generally suggested that they would willingly participate in non-regulatory biosecurity training initiatives, the hesitant response from a small number of depots made it clear that proceeding with such initiatives would depend on obtaining approval from the well-connected owners of these depots and the three large trading companies that 'regulate' this export trade. The ACIAR project 'Domestic and international market development for high-value cattle and beef in south-east Cambodia' (ACIAR project AH/2010/046; ACIAR 2012) plans to pursue this opportunity for improving biosecurity in the market chain for cattle moving between Cambodia and Vietnam.

As a result of less favourable exchange rates, increasing transport costs and increasing scarcity of Thai livestock, the transit trade from Thailand became less profitable for traders and declined substantially during 2010. By early 2011 the trade via Or Bey Chourn was estimated to represent only 650 animals per month. Ongoing Vietnamese demand for beef has been met (at least partly) by importing an increasing number of juvenile Cambodian cattle, which are fattened for up to 12 months on Vietnamese farms before slaughter.

Vietnamese section of the trans-boundary risk pathways

Although it appears that all Vietnamese provinces that border Cambodia are involved in the cross-border trade of cattle and buffaloes to some extent, four provinces are reported to channel the highest volumes: An Giang, Kien Giang, Tay Ninh and Long An. Not surprisingly, these four Vietnamese provinces are across the border from the Cambodian depots located in Takeo, Kampot, Kampong Cham/Prey Veng and Svey Rieng, respectively.

The geographical relationship between the Cambodian and Vietnamese provinces that feature in the cross-border livestock, and their proximity to the large beef market of Ho Chi Minh City, is shown in Figure 1.

Project research in 2011 confirmed:

- the volume of Thai cattle and buffaloes arriving in southern Vietnam via Cambodia peaked in 2008–09 and markedly declined in 2010–11
- an increasing trade has developed in juvenile Cambodian cattle for fattening in Vietnam.

Although the fattening scheme certainly involves Vietnamese border provinces, particularly An Giang province, many imported juvenile cattle are also distributed to other provinces in southern Vietnam for fattening. Because none of the imported Cambodian cattle are likely to have been vaccinated against FMD (unlike at least a proportion of cattle imported from Thailand), this growing trade represents a change in the disease risk to Vietnam associated with the cross-border trade.

Many of the cattle imports that enter Vietnam's An Giang province from Takeo province in Cambodia are gathered at Ta Ngau Assembly Market before being distributed to other locations. Vietnamese animal health authorities ensure FMD vaccination of livestock passing through this market, but only for animals leaving the province. Cattle retained for fattening within An Giang province wait for the free 6-monthly FMD vaccination campaign in border provinces that occurs in April–May and September–October of each year. Our DAH research colleagues recognised this finding as a weakness in their disease control protocols and a valuable output of our collaborative risk pathway research.

The main reason offered by Vietnamese traders for the significant and rapid decline in the trade in Thai cattle and buffaloes was unfavourable currency exchange rates, highlighting the narrow profit margins in this trade. Cambodian traders also blamed unfavourable exchange rates, in addition to increased transport costs.

Sources at the DAH expected that our simultaneous risk pathway research in Laos would find that the lower numbers of Thai cattle and buffaloes imported via Cambodia would be balanced by an increased number entering Vietnam through southern Laos. This was not the case.

Trade route delivering cattle and buffaloes from Thailand to central Vietnam via Savannakhet province in Laos

Savannakhet province is situated in central Lao PDR along the East–West Economic Corridor, a route extending over 1,300 km, linking the Indian Ocean to the South China Sea. Savannakhet has international borders with Thailand (Mukdahan province) along the Mekong River in the west and Vietnam (Quang Tri province) in the east (Densavanh/Lao Bao border gate) (Figure 2).

Research in 2009 reported that cattle and buffalo movements through Savannakhet province from Thailand to Vietnam were as high as 15,000 animals per month. Project researchers revisited Savannakhet province in May 2011 to see if those trade volumes had been maintained (or increased, as expected by the DAH in Ho Chi Minh City), and to assess the border-crossing protocols applied at each of the two borders to minimise the risk of disease spread.

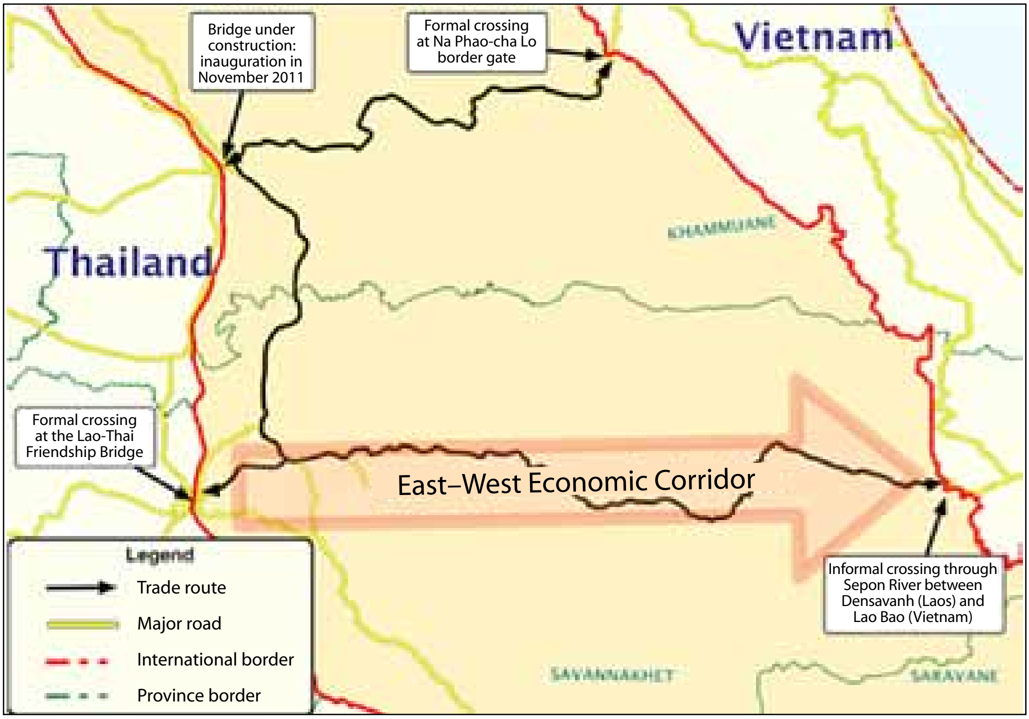

Figure 2. Transit pathway of cattle and buffaloes through Savannakhet and Khammouane provinces, Laos

It was planned that our project partners in the Lao DLF would provide retrospective information about recent FMD outbreaks along this trade route to compare the disease risks associated with different border-crossing protocols (unloading into export depots before border crossing compared with direct transit across borders). Unfortunately, due to the more urgent, non-project workload required of DLF project partners, the disease surveillance information was never provided, so the comparative risk assessment could not be carried out.

Quarantine office records at the Thai–Lao Friendship Bridge border crossing indicated that the Savannaket transit trade in large ruminants had declined markedly from its peak in 2009 (up to 15,000 per month) to 33,000 for all of 2010, and only 1,500 animals for the first quarter of 2011.

The reasons offered by traders and officials for this decline were:

- increased prices for Thai cattle due to shorter supply and unfavourable currency exchange rates
- floods in the Isaan region in eastern Thailand that reduced the availability of livestock.

A proportion of the livestock that are granted importation permits by Lao authorities for direct transit to Vietnam 'disappear' along the way, representing a possible disease risk. During the first few months of 2011, cattle and buffaloes in all 15 districts of Savannakhet were affected by FMD outbreaks, but the Lao DLF did not provide us with their evaluation of the source of those outbreaks.

'Fast-track' route delivering cattle from Thailand (and reportedly Myanmar) to China through the north-western Lao provinces of Bokeo and Luang Namtha

Early in 2010, while conducting feedback meetings for traders in the north-west of Laos, project staff reported the following:

> Chinese large ruminants demand: Chinese demand seems to have increased since last year. Now direct transit is officially done between Thailand and China through Bokeo and Luang Namtha provinces. This movement is official in Thailand and Lao PDR but apparently the entry in China would be informal. The volume is about 300 to 400 heads per week.

Project researchers returned to Bokeo and Luang Namtha provinces early in 2011 to investigate this cross-border trade, the 'fast-track' nature of which may help to reduce the risk of disease spread associated with longer border-crossing practices. The border-crossing pathway is shown in Figure 3.

The research on this border crossing found that:

- the trade began in 2008, apparently to help satisfy demand created by the Beijing Olympics, and operated mainly between September 2009 and May 2010; it had ceased by late 2010
- the trade volume was approximately 1,600 animals per month from October 2009 – September 2010, and was mainly comprised of Thai cattle, with some Lao cattle also sold into China
- it was not a 'fast-track' movement, and the trade was not official.

The reasons for stopping this trade included:

- unfavourable exchange rates
- stricter biosecurity measures taken by Chinese border officials
- scarcer supply of livestock in Thailand.

In terms of disease risk associated with the trade pathways into China, transiting animals and travelling traders were reported by one trader to be linked to FMD outbreaks in the north-western provinces and in Chinese depots, prompting stricter controls by Chinese authorities.

This research also suggested that this cross-border trade may well start again when conditions become more favourable, highlighting the versatility of traders who deal in commodities other than livestock when livestock are not profitable.

Discussion

It is clear that these particular trade routes cannot be considered a permanent feature of livestock movements in the region. The movement patterns that we reported in 2008–09 were considerably different from those described a few years earlier, which featured movement of cattle and buffaloes to the southern provinces of Cambodia for export to Malaysia by ship. By 2010 the movement patterns that we had described in 2008–09 were changing, with a greatly reduced number of Thai cattle moving to Vietnam.

However, certain aspects of the trans-boundary trade, particularly the identity of the major stakeholders and the practices of the traders, transporters, depot operators and other participants were likely to be less changeable and therefore more valuable to research to identify longer-term, risk-reduction strategies.

This research demonstrated that international livestock movement patterns in the Greater Mekong

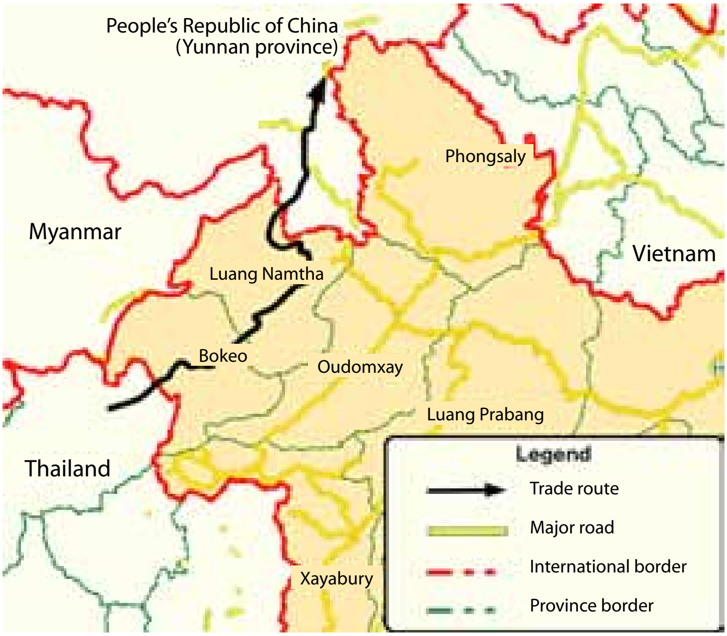

Figure 3. The main cross-border trade pathway for cattle and buffaloes moving through north-western Laos from Thailand to China

Subregion are very sensitive to factors such as currency fluctuations. Slim profit margins for traders mean that any additional expenses associated with the cross-border trade, including unfavourable exchange rates, puts them out of business (at least temporarily). This finding is an important consideration for policymakers in the Greater Mekong Subregion, as compliance with official border-crossing protocols currently makes the trade unprofitable for traders. Traders are therefore obliged to work around official pathways or stop trading.

The unofficial (but sanctioned) border-crossing arrangements that presently govern the international cattle and buffalo trade in the Greater Mekong Subregion require traders to make unofficial payments, often of a similar amount to those levied by the official pathways. The important difference between the official and unofficial border-crossing protocols is time. Where they exist, official border-crossing protocols require stays of up to 2 weeks in quarantine facilities. If available, stock feed in these facilities is expensive. Quarantine periods therefore cost traders money through purchasing feed and weight loss of the livestock. Crucially, the quarantine period also represents a significant delay for traders receiving payment from buyers. Such a delay is untenable for traders who operate with short-term, high-interest loans.

Although quarantine is an important and effective biosecurity measure when properly applied, investigation of quarantine facilities and protocols in the study area has identified issues that reduce their disease control effectiveness. The quarantine facilities do not operate on an 'all-in, all-out' basis, and consignments are often separated by no more than a fence. In some cases, water and feed troughs are shared between pens. Consignments with different origins and destinations therefore have excellent opportunity for contact. Obligatory FMD vaccination protocols for transiting consignments seem unlikely to outweigh the risk of disease spread in facilities that operate this way. In addition, the official requirement for slaughter consignments to be channelled through these facilities and vaccinated represents an unjustifiable expense to traders and an unnecessary risk of disease introduction for non-slaughter consignments that are also in the facility.

Conclusion

Our research identified that biosecurity practices could be greatly improved in both official (quarantine facilities) and unofficial (depots) livestock collecting points involved in cross-border movements of cattle and buffaloes. Interviews with traders in Laos, Cambodia and Vietnam identified trading practices throughout the market chain that carry a high risk of spreading livestock disease (Hawkins et al. 2012; Kerr et al. 2012). We concluded that biosecurity education for traders and other market chain participants would help to reduce trans-boundary disease spread in the Greater Mekong Subregion. Biosecurity educational materials were developed for livestock traders and village veterinary workers in Cambodia and Laos, and it is planned that biosecurity training materials for farmers and depot operators will be produced by the follow-on project 'Domestic and international market development for high-value cattle and beef in south-east Cambodia' (ACIAR project AH/2010/046).

