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Final report

project

Best Practice Health and Husbandry of Cattle, Cambodia

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Takeo province planting of seeds in Nor Mo village in May 2008

2 Abbreviations

ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AMP	Animal Movement project (ACIAR AH/2006/025)
BCS	Body Condition Score
BPHH	Best Practice Health and Husbandry of Cattle, Cambodia
BW	Body Weight
CIAT	International Centre for Tropical Agriculture
CSU	Charles Sturt University
DAHP	Department of Animal health and production
FMD	Foot and Mouth Disease
HI	High Intervention
HIS	Heat intolerance syndrome
HS	Haemorrhagic Septicaemia
LI	Low Intervention
KAP	Knowledge, Attitudes and Practices
MAF	Ministry of Agriculture and Fisheries
RAC	Royal Academy of Cambodia
SWOT	Strengths, weaknesses, opportunities and threats
TAD	Trans-boundary animal disease
UoS	University of Sydney
US$	United States dollars
VAHW	Village Animal Health Worker

3 Executive summary

Cambodia is one of the world's poorest countries with approximately 30% of the population living below the poverty line, with the majority of the country's poor residing in rural areas. Smallholder farmers own approximately 99% of cattle in Cambodia. Increasing productivity and profitability of cattle production has been recognised as a pathway to help alleviate rural poverty, with this project conducted to evaluate the participatory implementation of technologies for improving smallholder cattle productivity. The study examined the impacts of interventions in nutrition, animal health, husbandry management and marketing on smallholder cattle productivity and household incomes.

The project participated with smallholder farmers, village chiefs, village animal health workers, district and provincial veterinarians, working in six villages within the three provinces of Kampong Cham, Takeo and Kandal. Two villages in each province were designated as either 'high intervention' (HI) or 'low intervention' (LI). A best practice program of participatory research and farmer education was delivered over the 5 years duration to the HI sites, with interventions including education in animal health, biosecurity, nutrition, reproduction and marketing delivered by 'applied field research', 'on the job' training and 'formal training' modes. Practical interventions including forages technologies, regular vaccination programs against Haemorrhagic Septicaemia (HS) and Foot and Mouth disease (FMD), plus anthelmintic treatment where required, occurred in HI sites. The LI sites received HS and FMD vaccination only, and served as a baseline to measure and compare to any HI gains until the final 6 months of the study when the interventions used in the HI sites were provided. A total of 1,519 cattle from 645 households were initially enrolled into the program from the six sites, and a longitudinal survey was implemented with regular recording (2-11 month intervals) of production data, plus several assessments of farmer learning.

Farmer knowledge was shown to improve significantly in HI sites and analysis of baseline production data of over 7,400 weights from 2,100 project-enrolled cattle was obtained and reported. Champion farmers (rapid adopters) were used to promote successful best practice technology implementation through cross-visits to their farms. Between 2008-11, over 1,170 smallholder farmers both within *and beyond* the project sites developed forage plots for cattle feeding, totalling nearly 42 ha or an average of 356 m^2 per household. This rapid adoption of forage technology was driven by farmers seeking to both improve productivity and save time for household members in collecting feed for cattle. The additional time was used for other employment activities, farm enterprise expansion and in the case of children, additional time for schooling and homework. Analysis of the longitudinal survey identified that the average daily gains in cattle increased by a factor 2.4 in the HI sites when compared to cattle in the LI sites. The interventions significantly improved cattle weights in the latter part of the project, identifying a 'lag period' is required for the education and implemented technologies to be translated into measurable cattle weight improvements. Knowledge, attitude and practice and

socio-economic surveys completed in 2012 showed that over 86% of HI smallholders believed their annual income had increased and of these, nearly 62% believed their annual income had doubled or more than doubled as a result of the project.

The project confirmed that a number of best practice interventions are required simultaneously to increase productivity, with a systems approach used to address multiple health and productivity constraints proving very successful in engaging farmers. This methodology is advised as a useful strategy for smallholder farmers, extension workers, researchers and policy makers aiming to facilitate cattle production in the Greater Mekong Sub-region (GMS) as a means of addressing both regional food security and rural poverty. Economic evaluation of individual interventions (e.g. trans-boundary disease control through biosecurity practices) and further evidence of how this approach more rapidly encourages smallholder farmer to move from a subsistence to a production focus in managing cattle production (e.g. optimal reproduction) is suggested.

Conduct of a similar ACIAR funded project in northern Laos (AH/2006/159) over the same time period provided many insights into the complexities of improving large ruminant productivity amongst a range of cultural, geographical and political environments. While the end goal was the same, emerging differences in the projects contributed significantly to learning. In northern mountainous Laos where there is abundant grazing in a free-range environment, farmers successfully established feeding stalls and 'fattened' by target feeding cattle and buffalo for several months prior to sale, achieving higher sale prices. In the southern floodplains of Cambodia, farmers rapidly adopted forage growing and feeding to their cattle improving the average weight and body condition of cattle, with target feeding for sale in Cambodia, still appearing to be limited as farmers divide forages among all cattle with further education on target feeding required. Project ‘entry point’ interventions leading to successful farmer engagement were different in each project. In Laos, calf treatment for *Toxocara vitulorum* was a high priority while forage development captured farmer attention in Cambodia. Understanding of these entry point interventions is critical in that delivery of other interventions (e.g. biosecurity) relies on farmer trust that is best established through delivery of interventions that have early impact at the farm level. This is information of importance when designing future livestock projects to address regional food security and rural poverty within various regions of the GMS.

Villagers and project staff with forage in No Mor village August 2008

4 Background

Despite recent economic development, Cambodia remains a mainly agrarian country with approximately 75% of the population living in rural areas and dependent on agriculture (MAFF, 2011). Increasing agricultural outputs for both domestic consumption and export is considered an important opportunity to improve the livelihoods of smallholder farmers and accelerate the pace of poverty reduction (MAFF, 2011). Approximately 30% of Cambodia's total population of 14.3 million live below the national poverty line, and the majority of these people live in rural areas.

Preliminary estimates are that the agricultural sector contributed 29% of Cambodia's Gross Domestic Product in 2010, an increase from 26.8% in 2008 and 28% in 2009 (MAFF, 2011). Livestock are integral to the economic development of South-East Asia, and in Cambodia, the livestock sub-sector contributes 12.8% to the agricultural sector, behind crop production (53.9%) and fisheries (27.3%). With increased demand for red meat in many developing countries in Asia, opportunities have emerged for Cambodian smallholder farmers to access these markets provided they improve cattle production (Windsor, 2011). Improving regional large ruminant livestock production and trade is a potential pathway to improving smallholder farm profitability, potentially reducing poverty and contributing to future food security, although there are a number of major constraints that need to be addressed (Windsor, 2011).

Smallholder farmers own the vast majority of cattle (>99%) in Cambodia, with only a small number of commercial beef farms in operation. The mixed farming systems practiced by rural smallholders where cattle are used for draught, manure for fertilizer, fuel, a source of cash income and capital asset storage, means that these systems are highly interdependent. The total number of large ruminants (cattle and buffalo) in Cambodia was reported at approximately 4.17 million head in 2010 (MAFF, 2011), with a cattle population 3.48 million head, a decrease of about 2.6% from 2009 (MAFF, 2011). A number of factors may be influencing the decrease in the national herd size, including increased feed costs, illegal trading because of increased export demand, plus animal movements to replace market losses associated with regional climatic impacts (Khounsy et al., 2011). However it is likely that increased mechanization with a reduced need for draft animals and trans-boundary animal diseases, particularly endemic foot-and-mouth disease (FMD) and haemorrhagic septicaemia (HS), is of relevance to the dynamics of the large ruminant population in Cambodia. There has been a recent decrease in the number of cattle and buffalo used for draught in Cambodia, falling by 13.2% to 1.63 million animals from 2009 to 2010, which equates to 39% of the total large ruminant population. This trend may be associated with the recent increase in the numbers of tractors and hand tillers, increasing by 16.2% and just over 20%, respectively (MAFF, 2011).

A number of factors are currently constraining the development of the large ruminant sector in Cambodia. These factors include (but are not limited to):

- Endemic infectious diseases and parasites
- Poor nutrition and feeding management
- Low smallholder farmer knowledge of animal health and husbandry
- Poor veterinary services with limited resources
- Poor understanding of developing cattle market systems

Of particular importance in these constraints and crucial to the enhancement of trade within and outside the region, is improved control of highly infectious trans-boundary diseases, with FMD being the top priority (Perry et al., 1999). However whilst previous projects have been focused on addressing these constraints individually, context appropriate research is required that examines how multiple constraints can be addressed through mainly knowledge-based interventions. The integrated and interdependent nature of cattle production by smallholders combined with the broad range of constraining factors justifies the need for a systems approach to addressing these issues. The Best Practice Health and Husbandry of Cattle, Cambodia project seeks to research innovative technologies to achieve the successful uptake and adoption by smallholders.

The aim of this project was to examine how a systems approach to improving profitability of smallholder large ruminant production could more readily enable farmers to move from subsistence to production, addressing rural poverty and contributing to regional food security. Working at six project sites consisting of three sets of 'matched' villages in three provinces, the project conducted a longitudinal study that compared the impacts in villages where a 'best practice' or ‘high intervention’ health and production package was implemented over time, with those where a minimum or ‘low intervention’ strategy was applied.

5 Objectives

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

Activities

1.1 Consolidate, evaluate and report currently existing disease information.

1.2 Conduct a longitudinal survey targeting specific diseases as well as that passively occurring in target and non-target intervention communities.

1.3 Identify and test cost effective means of sample delivery to laboratories for confirmation and reporting of a diagnosis.

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

Activities

2.1 Measure key indicators of performance as baseline information for evaluation of outcomes based on interventions (morbidity and mortality rates, calving rates, inter calving intervals etc.)

2.2 Introduce and evaluate key interventions e.g. vaccination for bacterial and viral diseases of concern (FMD, Haemorrhagic Septicaemia), management of parasitic diseases (Fasciola gigantica, Toxocara vitulorum) and reproductive management (controlled mating, bull and cow soundness and fertility assessment, nutrition for lactation)

2.3 Introduce and assess various livestock handling approaches.

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

Activities

3.1 Targeted farmer surveys at the commencement of the study, at mid-point and at the end of the study and communication activities to stakeholders.

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

Activities

4.1 Describe the supply chain, the key drivers for profit and opportunities for valuing adding based on profit indicators and market organisation.

4.2 Implement and test approaches that increase value for livestock owners.

Objective 5. To communicate project outcomes to large ruminant stakeholders (*Project extension objective added in 2012*)

Activities

5.1 Large ruminant livestock sector stakeholder engagement and attendance to the project final workshop in July 2012.

5.2 The preparation and publication of an ACIAR Proceedings document from the July 2011 collaborative workshop attended to by the 'Best practice', 'Forage 4 Beef' and 'Animal Movement' project leadership and staff.

Project farmers with forage grown next to rice plantings.

6 Methodology

6.1 Project implementation

Prior to the commencement of the project in August 2007, a short research activity was conducted that included farmer attitude surveys where 90 households in the provinces of Kampong Cham, Takeo and Kandal (6 households in 5 villages per province) were interviewed by three research teams (one in each province). This farmer attitude survey confirmed the importance of large ruminants in smallholder rural development in Cambodia, identified the major knowledge gaps, tested the level of cooperation of stakeholders in the potential project sites, assisted in project site selection, and provided an informed basis for discussion at the project implementation workshop of how best to meet the project objectives. The project implementation workshop was held in Phnom Penh in September 2007 and was attended by 60 registered participants on day one and 64 on day two. On the second day there were also an additional six senior ministry officials accompanying the Minister of Agriculture for the closing ceremony, confirming the high profile of this activity in Cambodia. The workshop provided many insights into opportunities to address constraints to cattle productivity, with potential project interventions most desired by stakeholders involved in the project, more clearly defined.

6.2 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:

- High level of cooperation of farmers, local authority, district and provincial staff;
- Interest in adoption of technologies to improve husbandry and health;
- Evidence of interest in adoption of forage feeding systems;
- Evidence of interest in intensification of cattle production such as stall feeding;
- Preferably, access to export markets for sale of cattle;
- At least 250 cattle in each village (>100 adults, >50 weaners and >50 calves);
- Ease of access to project site(s), i.e. a suitable road for travel to the village
- The two project villages in each province were at least 10 km from each other.