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Improving knowledge and capacity

Distribution of forage seedlings from the forage bank in Nor Mo
village, Takeo province, at a field day early in the wet season of 2010.
(Photo: Luzia Rast)

Improvement in smallholder farmer knowledge of cattle production, health and biosecurity in southern Cambodia between 2008 and 2010[1]

Sonevilay Nampanya, Suon Sothoeun, Luzia Rast and Peter Windsor

Abstract

Farmer knowledge surveys were conducted in 2008 and 2010 in Cambodia to evaluate the impact of a research project studying interventions that can improve cattle production and health, including biosecurity and practices relating to risks of transmission of trans-boundary diseases. The project hypothesis is that by increasing the value of smallholder-owned large ruminants through nutritional interventions and improved marketing, knowledge-based interventions including risk management for infectious diseases such as foot-and-mouth disease (FMD) can be implemented into a more sustainable pathway for rural development. Between 2008 and 2010, significant improvements in farmer knowledge and attitudes were recorded in three villages in three provinces of southern Cambodia. This was achieved through participatory 'applied field research', 'on the job' training plus 'formal' training programs. No cases of FMD were recorded during the study period in the 'high-intervention' (HI) villages despite the common occurrence of the disease in a nearby 'low-intervention' and many other villages in the three provinces. Whilst it is likely that protection of these villages from FMD infection was from increasing the herd immunity by vaccination, it could also have been partly because of a decrease in risk behaviours by farmers as a result of their increasing knowledge of biosecurity. The research indicates that smallholder farmers are motivated by nutritional interventions that improve the value of their cattle 'bank' and offer better marketing opportunities. This provides a more receptive environment for introduction of disease risk management for infectious and other production limiting diseases, best implemented for smallholder farmers in Cambodia by intensive training programs. In lieu of a widespread public awareness program to deliver mass education of smallholder farmers in disease prevention and biosecurity, livestock development projects in South-East Asia should be encouraged to include training in disease risk management as an important intervention if the current momentum for trade in large ruminant livestock and large ruminant meat is to continue to progress and contribute to addressing global food security concerns.

Introduction

Cattle production is a very important livelihood activity for many Cambodian rural livestock smallholders. Cattle provide draught power for transport and rice planting plus manure that can be used as fertiliser and for biogas, but are most highly regarded as a 'bank' for conversion to cash when money for major household expenditure is required. There has been increasing demand for live cattle in South-East Asia for a decade to meet the growing consumption of beef as urban household incomes have improved in China and Vietnam (Quirke et al. 2003; Windsor 2008, 2011). Opportunities exist for smallholder

[1] Originally published in 2012 in Transboundary and Emergency Diseases 59(2), 117–127, and reproduced with permission.

cattle owners in Cambodia to supply this growing regional demand by improving their cattle health and husbandry practices and thus productivity and profitability. Hence, the improvement in smallholder cattle production in Cambodia is increasing and becoming an important activity in addressing both rural poverty and increasing concerns for our ability to meet future food security (Windsor 2011). However, development of the regional livestock and meat trade in South-East Asia is potentially compromised by the continuing threat of trans-boundary diseases (TADs) in the region, particularly foot-and-mouth disease (FMD) that is endemic in Cambodia, plus haemorrhagic septicaemia (HS) and internal parasites that limit survival and production of smallholder cattle, respectively.

The control and possible eventual eradication of FMD is a major challenge for many countries in the region that are coordinated under the SEACFMD program (OIE 2007; Windsor 2011). We see the current increasing demand for large ruminant protein in the region driving an urgent need for a more sophisticated research and extension system, one that integrates a series of interventions for smallholders that can simultaneously improve productivity, health, trade and marketing of cattle and buffaloes. Our working research hypothesis is that by increasing the value of smallholder-owned large ruminants through nutritional interventions and improved marketing of fattened animals, knowledge-based interventions including risk management for infectious diseases such as FMD can be implemented into a more sustainable pathway for rural development.

The Australian Centre for International Agricultural Research (ACIAR)–funded research project 'Best practice health and husbandry of cattle, Cambodia (ACIAR AH 2005/086)' is a collaborative research project between the governments of Australia and Cambodia (Windsor 2008). It is implemented by a research team from the University of Sydney and the Cambodian Department of Animal Health and Production (DAHP), with collaboration of the Royal Academy of Cambodia, the Cambodian Department of Agricultural Extension and a small number of consultants. The 4-year project commenced in June 2007 and has provided an important leadership role in progressing research for development of cattle production in Cambodia. The project has been working in six villages of the three southern provinces of Takeo, Kandal and Kampong Cham with two villages located in each province. Three of the six villages were classified as 'high-intervention' (HI) villages (one in each province) where a best practice health and production package has been gradually implemented. The package included enhanced nutrition (forage establishment and conservation), improved animal health (vaccination for TADs, parasite management and biosecurity), reproduction management (breeding selection, castration and husbandry) and marketing interventions. The remaining three villages were classified as 'low-intervention' (LI) villages (one in each province) where only vaccination for TADs was implemented (Windsor 2008). Large ruminant production (including weight, reproduction, morbidity and mortality) was measured regularly during this time in all six villages. This project design has enabled objective measurement of the changes in productivity and farmer learning over time rather than simple 'before and after' measure, and accounts for the likelihood that farmers will learn of interventions through other sources of information flow not directly related to the influence of the project.

An important component of the knowledge-based intervention strategy has been the training of DAHP extension staff, followed by a project village farmer training program. Surveys of the knowledge and attitudes of participating farmers were important to assess the effectiveness of the training programs. The surveys were particularly focussed on their awareness of biosecurity and risks of transmission of TADs, knowledge of parasitic diseases, adoption of cattle productivity technologies and trends in practices associated with marketing of cattle. The aims of the study reported in this paper were to assess farmer knowledge and attitudes in 2008 and again in 2010 in the three provinces of Kampong Cham, Takeo and Kandal to determine whether the progress of intervention extensions has positively impacted on farmers.

Methodology

Site and farmer selection

The study was conducted in six villages of the three southern provinces of Kampong Cham, Takeo and Kandal, with two villages located in each province. The six villages were selected for the ACIAR research project in 2007 through discussion and consultation between local and national authorities in Cambodia and the ACIAR team and were based on the following criteria:

1. high level of cooperation of farmers, local authority, district and provincial staff

2. interest in adoption of technologies to improve husbandry and health
3. evidence of interest in adoption of forage feeding systems
4. evidence of interest in intensification of cattle production such as stall feeding
5. preferably, access to export markets for sale of cattle
6. at least 200 cattle in each village (>100 adults, >50 weaners and >50 calves)
7. ease of access to project site(s), i.e. a suitable road for travel to the village.

In the three of six target villages classified as the HI villages (one in each province), a 'best practice health and production' package has been gradually implemented. The package includes vaccination programs for FMD and HS, forages planting as well as large ruminant disease and prevention knowledge training. The HI villages were Nor Mo village of Tram Kok district in Takeo province, Sen Son Tbong village of Prey Chhor district in Kampong Cham province and Preak Por village of Saang district in Kandal province. The remaining three villages were classified as LI where only the vaccination program was implemented as an incentive for farmer participation. The LI villages were Dem Pdet village of Trang district in Takeo province, Veal village of Prey Chhor district in Kampong Cham province and Koh Kor village of Saang district in Kandal province. The farmers targeted for enrolment in the project were selected through consultation between project staff and village headman, and farmer's participation and decision for inclusion were based on the criteria that they owned at least one head of cattle and displayed a high level of receptivity to possible introduction of new technologies.

An essential technology from the project was the introduction of forages to provide a superior nutritional base for the cattle. For many years, the usual practice in southern Cambodia has been the feeding of rice straw to cattle, supplemented with weeds collected from the paddy line in the wet season, when most available land has been planted with wetland rice. In the dry season, the cattle are mainly tethered on the dry paddy fields following the rice harvest. In the three HI villages between 2008 and end of 2010, forage technologies were gradually and then more rapidly introduced. The numbers of households establishing forage plantations and the land use for cultivating forage were recorded annually.

Training

The knowledge-based interventions introduced to the HI villages by the ACIAR project consisted of three components: participatory 'applied field research', 'on the job' training plus 'formal' training programs. Only the participatory 'applied field research' component was introduced to the LI villages. The three components are described as follows:

1. Participatory 'applied field research' consisted of the project-enrolled farmers presenting their cattle on seven occasions over a 2.5-year period for weighing, sample collection (e.g. faeces for internal parasites and blood for serology) and recording of additional health and production information. As the farmers and project team worked closely together regularly 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 interventions such as regular vaccination and anthelmintic treatments (when required) plus importantly, substantial improvements to nutrient availability. Because of the severe year-round deficiency of energy and protein in the diet of cattle in this part of Cambodia where for a major part of the year the nutrient base is rice straw, a major focus of the project was to assist farmers to establish and manage forage plantations. Between 2008 and 2010, the project assisted 773 households to establish forage plantations in the HI and surrounding villages, although few were established spontaneously in the LI villages.
3. The 'formal training' was conducted between February and March 2009 for Village Animal Health Workers and 80 farmers in each of the three HI villages. Training was conducted by the project team and in each week in each location, and project trainers conducted the course for 2 days, with another 2 days of training the following week. The training consisted of five modules, each module lasting for 4 days at each location. Topics covered included:
    I. Prophylaxis for controlling major animal diseases

- Good husbandry practices
- Nutrition
- Vaccination
- Biosecurity

II. Infectious diseases in cattle and buffaloes
- Haemorrhagic septicaemia (HS)
- Foot-and-mouth disease (FMD)
- Blackleg

III. Parasitic disease in cattle and buffaloes
- Fasciolosis
- Toxocariasis
- Paramphistomiasis
- External parasites: Ticks, Flies

IV. Forage cultivation and management
- Importance of the forage and nutrition
- Selection site for cultivation
- Land preparation
- Seed preparation
- Planting techniques
- Forage management
- soil and nutrition
- Weeds control
- Irrigation
- Cut and feeding management

V. Husbandry, breeding and reproduction
- Husbandry
- Feeding and feeding management
- Breeding selection, breeding management
- Reproduction.

Farmer selection for the knowledge surveys

A total of 150 (25 per village) farmers in 2008 and 120 (20 per village) farmers in 2010 that were participating in the project were randomly selected for the knowledge interview. The survey was modified from a questionnaire previously used successfully in Laos by the ACIAR project team (Nampanya et al. 2010) that was a semi-structured (categorical and quantitative) questionnaire consisting of open, closed and semi-closed questions (two-choice and ranking questions). The questionnaire design aimed to keep the wording as simple and brief as possible to accommodate the interview process.

The questionnaire was written in English and translated into Khmer. Questions covered social economic parameters, large ruminant marketing in general and focussed on farmer knowledge on biosecurity, animal husbandry and large ruminant diseases especially FMD, HS and blackleg. The survey team included central and district livestock officers. Prior to the survey, the survey teams were trained for 3 days to ensure that interviewers understood the aims and objectives of the study and were confident in their role in the team. The training in survey techniques was aimed at capturing actual information on the productivity of individual animals where possible. 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. The team interviewed the head of each household or the person who takes care of the family livestock. The interview was conducted in Khmer, and completed data sets were checked by the team leader before processing.

Data management and data analysis

The survey data were translated from Khmer into English and then transcribed into spreadsheets on Microsoft Excel (2003). For large ruminant knowledge questions, each farmer's answers were marked based on an answer guidelines developed by the ACIAR research team. A correct answer was given one mark, and an incorrect or I-do-not-know answer was given zero mark. Scores for each section and the entire interview were added to obtain knowledge scores for each farmer interviewed. These knowledge scores were used for data analysis.

Quantitative traits were analysed using a linear mixed model in Genstat 13th edition statistical package, and quantitative traits between low (LI)- and high (HI)-intervention villages and between provinces were compared (Table 1 and 2). Some of the variables were log-transformed (cultivated areas, available land and number of cattle per household) to fulfil the test criteria. Categorical and ranking data were analysed with the use of a Pearson's square test in Genstat 13th edition. A *P*-value <0.05 was used to indicate significant differences between the villages and provinces.

Examination of records of infectious disease

Information on disease occurrence in the six project villages was regularly collected by a visit each quarter to the project sites by the district officers involved in the research and reporting to the central DAHP office. National animal health records were collated to provide 2008 and 2010 data on the occurrence of FMD and HS of cattle and buffalo that were reported to DAHP and other animal health agencies working in Cambodia.

Results

The project commenced in late 2007 and by the end of 2008, 52 households in the HI villages had established forage plantations, including 34 households in Takeo, 12 households in Kampong Cham and six households in Kandal provinces, with a total cultivated farmer forage plantation area of 26,520 m^2. By the end of 2010, the project recorded that 456 households had established forage plantations. Of these, 263 households were located in Takeo province, 148 households located in Kampong Cham and 15 households located in Kandal, with a total forage plantation area of 195,938 m^2.

The numbers of farmers interviewed in each target village and province, outline of data analysis and quantitative traits of the survey results were tabulated (Tables 1 and 2). The survey in 2008 showed that the average number of cattle per household ranged from 3.08 heads in the LI village of Takeo to 5.28 heads in the HI village of Kampong Cham. The mean of total farmer knowledge scores of a total of 38 was 9.16–9.92 in the LI villages and 6.88–10.08 in the HI villages, respectively (Table 1).

The second survey in 2010 showed that the average number of cattle per household ranged from 2.5 head in the HI village of Kandal to 5.75 in the HI village of Kampong Cham. The mean of total farmer knowledge scores of 38 was 8.95–14.40 in the LI villages and 28.2–28.6 in the HI villages (Table 2).

Assessment of the resource availability and forages growing activity is presented in Table 3, displaying a comparison of the surveyed farmers' socioeconomic traits, including cultivated areas, available land and number of cattle per household. The baseline survey in 2008 showed that there were significant differences between farmer's economic traits between the LI and HI villages (Table 2). The prediction mean of the total cultivated areas per household was 0.59 and 0.75 ha per household in LI and HI, respectively ($P = 0.028$). The prediction mean of cattle per household was 3.31 and 3.86 in LI and HI, respectively ($P = 0.007$). The second survey showed that there was no significant difference between quantitative traits with the exception being the available land and cattle per household, where the prediction mean of available land per household was 195 and 477 m^2 per household in LI and HI, respectively ($P = 0.002$). The prediction mean of cattle per household across the target province ranged 2.89 in Kandal to 3.82 in Kampong Cham ($P = 0.016$).

The initial survey in 2008 showed that in each target village, none of the interviewed farmers has previously grown forages. The second survey in 2010 showed that the number of farmers growing forages was significantly different across the target provinces and villages (Table 3). The proportion of the interviewed farmers now growing forages ranged from 15% in Takeo to 50% in Kampong Cham and Kandal ($P < 0.001$), with 0% in LI to 77% in HI now growing forage ($P < 0.001$).

In relation to knowledge on large ruminant health and disease, the initial survey showed that the interviewed farmers had very limited knowledge of cattle health and production. There was no significant difference in total farmer knowledge scores across the target province and village (Table 4). The prediction mean of total scores (/38 marks) was 8.97 and 9.48 in LI and HI villages, respectively ($P = 0.576$).