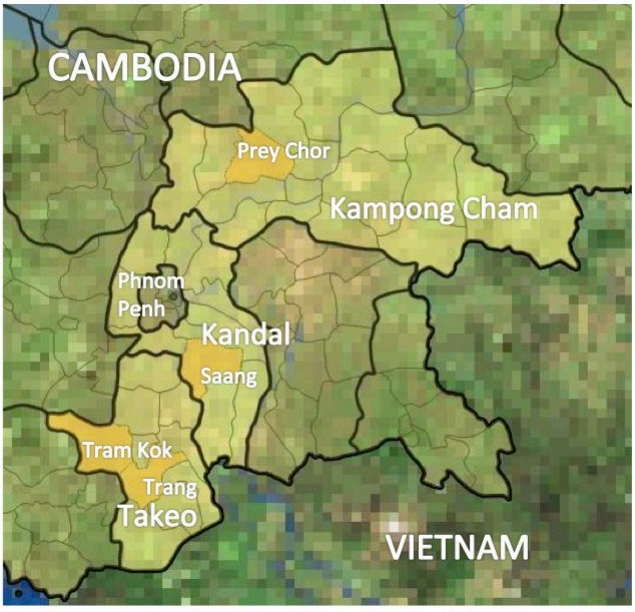
Three of the six target villages were classified as High Intervention (HI) villages (one in each province) and a ‘best practice health and production’ package was gradually implemented. The package includes vaccination programs for HS and where appropriate FMD, forage

planting and management, as well as large ruminant health and husbandry knowledge training. The remaining three villages were classified as Low Intervention (LI) where HS and FMD vaccination when necessary, were implemented as a participatory incentive. The LI village sites provided a longitudinal 'control' comparison to benchmark any productivity and health improvements observed between the sites.

Project sites (villages)

The selected HI villages were Nor Mo village of Tram Kok district in Takeo province, Senson Tbong village of Prey Chhor district in Kampong Cham province and Preak Por village of Saang district in Kandal province. The LI villages where only the vaccination program was implemented 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 three project provinces and districts are displayed (Figure 1).

Figure 1. Map of southern Cambodia showing the three project provinces (light green) and the four project districts (yellow) containing the six project villages



The farmers enrolled in the project were selected through consultation between project staff and the village chief. The decision for inclusion of a farmer was based on criteria that they owned at least one head of cattle and displayed a high level of receptivity to possible introduction of new technologies.

6.3 Best Practice Health & Husbandry Program

Over the life of the project a 'best practice' education program was implemented in the 3 HI villages and then also in the 3 LI villages in the final year of the project, as follows.

Training & Education Interventions

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

1. Participatory 'applied field research' consisted of the project-enrolled farmers presenting their cattle on eight occasions over a 4-year period for weighing, sample collection (e.g. faeces for internal parasites and blood for serology) and recording of additional health and production information (including reproduction and movement such as sale or death). 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. The regular weighing of cattle for the longitudinal survey provided farmers with periodic objective updates of the performance of their cattle (weight improvement) and assisted farmers with livestock valuation.

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, including regular vaccination and anthelmintic treatments (when required) plus importantly, substantial improvements to available nutrition through forages technologies. It was noted there was a severe year-round deficiency of energy and protein in the diet of cattle in this part of Cambodia, with mainly rice straw available in the wet season and limited grazing of the harvested rice paddy in the dry season. It became clear that a major focus of the project was to assist farmers to establish and manage forage plantations.

3. The 'formal training' was conducted between February 2009 and March 2012 with a series of 20 workshops delivered to over 420 Village Animal Health Workers and 630 smallholder farmers in each of the three HI villages. These 1 to 4 day workshops addressed topics on improving health and production, and followed additional technical training of district and provincial veterinary officers and project staff in the areas of biosecurity, disease investigation, sampling, control and reporting, by the University of Sydney (UoS) and Cambodian Department of Animal Health and Production (DAHP) teams.

The training workshops for smallholder farmers and VAHWs consisted of five modules and 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 buffalo

- Fascioliasis
- 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
- Weed control
- Irrigation
- Cutting and feeding management
- Silage development

V. Husbandry, breeding and reproduction

- Husbandry
- Feeding and feeding management
- Breeding selection, breeding management
- Reproduction

6.4 Longitudinal survey

The longitudinal study involved 1,519 cattle initially enrolled and an additional 607 cattle included as replacements, with repeated measurement of production parameters during visits by project staff to each village site on eight occasions during over a 47-month period of the project (data collections occurred at 2-11 month intervals). The survey collected a range of data including age, sex and breed, body weight (assessed by electronic scales), body condition score, skin condition, draught use and strength, plus reproduction information including number of mating's, bull selection, calves born, as well as treatments administered and samples collected. Movement from the project including sale and death was recorded. Despite a significant fall-out of cattle from the project (mostly due to sale), over 7,400 weight measurements were recorded. Data was recorded on animal record sheets and entered into Microsoft Excel database by project staff. Preliminary analyses occurred in 2010 with final analyses in 2012.

The longitudinal survey ensured regular contact between project staff and smallholder farmers, enabling multiple interventions to be performed in addition to data collection. These included vaccination and anthelmintic treatment, diagnostic testing for diseases and parasites through blood and faecal sampling, plus discussion of cattle marketing practices and current trends. Importantly, the longitudinal activities enabled the building of trusting collaborative learning relationships between farmers and project staff, where the interventions such as the forages could be developed and updates on the project outcomes could be communicated.

A copy of the Longitudinal survey collection sheet is provided (Appendix 1).

6.5 Animal health and biosecurity interventions

Vaccination: Cattle in both HI and LI villages were vaccinated for HS on a regular basis and FMD when appropriate, with the aim of vaccinating cattle every 6 months. This was subject to vaccine availability, with the final FMD vaccination occurring in August 2010 and the final HS round of vaccinations occurring in February 2012. Vaccination included both project enrolled and as many non-enrolled cattle in each village when available. Vaccination was performed during the longitudinal survey data collections.

Infectious disease surveillance and diagnostics: 120 project cattle were sampled and tested for presence of Bovine Brucellosis (*Brucella abortus*) using both Bovine Antibody Rapid Test and Rose Bengal Testing. All test results were negative. 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., 2011). FMD was reported to have occurred in the project village Veal, the LI village in Kampong Cham province (Nampanya et al, 2011). From July to November 2010, FMD affected about 20% of the cattle population in Veal (anecdotally mostly unvaccinated

introduced cattle) compared to almost 100% of cattle affected in neighbouring villages with the exception of the HI village of Senson Tbong that remained uninfected (Nampanya et al., 2011). PhD students collaborating with the project investigated vaccine efficacy by post-vaccination serosurveys for both HS and FMD (Ieng et al, 2013; Stratton and Tiang, 2013).

Parasitic diagnostics: 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 longitudinal survey.

Anthelmintic treatment: Cattle in HI villages were treated with Nilzan© or Fasinex© on four occasions between October 2009 and March 2011. A total of 859 cattle were treated resulting in 56-77% of project cattle being treated each time. Anthelmintic treatment was performed during the longitudinal survey data collection.

6.6 Forage interventions

Project staff worked with HI smallholder farmers to develop forage plots, using five species of forages: *Panicum maximum* (Simuang), *Brachiaria spp*. hybrid (Mulato II), *Brachiaria brizantha* (Marandu), *Paspalum atratum* (Terenos) and legume *Stylosanthes guianensis* (Stylo 184). These species were selected based on previous work that indicated their suitability to the Cambodian climate and superior nutritional quality to native grasses for cattle, with seeds obtained from CIAT on advice from Dr Werner Stür. Seedlings were established in nursery plots, initially in HI sites and then beyond, following meetings with commune leaders, village chiefs and farmers interested in the use of forages for cattle feeding beyond project sites. Cross-visits between village sites involving early adopter 'champion farmers' facilitated the demonstration of successful nutritional interventions.

The location, number of farmers, and plot size of forage development was recorded throughout the project. 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. By 2011 (inclusive) over 1,171 households (both within and outside of project villages) developed forage plots for a total area of 416,508 m^2, or average household forage plot size of 356 m^2.

A 51-page booklet titled 'Forages and Forage Cultivation Techniques' was prepared and published in Khmer in March 2012. A total of 3,000 copies were printed and distributed to smallholder farmers, VAHW's, District and Provincial Veterinarians, and village and commune leaders in order to promote and consolidate the impressive uptake of forage technology for cattle feeding.

Feeding Trial

A 3-month feeding trial involving 22 cattle was conducted between June and October in 2012 to establish if the principles for cattle fattening developed in Lao PDR (Stür & Varney, 2007) could be adopted by smallholder farmers in southern Cambodia in field settings. A total of 7 farmers including 3 from No Mor, one from Sen Ork, and 3 from Senson Tbong were recruited through consultation with the village chief, using the desired criteria of:

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 & Varney, 2007);
3. have the facilities to feed the trial animals in individual feeding pens;
4. have literacy levels appropriate for data recording;
5. are enthusiastic about participating in the study.

The cattle enrolled in the study included a range of ages and sex (castrated males, bulls and females) and were selected by the participating farmers, in accordance with their production goals, including improved breeding, enhanced power for draught, or to improve live-weight and BCS for sale. The number of animals selected was dependent on the amount of available forage. The 22 cattle included 14 as trial animals and 8 as controls. Cattle were vaccinated and drenched prior to the trial to ensure optimal health status during the trial. Farmers recorded intakes for each trial and control animals with the intention of feeding trial cattle 15% BW in forages per day. Cattle were weighed at approximately monthly intervals by project staff using electric Tru-Test 2000™ weigh scales.

6.7 Marketing interventions

Regular weighing of cattle during the longitudinal survey data collections provided farmers with objective measures of cattle weight and hence increased knowledge of a fair market value. The cattle market chain was investigated through interviews of stakeholders and trader surveys. Farmers were educated in feeding cattle for fattening and targeting markets and peak demand periods, rather than reflex selling of cattle when animals are sick or emergency cash is needed. Farmers were trained to seek multiple quotes from traders prior to sale. The use of weigh tapes was also trialled.

Trader surveys

Trader surveys were conducted in August and September of 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 included Kandal, Kampong Cham, Kampot, Takeo, and Phnom Penh. In 2011, traders from Kompong Thom were also surveyed due to its proximity to and supply of cattle to Phnom Penh.

The survey questionnaires were designed by the project team and included questions on trader practices, including 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, breed in the case of cattle, age group in years, and body condition score (BCS). 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 experienced. In addition to the 2009 survey, traders in 2011 were also requested to provide information on the source of purchased cattle, transport methods to slaughterhouse and markets and market locations.

Traders known to regional official DAHP staff were invited to the district veterinarians' offices in 2009 and to provincial veterinarians' offices in 2011. DAHP staff 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 was translated and entered into Microsoft Excel spread sheets by the DAHP project staff, and analysis performed.

A copy of the trader survey is provided (Appendix 2).

6.8 Knowledge, Attitude and Practice (KAP) Surveys

Three KAP surveys were conducted during the project, including 2008, 2010 and 2012, to provide objective measures of progress in smallholder farmer knowledge levels, changes in attitudes and improvements in practices relating to animal health, biosecurity, nutrition, reproduction and marketing. A total of 150 (25 per village) smallholder project farmers in 2008 and 120 (20 per village) farmers in 2010 were randomly selected for survey participation. The survey was modified from a semi-structured (categorical and quantitative) questionnaire previously used successfully in Laos by the ACIAR project team (Nampanya et al., 2010), consisting of open, closed and semi-closed questions (two-choice and ranking questions) to explore farmer knowledge. The questionnaire design aimed to keep the wording as simple and brief as possible and was written in English then translated into Khmer. Questions included social and economic parameters and large ruminant marketing, but focused on farmer knowledge on biosecurity, animal husbandry and large ruminant diseases especially FMD, HS and blackleg. The survey team included central project staff 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.

In 2012 the survey consisted of 3 distinct sections aimed at encompassing knowledge, attitudes and practical aspects of smallholder cattle production. Knowledge questions focused on 4 subtopics; infectious diseases (FMD, HS and blackleg) and biosecurity, internal

parasites, nutrition and reproduction. Marketing questions were included as well as questions about the farmer's beliefs on cattle production practices aimed at capturing their attitudes to concepts learnt. Practices relating to key knowledge topic areas were also investigated through a series of questions.

The questionnaire was based on that used in surveys conducted in 2008 and 2010 in Laos (Nampanya et.al. 2012) and used to determine both the levels of knowledge as well as current attitudes and practices. The third KAP survey consisted of 41 multiple choice questions where famers had the option of ranking or choosing multiple options in some cases. The survey was designed in English with questions formatted and worded to facilitate ease of translation into Khmer.

A total of 20 farmers were selected from each of the 6 project villages (total farmer sample of 120), equating to 60 farmers from each HI and LI cohort. Project staff contacted the 6 respective village chiefs who selected project participants for survey inclusion. Questionnaires' were conducted in March 2012 by project staff in each village using a combination of face-to-face and group interviews (of maximum 5 farmers). Consistency was maintained by having at least 2 project staff members present at each interview session.

The surveys allowed objective assessment between both HI and LI project cohorts, provinces and villages; as well as between years to show any trends in smallholder farmer KAP parameters.

Copies of the 2008 Farmer knowledge survey and the 2012 KAP survey are provided (Appendix 3 & 4).

6.9 Socio-economic evaluations

Socio-economic evaluations were conducted with the aim of assessing both project impacts and the impacts of the trans-boundary diseases FMD and HS.

Project impact survey

A survey was designed in January 2012 containing 17 questions directed at smallholder cattle farmers involved in the project to obtain socio-economic information. Questions focused on the current farming and household situation including farm size, number of household members, current management practices such as forage growing and investigated the associated socio-economic benefits such as annual income and time savings achieved through project intervention activities. Survey questions were kept simple and succinct to allow for ease of translation into Khmer and to facilitate the comprehension by farmers during the interview process. Survey responses were restricted to yes/no answers, numerical figures or rankings in order of importance to minimise verbosity and minimise potential reporting errors. Survey questions were incorporated into an existing smallholder farmer KAP survey to minimise the number of trips to project sites and the time spent interviewing farmers, reducing potential survey fatigue. The survey was distributed by project staff in March 2012 and

conducted in project village sites, with farmers selected to participate by the village chief. In order to minimise response bias, interviews were conducted on a one-on-one basis and where this was not possible, interviews were conducted in a small group setting (of no more than five farmers) and responses recorded individually for each farmer. All interviews were conducted in Khmer and all responses recorded for each farmer in Khmer onto a predesigned survey and answer sheet. The results were translated into English and collated in a Microsoft Excel 2010 database.

FMD Financial Impact Survey

In late 2010, FMD outbreaks occurred in the vicinity of four of the six project villages. Project staff conducted a financial impact survey questionnaire (FISQ) in September 2010, involving 62 farmers that all owned cattle affected by clinical FMD, located in the villages of Preak Taprum and Kompongous in Kandal Province, and Meemang and Tang Tpang in Kampong Cham Province. The FISQ contained questions on the number of household members, number of cattle owned, FMD morbidity and mortality during the outbreak, and financial information on the cost impacts of cattle affected by FMD infection. Farmers were asked to estimate the weight and value of their cattle prior to (pre-FMD) and after FMD infection (post-FMD), as well as the cost of treatment and management, disease duration, and finally, the costs of draught animal replacement. Financial information was provided in KHR (Cambodian Riel) and converted to US$ at the exchange rate of KHR 4200 = US$ 1 (September 2010). The FISQ results were recorded during each interview onto a purpose designed record sheet and later entered into a Microsoft Excel worksheet. Descriptive analysis was performed using the statistical software GenStat 12th Edition (VSN International).

HS Financial Impact Survey

The financial impact of outbreaks of HS in 2012 on smallholder farmers in Cambodia was investigated in August and December 2012, using a FISQ questionnaire involving 67 smallholder cattle and buffalo farmers from the five villages of Lvea and Alek in Kampong Chhnang province, Tropangplong I and Rel Krom in Kampong Cham province, and Cheou Pleung in Pursat province. Epidemiological and financial impact information was collected by interviews with affected farmers in each of the study villages by face to face farmer interviews in order to maximise details and accuracy of information obtained from each farmer. In addition, interviews with the village chief (VC) or the village animal health workers (VAHWs) were attempted in each study village and interviews were carried out using pre-structured questionnaires. Data was analysed to assess the financial impact and a partial budget used to assess the net benefit or cost to smallholders of using HS vaccination.

A copy of the 2012 Large ruminant disease FISQ is provided (Appendix 5).

Investigating the chronic effects of FMD

With the aim to undertake a survey to investigate the occurrence of clinical signs consistent with chronic FMD in cattle in Cambodia, DAHP Extension Office staff worked with a UoS

veterinary student to design and implement a phone survey of District Veterinarians (DV's) to broadly estimate the incidence of chronic FMD. No sampling frame (list of DV's) was readily available, so Provincial Veterinarians were contacted from the three provinces Takeo, Kandal and Kampong Cham and asked to supply up to 6 telephone numbers of DV's working in their province, with 16 phone numbers of District Veterinarians obtained.

The survey consisted of four questions, investigating clinical signs, proportion and time frame of clinical signs, consequences of infection, as well as an open-ended question requesting description of any other chronic sequelae observed following FMD infection. All clinical signs included in question one had previously been reported as associated with 'heat-intolerance syndrome (HIS), except for 'increased time spent in water.' This behaviour had been reported anecdotally by farmers during field trips, and was included as a behaviour potentially related to impaired thermoregulation. The numbers of questions were limited to reduce the time taken to conduct the survey and wording was kept simple to facilitate ease of translation. The survey was translated into Khmer for the survey and then back translated and inputted into Microsoft Excel for analysis.

6.10 Village Animal Health Worker Survey

A large-scale interview of VAHWs was conducted with the aim of establishing the potential of improved links between VAHWs, government and farmers in FMD control in Cambodia. The study was conducted during the first half of the project in 2008-09 by a PhD student (John Stratton) from the UoS, using a 'guided group interview', with 445 VAHWs interviewed from 19 of the 24 provinces in 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 for clarifications regarding the questions and answer options was provided, and the circled answer was completed individually, prior to advancement to the next question in the survey. Khmer staff circulated amongst interviewee groups to provide assistance where required for this mainly multiple choice interview questionnaire.

The questionnaire comprised 30 questions covering five topic areas; training received; farmer contact and income; government contact and reporting; HS; and a larger group of questions relating to FMD. Accompanying the questionnaire was a simple quiz with six multiple-choice questions that tested the basic knowledge of VAHWs of FMD. Unlike the questionnaire, this quiz was conducted as a written exam without 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 supplied on FMD basic epidemiology (in Khmer) and demonstration of practical cattle restraint.

6.11 Project Personnel, Collaborators and Students

A number of people and organisations contributed to this project.

Core Project team

University of Sydney, Australia

Professor Peter Windsor – Australian Project Leader
Dr Russell Bush – Project Advisor
Lynn Henry – Project Advisor
Luzia Rast – Project Officer 2007-11
James Young – Project Officer 2012-13

Department of Animal Health and Production, Cambodia

Dr. Suon Sothoeun – Cambodian Project Leader
Kea Pha – Chief, Extension Office
Leoung Van Irng – Vice Chief, Extension Office
Thong Samnang – Vice Chief, Extension Office
Hout Savouth – Vice Chief, Animal Production Research Institute
Hing Sarin – Administration Manager, Animal Production Research Institute

Collaborative Scientists

Dr Werner Stür – Forage and Livestock Systems CIAT Asia

Student contributors

Royal Academy of Cambodia

- Ieng Savoeurn – The epidemiology of haemorrhagic septicaemia (PhD)
- Dr Mong Seang Ngim – Investigating forage feeding for improving cattle productivity (PhD)
- Dr Tiang Sin – The epidemiology of foot-and-mouth disease (PhD)

University of Sydney

- John Stratton – linking VAHWs, government and farmers in FMD control (PhD)
- John O'Connell – analysis of trader surveys (MVPHMgt research project)
- James Young – longitudinal cattle productivity (MVPHMgt research project)
- Daniel Wills – a pilot FMD vaccination field trial in Takeo Province (BVSc Hons)
- Luke York - spatial & temporal trends in smallholder cattle production (BAVBioSc Hons)
- Hugh Stahel – analysis of smallholder cattle market chains (BAVBioSc Hons)
- Katherine Ashley – socio-economic benefits of improved health and husbandry of cattle (BAVBioSc Hons)
- Rachael O'Reilly – evaluation of participatory based interventions (BAVBioSci Hons)
- Brianna Page – forage feeding for improving cattle productivity (BAVBioSc Hons)

- Anne Jordan – investigating impacts of chronic FMD (BVSc RPP)
- Naomi Boyd – impact of FMD: a case study (BVSc RPP)
- Minae Kawasaki – financial impact of haemorrhagic septicaemia (BVSc RPP)

Harvesting forage in Senson Tbong village in Kampong Cham

7 Achievements against activities and outputs/milestones

No.	Activity	Outputs/Milestones	Completion Date	Comments
Objective 1. To confirm current knowledge of disease limitations to large ruminant production.				
1.1	*Consolidate, evaluate and report currently existing disease information.*	Assessment and summarisation of current information available from the DAHP on status of large ruminant diseases was conducted. Official epidemiological disease data from between 2008-11 summarised for FMD, HS & Blackleg, and documented in the ACIAR Cattle Proceedings.	Jul '12	Disease underreporting recognised as an issue within Cambodia.
1.2	*Conduct a longitudinal survey targeting specific diseases as well as that passively occurring in target and non-target intervention communities.*	Disease surveillance was conducted as part of the longitudinal survey and best practice program: *Parasites*- Faecal samples from 1,080 cattle from project sites collected during wet and dry seasons in 2009. 859 anthelmintic treatments given to HI cattle over 4 visits resulting in 56-77% of enrolled cattle treated at each visit. *Infectious diseases*- Post vaccination HS and FMD serosurveys conducted. 120 project cattle sampled and tested for Bovine Brucellosis. Results are documented in the Cattle Proceedings.	Feb '12	FMD, HS, Blackleg, Fascioliasis and Paramphistomiasis confirmed as diseases of priority. No evidence of Brucellosis on testing. Laboratory testing was limited due to high cost of performing laboratory tests and significant delays in receiving results.
1.3	*Identify and test cost effective means of sample delivery to laboratories for confirmation and reporting of a diagnosis.*	Project staff, district and provincial veterinarians trained in best practice concepts research and extension methods, large ruminant husbandry, disease investigation, sample collection, surveillance, reporting, disease control, biosecurity and food safety Linkages of extension expertise between DAHP, AED and provincial AHP offices with NAVRI staff during a Biosecurity workshop in March 2012.	Sep '08, Dec '08, Sep '09, Mar '10, Dec '10, May '12	Training in epidemiology including diagnosis, sample taking and laboratory submission was undertaken in March 2012. Project laboratory testing included post vaccination serosurveys for both HS and FMD, testing for Brucellosis, and faecal sedimentary and flotation for examination for helminth infection. NAVRI high test costs and significant delays in result procurement (in one case over a year) limited undertaking testing through NAVRI.

No.	Activity	Outputs/Milestones	Completion Date	Comments
Objective 2. To implement, test and demonstrate the value of interventions preventing key diseases, preventing introduction of diseases and managing reproduction.				
2.1	*Measure key indicators of performance as baseline information for evaluation of outcomes based on interventions (morbidity and mortality rates, calving rates, inter calving intervals etc.)*	Over 2,100 cattle were enrolled into the longitudinal survey between March 2008 and February 2012 from the 6 project village sites. 8 data collections were undertaken at 2-11 month intervals, with cattle age, sex, weight, BCS, calves born, matings, faecal and blood testing were recorded. In addition interventions including vaccination (HS and FMD), anthelmintic treatment and forage plot development was performed. Baseline data was recorded, analysed and reported with preliminary results published in the Cattle Proceedings and a journal article in preparation.	Feb '12	Over 7,400 cattle weight measurements taken from over 2,100 enrolled project cattle. Forage feeding and cattle nutrition identified as major focus and acted as an extension 'entry point' to deliver disease prevention and biosecurity interventions. A positive relationship in production and health was identified using a systems approach to improving cattle productivity, as demonstrated by higher average weights and daily gains in cattle from the high intervention sites.
2.2	*Introduce and evaluate key interventions e.g. vaccination for bacterial and viral diseases of concern (FMD, Haemorrhagic Septicaemia), management of parasitic diseases (Fasciola gigantica, Toxocara vitulorum) and reproductive management (controlled mating, bull and cow soundness and fertility assessment, nutrition for lactation)*	FMD and HS post vaccination serosurveys were performed in cattle assessing the antibody responses of cattle following vaccination. Faecal analysis was performed in cattle following treatment regime with anthelmintics. The longitudinal survey captured data on reproductive indices following basic education in reproduction management. Financial assessments of disease impacts of farmers and benefits of FMD vaccine use were conducted in 2010 through a financial impact survey questionnaire.	2008-12	Serosurveys of HS vaccine showed a strong serological response, and recommends evaluation beyond 180 days in future studies. FMD vaccine serosurveys showed 90% cattle had serological titres suggesting immunity from FMD type O by ELISA at 21 days post vaccination. Faecal analysis indicated anthelmintic treatments were highly effective in project cattle. Reproductive performance was higher in HI villages with more calves born and shorter inter-calving intervals however not at a statistically significant level. Financial assessment showed a very strong financial incentive for FMD vaccine use once direct and indirect costs were accounted for.