The second survey showed a significant improvement in farmer knowledge of cattle health and production. The survey also showed significant differences in the total knowledge scores and scores on infectious disease questions across the village and province (Table 4). The prediction mean of total farmer score (/38 marks) was 11.85 in LI and 28.37 in HI villages ($P < 0.001$). The prediction mean of score on infection questions was 6.65 in LI and 17.65 in HI ($P < 0.001$).

In addition, the comparison of total farmer knowledge score between the LI villages in 2008 and 2010 was significantly different, as was the comparison of total farmer knowledge score between the HI villages in 2008 and 2010 (Table 5). The prediction mean of total knowledge score (/38 marks) in LI villages was 9.48 and 11.85 in 2008 and 2010 survey, respectively ($P = 0.001$). The prediction mean of total knowledge score (/38 marks) in HI villages was 8.97 and 28.37 in 2008 and 2010 surveys, respectively ($P < 0.001$).

The assessment of knowledge on large ruminant marketing in both surveys showed that there was significant difference in the proportion of farmers who knew about the market price before selling their livestock (Table 6). The baseline survey showed that the proportion of farmers who knew about the market price before selling their livestock was 30% and 68% in Kandal and Takeo provinces, respectively. The proportion of farmers who obtained a quote from more than one trader before selling their cattle was not significantly different between the province and villages in both survey results. The baseline survey in 2008 showed that 72% and 82% of cattle

Table 1. Number of interviewed farmers and survey data analysis outline baseline survey 2008

Variable	Province			
	KPC	TK	KD	
Low-intervention village (LI)				Mean for each parameter was compared between low- and high-intervention village
Farmer interviewed				
Total	25	25	25	
Female	10	10	2	
Mean age (years)	45.76	42.76	46.64	
Mean economic parameters				
Cultivated areas (ha/hh)	0.53 (±0.36)	1.07 (±0.74)	0.57 (±0.44)	
Available land (m^2/hh)	232 (±311)	288 (±787)	164 (±221)	
No cattle (head/hh)	3.96 (±1.74)	3.08 (±1.35)	4.16 (±2.54)	
Mean of knowledge scores on				
Parasitic questions (/7)	0.72 (±1.51)	1.04 (±1.48)	0.96 (±1.37)	
Infectious questions (/21)	5.24 (±2.67)	4.60 (±3.50)	4.44 (±3.88)	
Nutrition questions (/5)	2.52 (±1.22)	2.32 (±1.24)	1.92 (±1.32)	
Reproduction question (/5)	1.42 (±0.87)	1.40 (±1.26)	1.84 (±0.94)	
Total mark (/38)	9.92 (±3.56)	9.26 (±5.42)	9.16 (±4.74)	
High-intervention village (HI)				
Farmer interviewed				
Total	25	25	25	
Female	5	4	0	
Mean age (years)	40.04	46.92	38.28	
Mean economic parameters				
Cultivated areas (ha/hh)	0.94 (±0.64)	0.99 (±0.55)	0.72 (±0.41)	
Available land (m^2/hh)	448 (±996)	434 (±347)	1308 (±2380)	
No cattle (head/hh)	5.28 (±5.27)	4.32 (±1.67)	3.84 (±1.51)	
Mean of knowledge scores on				
Parasitic questions (/7)	0.12 (±0.60)	0.84 (±1.65)	0.52 (±1.29)	
Infectious questions (/21)	5.80 (±4.37)	4.36 (±4.83)	6.04 (±3.92)	
Nutrition questions (/5)	2.28 (±1.17)	1.16 (±1.52)	2.00 (±1.35)	
Reproduction question (/5)	1.76 (±0.88)	0.52 (±0.77)	1.52 (±1.16)	
Total mark (/38)	9.96 (±5.87)	6.88 (±7.55)	10.08 (±5.22)	
Mean from each parameter was compared between the target province				

hh = household; KD = Kandal; KPC = Kampong Cham; TK = Takeo
Note: Mean ± SD.

smallholders in LI and HI obtain a price quote from many traders before selling their stock ($P = 0.118$). Similarly, the second round survey in 2010 showed that 90% and 92% of the interviewed farmers in LI and HI obtain a price quote from many traders before selling their stock ($P = 0.75$).

In the six project villages, there were no reported outbreaks of HS during the project, although FMD was recorded in 2010 in Veal, the LI village in Kampong Cham province. It was reported that the outbreak occurred from July to November in 2010 and affected about 20% of the cattle population, compared to almost 100% of cattle affected in neighbouring villages. Data on reports to DAHP of infectious disease indicated that in 2008, 42 outbreaks of FMD were reported from 14 provinces, involving 27,691 large ruminants (mostly O serotype, rarely Asia 1). In addition, HS was reported from 17 provinces as causing sickness and/or death in 20,027 cattle or buffalo. In 2010, 82 outbreaks of FMD from 17 provinces were reported, involving 60,368 large ruminants (mostly O serotype, rarely Asia 1). Further, 52 outbreaks of HS were reported from nine provinces involving 3,210 large ruminants.

Table 2. Number of interviewed farmers and survey data analysis outline in the 2010 survey

Variable	Province			
	KPC	TK	KD	
Low-intervention village (LI)				Mean for each parameter was compared between low- and high-intervention village
Farmer interviewed				
Total	20	20	20	
Female	3	3	6	
Mean age (years)	41.35	46.40	52.50	
Mean economic parameters				
Cultivated areas (ha/hh)	0.62 (±0.43)	0.84 (±0.65)	0.84 (±0.70)	
Available land (m^2/hh)	145 (±285)	0	140 (±320)	
No cattle (head/hh)	3.40 (±1.70)	4.05 (±1.82)	2.95 (±1.54)	
Mean of knowledge scores on				
Parasitic questions (/7)	0.55 (±1.23)	0	0	
Infectious questions (/21)	8.45 (±2.84)	4.35 (±2.37)	7.15 (±2.89)	
Nutrition questions (/5)	2.85 (±1.13)	2.40 (±1.14)	2.90 (±0.85)	
Reproduction question (/5)	2.53 (±0.82)	2.20 (±1.01)	2.15 (±0.81)	
Total mark (/38)	14.40 (±3.59)	8.95 (±3.20)	12.20 (±3.33)	
High-intervention village (HI)				
Farmer interviewed				
Total	20	20	20	
Female	13	4	3	
Mean age (years)	41.20	39.95	47.10	
Mean economic parameters				
Cultivated areas (ha/hh)	1.05 (±0.92)	0.45 (±0.26)	0.82 (±0.39)	
Available land (m^2/hh)	636 (±866)	467 (±1329)	330 (±191)	
No cattle (head/hh)	5.75 (±4.49)	2.50 (±1.14)	3.60 (±1.14)	
Mean of knowledge scores on				
Parasitic questions (/7)	3.80 (±0.61)	3.90 (±0.44)	4.20 (±0.77)	
Infectious questions (/21)	17.85 (±1.72)	17.30 (±1.30)	17.80 (±1.60)	
Nutrition questions (/5)	3.90 (±0.45)	3.95 (±0.22)	3.55 (±0.65)	
Reproduction question (/5)	2.65 (±1.04)	3.15 (±0.98)	3.05 (±0.94)	
Total mark (/38)	28.20 (±2.52)	28.30 (±2.07)	28.60 (±2.25)	
Mean from each parameter was compared between the target province				

hh = household; KD = Kandal; KPC = Kampong Cham; TK = Takeo
Note: Mean ± SD.

Discussion

This study in six villages in three southern provinces of Cambodia identified that significant improvements can be made in just 2 years in farmer knowledge and attitudes to cattle production, marketing and importantly animal health, including risks of TADs and biosecurity. The validity of these observations is supported by the high-level response rate to all questions, exceeding 95%. This was accomplished through conducting face-to-face interviews in Khmer language to ensure good understanding by farmers.

The results showed a marked improvement in farmer knowledge scores on the important disease risks of cattle in the HI villages of each province between 2008 and 2010. Although a significant improvement in the knowledge scores in the LI villages was also observed, the scores were still low, indicating that there is a considerable extension effort required for farmers in the LI villages to achieve knowledge improvements similar to those in the HI villages. The findings suggest that although participatory ‘applied field research’ of the nature used in this project will improve farmer knowledge,

Table 3. Total cultivated area, number of larger ruminant owned per household and number of forage grower across the surveyed province and village from baseline 2008 and second survey 2010

Variable and categories	Across province				Across village		
	KPC	TK	KD	*P*-value[a]	LI	HI	*P*-value[a]
2008 Baseline survey							
Cultivated area (ha/hh)							
Prediction mean	0.64	0.86	0.54	0.001	0.59	0.75	0.028
SE	1.09	1.09	1.09		1.07	1.07	
Available land (m^2/hh)							
Prediction mean	340	361	736	0.142	228	730	0.007
SE	158	158	158		129	129	
No of cattle (heads/hh)							
Prediction mean	3.86	3.34	3.55	0.355	3.31	3.86	0.007
SE	1.07	1.07	1.07		1.05	1.05	
Forage grower (%)							
Yes	0	0	0	~1	0	0	~1
No	100	100	100		100	100	
2010 Second survey							
Cultivated area (ha/hh)							
Prediction mean	0.64	0.67	0.50	0.129	0.59	0.61	0.743
SE	1.11	1.11	1.11		1.09	1.09	
Available land (m^2/hh)							
Prediction mean	389	235	233	0.497	195	477	0.002
SE	106	106	106		87	87	
No of cattle (heads/hh)							
Prediction mean	3.82	3.01	2.89	0.016	3.08	3.35	0.322
SE	1.07	1.07	1.07		1.06	1.06	
Forage grower (%)							
Yes	50	50	15	<0.001	0	77	<0.001
No	50	50	85		100	23	

hh = household; HI = high-intervention village; KD = Kandal; KPC = Kampong Cham; LI = low-intervention village; TK = Takeo
[a] Indicates significant different between the mean of each parameter ($P < 0.05$).

for more significant gains, 'on the job' and 'formal training' programs will result in more successful outcomes.

In the LI villages of each province, knowledge scores of the interviewed farmers in relation to the questions on parasitism were very low in 2008 and even lower in 2010. In the HI villages, there was improvement from a score <1 in 2008 to over 50% correct in 2010. However, this indicates that further improvement in knowledge of parasites of cattle is required even in the HI villages. Trematode (particularly *Fasciola gigantica*) and nematode infestations of cattle have been described in Cambodia and can be important causes of production loss and disease, manifest as ill thrift, low body condition scores (BCS) and potentially anaemia and soft faeces (Suon et al. 2006; Dorny et al. 2011). Differentiating the relative contributions of parasitism, nutritional deficiencies and infectious and non-infectious diseases as a cause of low BCS and poor productivity in cattle usually requires intensive veterinary investigations. These are rarely performed in Cambodia, probably because of limited availability and cost of veterinary services and the widespread tolerance by smallholder farmers of 'skinny' cattle under the current subsistence system of husbandry. Increasing farmer knowledge of ways to address low BCS through nutrition may lead to increasing demand for investigations that can provide evidence-based interventions to resolve parasitic disease issues in Cambodia, as relatively simple management interventions can address most parasitic problems of cattle.

Table 4. Statistic analysis of farmer knowledge score on large ruminant health and disease in 2008 and 2010 survey

Variable and categories	Across province				Across village		
	KPC	TK	KD	*P*-value[a]	LI	HI	*P*-value[a]
2008 Baseline survey							
Scores on parasitic questions (/7)							
Prediction mean	0.42	0.94	0.74	0.16	0.91	0.49	0.065
SE	0.19	0.19	0.19		0.16	0.15	
Scores on infectious disease questions (/21)							
Prediction mean	5.52	4.48	5.24	0.37	4.76	5.40	0.31
SE	0.54	0.54	0.54		0.44	0.44	
Scores on nutrition Questions (/5)							
Prediction mean	2.40	1.74	1.96	0.040	2.25	1.83	0.042
SE	0.19	0.19	0.19		0.15	0.15	
Scores on reproduction Questions (/5)							
Prediction mean	1.60	0.96	1.68	<0.001	1.56	1.27	0.073
SE	0.14	0.14	0.14		0.12	0.12	
Total scores (/38)							
Prediction mean	9.94	8.12	9.62	0.217	9.48	8.97	0.576
SE	0.78	0.78	0.78		0.38	0.638	
2010 Second survey							
Scores on parasitic questions (/7)							
Prediction mean	2.17	1.95	2.10	0.314	0.183	3.97	<0.001
SE	0.11	0.11	0.11		0.09	0.09	
Scores on infectious disease questions (/21)							
Prediction mean	13.15	10.82	12.47	<0.001	6.65	17.65	<0.001
SE	0.35	0.35	0.35		0.29	0.29	
Scores on nutrition Questions (/5)							
Prediction mean	3.37	3.17	3.22	0.528	2.18	3.80	<0.001
SE	0.13	0.13	0.13		0.11	0.11	
Scores on reproduction Questions (/5)							
Prediction mean	2.60	2.67	2.60	0.919	2.30	2.95	0.001
SE	0.15	0.15	0.15		0.12	0.12	
Total scores (/38)							
Prediction mean	21.30	18.63	20.40	<0.001	11.85	28.37	<0.001
SE	0.46	0.46	0.46		0.37	0.37	

hh = household; HI = high-intervention village; KD = Kandal; KPC = Kampong Cham; LI = low-intervention village; TK = Takeo
[a] Indicates significant different between the mean of each parameter ($P < 0.05$).

Table 5. Comparison of total farmer knowledge score across the villages

	Total knowledge score across the year (/38)		
	2008	2010	*P*-value[a]
LI	9.48 (±0.48)	11.85 (±0.48)	0.001
HI	8.97 (±0.57)	28.37 (±0.64)	<0.001

HI = high-intervention village; LI = low-intervention village.
[a] Indicates significant difference between the mean of each parameter ($P < 0.05$).
Note: Mean ± SD.