No.	Activity	Outputs/Milestones	Completion Date	Comments
2.3	*Introduce and assess various livestock handling approaches.*	During the 8 data collections and feeding trial a cattle crush was erected at village sites for safe restraint and animal handling to perform interventions such as vaccinations and treatments and weighing. Farmers were educated on the use of feeding troughs for target feeding and cattle stalls for over-nighting of cattle. Bleeding poles were used for restraint for blood sample collection for the serosurveys.	Feb '12	Traditionally cattle are restrained and led through the use of a halter passing through the nose and around the ears that is tied to a rope. The rope may vary in length but is typically about 3 m long. Cattle led by owners or keepers would often balk at the cattle crush entrance and required a lot of effort to get into the crush and onto the scales.
Objective 3. To assess attitudes of farmers in targeted communities to health, husbandry and market issues, and communicate project outcomes to large ruminant stakeholders in target areas.				
3.1	*Targeted farmer surveys at the commencement of the study, at mid-point and at the end of the study and communication activities to stakeholders.*	2 Knowledge surveys conducted and compared in 2008 (150 farmers – 25 per village) and 2010 (120 farmers – 20 per village). A further Knowledge Attitudes and Practices (KAP) survey conducted in 2012 (120 farmers – 20 per village) to compare to 2008 and 2010 surveys was conducted.	March '12	Surveys indicated baseline farmer knowledge was low and importantly showed significant improvement during the life of the project in both HI and LI farmers. HI farmers had significantly higher knowledge gains than LI farmers.
Objective 4. To improve knowledge of the cattle supply chain and key drivers in the targeted communities.				
4.1	*Describe the supply chain, the key drivers for profit and opportunities for valuing adding based on profit indicators and market organisation.*	An analysis of smallholder cattle industry and assessment of current trends in cattle trade were completed in 2012, through conducting two trader surveys in 2009 and 2011-12, stakeholder meetings with project participants and DAHP staff. Two papers have been written for inclusion in the ACIAR Cambodia Cattle proceedings as updates on current research.	July '12	The project has confirmed the two primary constraining issues for smallholders are improving nutrition for cattle and limiting infectious diseases. There are a number of other issues, including the lack of a Market Information System (MIS), lack of formal domestic and export markets and a lack of producer knowledge of best practice health and husbandry techniques. Trader surveys show that prices of cattle have increased significantly in the last 3 years, further highlighting the strong demand for red meat in the region. There is enormous opportunity for smallholder farmers to increase profitability through increasing cattle weight and condition and receive a premium price for a premium product. The promotion of target feeding of cattle for profit is strongly recommended.
4.2	*Implement and test approaches that increase value for livestock owners.*	The development of forage plots for cattle feeding in HI villages was undertaken from 2008-12. Anthelmintic treatments and vaccination was performed regularly. A feeding trial was conducted in the wet season (June-September) in 2012 to evaluate target	October '12	Rapid forage uptake offered an entry point to deliver animal health interventions which together led to increased cattle weights as demonstrated through the longitudinal study. The feeding trial also showed increased value through feeding forages. The use of a weight tape would likely ensure smallholder farmers receive a fair price at the point of sale.

No.	Activity	Outputs/Milestones	Completion Date	Comments
		feeding practices. The use of a weight tape was piloted on approximately 240 cattle to evaluate its use in the field setting.		
Objective 5. To communicate project outcomes to large ruminant stakeholders (Project extension objective added in 2012)				
5.1	*Large ruminant livestock sector stakeholder engagement and attendance to the project final workshop in July 2012.*	The final workshop was held was held in Phnom Penh on the 19th and 20th of July 2012 and was attended by 40 stakeholder participants.	July '12	This meeting allowed sharing and discussion of research activities among both local and international researchers, institutions and stakeholders.
5.2	*The preparation and publication of an ACIAR Proceedings document from the July 2011 collaborative workshop attended to by the 'Best practice', Forage 4 Beef' and 'Animal Movement' project leadership and staff.*	21 papers including 5 reprints of original work published during the project were written and edited for this important collaborative project document.	January '13	Delays in receiving original papers from authors and a range of writing styles led to significant delays in the editing of this text. After an initial submission in November 2012 ACIAR requested several required revisions that were made and the full document was resubmitted in late January 2013. Planned publication for June 2013. This will be a valuable cattle production resource for extension workers, researchers, policy makers and students.

8 Key results and discussion

The results of the project are presented under the five main themes that emerged through the course of the project, including: (1) improving cattle production; (2) improving cattle health; (3) improving marketing and trade; (4) improving knowledge and capacity building; and (5) assessment of financial and socioeconomic impacts.

8.1 Theme 1: Improving cattle production

In the traditional Cambodian rural smallholder cattle farming system, there is limited year round nutrition available to large ruminants, reflected in the generally low BCS of animals in the rice growing regions. During the rainy season, typically from June to October, rice growing occupies a significant proportion of arable land and the need to prevent animals from accessing rice paddies results in restricted nutrition, usually to weeds available on the roadside, levy banks and other non-cultivated areas, supplemented by rice straw. Although green, these are typically native grasses with low digestibility or nutritional value. In the dry season, typically from November to May, the primary source of nutrition is provided from tethered grazing of rice paddies, foraging weeds between the rice stubble and often requiring animals to walk for long distances. Rice straw conserved post-harvest is widely available and used but is of low nutritional value with high energy costs in digestion of this high fibre low energy and protein 'filler'.

These feeding practices mean that large ruminants are traditionally fed for survival, resulting in very low body condition scores (BCS), increased susceptibility to disease, poor reproduction, and generally low productivity, with returns to farmers who sell when cash is required rather when animals are most marketable. For females the consequences include extended inter-calving intervals (up to three or more years) and low milk production resulting in slow calf growth, plus reduced power of bullocks and cows used for draught. Improving the quantity and quality of the nutrition offered to these animals is a necessity. It is considered that this is best be achieved by the introduction of rapidly growing forage species to provide superior yields and nutrient supplies compared to local native grasses. Irrigation to extend the growing season for these forages plus silage production to conserve fodder and provide better quality feed during the dry season, provides substantial opportunities for improved productivity. A major focus for improving productivity in the project was the investigation of:

- introduced forage productivity and quality in the smallholder environment;
- undertaking a longitudinal cattle production survey to provide baseline data and measure project intervention impacts;

- measure the level of forage technology uptake and adoption both within and in surrounding areas of project sites;
- and conduct a field study of target feeding.

Introduced forage productivity and quality in the smallholder environment

Results showed that forages are typically ready for harvest two months after planting to yield 6.2-7.4 kg/m^2 for fresh grasses and 3.2 kg/m^2 for fresh legume (Table 1). The crude protein (CP) ranged from 11.7% to 15.9% for the four grass forages, and the legume (Stylo 184) recorded the highest CP of 17.8% as expected (Table 2). The digestibility of all forages was more than 60%. The average daily weight gain ranged between 0.33 kg to 0.52 kg, the higher gains achieved with cattle fed Mulato II and Terenos and achieved with a daily consumption of approximately 21 kg of fresh forage (Table 3), confirming that these forages provide improved nutrition for cattle production. Extending the fattening period through use of irrigation as well as fodder conservation as silage was also demonstrated.

Table 1. Fresh Forage yield (kg/m^2)

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

Note: ^{ab} Means within columns with different superscripts are significantly different (P < 0.05)

Table 2. Chemical composition of forages (%) at 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*

Note: ^{abc} Means within columns with different superscripts are significantly different (P < 0.05)

Table 3. Daily weight gain and consumption of forages (kg)

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

This study demonstrated that utilisation of introduced forage species will increase the quantity and quality of nutrition available to feed animals. The data indicates that forages are more appropriate for feeding animals to improve production when compared to rice straw. Rice straw contains between 4.0 and 6.5 MJ of metabolisable energy per kg of dry matter, has a very low CP concentration ranging between 2.0 and 6.0% with large amounts of silica (12-16%) of no nutritional value compromising palatability and reducing the amount ruminants will eat (Nour, 2003). 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 of maturity and improve the average daily weight gains that ranged between 0.33 kg to 0.52 kg. Notably, the cattle fed Mulato II and Terenos achieved between 0.51 and 0.52 kg gains per day respectively, with Simuang and Marandu fed cattle achieving 0.33 and 0.36 kg gains per day respectively. Possible reasons for this difference may include the higher CP for Mulato II (15.9%) and increased digestibility of Teronos (DMD 70.38%), although further investigation is required and could include methods to increase the daily consumption of approximately 21 kg of fresh forage that occurred in this study. Future studies should also include studies with a legume such as Stylo 184 to determine the contribution to animal growth and development of a forage combination with high CP. If farmers decide to ‘target feed’ animals to increase the value of individual animals and attract premium prices from traders, they will require high yielding forages of superior quality. This requires farmers to grow introduced forage varieties, especially if they are to extend the fattening period by irrigation and conserved fodder as silage to optimise cattle live weight gains.

Longitudinal survey results

Initially 1,519 cattle from 645 households were enrolled from the six villages. Five villages exceeded the initial target of 250 animals, and Dem Pdet enrolled 247. A further 607 cattle were subsequently enrolled during the project to account for cattle removed from the project (such as sale, death etc.). During the course of the project 8 repeat measures were taken from cattle, providing a total of 7,433 cattle weights and production data records from the 2,123 cattle enrolled.

Despite the additional 607 cattle enrolled, a significant amount of 'fall-out' was encountered during the 47-month duration of the longitudinal study, with 1,430 cattle having a movement designated as being sold, at which point they were unavailable for data collection. This was approximately 67% of the project enrolled cattle. Between each sampling period, 14.6%, 14.1%, 15.8%, 17.4%, 27.5%, 9.9%, and 23.5% of project (enrolled) cattle were sold respectively, being an average of 17.5% of the project population at each sampling interval. As the time interval between samplings varied, this was standardised to an annual sale rate of project cattle of 17% per year (note that records on reasons for sale were not available).

Baseline production data

Cattle ownership, cattle breed, sex, age and draught use

Of the initially enrolled cattle, 28.7% of farmers owned one, 39.0% owned two, 17.3% three, 8.4% four, and 6.6% of farmers owned five or more cattle. Two cattle breeds were represented in the study; 16.5% designated as local breed and 83.5% designated as crossbreeds. Of the 1,516 animals initially enrolled in the study, 55.2% were females and 44.8% (678) were males, although 58.0% of the males were castrated. The mean age of all cattle initially enrolled was 3.5 years, with a range of 0.1-13.0 years. The mean age for crossbreed and local breed cattle was 3.6, and 3.3 years respectively and was not significantly different ($P = 0.056$). Of the initially enrolled cattle, 26.5% were designated as used for draught, and 97.5% of all draught cattle were castrated males (bullocks). The mean age of cattle used for draught was 4.9 years and was significantly higher than non-draught cattle at 3.0 years of age ($P < 0.001$). Cattle in the HI and LI groups had a mean age of 3.1 and 4.0 respectively that was significantly different ($P < 0.001$).

Cattle weight

The mean weights of cattle of initially enrolled cattle at the first sampling are presented (Table 4).

Table 4. Descriptive statistics of cattle live weights (kg) by groups indicating baseline production at study commencement in 2008

Variables	*n*	Mean	Median	Min	Max	SD
All Cattle	1416	228.9	207.0	48.0	682.0	102.6
Age group (years)						
0 to < 1	110	123.0	120.0	48.0	263.0	38.3
1 to < 2	284	148.6	140.0	60.0	330.0	47.9
2 to < 3	216	191.5	179.0	84.0	472.0	59.0
3+	806	281.7	260.0	130.0	682.0	98.0
Breed						
Crossbreed	1165	239.6	214.0	48.0	682.0	106.4
Local breed	251	179.5	178.0	53.0	376.0	62.7
Draught use						
Yes	398	327.6	312.0	79.0	682.0	104.9
No	1014	190.1	180.0	48.0	626.0	71.1
Sex						
Female	745	198.6	192.0	48.0	439.0	68.3
Male castrate	396	328.9	312.0	144.0	682.0	103.2
Male*	269	160.6	150.0	54.0	455.0	58.3
Bull	6	464.3	441.0	296.0	626.0	129.3
Body Condition Score						
BCS 1	855	180.0	174.0	48.0	360.0	60.0
BCS 2	426	259.2	254.5	59.0	420.0	71.2
BCS 3	122	425.8	420.0	176.0	572.0	71.0
BCS 4	13	609.5	602.0	554.0	682.0	38.8

*Entire non-breeding male

Body condition score

The mean BCS of cattle at the start of the project was 1.51 (n = 1,416) indicating cattle were in very poor body condition.

Cattle Reproduction

Of the total 2,123 cattle enrolled during the project, 1,204 were female. The average age of these animals was 3.6 years at enrolment, with 64% of farmers reporting using bull selection when cows were mated. The mean age at first calving was 48 months for the 63 females that had a calving date and were two or less years of age at enrolment. Of the 63 primiparous dams, 27 were weighed in the preceding data sampling, and had a mean weight of 233.2 kg.

During the four-year study period, 395 cows had at least one calf, with 726 not having recorded a calving during the project. Of the 395 cows that did give birth, 82 calved twice and one cow was recorded as having 3 calves. The mean inter-calving interval of the 82 'reproductively active' cows that had two calves during the project was 605 days (SD ± 179.8, n = 74) or 20.2 months.

Seasonal weight gain analysis

Weight gain periods for each animal were assessed by date and grouped into either dry or rainy seasons during the first 6 data collections, based on the date of sampling. The following table shows the difference in mean daily weight gains for each season.

Table 5. Descriptive analysis of mean daily weight gains (kg) for each season

Season	*n*	Mean	Difference	95% CI
Dry	1,328	0.04	0.09	0.080 - 0.092
Rainy	2,024	0.13		

As the timing of data sampling varied between years, this result should be interpreted with caution and used as an indicator only.

Forage technology uptake and adoption

During the course of the project between 2008 and 2011 (inclusive), over 1,171 households (both within and outside of project villages) developed forage plots for a total area of 416,508 m^2 (almost 42 ha) or an average household forage plot size of 356 m^2. The number of farmers, total cultivated area and average area cultivated by smallholders both within and beyond project sites are presented (Table 6).

Table 6. Forage development and cultivation in both project sites and beyond project sites between 2008-11

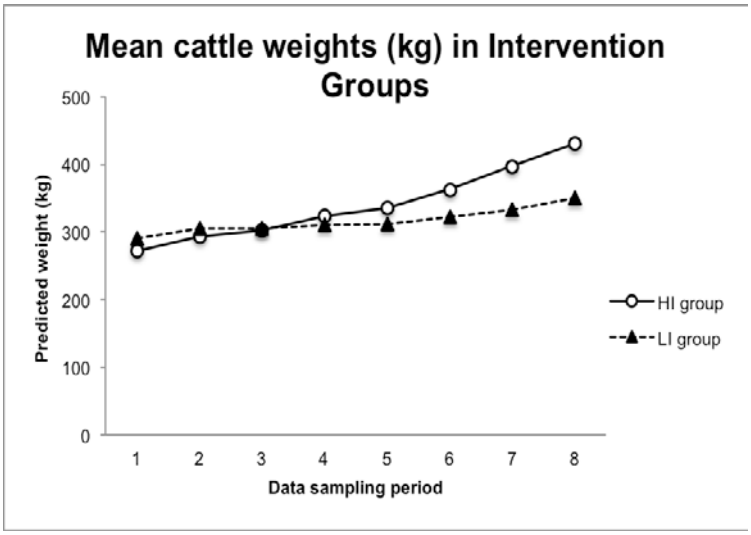
Province	Number of farmers	Total area cultivated (m^2)	Average area cultivated per farmer (m^2)
Kampong Cham			
Within project	225	125,978	560
Beyond project	112	24,750	221
Takeo			
Within project	495	166,200	336
Beyond project	218	43,630	200
Kandal			
Within project	29	28,450	981
Beyond project	62	15,500	250
Kampot			
Beyond project	30	12,000	400
Total	1,171	416,508	356

Impacts of Interventions

Quantitative analysis of impact on cattle weight

Univariable analysis showed that the intervention effect of all cattle weight measurements (n = 7,433) was not significant (P < 0.05). As intervention was the variable of interest, it was forced into the multivariable model, where it was non-significant (F = 0.8, df = 1,2; P = 0.471). Sampling period, age, breed, draught, sex and the interaction terms intervention-draught use and intervention-sampling period were significant (P ≤ 0.005 level). The mean predicted cattle live weights at each sampling period are presented (Figure 2). When the individual sampling collection periods were assessed using LSD (5%), the final three collection periods showed that the difference between the intervention groups in predicted live-weight was statistically significant (P < 0.05) and from sampling period 4, the HI group commenced to deviate above the LI group, and gained further divergence with each successive collection (Figure 2). This is explained by the significant effect modification (or interaction) of the interventions and sampling period variables.

Figure 2. Predicted cattle live weights (kg) in intervention groups using REML



Average daily weight gains (ADG)

The REML analysis and predictions of the 243 cattle that had weights recorded at the first and final sampling period showed that cattle in the high intervention group gained 116 grams (SE 0.39) per day compared to the low intervention group of 49 grams per day (SE 0.40) during the four year study (F = 113.72, df = 1,2; P = 0.009).

Impact on Body Condition Score

The mean BCS at the start of the project was significantly lower in the HI group at 1.42 (SD ± 0.65, n = 759) and 1.61 (SD ± 0.70, n = 756) in the LI group ($P < 0.001$). At the final sampling, the mean BCS in the HI group was significantly higher at 2.92 (SD ± 0.53, n = 142), and 2.05 (SD ± 0.58, n = 118) in the LI group ($P < 0.001$) (Figure 2).

Field study of target feeding forages to *Bos indicus* cattle in southern Cambodia

This trial aimed to determine if the principles for cattle fattening developed in Laos (Stür & Varney, 2007) could be effective when applied in a participatory field environment with smallholder farmers in southern Cambodia. Previous studies in Cambodia have reported cattle weight gains in experimental situations but there is scant documented evidence that these techniques can lead to measurable improvements when implemented by farmers in field situations. It was anticipated that if positive results ensued, they would assist in promoting the advantages of targeted animal feeding to smallholder farmers.

The 3-month study took place from June to October 2012. A total of 22 crossbreed cattle were enrolled in the study, including one bull, two castrated males and 19 females, ranging in age from 0.8 to 6.0 years, with a mean of 3.4 and median of 3.0 years. Although all cattle were available for the first three weight measurements, two from Kampong Cham province were sold prior to 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.

The size of the forage plots owned by the farmers in the trial varied from 300 m^2 to 10,000 m^2, with an average size of 2,514 m^2, and a median of 800 m^2. The forage plot size per animal ranged was from 150 m^2 to 909 m^2. When asked in the post-trial survey if their forage growth this season and been poor, average or good, the 6 farmers available for interview all answered ‘average’.

The estimated value of the cattle was assessed by the farmers, pre-and post-trial. On average, trial animals increased in value by US$ 137.43, with control animals increasing in value by US$ 76.14 during the trial. This indicates the target fed animals increased their value by US$ 61.29 on average more than the control animals during the trial (Table 7).

Table 7. Mean estimated value of cattle prior to and after the feeding trial period

Cattle classification	Pre-trial value US$	Post-trial value US$	Difference US$
Trial	882.50	1019.93	137.43
Control	444.89	521.03	76.14

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

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, being the 'estimated effect' of the target feeding in this trial (Table 8).

Table 8. 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	-	-

The trial indicates that Cambodian farmers keeping cattle tethered in a feeding stall with target feeding for a duration of three months and aiming to feed 15% of their animal's BW as fresh forage per day, achieved higher weight gains than control animals (P = 0.057). Although the 0.05 level of significance was not met in this trial, this was expected as the farmers did not meet the forage feeding target of 15% BW, achieving only 8% and 5% BW on average for the trial and control animals respectively. The inability of farmers to meet the 15% BW target of forage intake was considered due to both a lack of available forage, and the limited use of individual fattening pens.

The best results for target forage feeding are achieved by tethering the animal in a feeding stall and feeding the optimal amount of forage for approximately three months. The 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, as these nutritional considerations contribute to digestibility and intake. Failure to meet these requirements may compromise desired productivity. The feeding of the control cattle at a level just below that of the target fed cattle indicates the difficulty of translating research findings to field situations where Cambodian farmers were keen to try forage fattening and could see the benefits accrue in the target fed animals.

The differences in weight gains measured over the three months varied between province, with Senson Tbong village in Kampong Cham lower (0.05 kg/day) than 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 in Kampong Cham, further demonstrating the difficulties of field trials in meeting feed targets to achieve optimal results.

The average value of all cattle as estimated by the farmers increased during the three month trial, with target fed cattle increasing by US$ 61.29 more than the control cattle. Although this is a subjective and potentially biased assessment, it does indicate that the trial farmers saw financial gains in target-feeding with potential to provide direct economic benefits to the household. The trial farmers indicated they would continue to use this practice as they anticpated that the sale of these animals for imprved profit would encourage further fattening activities that would increase household income.

That smallholder cattle farmers in Cambodia are able to achieve improved weight gain in their cattle is important as this potentially enables them to more readily particpate in the expanding regional meat trade by value adding their product. Whether their goal is to buy thin animals to fatten 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, targeted fattening offers considereable benefits to these farmers. The practices of having breeding cows in calf as often as possible to grow and sell the young, and of buying thin animals to fatten and sell for profit, need to be promoted in Cambodia as an alternative to the common practice of selling animals only when the family needs cash or when the animal is old and/or sick, with important biosecurity implications.

There is limited growth of forage in the dry season in Cambodia unless irrigation is provided. The BPHH project witnessed the building of water storage capacity as earthen dams in the HI sites, offering irrigation to extend the forage growing season and availability of improved nutrition to animals. The project also initiated silage production workshops to assist in fodder conservation for use in the dry season. Fattening guidelines suggest that the ideal amount of forage to grow per cow is 800-1,000 m^2 (Stür and Varney, 2007). This is a challenge for many smallholders with the current low availability of land and in our trial the size of the forage plots per animal owned ranged from 150 m^2 to 909 m^2, with only one farmer possessing the recommended amount of forage per animal owned (909 m^2/head). Despite this, the results indicate fattening can be achieved in field situations with less than the ideal amount of land dedicated to forage growing. The use of the legume forage *Stylosanthes guianensis* (Stylo 184) due to its high protein content and proven benefits for fattening as well as its contribution in providing a source of nitrogen to surrounding grass forage species within the plot, has been promoted (Stür et al., 2002).

Participatory research projects should aim to progressively improve the knowledge of participants, resulting in positive attitudinal change as sustainable productivity improvements

develop.There is little benefit in administering interventions that are not understood or desired by the community as their will be no positive attitudinal change. 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, an encouraging response showing that despite the data being insufficient to demonstrate a statistically significant difference between trial and control animals, the farmers considered they gained new skills and intended to continue to use the technique. Further studies are required to assess if these farmers become ‘champions’ of these techniques and can assist other farmers in implementing improved cattle feeding.

This 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 usually willing to enrol two cattle in the study and have one as a control. To adequately control the experiment, the control animals should be of the same quantity, as well as the same age and gender as the trial animals, and owned by the same farmer to ensure all cattle are subjected to the same conditions. This is challenging when designing field experiments in Cambodia as study objectives and methods do not readily align with the goals and daily practices of farmers, with some participants simply not having enough animals to allow the required level of replication. Despite these difficulties in implementation and failure to target feed to the fattening guidelines stipulated, positive results can be achieved in the field with Cambodian cattle farmers by following the basic principles of target feeding. Although more research is needed, the encouraging results in this study should assist in the promotion of the practice of forage feeding combined with preventative animal health.

Chopping for forage to prepare silage in Kampong Cham.

8.2 Theme 2: Improving cattle health

Strategies for improving animal health in the project were investigated by the following activities:

- summarising of large ruminant infectious disease reports to DAHP;
- conducting surveillance for infectious diseases and parasites;
- implementing vaccination for FMD and HS and anthelmintic treatments;
- a study of FMD epidemiology;
- a study of HS epidemiology;
- a serological study of Bovine Brucellosis;
- s study of parasitic disease in project villages;
- conducting post-vaccination FMD and HS serosurveys to investigate vaccine induced immunity and efficacy;
- a study of the chronic effects of FMD by a phone interview of District Veterinarians.