An important intervention in both the HI and LI villages was vaccination against FMD and HS as both diseases are endemic in this country and outbreaks are common. However, there has been a concerted effort for a number of years to achieve widespread vaccination against HS, and it is considered that up to 50% of the adult cattle population has received some immune protection from this program (Savoeurn, Sothoeun and Windsor, unpublished data). However, vaccination for FMD is rarely performed, and it has been estimated that less than 0.5% of the large

Table 6. Contingency table of farmer knowledge on large ruminant market from baseline 2008 and second survey 2010

Variable and categories	Across province				Across village		
	KPC	TK	KD	*P*-value[a]	LI	HI	*P*-value[a]
Baseline survey 2008							
Farmers know market price before selling animals (%)							
Yes	46	68	30	<0.001	36	60	0.003
No	54	32	70		64	40	
Farmers obtain a quote from more than one trader (%)							
Yes	88	76	68	0.05	72	82	0.118
No	12	24	32		28	18	
Second survey 2010							
Farmers know market price before selling animals (%)							
Yes	38	68	60	0.019	45	65	0.027
No	62	32	40		55	35	
Farmers obtain a quote from more than one trader (%)							
Yes	92	82	97	0.060	90	92	0.75
No	8	18	3		10	8	

HI = high-intervention village; KD = Kandal; KPC = Kampong Cham; LI = low-intervention village; TK = Takeo
[a] Indicates significant different between the mean of each parameter ($P < 0.05$).

ruminant population in Cambodia has received immune protection (Sothoeun, unpublished data). As shown in the data on reported outbreaks of FMD, the disease occurred commonly in the study period and was frequently observed in the vicinity of the project sites, particularly in 2010 when there was a marked increase in reports of disease compared to 2008 (although acknowledged that an imperfect surveillance system exists in Cambodia and these reports represent a minimum of the true occurrence of FMD and HS during the study). However, no cases of HS or FMD were recorded during the study period in the HI villages despite the common occurrence of both diseases in other villages in the three provinces, including the occurrence of FMD in Veal. The significant difference in the scores on infectious disease questions across the village and province suggests that farmers in the HI villages did obtain the knowledge and understanding that can change attitudes and practices related to risk behaviours for infectious disease spread. A KAP survey (knowledge, attitudes and practices) is planned for 2012 to determine whether this new knowledge on biosecurity will lead to sustainable changes in practice.

An outstanding improvement in number of farmers growing forages between 2008 and 2010 was observed in HI villages of each province, with 77% of the interviewed farmers having grown forages in the HI sites compared to 0% in the LI sites. The project records indicated that in the three HI villages between 2008 and end of 2010, the numbers of households with established forage plantations increased from 52 to 456 and the total cultivated farmer forage plantation area increased from 26,520 to 195,938 m^2. It was noted that the forage plantation area per household appeared to decrease slightly from 510 to 430 m^2, indicating that the substantial increase in forage area was a result of increased recruitment of farmers, many of whom started with growing smaller plots that were likely to expand when the farmer becomes more confident with his ability to produce forage. Although the surveys identified that 77% of the surveyed farmers in the HI villages in 2010 were forage growers compared to one in the 2008 survey and none in the LI villages in either survey, this is not reflected by an increase in numbers of cattle head per household as there is known to be a very high turnover of cattle in Cambodia, and if extra cattle had been produced, they would likely have been sold. The substantial increase in forage growing in the HI villages in Takeo and Kampong Cham, with 100% of HI villages compared with 0% of LI villages in 2010 (thus shown as 50% of all villages growing forage in 2010) (Table 3), was not reflected in differences in cultivated area and available land. This is interpreted as resulting from misinterpretation of this question, with farmers providing data mostly relating to rice production that remains the major focus of land use in the project villages, rather than just the land area now used for forage production. Note that there was less adoption of forages in Kandal as these farmers live in close proximity to Phnom Penh and grow vegetables for the capital city market, so less land is available for forage growing for cattle.

Comparing the responses to marketing questions in 2008 and 2010, there is a trend showing that cattle smallholders in both LI and HI villages are increasingly likely both to know the market price and to seek quotes from many traders prior to sale of their stock. It is probable that the participatory 'applied field research' where project-enrolled farmers in both HI and LI villages presented their cattle regularly for weighing is likely to have improved farmer knowledge of animal values.

A key objective of this research is to gain a better understanding of how farmers learn different aspects of the cattle production system, that is, what training approaches work best? Our preliminary conclusions from this work are that participatory 'applied field research' and 'on the job training' are very useful in improving knowledge of some interventions, such how to establish forages, feed and market animals and introduce some health interventions including the use of vaccines to prevent infectious diseases. Cross visits to champion farmers have been promoted as a superior extension tool for teaching farmers about these interventions (Millar and Phoutakhoun 2008), and we found this approach very useful in assisting the adoption of forage technology. However, more abstract concepts such as disease prevention interventions through animal movement controls and biosecurity require more 'formal' training program as this requires a theoretical component, delivered over time, with repetition.

Our research is under review at a significant time in regional TAD control, with the Republic of the Philippines having just achieved World Organisation of Animal Health (OIE) certification of FMD freedom with vaccination. A recent review of the eradication of FMD from the Bicol surveillance zone of the Philippines discussed the relative strengths and weaknesses of the four components of the disease control strategy used in the Philippines FMD program, including quarantine and animal movement controls, strategic vaccination, surveillance and disease investigation, and enhanced public awareness (Windsor et al. 2011). It was considered that the cessation of outbreaks in Bicol was more likely a result of animal movement controls, improved surveillance and emergency response capability, and importantly reduction in FMD-risk behaviours by livestock owners. The change in livestock owner behaviour was achieved through efforts to enhance public awareness of biosecurity measures by the training of traders, livestock industry personnel and both commercial and smallholder farmers (Windsor et al. 2011). To deliver this training, sociologists with expertise in mass public awareness education programs were recruited, facilitating an intensive 'school on the air' radio program that delivered animal health training to smallholder farmers within a theoretical framework, delivered over several weeks and enabling time for farmers to understand the more difficult concepts of disease risk management.

Cambodia is yet to embrace FMD control and eradication as many development steps are required to improve the capacity to deliver on all four of the components required for the program as implemented in the Philippines. However, as demonstrated in this ACIAR research project, substantial improvements in farmer knowledge and attitudes to cattle production and health including biosecurity and practices relating to risks of transmission of TADs were recorded in three villages in three provinces of southern Cambodia, between 2008 and 2010. This was achieved through participatory 'applied field research', 'on the job' training plus 'formal' training programs. The project also introduced annual vaccination of all project animals against FMD and HS, and no cases of either disease were recorded during the study period in the HI villages despite the common occurrence of both diseases in many villages in the three provinces. In an attempt to attain high levels of herd immunity, efforts were made to ensure that at least 70% of the cattle population was vaccinated for both diseases in all six villages. However, because of the high rate of movement of animals out of villages, it was likely that this target could not always be achieved and may be a risk factor for the occurrence of FMD in the LI village. It remains undetermined whether the absence of TADs in the HI villages was because of herd immunity from vaccination, owing to decrease in risk behaviours by farmers as a result of the increasing knowledge on biosecurity or a combination of these factors. However, what is encouraging is our evidence that smallholder farmers in Cambodia are significantly motivated by nutritional interventions that improve the value of their cattle 'bank' and offer better marketing opportunities. Improving productivity and marketing potential of cattle provides a more receptive environment for introduction of knowledge-based interventions such as disease risk management for infectious diseases. Currently in Cambodia, this is best implemented by intensive training programs for smallholder cattle farmers to improve knowledge of biosecurity and reduce risk behaviours. In lieu of a widespread public awareness program to deliver mass education of smallholder farmers in disease prevention and biosecurity, livestock development projects in South-East Asia should be encouraged to include training in disease risk management as an important intervention if the current momentum for trade in large ruminant livestock and meat is to continue to progress in a more safe and sustainable way.

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Village animal health workers as a link between the government and farmers in foot-and-mouth disease control in Cambodia

John Stratton

Abstract

Using a new 'guided group interview' technique, 445 village animal health workers (VAHWs) from 19 provinces in Cambodia were interviewed to establish their current practices and knowledge. The aim of the study was to identify the strengths and weaknesses of the VAHW resource in village-level bovine disease management and control, with a focus on foot-and-mouth disease (FMD). Widespread improvement of farmer-level knowledge of disease management is likely to require intensive education and training programs that involve significant time and resources. Therefore, delivery of extension and disease control by improving VAHW skills may offer a pathway for governments to improve FMD control. The study identified that VAHWs had good contact with farmers (61.5% of VAHWs visit more than one farm each day), and high rates of disease reporting (72.5% of VAHWs report diseases immediately and 73.6% report monthly). Outbreaks of FMD were reported as being regular and widespread, with 63.8% of surveyed VAHWs seeing FMD in their village during 2009. Vaccination was either unavailable or considered too expensive for smallholders according to 82.7% of VAHWs. The study concluded that the VAHW system provides field animal health services to smallholder farmers in Cambodia and has potential to fill the current gap that exists in FMD control between government services and farmers in delivering disease control programs. Although the VAHW system has potential to improve the nationwide government-managed FMD vaccination programs, further research is required, particularly to test whether VAHWs can improve vaccine delivery in the face of FMD outbreaks.

Introduction

In rural Cambodian villages, the village animal health worker (VAHW) is usually a farmer that has had rudimentary training (typically of 1-month duration) in animal health and disease, and provides fee-based clinical services and animal treatments to livestock smallholder farmers within their village. In 2010 there were 12,474 VAHWs in Cambodia, of which 1,788 were refreshed in training courses by the Avian and Human Influenza Control and Emergency Preparedness Project under financial support from the World Bank (MAFF 2011).

In the veterinary field, there is an ongoing debate about whether VAHWs help or hinder the development of an appropriately skilled field animal health network in developing countries. People who are opposed to VAHW (or equivalent) systems claim that they are an ongoing inferior replacement for properly trained private or public field veterinary or paraveterinary professionals, because they absorb any animal health income-generating capacity from the field. The World Organisation for Animal Health (OIE) 'Terrestrial animal health code' does not recognise VAHWs as being part of the field of veterinary services unless they are authorised or approved by the veterinary authority to undertake delegated animal health functions (OIE 2012). General concerns include a lack of sufficient training and skills, and a corresponding lack of reliability for tasks such as passive surveillance (Fermet-Quinet, pers. comm., April 2010). Research in Uganda comparing VAHW perspectives and reporting with serological measurement of protection from rinderpest vaccination demonstrated that VAHWs could not be relied on to provide accurate data (Jost et al. 1998).

Many researchers and workers in animal health development support VAHW systems as being beneficial to national livestock health and rural livelihoods (Huttner et al. 2001; Curran and MacLehose 2002; Grace et al. 2009; Collinson 2011). Income from smallholder payments for animal treatment in developing countries may not adequately support more highly skilled veterinarians or even paraveterinarians. In the absence of VAHWs, smallholder farmers would be denied these essential field services or would undertake them themselves without training, increasing the risk of misdiagnosis or incorrect treatment choice or dosage. With their practical experience, VAHWs become useful in recognising clinical signs and alerting authorities to undertake further diagnostic investigations where required.

In Cambodia there is a sustainable private VAHW system based on fee for service and drug delivery to farmers. Government engagement comprises registration, informal contacts for surveillance and reporting, and engagement for delivery of a national haemorrhagic septicaemia (HS) vaccination program. The aim of this research was to investigate the current knowledge and practices of the Cambodian VAHWs, and determine if they could partner with the government to improve foot-and-mouth disease (FMD) control.

Materials and methods

Interviews were conducted with 445 VAHWs from 19 of the 24 provinces in Cambodia. A novel methodology called 'guided group interviews' was developed, which proved a robust and powerful tool for gathering survey questionnaire data from less-educated villagers in rural Cambodia. Groups of 20–30 VAHWs were gathered for full mornings or afternoons, and were provided with a multiple-choice questionnaire in Khmer that was checked for accuracy through back-translation. Each question and all answer options were read aloud and explained to the group. An opportunity to clarify the questions and answer options was provided, and each VAHW circled their answer before moving to the next question in the survey. Khmer staff circulated among the groups to provide assistance where required. They reported that, generally, questions were clearly understood. To promote honesty, the questionnaire was anonymous and the circled answer sheets were returned in a random order as they were completed. Translation error was minimised and data management and analysis were simplified through the structured multiple-choice nature of the questionnaire.

The questionnaire comprised 30 questions covering five topic areas: training received, farmer contact and income, government contact and reporting, HS and FMD. In addition, a simple quiz accompanied the questionnaire, with six multiple-choice questions that tested VAHW basic knowledge of FMD. Unlike the questionnaire, this quiz was conducted under written exam conditions with no group discussion. The opportunity was also taken for VAHW training, including a lecture on FMD based on answers to the quiz, a one-page laminated handout on basic FMD epidemiology (in Khmer) and a practical cattle restraint demonstration.

Only 14 of the 30 questions are presented and discussed in this paper. For each question, results are the average of the 445 VAHW responses across 19 provinces in Cambodia. The author of this paper can be contacted for a copy of the questionnaire.

Results

VAHW farmer contact and income

Approximately 10% of VAHWs visit more than three farmers per day, 61.5% visit more than one farmer per day and 38.5% visit less than one farmer per day (Figure 1). Of the VAHWs surveyed, 20.7% obtained up to 20% of their annual income from being a VAHW in the previous year (2008) (Figure 2). Nearly 46% obtained between 20% and 40% of their household income through VAHW activities, and just over 24% of VAHWs obtained between 40% and 60% of annual household income. Only 9.6% of VAHWs obtained greater than 60% of their annual income from VAHW activities.

Government contact

Cattle diseases are reported routinely each week to the district or provincial authority by 9% of VAHWs (Figure 3). Monthly reporting was conducted by 73.6% of VAHWs, and 72.5% of VAHWs reported immediately. A small proportion of VAHWs (12.5%) reported disease at 6–12 month intervals, and only very few (2.8%) never reported disease to authorities. Of the disease types that were reported, FMD and HS were reported by 82.9% and 82.0% of VAHWs, respectively (Figure 4). Blackleg and anthrax were reported to a lesser extent (by 29.3% and 16.6% of VAHWs, respectively).

Haemorrhagic septicaemia

Of the VAHWs surveyed, 71.2% reported that HS causes three or fewer deaths each year, and 12.7% reported that HS caused four or more deaths each year. Vaccination was offered to farmers within the past 6 months by 50.2% of VAHWs, and within the past 12 months by 98.9% of VAHWs. When asked how many farmers undertook HS vaccination, 47.5% of VAHWs reported that 60–80% of farmers agreed to HS vaccination.

Foot-and-mouth disease outbreaks

Foot-and-mouth disease was reported to occur nearly every year by 41.5% of VAHWs, and every few years by 27.4% of VAHWs (Figure 5). When asked when the last outbreak was, 44.1% of VAHWs reported less than 6 months ago, and 19.7% reported 6–12 months ago (Figure 6). During the

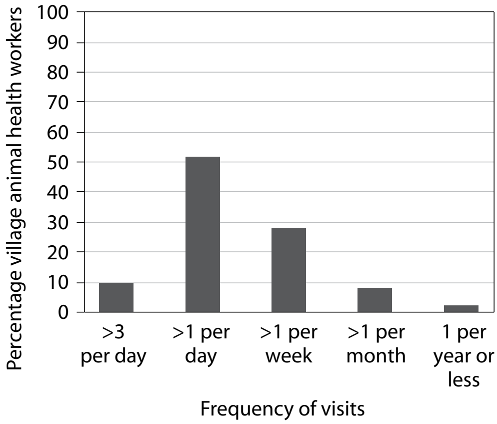

Figure 1. Average frequency of visits by village animal health workers to individual farmers

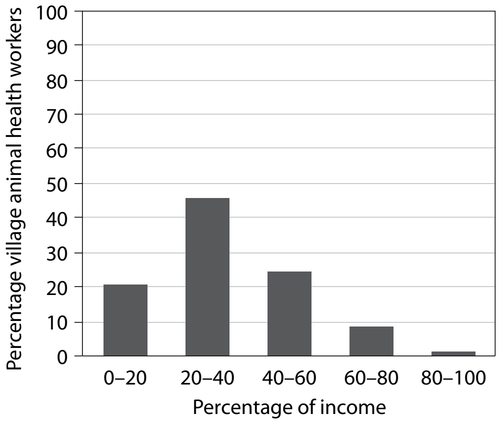

Figure 2. Proportion of full household income from village animal health worker activities in the last year

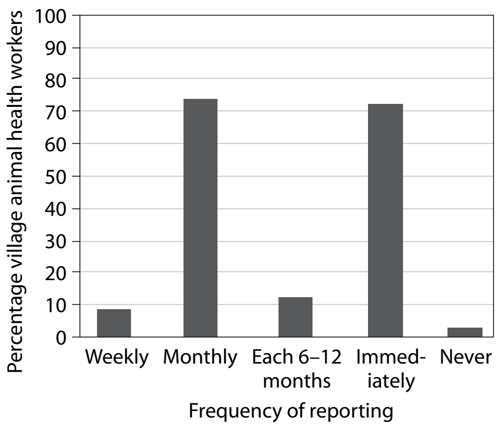

Figure 3. Average disease reporting frequency to district or provincial veterinarian by village animal health workers

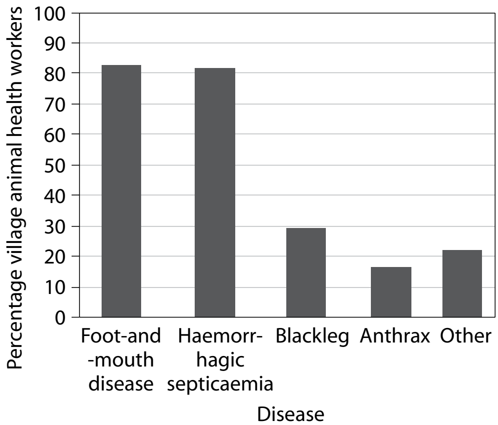

Figure 4. Disease type reported by village animal health workers

village outbreaks, 45.4% of VAHWs reported that greater than 60% of the village herd was affected, and 54.6% reported that less than 60% was affected (Figure 7).

Foot-and-mouth disease response

In responding to FMD, almost three-quarters (74.2%) of VAHWs treated infections with antiseptics or antibiotics and reported the disease to authorities (the district veterinarian) immediately (Figure 8). Some form of advice on biosecurity and movement control was given to affected farmers by 56% of VAHWs. Relating to livestock movement during outbreaks, 74.9% of VAHWs reported a reduction in movement, while 13.2% reported the same or increased movement. The FMD vaccine was reportedly either inaccessible or too expensive for 82.7% of VAHWs. When VAHWs were asked to rank animal health issues in order of importance, the order was (lowest score is most important): HS (1.6), FMD (2.3), lack of adequate nutrition (3.4), parasitic infections (3.5) and reproduction problems (4.1).

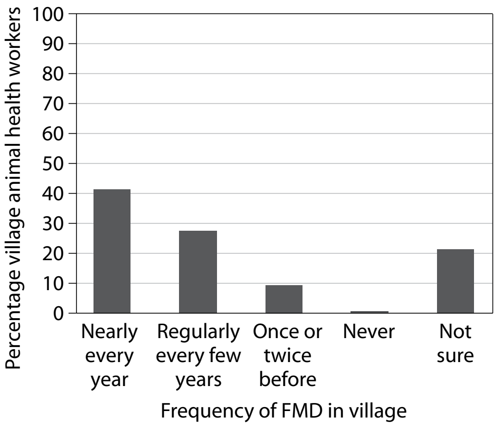

Figure 5. Frequency of foot-and-mouth disease (FMD) in village cattle

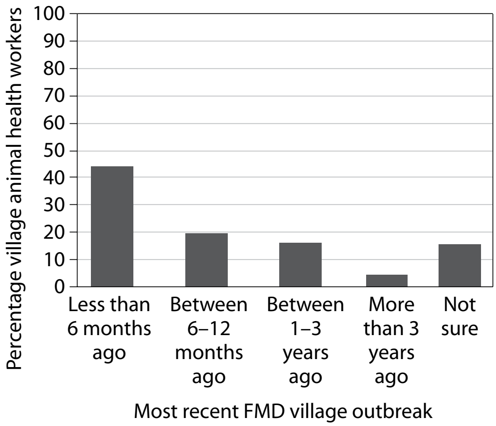

Figure 6. Occurrence of the most recent foot-and-mouth-disease (FMD) outbreak in the village

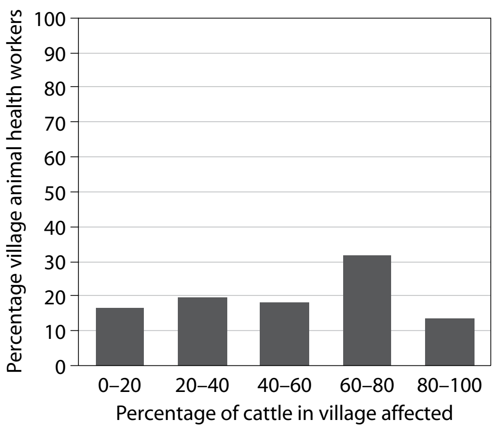

Figure 7. Approximate proportion of cattle affected during the most recent village foot-and-mouth disease (FMD) outbreak

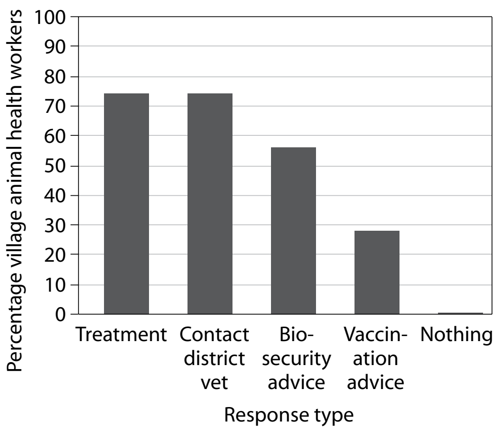

Figure 8. Village animal health workers' responses to the most recent foot-and-mouth disease (FMD) outbreak

Foot-and-mouth disease quiz results

Results of the six quiz questions are shown in Figure 9, with VAHWs scoring well in identifying the species affected (81.6% correct), viral aetiology (79.2% correct), clinical signs (70.6% correct) and FMD transmission (72.2% correct). Identifying disease control (managing the disease) and biosecurity (prevention) scores were lower, with 55.8% and 52.4%, respectively, obtaining correct answers.

Discussion

Questionnaire for village animal health workers

The participating VAHWs were quite active in visiting smallholder farmer properties, with 61.5% of respondents visiting more than one farm per day and nearly 10% being very active and visiting more than three farms per day. Around 10% of respondents were relatively inactive, visiting less than one farm per month. The VAHWs are often farmers themselves, and the animal health work is a secondary occupation for most. Sixty-six per cent of VAHWs earned less than 40% of their income from VAHW activities. However, VAHW income is a valued 'sideline', with approximately half of VAHWs earning 20–40% of their household income in the role. Very few VAHWs survive solely from this work—only 1.1% (approximately five VAHWs) earn 80–100% of household income from VAHW activities. Overall, this secondary employment is a relatively lucrative occupation per unit of time, and VAHW activity contributed an average of 35% of household income overall for relatively little effort (less than one visit per day).

The recorded government reporting of cattle diseases was commendable, with around three-quarters of sampled VAHWs reporting monthly and/or immediately when there is a disease outbreak. As expected, most VAHWs reported FMD (82.9%) and HS (82.0%). These results should be interpreted with caution due to potential sampling bias because the VAHWs interviewed were organised and accessed through official government channels. Although it was emphasised that the sample should be randomised, it is possible that the VAHWs that were already in regular contact with the government officials (district and/or provincial veterinarians) would be selected. Therefore, disease reporting results may not be representative of all VAHWs and may be skewed towards the best VAHW reporters. Nevertheless, the high reporting rate is

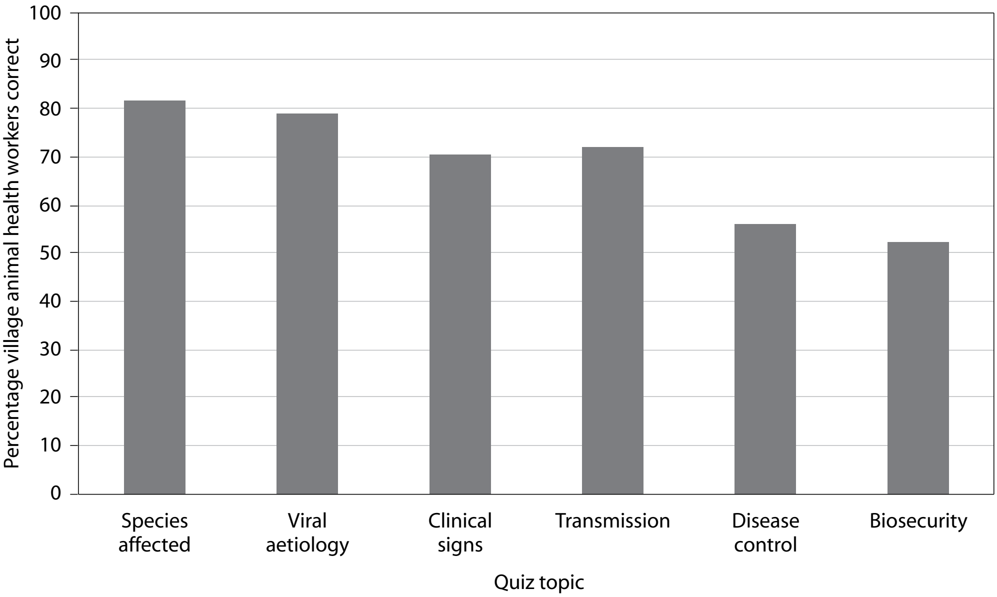

Figure 9. Results of the foot-and-mouth disease quiz

commendable, and the anonymous answer sheets should have assisted with any issues of sensitivity and encouraged honesty.

Haemorrhagic septicaemia remains a problem for Cambodian smallholder cattle farmers, despite reasonably good levels of vaccination across the cattle population through a long-running national program of government-subsidised HS vaccination. In their answers to the questionnaire, 61% of VAHWs reported that HS killed, on average, 1–3 cattle per year in their village. Almost all (99%) VAHWs had offered HS vaccination to their farmers in the last 12 months as part of the national program. Uptake was reasonable, with half of the VAHWs reporting that 60–80% of farmers had accepted vaccination in the most recent round. These results show that farmers are in favour of vaccine use and uptake, and the relatively low annual HS mortalities are assumed to be associated with protection.

Foot-and-mouth disease occurs widely and regularly in Cambodian cattle populations. Of concern, 42% of VAHWs reported FMD occurring 'nearly every year', with another 27% reporting it as occurring 'regularly every few years' in their village. Furthermore, 44% reported FMD as occurring within the last 6 months. During an outbreak, village cattle morbidity is often high—45% of VAHWs reported that more than 60% of the cattle in their village were infected during the last outbreak. Other than foot or mouth abscesses and hoof injuries, there is no differential diagnosis for FMD clinical signs in cattle (unlike pigs) in Cambodia.

Several key issues were highlighted in the FMD response section. These include a high level of disease reporting and treatment (around 75% of VAHWs) and reduced livestock movements during an outbreak (around 75% of VAHWs). This contradicts Sieng and Kerr (2013) and Pich (pers. comm., 2011), who reported increased movements during FMD outbreaks due to traders buying and selling sick animals, and more cattle being brought in to provide coverage for draught purposes. The FMD vaccine was reported to be either inaccessible or too expensive for farmers by 82.7% of VAHWs, despite FMD ranking as the second most important issue after HS. This means that, other than through the limited impact of sparsely delivered biosecurity advice provided to farmers by VAHWs and/or government staff, outbreaks generally ran their course. The VAHWs rated FMD as very important to cattle farmers, with FMD ranking closely behind HS in terms of problems facing their cattle, and ranking higher than reproductive, nutritional and parasite problems.

Participating VAHWs scored well in the six multiple-choice question quiz, with an average total score of 4.2 out of 6 (70%), though there was considerable variability across the provinces. The VAHWs scored well in questions on species affected (81.6% answered correctly), FMD of viral aetiology (79.2% correct), major clinical signs (70.6% correct) and how FMD is spread (72.2% correct). They scored worse for questions relating to disease control and biosecurity, with 55.8% and 52.4% obtaining correct answers, respectively, indicating that this should be an area of focus for further training.

Guided group interview

The 'guided group interview', a novel questionnaire technique, proved to be powerful and effective, and could be applied more widely (Tilbury, pers. comm., May 2008). The guided group interview is a hybrid questionnaire technique, involving features of group interviews (questions are asked simultaneously of all participants), postal questionnaires (respondents record their own answers) and one-on-one interviews (every respondent is required to answer all questions).

The technique is powerful and repeatable, as data can be gathered efficiently from many participants with little risk of inconsistent approaches and interpretations by interviewers and respondents.

Conclusion

Results from the guided group interview delivery of the VAHW questionnaire indicate that the Cambodian VAHW system is functional and useful. The VAHWs have the contacts, knowledge and attitudes, but not yet the practices, to effectively partner with the government as a provider of field veterinary services for FMD control. The questionnaire showed that farmer and government contact was strong, FMD outbreaks were regular and widespread, and both VAHW and government response activities were weak. Basic knowledge of FMD among VAHWs was strong in all areas except those relating to effective control measures (i.e. vaccination and biosecurity).