Despite the recognition of difficulties in maintaining a sufficient percentage of vaccinated large ruminants in the village populations due to high rate of livestock turnover during the project, the vaccination strategies for both FMD and HS plus the anthelmintic treatment strategy were considered effective, particularly when compared to anecdotal reports of frequent disease outbreaks in neighbouring villages. Clinical cases of HS or FMD were not reported in HI project animals or villages during the project, although an FMD outbreak was reported to have occurred in the LI village Veal. Investigations indicated that the cases were mainly in recently introduced animals that had not been vaccinated. This suggest that vaccination needs to be delivered with biosecurity information and education as occurred in the HI sites and vaccination may not be as effective if delivered in the absence of such education. The history of the outbreak was consistent with the high level of animal movement and trading in the project villages, presenting an ongoing biosecurity risk if introduced animals are unvaccinated. Control measures for TADs require biosecurity education that recognises the dynamic nature of the cattle population in Cambodia, raising concerns that annual ‘top down’ vaccination strategies may well be inadequate for achieving a level of protection of the population that prevents regular outbreaks. The project identified the importance of a long term goal that empowers individual farmers to take control of disease risk management by a combination of improved biosecurity practises and when necessary, vaccination that optimises the immune status of their animals against HS and FMD.

Large ruminant diseases in Cambodia

With an estimated 80% of the population living and working in rural areas, smallholder farm systems that integrate cash crops and livestock are crucial to Cambodian rural society.

Addressing the numerous constraints that impact on this activity through simultaneous introduction of multiple interventions that utilise market drivers to enhance productivity, are considered to offer a more sustainable pathway to improve smallholder incomes and reduce rural poverty (Windsor, 2011). However a major issue of concern is the recent decline in the national population of both large ruminants and swine livestock between 2009 and 2011. Several factors have influenced this change, including regional market trends in demand for protein, feed costs, climate shock issues (eg floods) and illegal trade in livestock and importantly endemic disease.

TADs remain a major limiting constraint to expansion of the cattle trading sector in Cambodia. In each of the years 2008 through 2011, many outbreaks of both FMD and HS were reported to DAHP respectively, indicating FMD and HS are endemic and widespread (Tables 9, 10) despite concerns that there was considerable under-reporting of both diseases. Further, vaccination coverage of the national large ruminant population against FMD and HS in 2010 and 2011was low, estimated at 2.7% and 2.1% for FMD and 43.8% and 41.0% for HS. The poor FMD coverage is a major issue of concern, particularly with the significant prevalence of FMD in that period and our more recent assessment of financial impacts of FMD on smallholder farmers indicating that severe losses can occur (Young et al, 2012). Low vaccination coverage indicates that programs to promote the prevention of infectious diseases through biosecurity measures that reduce risk behaviours is of utmost importance, particularly in a country where vaccine availability is limited and farmers are hesitant to use vaccine or resistant to paying for it.

Table 9. FMD outbreak reported between 2008 and 2011

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

Source: DAHP, Cambodia

Table 10. HS outbreak reported between 2008 and 2011

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

Source: DAHP, Cambodia

Targeted surveillance of infectious and parasitic diseases

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., 2011). As mentioned, FMD was reported to have occurred in the project village Veal, the LI village in Kampong Cham province (Nampanya et al, 2011). From July to November 2010, FMD affected about 20% of the cattle population in Veal, although reports from the VAHW were that these were mostly unvaccinated introduced cattle. It was also noted that almost 100% of cattle were affected by FMD in neighbouring villages with the exception of the HI village of Senson Tbong that remained uninfected (Nampanya et al., 2011).

Evaluation of FMD vaccination delivery

A vaccination study involving collaboration of the project with the OIE SEACFMD, the attitudes of untrained smallholder farmer to FMD control were surveyed and a sero-surveillance study conducted to assess the routine delivery of FMD vaccine by government and project staff working with smallholder cattle farmers. The serological study by liquid phase ELISA testing at day 21 after vaccination, found that 90% of cattle sampled had positive serological titres suggesting likely protective immunity to FMD Type O (Table 11). However interviews with participating smallholders in this study (habituated to government-provided vaccination programs) found that they were currently unable to commit themselves adequately to FMD control, either financially through purchase of vaccine, or technically through improving farm biosecurity practices, in the short to medium term. This study identifies the challenges in protecting a population of cattle owned by smallholders untrained in the benefits of vaccination or biosecurity if encouraged to adopt a semi-commercialised cattle production system. Effective vaccination and biosecurity training involves more government resources than are currently available in Cambodia.

Although the preliminary evidence from the work in our HI villages is suggestive, further research is required to determine whether the increase in income generated through improved marketing of superior cattle can influence farmer investments in animal health interventions, such as for FMD vaccination and biosecurity measures. Alternatively, a new approach that utilises a major public education campaign to significantly improve farmer knowledge, attitudes and practices to TAD control may be required to ensure delivery of sufficient vaccine and minimise disease risk behaviours in future outbreaks of FMD in Cambodia.

Table 11. Percentage (%) of samples of the 60 cattle from the three project villages showing various FMD positive titres post vaccination

Collection Sample Point	Serotype	Serial dilution						
		1:40	1:80	1:160	1:320	1:640	1:1280	1:2560
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

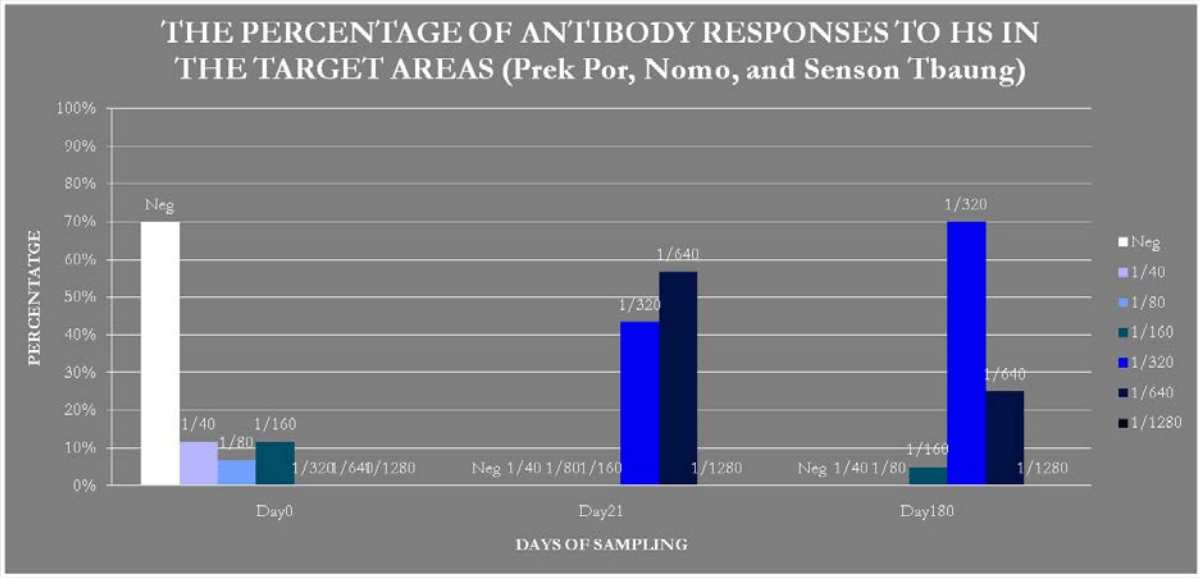
HS epidemiology and serosurvey

Outbreaks of HS are common in Cambodia, with high morbidity and mortality rates reported. Although under-reporting is a concern, the DAHP received reports of 82 HS outbreaks in 15 provinces in 2009 and 52 HS outbreaks in 10 provinces in 2010. Although buffalo are generally considered to be more susceptible than cattle, both species were affected and in case studies of outbreaks conducted in Koh Pen and Kampong Reap in Kampong Cham province in 2010, the morbidity in cattle was 59% and in buffalo lower at 39%. Mortality rates were very high in both species at 97% and 98% for cattle and buffalo respectively. Diagnostic investigations of these outbreaks led to isolation and confirmation by serology and PCR that both were associated with infection by *Pasteurella multocida* Type B2.

Widespread vaccination for HS occurs in Cambodia although vaccine coverage currently appears to be less than the often claimed 50% level of protection of the large ruminant population. Further, there is scant information on the efficacy of the vaccine in current use. A post-vaccination serology study compared titres of 60 vaccinates injected subcutaneously with 2 ml/head of killed HS vaccine in an aluminium hydroxide gel adjuvant (manufactured in India by Brilliant Industries Pty. Ltd.) with those from 20 control animals. Sera were collected at day 0, 21 and 180 and results confirmed a very strong serological response to vaccination. Serology at day 21 identified 100% of vaccinates with a titre >1:320. At day 180, 100% of vaccinates had a titre >1:160 with 95 % >1:320 (Figure 3). This suggests that if post-vaccination titres are correlated with or at least a useful indicator of protection against infection, then HS vaccine efficacy as currently practiced at least in this trial in Cambodia, appears to be very good indeed, questioning the recommendation of vaccinating every 6

months for HS. It is recommended that further work to determine if such high titres persist for much longer than 180 days be conducted.

Figure 3. Percentage of animals and titre at 3 time points when vaccinating for HS



Brucellosis

There are no reports of Brucellosis occurring in Cambodian cattle in the scientific literature, and no positive samples were detected in this study (although there are anecdotal reports of some positive titres detected on previous screening tests; Sorn Sarn, personal communication). All 120 blood samples collected from project cattle and tested for presence of *Brucella abortus* were negative on both Bovine Antibody Rapid Test and Rose Bengal Testing.

Parasitic disease surveillance in project villages

Large ruminant gastrointestinal nematode and trematode infections are common in Cambodia due to favourable climatic conditions and husbandry practises (eg close confinement, grazing of still water courses). They cause ill-thrift and production losses to smallholder cattle farmers and there is generally little awareness of these parasites and knowledge of management strategies, despite previous studies on Fascioliasis (Suon et al, 2006). Parasitic genera and their prevalence were investigated within project cattle, with faecal samples collected from 1,080 cattle in the 6 project villages during the dry and rainy seasons in 2008, and flotation and sedimentation analyses performed.

In these samplings, three nematode and two trematode genera were identified. *Paramphistomum spp.* was found in nearly all cattle sampled, and *Fasciola gigantica* occurred

in samples from Kandal and Kampong Cham but not Takeo provinces. Nematode genera identified included *Bunostomum spp.*, *Cooperia spp.* and *Strongylus spp.* During the project, cattle in HI village sites received a total of 859 anthelmintic treatments over 4 occasions resulting in 56% to 77% of project cattle being treated on each occasion. Stratification of age showed that cattle of different ages had evidence of helminth infection, suggesting that production-limiting impacts may not be limited to young cattle in this environment.

Table 12. Summary of number and percentage of project cattle treated in each village for the four treatments

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								
No Mor	156	99 (63%)	124	94 (76%)	95	70 (74%)	81	60 (74%)
Dem Pdet	134		100		64		57	
Kandal								
Preak Por	113	63 (56%)	94	58 (62%)	75	45 (60%)	72	45 (63%)
Koh Kor	114		81		51		44	
Kampong Cham								
Senson Tbong	152	100 (66%)	125	90 (72%)	93	72 (77%)	86	63 (73%)
Veal	146		116		73		67	
Grand Total	815	262	640	242	451	187	407	168

Table 13. 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%
Between 1 and 3	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 to 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%

Investigation of a suspected chronic FMD syndrome

With the exception of the usually low level of mortalities, mostly in young animals, the majority of large ruminants recover from acute FMD within 8–15 days (Artz et al., 2011) with the common perception they make a full recovery, implying that FMD has only short-term impacts.

However a chronic post-FMD syndrome has been recognised (Alexandersen, 2003) and described as 'heat-intolerance syndrome (HIS)', 'hairy panters', 'asoleadas' (in Argentina) and 'peludas' (in Brazil) (Artz et al., 2011) and of potential concern to FMD control efforts in Europe and South America (Minett, 1948). The disorder has subsequently been described in India and Pakistan (Maqsood et al., 1958) and more recently in Africa (Barasa et al., 2008; Ghanem and Abdel-Hamid, 2010) and anecdotally in Turkey (Artz et al., 2011).