This study represents the first time that VAHWs across the country and in large numbers have been used as a source of national-level data. In addition to useful information on their knowledge, training, and farmer and government contact levels, they also provided a direct source of information on national livestock disease status and management, for both HS and FMD.

This research also confirmed that FMD outbreaks were regular and widespread, and that outbreaks generally ran their course, revealing a large gap in effective management of FMD by either the private or public sector.

The VAHWs have the potential to partner with governments by providing the important link for village-level FMD control that is essential for successful national FMD control. It is recommended that they receive targeted training and education in biosecurity and vaccination.

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Public and private sector roles in foot-and-mouth disease control in Cambodia

Taing Sin and John Stratton

Abstract

The 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project has shown that a centrally controlled foot-and-mouth disease (FMD) vaccination program can measurably protect smallholder cattle if project funding is provided for national government project staff to direct delivery. In addition, it raised the prospect that farmer knowledge interventions can improve productivity, reduce disease risk behaviours and increase interest in self-funded FMD vaccination. In a vaccination study involving collaboration of the BPHH project with the World Organisation for Animal Health South-East Asia and China Foot-and-Mouth Disease Campaign, untrained smallholder farmer attitudes to FMD control were assessed, and a serosurveillance survey was carried out to assess the delivery of FMD vaccine by government and project staff working with smallholder cattle farmers. The effectiveness of routine FMD vaccination was assessed by serological assay and showed that 90% of cattle sampled had antibody titres that suggested immunity from FMD type O by liquid-phase enzyme-linked immunosorbent assay (ELISA) testing at 21 days post-vaccination. However, interviews with participating smallholders in this study found that they cannot be expected to commit themselves adequately to FMD control in the short to medium term, either financially by purchasing vaccine, or technically by improving farm biosecurity. The development of a semi-commercialised cattle production system that might be the foundation for widespread disease risk behavioural change is a long-term prospect. This means that other approaches targeting vaccination and biosecurity that involve more government resources are needed in the interim, such as central government delivery of vaccination to provide sufficient protection in vaccinated villages. Further research is required to measure whether the increase in income generated through marketing of cattle can influence farmer investments in animal health interventions, such as for FMD vaccination.

Introduction

Commercial or semi-commercial cattle production remains at a limited scale in Cambodia. Cambodian villagers primarily keep cattle as a source of wealth or a 'bank', to be sold only in times of need (such as for family illnesses, weddings or funerals) and for use for draught power, mainly in rice cultivation. Higher-input farming systems involving breeding or fattening cattle with regular turnover to generate profits are yet to develop (MacLean 1998; Knips 2004; Harding et al. 2007).

Within this context, the 'Best practice health and husbandry of cattle, Cambodia' (BPHH) project had the broad vision of equipping farmers with the knowledge and tools in higher-input, integrated cattle production to shift them towards semi-commercial systems. This would help realise the capacity of Cambodian cattle farming to create wealth and reduce rural poverty. This research focused on aspects of the broader project relevant to field veterinary services and foot-and-mouth disease (FMD) control.

There is an ongoing debate in animal health development about the degree to which non-regulatory training and extension approaches that target farmers and/or traders should be focused on in the hope of engendering private sector management of trans-boundary animal diseases. Many non-government and international organisations choose to work directly with farmers through community-based approaches. This is partly in response to an environment where regulatory and other government-driven approaches are limited by lack of funding, governance issues and weak technical capacity of the veterinary authorities. Despite such difficulties, other programs such as the South-East Asia and China Foot-and-Mouth Disease (SEACFMD) Campaign and the World Organisation for Animal Health (OIE) Performance of Veterinary Services Pathway have a greater focus on building the capacity of governments, including their regulatory capacity. Research that targets the most effective balance between the two contrasting approaches for Cambodian FMD control is required to allocate the resources and efforts of donors and governments most effectively.

Aim

The objective of this research was to define the roles of public and private-sector stakeholders that most effectively control trans-boundary diseases, especially FMD.

Materials and methods

The BPHH project worked with the Office of Extension of the Cambodian Department of Animal Health and Production (DAHP) to research the impacts of knowledge-based farmer training. It measured the impacts (cattle daily weight gain, reproductive performance and farmer attitudes) of various knowledge-based cattle-raising interventions (forage growing, reproductive practices, vaccinations, anthelmintic use, biosecurity measures and marketing) in six paired high-intervention (HI) and low-intervention (LI) villages in three provinces in Cambodia over a period of 4 years (Nampanya et al. 2012; Young et al. 2013). Aspects of the BPHH project that are directly relevant to FMD control included a hypothesis that knowledge-based interventions could create an integrated and profit-driven cattle production system, improving smallholders' practical and financial commitment to FMD vaccination and biosecurity.

An FMD post-vaccination serosurveillance study was undertaken in early 2008 by Taing Sin (co-author on this paper), a postgraduate student at the Royal University of Agriculture. Project staff at DAHP conducted regular, free FMD vaccinations (2-mL subcutaneous dose of trivalent Indian Immunologicals vaccine) for project cattle in each of the six project villages (HI and LI). Random blood samples were collected from every fourth animal that presented during project longitudinal sampling to obtain 20 samples from each of the three HI project villages (Preak Por, Sensong Tbong and No Mor) at day 0 of the study. Cattle identification was recorded, and further sampling from the same animals occurred on day 21 and day 180 after vaccination. Blood samples were also taken at the same intervals in a non-vaccinated control village outside of the project; these cattle had not been recently vaccinated against or infected with FMD. Samples were transported using a cold chain, and serum was separated using a centrifuge and frozen. There was a delay of approximately 1 year between sampling and reporting of test results from the Cambodian National Animal Veterinary Research Institute (NaVRI), which performed antibody testing using liquid-phase blocking enzyme-linked immunosorbent assay (ELISA) for serotypes O, A and Asia 1.

Results

Results from the BPHH project demonstrate that knowledge-based interventions, particularly forage growing for improved nutrition, can be taken up and have a positive impact on cattle weight gain (Young et al. 2012). Knowledge, attitudes and practices (KAP) surveys will be conducted in 2012 to determine if the farmer training and weight gains lead to improved profits from better marketing of cattle in the project villages, and whether this improves investments in animal health, such as FMD control.

The FMD post-vaccination serosurveillance study results are presented in Table 1. It shows the percentage of antibody response (seropositive) results for twofold dilutions using liquid-phase blocking ELISA. The control village (no vaccination) showed no antibody response on days 0, 21 or 180 (including at the lowest dilution of 1:40) and is therefore excluded from the table.

At day 0, no antibody response was detected in any animals. At day 21, strong antibody responses were detected in animals across the three vaccinated villages, and 100% of samples were seropositive for all three serotypes at the lowest dilution of 1:40. At 1:80, which is taken as the threshold for some serological protection from vaccination, 90% of samples were seropositive for FMD serotypes O and A, and 96.7% seropositive for FMD serotype Asia 1. For serotype O (the most common serotype), the percentage of samples showing antibody response reduced with greater dilutions. At 1:320, where an antibody response demonstrates a very high level of immunity, 40% of samples remained seropositive for

Table 1. Percentage of samples of the 60 cattle from three high-intervention project villages that showed positive antibody titres against foot-and-mouth disease after vaccination

Collection sample point	Serotype	Serial dilution						
		1:40	1:80	1:160	1:320	1:640	1:1,280	1:2,560
Day 0	O	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Asia 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Day 21	O	100.0	90.0	66.7	40.0	16.7	6.7	0.0
	A	100.0	90.0	80.0	60.0	36.7	3.3	0.0
	Asia 1	100.0	96.7	93.3	73.3	50.0	26.7	6.7
Day 180	O	100.0	93.3	90.0	70.0	46.7	26.7	16.7
	A	100.0	96.7	90.0	63.3	40.0	16.7	3.3
	Asia 1	100.0	96.7	96.7	83.3	56.7	36.7	10.0

serotype O. This tapered off at the higher dilutions, with only 6.7% seropositive at a dilution of 1:1,280, and none at 1:2,560. At day 180, serological protection had remained remarkably high as reported by NaVRI, and was higher than at day 21. For example, at the threshold dilution for protection of 1:80, 90% of samples were seropositive for type O on day 21, and 93.3% of samples were seropositive at day 180. At a dilution of 1:320, 40% of samples were seropositive at day 21, which increased to 70% at day 180. These data are summarised in Figures 1 and 2.

Discussion

In the short to medium term, smallholder training and extension alone cannot be relied on to manage animal health issues, such as FMD control. The animal health component of the BPHH project was based on the hypothesis that by improving the other components (e.g. nutrition and marketing) of an integrated cattle production system, farmer attitudes to health can shift as they seek to protect the income-generating livestock asset (Figure 3). The project proved the first

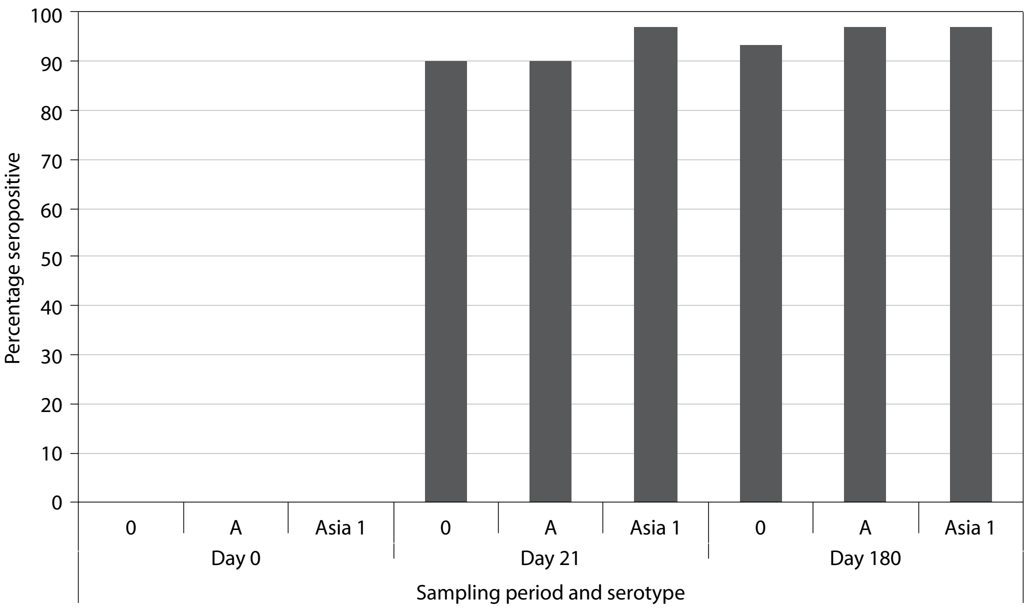

Figure 1. Percentage of seropositive samples at a dilution of 1:80 at days 0, 21 and 180

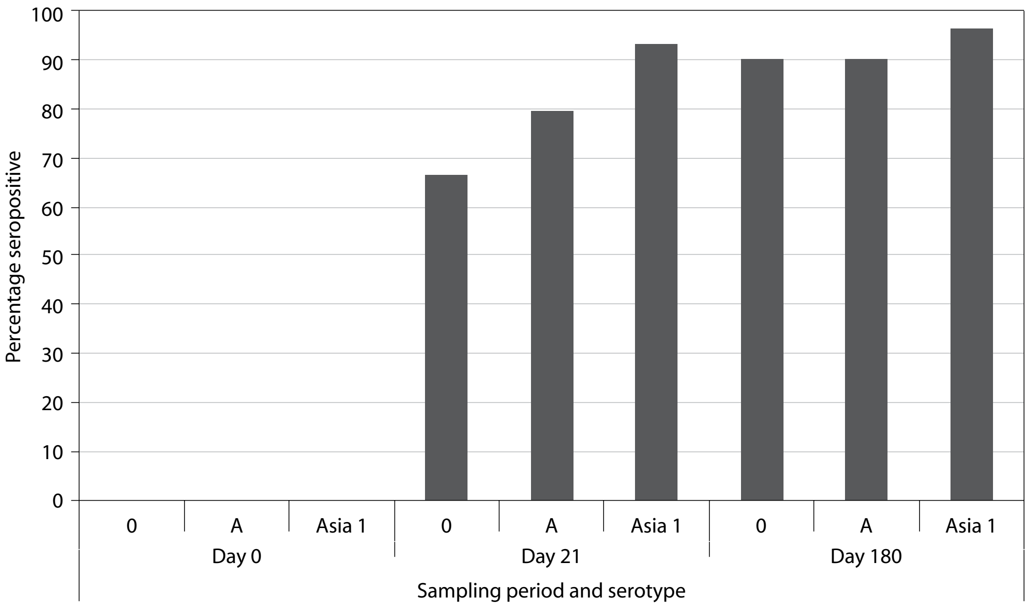

Figure 2. Percentage of seropositive samples at a dilution of 1:320 at days 0, 21 and 180

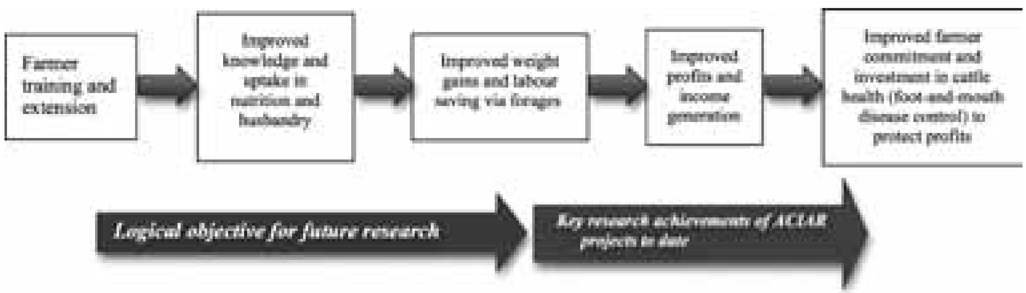

Figure 3. Best-practice project hypothesis: an improved and integrated cattle production system leads to stronger farmer commitment to animal health

steps in this hypothesis—that training can change practices and result in weight gains, especially through forage growing—but the transfer of such gains into income generation requires a fundamental paradigm shift for Cambodian farmers. The major benefit of forage growing has been household labour saving by reducing grazing and fodder cut-and-carry tasks. For now, even within the project, there is no evidence that farmers have changed to viewing their cattle as income sources rather than emergency stores of wealth or as sources of draught. The next step of whether income generation leads to investment in animal health in Cambodia also remains to be proven, though this seems logical given that FMD is generally a non-lethal and production-limiting disease.

It is clear that this ‘self-help’ or non-regulatory, private model of animal health control, with the government (or other agents) restricted to communications and extension activities, is a long-term prospect for Cambodian smallholders. The SEACFMD target of FMD eradication (with vaccination) by 2020 requires a more direct government-led approach for faster results. Most Cambodian farmers do not yet contribute to animal health activities that are for private benefits, such as deworming or haemorrhagic septicaemia vaccination. Given this, a commitment to less obvious advantageous practices such as farm biosecurity measures, and more costly practices such as FMD vaccination, is unlikely in the short to medium term. This was confirmed in recent field trial work where farmers did not commit to FMD vaccination, even with an education campaign and during the high-risk period of an outbreak (Stratton 2013). With a fully private model discounted for the short to medium term, a stronger government role in the public–private partnership for FMD control is required.

The vaccination serosurveillance study showed a very high level and persistent immune response following vaccination in the sampled animals. This demonstrates that very high levels of protection can be achieved where vaccination planning and delivery is directly performed by central government veterinary staff. In this situation, issues such as vaccine availability, an unbroken cold chain, adequate restraint of healthy cattle and good vaccination technique can be assured.

Considering the likelihood of exposure to FMD in Cambodia, it is surprising that there was no antibody response, even at the lowest dilution, for all three sampling points in the control village and at day 0 in all vaccinated villages. Although the sample size was small, it was expected there would be background seropositive results arising from natural immunity in some of the cattle in the sampled villages. Other serosurveillance studies undertaken in Cambodia support this. A background FMD serosurveillance study undertaken across eight southern provinces of Cambodia in the same years as this study found that 54.4% of 923 samples were seropositive (mostly to type O) at a 1:40 dilution (Tum 2010). Due to difficulties in test procurement in the current study, there was an extended delay (approximately 1 year) between sample submissions and reporting of serological titres. This means that changes in the serological properties could have occurred during sample storage that may account for the lack of background seropositive results. According to the OIE's 'Terrestrial manual' (2012), sera may be stored for periodic use or kept in long-term storage, provided that storage conditions minimise loss of immunological and other biochemical properties of the sera. Long-term storage of sera requires a core temperature below –60 °C to be maintained in a deep-freezer. The lower the temperature the better, but lower temperatures are more expensive to maintain (OIE 2012). The age of the cattle sampled may also affect the results because younger cattle would be expected to have had less chance of previous exposure than older cattle.

The serological results indicate that serological protection increased between day 21 (expected to represent the 'peak' level of protection) and day 180 (expected to represent the time when protection is waning). At a dilution of 1:320, where a seropositive result represents a very high level of immunity, only 40% of samples were seropositive to type O at day 21, compared with a remarkable 70% at day 180. It is possible that seasonal effects and the corresponding health and condition of the cattle might have influenced the immune response at different times (i.e. weaker at day 21 and strengthening up to day 180). Alternatively, although an outbreak was not reported in the area, vaccinated cattle may have been exposed to FMD virus between day 21 and day 180, which would have increased antibody titres for the day 180 measurement. Non-structural protein ELISA was not undertaken to differentiate antibody responses from vaccination antibody responses from infection; this should be considered in future studies and accompanied by close clinical surveillance both before vaccination, and between vaccination and sampling days. It is recommended that the FMD reference laboratory is used for any follow-up research to ensure the validity of laboratory testing undertaken in Cambodia.

Conclusion

The BPHH project has provided evidence that cattle smallholder training can improve knowledge and practices, leading to increased daily weight gains of cattle. It appears likely that these gains also increase smallholder incomes. Improved cattle breeding or fattening can further increase income if it is combined with improved disease risk management knowledge, and this should lead to increased farmer investments in FMD. However, the pace of such fundamental changes suggests this is a long-term prospect for assisting FMD control in Cambodia. Currently, a package of FMD control measures that include stronger government action and international agency contributions is needed. The tight controls of the central government in directly delivering FMD vaccination in the field was shown to provide excellent serological protection in randomly sampled vaccinated animals. The uniformity, degree and length of time of serological protection in response to vaccination was surprising, although these findings require further validation in future studies that should include validation of laboratory tests for FMD.

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Biosecurity education for traders to reduce the spread of animal diseases in Lao PDR and Cambodia

James Kerr, Malcolm Anderson, Phouth Inthavong, Kate Blaszak, Axelle Scoizec and Socheat Sieng

Abstract

It has been recognised that regulation alone has limited potential for controlling trans-boundary diseases in the Greater Mekong Subregion. The 'Understanding livestock movement and risk of spread of trans-boundary animal diseases' project therefore aimed to investigate novel non-regulatory methods of reducing the disease risk associated with livestock movements. During 2008 and 2009, meetings and interviews were conducted with livestock traders throughout Cambodia and Laos. These identified a number of trading practices that carried a high risk of spreading disease, and suggested that many traders were keen to receive education about preventing disease spread. In early 2010, the project began developing and trialling educational materials for improving biosecurity practices by livestock traders in the two countries. Traders requested that information be presented in a colour booklet with many images and minimal text. To include people with limited literacy, a digital story was produced that matched a spoken commentary with video or DVD images, and could be easily distributed throughout Laos and Cambodia. English and Lao versions of the booklet and digital story were refined, with disease prevention messages distilled into a '5-step' approach to biosecurity for traders to routinely apply on all purchasing trips.

Introduction

Trans-boundary animal diseases including foot-and-mouth disease (FMD) and classical swine fever (CSF) cause significant losses in South-East Asia. These diseases cross national borders and spread to new areas primarily through livestock movements. Laos and Cambodia feature prominently in regional animal movement pathways and livestock trading networks involving China, Vietnam, Myanmar, Thailand and Malaysia. The long-shared borders allow easy unofficial passage for animals, making livestock disease control a challenging regional issue. To support regional efforts to reduce the spread of trans-boundary diseases in the Greater Mekong Subregion, an Australian Centre for International Agricultural Research (ACIAR) project was initiated in 2006 to understand livestock movement and the risk of spread of trans-boundary animal diseases (ACIAR project AH/2006/025).

Aim

The objective was to understand the drivers of livestock movement patterns to enable the development of strategies to reduce the risk of regional disease spread.

Methods

Meetings and interviews with livestock traders were conducted in most provinces of Laos and Cambodia during 2008 and 2009 to understand the drivers, networks, practices, pathways and impediments that determine trade patterns within these countries and across their borders. In Cambodia, trader information was collected by questionnaire in confidential one-on-one interviews from which government officials were excluded. The Cambodian questionnaire specifically sought sociological information about traders, as well as assessing their understanding, recognition and attitude towards several important livestock diseases. In Laos, trader information was obtained using a less rigid checklist approach, with Department of Livestock and Fisheries (DLF) staff present as translators.

After analysing the information from livestock traders, a nationwide series of feedback meetings was conducted for traders and other stakeholders throughout each country early in 2010. We presented our research findings and canvassed trader opinion about possible measures to reduce the risk of disease spread associated with livestock trading. Educational materials designed to teach traders how to prevent disease spread (biosecurity) were subsequently produced in Laos and trialled with trader focus groups in Xieng Khouang province in mid 2010. The Australian and Lao staff from 'Extension approaches for scaling out livestock production in northern Lao PDR', (EASLP) (ACIAR project ASEM/2005/125) greatly assisted by training our own project staff in digital story making and guiding the production of the initial version. Feedback about the draft educational materials was also sought from project partners at a project meeting in Siem Reap in August 2010, and from DLF representatives from all Lao provinces in September 2010. Ongoing trial and feedback-driven refinement of these materials continued during 2011, and widespread distribution and evaluation of these materials is planned for 2012.

Research outputs

Project research during 2008 and 2009 identified a number of trading practices that carried a high risk of spreading disease, including the common and profitable practice of buying FMD-affected livestock at discounted prices during disease outbreaks. Fortunately, many traders were keen to receive education about disease epidemiology and biosecurity (i.e. how disease spreads and how to prevent it spreading). Consequently, the project decided to develop and trial educational materials aimed at improving the biosecurity practised by livestock traders in these two countries. These activities were conducted in collaboration with the project's partners in South-East Asia, the Lao DLF and the Cambodian Department of Animal Health and Production.

Biosecurity education for traders

The project began developing trader educational materials in mid 2010, using feedback collected from Lao traders in 2009 and early 2010. Traders requested an information booklet that featured plenty of pictures and excluded all unnecessary and technical information. It was determined that the most effective way to teach traders about the biosecurity measures that they should apply in the course of their work was to structure the biosecurity message in a step-by-step format. These steps outlined a typical buying trip:

Step 1. Before you go
Step 2. On arrival at the village/farm
Step 3. Before buying animals (inspecting animals and questioning owners)
Step 4. When moving between farms and villages
Step 5. When you return home.

A digital story was developed in addition to the booklet, with the advantage that it could deliver the educational message by spoken word to less-literate traders (and other villagers), and could be produced and modified (if necessary) much more cheaply than a colour booklet. It was likely that a reasonable proportion of the target audience would have access to a DVD player to view the digital story.

This research had also determined that many traders and farmers were far more interested in learning about prevention of haemorrhagic septicaemia (HS) than prevention of FMD, because HS is often fatal but FMD is not. Information about HS prevention was therefore included in the biosecurity materials as a 'hook' to create audience interest, with the overall biosecurity message designed to teach a standard approach that should routinely be applied by traders on a daily basis. To increase the likelihood of traders adopting biosecurity measures, the measures proposed needed to be simple, easy, low-cost or no-cost, and have an appreciable benefit to traders. The decision to advocate a generic approach to biosecurity was based on the following considerations:

- Traders (and others) need to understand that biosecurity precautions should always be applied, not just when HS, FMD or other diseases are suspected.
- Traders cannot be expected to have a diagnostic knowledge of numerous diseases and an associated understanding of when biosecurity is more or less important.
- Traders cannot always expect to know when they will encounter diseased animals during their work, so they always need to be prepared.
- Even a well-trained trader will be unable to detect an incubating or convalescing (but infectious) case of disease.

Project research also suggested that separate, but similar, educational materials needed to be developed for traders dealing in different species of livestock. Pig traders buy, transport and sell their animals in a different way to those dealing in cattle and buffaloes, and will require biosecurity educational materials that are specific to their needs.

We developed prototype materials for cattle and buffalo traders in Laos and Cambodia as our first initiative because our research had also highlighted the particularly high risk of trans-boundary disease spread that these traders represent within the Greater Mekong Subregion, particularly with respect to FMD. The following features of the cattle and buffalo trade in these countries contribute significantly to the regional disease risk:

- Foot-and-mouth disease and other livestock diseases are endemic in Cambodia and Laos, and control strategies such as vaccination and movement control are limited or absent.
- Cambodia and Laos are exporters of cattle and buffaloes to neighbouring countries, and also act as transit pathways for ruminants travelling from Myanmar and Thailand to Vietnam and China.
- The trans-boundary trade routes for cattle and buffaloes in Cambodia and Laos feature rapid, long-distance road transport of livestock, preceded and followed by mixing of consignments from different origins in export depots, on trucks, and in the process of walking or swimming these animals across the 'green' borders with neighbouring countries.

A booklet and digital story were developed and trialled with Lao cattle and buffalo traders, and with provincial animal health staff, in the second half of 2010. These materials were refined in 2011 after considering audience feedback. A poster that summarises the booklet is shown at the end of this paper. The project team in Cambodia also received training in digital story-making from the EASLP project during 2010, and subsequently collaborated with the Lao project staff during 2011 to develop equivalent Khmer language biosecurity materials for Cambodian traders using the same five-step approach.

Biosecurity education for village animal health workers

Early in 2010, the project reviewed existing animal health publications in Cambodia and Laos. This review included an assessment of the field manuals available for the village-based paraveterinary workers known as village veterinary workers (VVWs) in Laos and village animal health workers (VAHWs) in Cambodia. These publications contained inadequate advice about the biosecurity precautions that VVWs and VAHWs should take when sampling and treating sick livestock, meaning that these frontline animal health workers represented a clear risk of spreading animal diseases within and between villages in the course of their work. An opportunistic case study undertaken by the project during the FMD outbreak that occurred throughout Cambodia during the second half of 2010 provided further support for the proposition that VAHWs play an unintentional role in spreading disease during outbreaks (Sieng and Kerr 2013).

The project therefore developed biosecurity training materials for VAHWs in Cambodia and VVWs in Laos during 2011, in the form of a simple colour booklet with a digital story included in a pouch inside the back cover. In addition to planned distribution among VVWs and VAHWs, village-level feedback suggests that café and restaurant owners will be happy to play these digital stories as background entertainment for their patrons.

Discussion

Feedback from DLF and Provincial Agriculture and Forestry Office (PAFO) staff in Laos in late 2010 indicated that they believed non-regulatory methods alone would be unlikely to change trader behaviours, and needed to be combined with a legislative approach. This seems particularly valid in the case of livestock traders who view FMD-affected livestock as an opportunity for greater-than-normal profit—45% of Cambodian traders interviewed admitted to trading in FMD-affected livestock (Kerr et al. 2013). However, DLF and PAFO staff agreed that developing simple biosecurity educational materials for traders would be a useful initiative that should be broadened in scope to include other participants in the livestock market chain, including farmers and slaughterhouse operators.

The EASLP project found that digital stories should be short and simple to effectively deliver a message to low-literacy audiences. This limitation is a useful restraint for those creating educational materials, and echoes the feedback from traders and departmental staff that educational materials should contain plenty of pictures and eliminate all technical information. Three of the specific challenges confronting biosecurity education as a means of changing behaviour are discussed below.

1. Identifying appreciable benefits for people who are being advised to changed their behaviour

The greatest obstacle that we have faced, and not properly addressed, is the lack of convincing reasons why traders, farmers and others should make an effort to prevent livestock diseases, particularly FMD. Although the literature features numerous studies that demonstrate the benefits associated with FMD control and eradication, smallholder attitudes may still reflect the 1997 finding from the Food and Agriculture Organization of the United Nations that, in Cambodia and Laos, 'the financial effects of FMD in low-productivity systems are small and the benefits of control are less than the cost of vaccination' (FAO 1997). Foot-and-mouth disease in particular appears not to be viewed as a very serious disease by many farmers, traders and officials because it is generally not fatal. Disruption to draught power at times of rice cultivation is generally felt by smallholders to be its most serious consequence, although discounted sale prices during outbreaks can certainly represent a financial loss for affected farmers. In general, biosecurity measures to prevent FMD might be difficult to sell to many farmers and local-level traders, who requested instead that we provide information about protecting against HS. We therefore tried to tie the biosecurity message for cattle and buffalo traders to prevention of HS rather than FMD alone.