Chronic disease has been reported from around four weeks after acute FMD (Kitching, 2002). Several conditions have been associated with chronic infection, including heat intolerance (Barasa et al., 2008), pronounced panting during hot weather, increased body temperature and increased pulse rate (Minett, 1948), hirsutism (Ghanem and Abdel-Hamid, 2010) and hypertrichosis as a result of failure of seasonal shedding (Minett, 1948; Maqsood et al., 1958). Infected animals may have reproductive disturbances, including anoestrus, nymphomania, abortion and birth of weak or dead calves (Artz et al, 2011). Non-specific signs associated with chronic infection also include failure to thrive, emaciation (although an obese form has also been described; Artz et al., 2011), impaired milk production (Ghanem and Abdel-Hamid, 2010) and agalactian (Minett, 1948). It has been suggested that there is no permanent natural recovery, with signs recurring during hot weather for the duration of life of an affected animal (Artz et al, 2011).

Cases of chronic FMD in Cambodia have not been previously been reported although animals with suggestive clinical signs were reported to researchers during project field work in various provinces of Cambodia. Investigation of suspected chronic FMD was considered to be warranted as such cases may increase the economic impact of FMD on smallholders. Anecdotal reports from 2010 suggest that villagers from Chum Ney (Prey Veng Province) firmly believed that recently infected (but recovered) cattle are physically weaker with poor endurance and taking longer to recover from work, cannot walk or perform draught effectively and may have ongoing foot problems, plus may have other problems including photosensitivity and a shaggy coat with longer hair. The severity of these medium term effects was reported as correlating with the severity of the signs during the clinical period (John Stratton, personal communication). Behavioural changes reported include heat intolerance syndrome, with reduced time grazing and more time resting in the shade of trees (Ghanem and Abdel-Hamid, 2010) suggesting impaired thermoregulation.

To investigate further, a DAHP Extension staff member conducted a telephone survey on 12 December 2012 with 13 of 16 District Veterinarians successfully contacted and surveyed, including 5 from Kampong Cham, 4 from Kandal, and 4 from Takeo. When asked when (time after FMD infection) chronic changes occurred, responses ranged from 5 to 180 days. Based on these responses, the duration of clinical signs enabled the reports to be grouped into either acute FMD (<30 days) or sub-acute to chronic FMD (>30 days) to differentiate signs associated with each syndrome. Five DVs reported signs of chronic FMD from the districts of

Bunnekrak, Srey Sator, Kandal Steang, Kirivong, and Bati, with clinical signs tabulated (Table 14).

Table 14. Clinical signs of chronic FMD as reported by District Veterinarians

Clinical sign	% of DVs reporting seeing condition (n = 5)	Chronic cases seen as a % of cattle previously infected with FMD (mean)	Range (%)
Panting / respiratory	60	15.8	2.5 - 25
Abnormally hairy coat	100	22.0	5 - 50
Change of coat colour	100	18.0	5 - 35
Increased swimming / time in water	60	7.33	2 - 10
Increased number of birth of weak /dead calves	100	8.0	3 - 20
Failure to get in calf	100	12.8	4 - 20
Did not gain weight	100	20.5	10 - 30

The range in time after infection indicated that there was confusion in differentiating acute and chronic disease with 8 out of 13 DV's reporting signs <30 days after initial infection. There are several reasons this may have occurred including misunderstanding of the survey question, translation errors, or simply a lack of knowledge on the topic. All DV's reporting chronic changes indicated that they see an increase in: weak calves at birth, stillbirths, failure to get in calf, and difficulty in gaining weight, plus reported seeing abnormally hairy coats and changes to coat colour. Of interest was that that 60% (3/5) of these DV's also reported observing animals with increased panting or respiratory signs and increased time spent in water. DV's reporting chronic changes indicated that on average between 8 and 22% of animals showed at least some of the clinical signs.

None of the DV's reporting chronic disease following FMD indicated that farmers sold these chronically affected cattle. In the village of Chum Ney it was reported that almost the entire village sold all their cattle that had been infected during the FMD outbreak of 2010, with some selling their cattle when sick, but most when their cattle had recovered. Only two households were reported to have kept previously infected cattle, retaining their breeding females. It is apparently generally considered acceptable to keep previously infected females for reproduction but not to retain castrated males for draught due to the physical work required (John Stratton, personal communication). However as DV's also reported that they didn't know the outcome of 78% of FMD cases, it is very likely that sale of chronically infected animals does in fact occur.

Despite this limited survey, it does suggest that chronic FMD may be more prevalent in Cambodia than in the 0.1-2.0% of animals previously reported (Barasa et al, 2008). There are several host, pathogen and environmental factors that may offer an explanation for the suggested observation that rates of chronic FMD are higher in Cambodia than elsewhere,

such as predisposition of the cattle and their management system to FMD, or FMD strain differences in pathogenicity involved in recent outbreaks. More likely is that the subjectivity of this pilot survey may contribute to the high response rate, particularly as the non-specificity of clinical signs may have resulted in inclusion of all other causes of chronic disease in the responses from eth DV's. It is considered more likely that the 2-3% for cases of HIS as suggested by the DV of Pursat District is a more realistic estimate of chronic FMD than the 22% offered by the pilot phone survey. Despite the subjectivity of this initial investigation, the positive responses from the DV's does suggest that there currently exists a subset of animals in Cambodia with clinical signs consistent with chronic FMD and some of these do appear they may be affected by an endocrine disruption disorder subsequent to clinical FMD.

Chronic FMD is likely to be a cost to farmers in addition to that incurred from acute FMD infection. No DV's reported that animals died from the condition, 63% of DV's reported that use of the animal continued and 92% of DV's reported that animals were treated, indicating additional costs for HIS were incurred by the farmer. A benefit cost analysis of both acute and chronic FMD in Africa indicated that the economic impact of FMD is greater when chronic syndromes are taken into consideration, with chronic FMD calculated to account for 28.2% of losses (Barasa et al., 2008). This cost may be incurred directly, through cost of treatment and decreased value of animals. In Chum Ney village it was reported that an animal with active FMD could be sold for approximately 50% of the price of a healthy animal. However if farmers waited until their animal recovered they usually received only about 70% of the price of an animal that had never been infected indicating that an animal that has had FMD does not regain its former value and is significantly discounted (John Stratton, personal communication). Additional costs may also be incurred indirectly, through lowered milk yields leading to poor calf growth rates and calf mortality, as well as decreased productivity including reduced power for draught.

The financial impact of FMD in developing countries is often underestimated (Rast et al., 2010; Young et al, 2012) and our recent studies evaluating the economic impact of acute FMD suggest that the disease is significant at the village level and potentially at a national level, potentially compromising the development of regional export markets through trade barriers (Young et al, 2012). As previous studies suggest that a chronic form of FMD exists and anecdotal evidence from this preliminary investigation indicates that further chronic FMD is present in Cambodia, further studies are warranted, commencing with a broader survey of DV's, surveys of farmers and cattle traders and clinical and pathological investigations of suspected cases. Such information is required to better understand the economic impacts of FMD on smallholder households in Cambodia and in the region.

8.3 Theme 3: Improving marketing and trade

The last decade has seen consistent development of the regional powerhouse economies of Thailand, Malaysia, Vietnam and China, and to a lesser extent internal urban growth within Cambodia, resulting in burgeoning regional demand for livestock products as part of the 'livestock revolution' (Shanker et al., 2012). The income and population growth in these countries that is driving increased demand for red meat is expected to continue over the coming decades (Harding et al., 2007; Windsor 2011). This is now recognised as an opportunity for Cambodia and improvements in smallholder productivity may contribute significantly to these developments, offering improved regional food security and a potential pathway to address rural poverty (Windsor, 2011).

In addition to health and productivity constraints imposed by endemic disease and poor husbandry (Maclean, 1999; Young et al., 2012), the undeveloped trading and marketing system further limits the development of the Cambodian cattle production system (Windsor, 2008). Typical cattle trading in Cambodia is characterised by the absence of formal markets and mostly involves just the one licensed trader infrequently visiting a circuit of villages, purchasing animals when a farmer needs to sell because the household requires cash to pay a bill, or culls become available when they are no longer fit for draught. This system means that smallholder farmers are 'price takers' and have limited understanding of animal values. Despite traders being integral in the cattle marketing chain in Cambodia, there is limited knowledge of how the trader system operates in livestock pricing and distribution, or of interventions that can improve the system. Knowledge of local marketing systems and trends is important if improved on-farm productivity is to translate to increased farm gate returns for farmers and traders.

Marketing and trade associated activities conducted during the project included:

- farmer training in basic marketing activities such as
    - seeking multiple quotes for sale
    - target feeding cattle for sale in an improved BCS
    - target feeding cattle for sale into specific markets or time of year
    - increasing knowledge on animal BCS and weight for fairer valuation;
- an analysis of the market chain including a SWOT analysis;
- trader meetings and discussion groups to determining cattle weight/value assessment;
- trader surveys undertaken in 2009 and 2011-12; and
- a pilot assessment of a weight tape for Cambodian cattle to assist farmers in valuation of their animals.

Farmer training

Results of farmer training activities and impacts are reported in the subsequent section: 'Results Theme 4: Improving knowledge and capacity building'.

Trader meetings and discussion groups

A series of provincial meetings held between the Australian and Cambodian project teams with traders and slaughterhouse managers occurred in February 2008. The traders were asked their opinions on current constraining market issues and the future development of marketing cattle and buffalo in Cambodia.

During the survey the traders admitted that although they used BCS as a means of assessing animal weight they had difficulty in determining the actual bodyweight of animals. In response to this a field visit was organised in June 2010 to provide an opportunity for farmers, traders and village/provincial staff to visually assess cattle at the Tamao Breeding Station and estimate BCS, weight and animal value. Following the visual assessment, a girth weigh tape was used to estimate the animal's weight and then all animals were weighed on electronic scales. Comparisons made between the estimated and actual weights and differences between estimated and actual weights were discussed in relation to their impacts on animal values. Five animals were chosen for the visual and objective assessment activity and were purposively selected from the cattle on display to provide a range of BCS's. For some of the animals the trader estimate of BW was only marginally (3-4%) different to the electronic scales, but for other animals the trader consistently underestimated the weight of the animal by as much as 24%, equating to 50-60 kg. It appeared that the lighter the BCS, the more likely there was for a lower weight and value estimate to occur. The farmers and village/provincial staff in attendance also estimated the animals. In some cases the participants were 75% accurate in placing the animal within a weight range based on 25 kg increments. However for an animal weighing 131 kg, all participants underestimated the weight, with 11/14 participants assessing the animal in the same weight range (90–100 kg) as the trader. When assessing an animal weighting 350 kg, 16/26 participants assessed the animal in the same weight range (325–350 kg) as the trader. The conclusion of this field day was that low weight estimates were common, especially for lighter BCS animals that this practise may translate to a potential loss of income for the farmer.

In discussions with traders, it became clear they wanted a marketing system to monitor the quantity of the animals being bought and sold as well as wanting to see improvements in

cattle fattening as they were demanding better quality animals especially for supply to the Vietnamese market. One of the main issues that emerged from the trader survey and the trial to determine animal values was that currently, both farmers and traders are using different grading systems and methods to value the animals bought or sold. A challenge for establishing marketing interventions is for all parties to be aware of market information and to be able to grade animals by the same methods. The use of a standardised grading system for both farmers and traders would assist the flow of information throughout all sections of the market chain and reduce the costs of marketing, potentially leading to improved pricing structures. With the current need for farmers to 'target feed' animals in order to increase the value of individual animals and attract premium prices from traders, farmers and traders need to learn to identify animals for sale of superior quality. To satisfy trader requirements, as well as maximise returns for the farmer, it would be beneficial to closely monitor the changes in demand for animals throughout year, adjusting management to deliver the most suitable animals at peak demand periods.

Trader surveys

Surveys of trader practices were conducted in August and September of 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 included Kandal, Kampong Cham, Kampot, Takeo, and Phnom Penh. In 2011, traders from Kompong Thom were also surveyed due to its proximity to 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 of 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 had. In addition to the questions in 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.

In 2009 the 55 traders interviewed reported 14,230 trade transactions of cattle, with no reports of buffalo transactions. In 2011, the 100 surveyed traders reported 22,746 large ruminant transactions, consisting of 441 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 either purchased large ruminants directly from the farmer, a broker (who takes a commission on the transaction), or a store farmer who may purchase cattle from individual farmers and keep them for varying periods of time. The source/s of large ruminants purchased were; 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 sending stock directly to a slaughterhouse in Phnom Penh, the other transporting 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. Details of the BCS of animals traded (Table 16) are presented.