Some livestock traders reportedly made their greatest profits by buying and selling infected animals during FMD outbreaks. It may seem that traders would resist educational initiatives aimed at preventing FMD outbreaks as an attack on their income. However, our research also suggested that trader attitude towards FMD varied according to the level at which they operated, as did their interest in our biosecurity message. The traders who profit from buying and selling diseased animals tend to be local-level operators, with most of the affected livestock destined for prompt local slaughter. This group of traders is important in the spread of FMD within and between villages, and requires biosecurity training aimed at their particular operating environment. Because a change in their high-risk trading practices would represent greater benefits to their community than to themselves, disease and biosecurity education for the other members of their communities could help to achieve that change through community pressure.

A community educational task such as this would be a considerable undertaking even on a district scale; however, it may be feasible to educate influential community members such as village chiefs and headmen to drive such a change. Punishing traders who trade in diseased livestock would be an inappropriate and counterproductive strategy, given that purchase of these animals for slaughter will continue to be an important salvage option required by farmers. Educational initiatives aimed at these traders and their communities should attempt to modify trading practices so that sale of diseased livestock for slaughter can contribute to disease control rather than disease spread.

As opposed to local-level traders, traders who deal in long-distance, inter-provincial and international livestock trade are anxious to avoid disease in their consignments, because disease results in price discounting and delayed or cancelled transactions. Traders operating at this level are influential participants in the trans-boundary market chains and the associated risk pathways for diseases, including FMD. Their feedback suggests that biosecurity education will be a welcome initiative.

This finding highlights the importance of the project's research that demonstrated that traders are not a homogeneous group with identical interests. We succeeded in identifying within this group a subgroup for whom biosecurity education held considerable benefits.

Another approach to the challenge of achieving biosecurity benefits for the livestock industry is to find ways in which biosecurity improvements can be obtained from initiatives aimed at other outcomes. For instance, 'Improved feeding systems for more efficient beef cattle production in Cambodia' (ACIAR project AH/2003/008) encourages farmers to grow forage crops at home, allowing animals to be housed in pens and fed cut grass from these forage plots. In addition to the desired weight-gain benefits, pen-feeding production systems offer distinct biosecurity advantages over the communal grazing systems that are otherwise the norm in Cambodia and Laos. Communal grazing and watering of livestock maintains parasitic diseases such as liver fluke, and encourages rapid disease spread within and between villages during outbreaks of FMD. Interestingly, even the appreciable production advantages offered by pen-feeding systems are of secondary importance to some farmer converts to this system, for whom the labour-saving benefits have been the most highly valued outcome. Time previously spent cutting grass in distant locations or managing livestock in communal grazing areas is now available for farmers to pursue other income-generating activities and for children to attend school (Dimang et al. 2010).

2. Identifying biosecurity measures that are simple, practical, and no-cost or low-cost

For livestock traders operating with very small profit margins, it is vital to promote biosecurity initiatives that are genuinely feasible for them to apply. As soon as the biosecurity suggestions become onerous or unrealistic in terms of time, labour or cost, the audience will become disenchanted. This should guide the creation of future educational materials for farmers, VVWs/VAHWs and others. For instance, although our biosecurity stories advocate that traders should preferentially buy livestock that have recently been vaccinated against important livestock diseases (including FMD, HS and CSF), the very low rates of vaccination in Cambodia and Laos mean that it is very difficult for most traders to do this.

It is also important to note that well-intentioned ‘biosecurity’ measures do not inadvertently increase the disease risk that they are intended to reduce. For instance, washing and disinfecting trucks may well be ideal practice after transporting livestock, especially if the consignment included diseased animals. Our research suggested that wash down of trucks that have been used for carrying livestock in Cambodia and Laos is reasonably common, especially if the truck is then needed to carry non-livestock cargo; however, we could find no evidence that disinfectants were ever used in the process. Disinfectants cost money and can be corrosive, but washing trucks without using disinfectants may increase the risk of vehicle contamination by creating an infectious slurry puddle of run-off. This is far more likely to stick to tyres and undercarriages of washed vehicles, and all other vehicles that pass through that area.

Rather than promoting unrealistic Western images of people in rubber boots and overalls performing high-pressure wash down of trucks, our trader education message concentrates on advising traders to avoid the arduous process of vehicle decontamination by taking the simple biosecurity measure of parking outside farms until the prospective purchase stock has been checked for diseases.

It is also important to emphasise to our audience that, in tropical environments, close contact between animals is the main method of spread for FMD, HS and CSF. This means that biosecurity measures to keep infected and uninfected animals separate are far more important than efforts to clean every inch of a truck. Given that the disease-causing agents for FMD, CSF and HS are sensitive to desiccation and exposure to sunlight, a no-cost biosecurity measure that we suggested is merely to park the stock-carrying part of the truck in the sun when the truck is not in use.

It is recognised that some traders will continue to intentionally trade in FMD-affected cattle and buffaloes, which they often store at their own home prior to slaughter or resale. Because most traders have household livestock of their own and are well aware of the reduced value associated with FMD infection, our intention is to at least help them avoid infection of their own livestock (and those in their home village) by describing sensible separation distances and precautions to take between handling infected and uninfected animals. We will also continue to suggest to national and regional disease control strategists that primary targets for strategic allocation of FMD vaccine supplies aimed at risk reduction should include the livestock owned by traders and VVWs/VAHWs, whose work with sick livestock provides their own livestock with a high risk of infection and of becoming a source for further disease spread throughout the area.

3. Measuring whether the biosecurity message has been understood, and whether it has succeeded in changing high-risk trading behaviours

Although ACIAR project AH/2006/025 will conclude in October 2011, plans are being made and funding set aside for evaluating the effectiveness of our biosecurity education materials in mid 2012. Fortunately, a proposed new ACIAR-funded research project expected to begin in Cambodia during 2012 plans to continue the development and evaluation of the biosecurity education activity, broadening the audience to include other participants in the livestock market chain, including farmers.

Conclusion

The creation and distribution of educational materials about livestock diseases and biosecurity remains a worthwhile research and development activity that will help people in the livestock market chain to protect their animals and their incomes from the effect of livestock diseases. However, because regulation cannot realistically be expected to effectively support biosecurity initiatives by farmers and traders in the near future, biosecurity improvements in the regional livestock market chains are unlikely to be rewarded and gain momentum until there is a market demand for safer and lower-risk livestock.

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Poster summarising the booklet for improving biosecurity practices by livestock traders

LIVESTOCK TRADERS – 5 SIMPLE STEPS TO STOP ANIMAL DISEASE SPREAD

STEP 1: BEFORE YOU LEAVE

- ✓ Phone ahead to see if there are any recent disease outbreaks in the village where you intend to buy livestock.
- ✓ Try to buy vaccinated animals.
- ✓ Vaccinate your own animals.

STEP 2: ON ARRIVAL AT FARM

- ✓ On arrival at the village, park your vehicle outside.
- ✓ Check that there is no sign of disease outbreak before entering.
- ✓ You don't want to carry disease on your tyres.

STEP 3: LOOK AND ASK BEFORE BUYING

- ✓ Look at all the stock for signs of serious diseases.
- ✓ Ask if there has been recent disease, as recovering animals can be infectious.
- ✓ Animals appearing well may be developing disease if others are already sick or dead.

STEP 4: MOVING BETWEEN FARMS

- ✓ After visiting a farm, clean hands and footwear.
- ✓ Don't overload the truck or cause stress to the animals being transported. This can lead to the development of some diseases.

STEP 5: WHEN YOU GET HOME

- ✓ Don't mix purchased stock with your own livestock or village animals.
- ✓ If resting stock, keep them separate to risk transferring any disease.
- ✓ Clean the vehicle before the next trip and park it in the sun, as sunlight kills disease germs.

Avoid buying sick animals and use these steps to help prevent the spread of animal diseases to your own animals and other people's livestock.

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៥ ជំហានសំខាន់សម្រាប់អាជីវករទិញលក់គោក្របី ចូលរួមជួយទប់ស្កាត់ការឆ្លងរាលដាលនៃជម្ងឺឆ្លងសត្វ

ជំហានទី ១: មុនពេលចេញដំណើរទៅ

- ✓ ទូរស័ព្ទទាក់ទង និងសួរនាំពីស្ថានភាពនៃជម្ងឺឆ្លង (ផ្ទុះជម្ងឺឆ្លង) នៅក្នុងភូមិដែលបម្រុងនឹងទៅនោះ
- ✓ ព្យាមយាមទិញតែសត្វដែលបានចាក់ថ្នាំការពាររួច
- ✓ សត្វរបស់អ្នកចាំបាច់ត្រូវតែចាក់ថ្នាំការពារជម្ងឺឆ្លង។

ជំហានទី ២: ពេលទៅដល់ផ្ទះកសិករលក់សត្វ ឬកន្លែងទិញសត្វ

- ✓ ពេលទៅដល់ផ្ទះកសិករ ឬកន្លែងទិញសត្វ ចតមធ្យោបាយដឹកជញ្ជូន ឬធ្វើដំណើរនៅខាងក្រៅផ្ទះ
- ✓ ពិនិត្យមើលឱ្យដឹងច្បាស់ថា គ្មានសញ្ញានៃជម្ងឺ (គ្មានផ្ទុះជម្ងឺ) មុននឹងចូលទៅក្នុងទីកន្លែងនោះ ពីព្រោះអ្នកមិនចង់នាំមេរោគនៃជម្ងឺទៅទីកន្លែងដ៏ទៃទៀតតាមរយៈកង់ឡាន ឬមធ្យោបាយដឹកជញ្ជូនរបស់អ្នក។

ជំហានទី ៣: ពិនិត្យមើល និងសួរនាំមុននឹងទិញ

- ✓ ពិនិត្យរកមើលរោគសញ្ញានៃជម្ងឺឆ្លងនៅលើសត្វទាំងអស់នោះ
- ✓ សួរមើល តើមានជម្ងឺផ្ទុះឡើងនាពេលថ្មីៗនេះដែរឬទេ ព្រោះសត្វជាសះស្បើយក៏អាចចម្លងជម្ងឺបានដែរ
- ✓ សត្វដែលមើលទៅមិនឈឺអាចឈឺស្ថិតនៅក្នុងភាពសម្ងំ បើសិនជាមានសត្វឯទៀតនៅក្បែរកំពុងឈឺ / ងាប់។

ជំហានទី ៤: ដឹកជញ្ជូនសត្វ ឬធ្វើដំណើរពីកន្លែងមួយទៅកន្លែងមួយទៀត

- ✓ បន្ទាប់ពីបានទៅដល់ទីកន្លែងទិញសត្វមួយត្រូវលាងសំអាតដៃជើង និងស្បែកជើងរបស់អ្នក
- ✓ ជៀសវាងដឹកជញ្ជូនសត្វហួសចំណុះ ឬធ្វើឱ្យសត្វទទួលភាពស្ត្រេសដោយសារការដឹកជញ្ជូន ព្រោះវាអាចជាមូលហេតុដែលបណ្តាលឱ្យសត្វនោះងាយទទួលជម្ងឺបាន។

ជំហានទី ៥: ពេលត្រឡប់មកដល់ផ្ទះវិញ

- ✓ ហាមដាក់សត្វដែលទើបតែទិញបានជាមួយសត្វរបស់អ្នកដែលមានស្រាប់ ឬសត្វដ៏ទៃទៀតនៅក្នុងភូមិ
- ✓ បើឈប់សម្រាកការដឹកសត្វដែលទិញបាន ត្រូវទុកថែរក្សាវាឱ្យនៅដោយឡែក ជៀសវាងការចម្លងជម្ងឺ
- ✓ លាងសំអាត និងទុកមធ្យោបាយដឹកជញ្ជូននៅក្រោមកំដៅថ្ងៃអាចជួយសម្លាប់មេរោគមុនទៅទិញសត្វម្តងទៀត។

ជៀសវាងទិញសត្វឈឺជម្ងឺឆ្លង សូមប្រើប្រាស់ជំហានទាំង៥ ខាងលើដើម្បីជួយទប់ស្កាត់ការឆ្លងរាលដាលនៃជម្ងឺ ដល់សត្វរបស់អ្នក និងសត្វអ្នកដ៏ទៃទៀត!

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Appendix 1

Workshop focus group questions

Group 1: Knowledge gaps

- Describe the key areas in which we need more research information to improve extension messages, and how to achieve this.

Group 2: Extension manual (in Khmer)

- Describe the key messages we need to include in a manual to enable village animal health worker and farmer training, and how to deliver it.

Group 3: Engaging stakeholders

- Describe the key stakeholders we need to engage more deeply with, and how to do this.

Summary of key recommendations for further research and extension

Theme 1: Improving animal production

- Compare growth rates of cattle on forages versus native grass/straw
- Feeding rice straw, need a mix of grass and legume; add > 30% grass and < 30% Stylo
- Need more case studies of financial benefits of feeding for fattening and reproduction
- Establish how extra time available from forages is used (e.g. schooling for children, crafts, and men's activities)
- Establish cost of feeding and opportunity cost of not feeding

Theme 2: Improving animal health

- Haemorrhagic septicaemia: extend study beyond 6 months (i.e. is there still protection at 9 months?)
- Foot-and-mouth disease: biosecurity training for village animal health workers, vaccine care and coverage etc. required
- Village animal health worker knowledge exists and should be used for disease reporting and response
- Foot-and-mouth disease vaccine practices need improvement: training, serotype, cold chain etc.
- Farmer training program on biosecurity, vaccination, response at provincial office level required

Theme 3: Improving animal trade

- Farmers to 'target feed' animals, and liaise with traders requiring superior quality
- Improved knowledge of animal values needed (e.g. require weight tapes in use)
- Need non-regulatory ways to make trade safer with less disease; trader meetings?
- Education of traders on interventions to decrease disease risk
- Minimise time animals retained in holding facilities
- Develop rapid transport capability; transit can be as short as 15 hours
- Make inspections count (i.e. improved surveillance for disease)
- Vaccination prior to transport required (i.e. a vaccine strategy and animal identification system) plus education of traders and producers

Theme 4: Improving knowledge and capacity

- Need to address knowledge gaps by training, with trader education critical to lowering risks of spreading disease. This means translation of digital stories, development of booklets and posters in Khmer etc., plus a dissemination strategy
- Need for formal training in low-intervention villages, knowledge, attitudes and practices (KAP) assessments and case studies, especially on financial impacts of interventions such as forage use and vaccination

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