Table 16. Percentage of large ruminants traded by BCS

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	-	21.5	78.5
Takeo	7.0	39.2	53.8	-	47.2	52.8
Kampot	13.2	56.1	30.7	-	72.5	27.5
Phnom Penh	2.3	22.5	75.2	-	75.7	24.3
Kampong Thom	-	-	-	-	56.3	43.7
All Provinces	10.7	37.6	51.7	0.9	62.2	36.9

No traders currently weigh cattle at the time of purchase, and the price of the animal is determined by consideration of the general appearance and BCS of the animal. The average purchase price and percentage change between 2009 and 2011 for local and crossbreed cattle are presented (Tables 17 and 18), stratified by cattle age and BCS.

Table 17. Average purchase price of local breed cattle (US$), and the percentage change in prices between 2009 and 2011 by sex, age and BCS

Year	Sex	Age and body condition of cattle								
		0 – 2 Years of age			2 – 4 Years of age			4 – 10 Years of age		
		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%

There were very large price ranges within the same cattle breed and sex/BCS/age groups across and within provinces, i.e. for local breed females in a fat BCS grouping prices ranged from US$ 296 to US$ 914 for 2–4 year old and US$ 296 to US$ 815 for 4–10 year old. In a further example, local breed males categorised as a medium BCS prices ranged from US$ 296 to US$ 864 for 4–10 year old cattle.

Table 18. Average purchase price of crossbreed cattle (US$), and the percentage change in purchase prices between 2009 and 2011 by sex, age and BCS

Year	Sex	Age and body condition of cattle								
		0 – 2 Years of age			2 – 4 Years of age			4 – 10 Years of age		
		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%

The average price of meat per kg at the market in 2011 from each province is presented (Table 19). 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 kg.

Table 19. 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**

Major costs borne by traders included transportation 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 head in 2009 (for 29 of the 55 traders), and US$ 3.21 to US$ 4.94 per head in 2011 (57 of the 100 traders) with some traders paying no slaughter fees.

The BSC 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 fall in the proportion of both skinny and fat cattle purchased, there appeared to be a trend of stronger demand for cattle in a medium condition, although this implies lost opportunities for farmers in selling medium rather than fat animals for slaughter.

Average prices of cattle based on age, sex and BCS show a trend of higher prices for older and better-conditioned cattle as expected. Younger cattle of a higher BCS fetched on average higher prices than older cattle in poorer BCS. Price increases between the surveys of 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 166% increase in average prices of males in medium BCS of 4-10 years of age.

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$ 1000. 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 over 200% in young cattle aged 0-2 years old.

In the 2009 survey, the major concerns the traders had related to the high prices they had to pay for livestock compared to what they 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 skins. They were also keen to have access to better quality animals, wanted to see tax discounts for slaughter houses, prevent the importation of cattle and admitted they had difficulty in assessing animal's 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 in 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 due to the FMD outbreak of 2010-11, widespread flooding and limited feed available in 2011. Multiple traders still would like the establishment of a domestic market or saleyard system to provide better access to cattle, and expansion of training to farmers for continual production of higher quality animals.

Major price variations reported by traders for a particular animal class at both the provincial and district level may indicate a significant opportunity cost for farmers aiming to maximise

their returns from large ruminant sales. The lack of a readily accessible market information system plus the current practise of farmers 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. Weigh tapes could offer one potential solution, combined with training of farmers, traders and extension staff in their appropriate use. The option of a village or commune investment in weigh scales could be further supported by cost benefit studies. The development of village or commune cattle yards that could be used for both marketing and animal health activities may offer benefits although should be considered carefully in the current context where biosecurity and disease management is poor. This strategy may be more appropriate following improved control of FMD.

With evidence of substantial market price increases for slaughter cattle, these animals should no longer be seen as a by-product of the system requiring animals mainly for draught for rice production. More focus is warranted on increasing productivity from these multi-purpose livestock. Crossbreed cattle are obtaining substantially higher prices compared to local breed cattle, therefore farmers of local breed cattle should consider changing, provided they have the feed resources to meet the greater energy needs of these larger animals.

Pilot weigh tape assessment

During the 8th and final data collection of the longitudinal survey conducted in February 2012, 258 project cattle in addition to being weighed with electronic scales were also measured using a weight tape (*Beef Cattle Coburn Tape*, USA). The tape had metric (centimetres and kilograms) on one side and empirical (inches and pounds) units on the other. This particular tape is sectioned in four categories (thin, moderate, fleshy and very fleshy), which were interpreted to correspond to the 4 point body condition score (BCS) of 1=very skinny, 2=skinny, 3=medium and 4= fat used during the BPHH project. Although the initial intention was for staff to record the girth in centimetres, only the weight in kilograms was recorded.

Data from 257 cattle that were measured using the weigh tape and electronic scales was recorded and analysed for variation between the two weight assessment methods. One outlier with a variation of over 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 weigh tape. The mean variance between the weight scale and weigh tape was 3.4 kg, equivalent to only 1% of the actual (scale) live-weight. The two methods of cattle weight measures showed such remarkably similar measures that it was considered likely that the project staff may have referred to the weight scales for confirmation of the closest fitting BCS to the weigh tape. This would result in systematic bias and affect the validity of the 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 the pilot weigh tape study did show the potential for accurate weight assessment using this method.

8.4 Theme 4: Improving knowledge and capacity building

Improving the knowledge of smallholder farmers and key stakeholders including Village Animal Health Workers (VAHW), Provincial and District Veterinarians, Cambodian and Australian agricultural and veterinary students and project staff from the DAHP extension office, was a major focus of the project. Key project research activities involved in measuring knowledge and activities included:

- two smallholder farmer knowledge surveys conducted in 2008 and again in 2010;
- a smallholder farmer Knowledge Attitude and Practice (KAP) survey conducted in 2012; and
- a large scale VAHW survey of knowledge and practices in 2008-9.

The delivery of workshops, student involvement, and project and District and Provincial Veterinary capacity building is reported separately (see section 6 Methodology and section 7 on Theme 4: Improving knowledge and capacity building).

Smallholder farmer knowledge surveys

Results from the 2008 and 2010 surveys

The survey in 2008 showed the mean of total farmer knowledge scores out of a total of 31, were 7.2 to 9.6 in the LI villages and 5.0 to 9.7 in the HI villages respectively (Table 20). The second survey in 2010 showed that the mean of total farmer knowledge scores out of 31 was 8.6 to 11.3 in the LI villages and 24.5 to 28.9 in the HI villages (Table 20).

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. However there were differences in knowledge at the initial survey and farmers had higher knowledge scores in relation to FMD for example in LI and HI villages compared to internal parasites in 2008 (Tables 21 and 22).

Table 20. Average knowledge scores 2008 and 2010

Village	Average score 2008 (Maximum 31)	Average Score 2010 (Maximum 31)	Change
Preak Por (HI)	9.7 (31.2%)	26.7 (79.5%)	+17.0 (48.3%)
Koh Kor (LI)	7.2 (23.4%)	11.2 (36.1%)	+ 4.0 (12.7%)
Senson Tbong (HI)	8.2 (26.5%)	24.5 (79.0%)	+16.3 (52.5%)
Veal (LI)	9.6 (30.8%)	11.3 (36.5%)	+ 1.7 (5.7%)
Nor Mo (HI)	5.0 (16.0%)	28.9 (80.1%)	+ 23.9 (64.1%)
Dem Pdet (LI)	8.7 (28.1%)	8.6 (27.7%)	- 0.1 (-0.4%)

Table 21. Knowledge scores on FMD 2008 and 2010

Village	Average score 2008 (Maximum 14)	Average Score 2010 (Maximum 14)	Change
Preak Por (HI)	4.8 (34.6%)	11.2 (79.6%)	+ 6.3 (45.0%)
Koh Kor (LI)	4.1 (29.4%)	5.3 (37.5%)	+ 1.1 (8.1%)
Senson Tbong (HI)	4.7 (33.4%)	11.3 (80.4%)	+ 6.6 (47.0%)
Veal (LI)	4.4 (31.4%)	5.4 (38.2%)	+ 1.0 (6.8%)
Nor Mo (HI)	2.8 (19.4%)	10.9 (77.9%)	+ 8.2 (58.5%)
Dem Pdet (LI)	3.8 (26.9%)	3.9 (27.5%)	+ 0.0 (0.6%)

Table 22. Knowledge scores on internal parasites 2008 and 2010

Village	Average score 2008 (Maximum 7)	Average Score 2010 (Maximum 7)	Change
Preak Por (HI)	0.6 (9.1%)	6.0 (85.7%)	+ 5.4 (76.6%)
Koh Kor (LI)	0.2 (3.4%)	0.0 (0%)	- 0.2 (-3.4%)
Senson Tbong (HI)	0.2 (2.3%)	6.0 (85%)	+ 5.8 (82.7%)
Veal (LI)	1.0 (13.7%)	0.9 (12.1)	- 0.1 (-1.6%)
Nor Mo (HI)	1.1 (16%)	5.9 (83.6%)	+ 4.7 (67.6%)
Dem Pdet (LI)	1.1 (15.4%)	0.0 (0%)	-1.1 (-15.4%)

This study in six villages in three southern provinces of Cambodia identified that significant improvements can be made over two years in farmer knowledge and attitudes to cattle production, marketing and importantly animal health (including risks of infectious diseases 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.

These results showed a marked improvement of 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, for more significant gains ‘on the job’ and ‘formal training’ programs will result in more successful outcomes (Nampanya et al., 2012).

An important intervention in both the HI and LI villages was vaccination against FMD and HS as both diseases are endemic in Cambodia 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 claimed that up to 50% of the adult cattle population has received some immune protection from this program, although recent data suggest this is closer to 40%. Vaccination for FMD is still rarely performed in Cambodia with claims that 25 are vaccinated but other estimates that less than 0.5% of the large ruminant population has received immune protection (unpublished data). 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 the LI village of Veal. The significant difference in the scores on infectious disease questions across the village and province suggest that farmers in the HI villages did obtain the knowledge and understanding that can change attitudes and practices related to risk behaviours for the spread of infectious diseases.

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 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 has improved farmer knowledge of animal weights and 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 has been promoted as a superior extension tool for teaching farmers about these interventions (Millar and Phoutakhoun, 2008) and this approach proved to be very useful in assisting the wider adoption of forage technology. However more abstract concepts such as disease prevention interventions through animal movement controls, biosecurity and farmer sourced vaccination, require more ‘formal’ training program as this requires a theoretical component to be delivered over time with repetition (especially as the majority of smallholder farmers have low literacy).

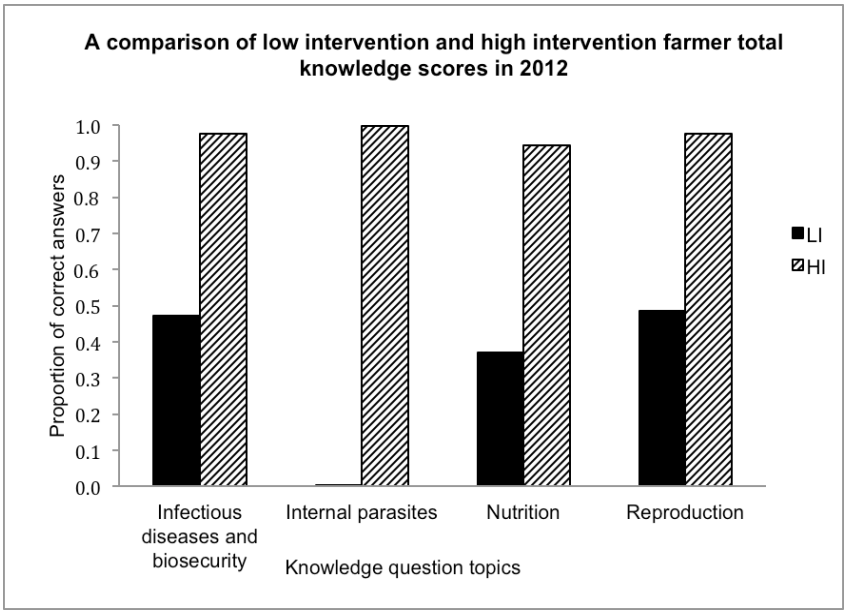
It is encouraging that this study provided evidence that smallholder farmers in Cambodia are significantly motivated by nutritional interventions that improve the value of their cattle 'bank' and offer better marketing opportunities. Improving productivity and marketing potential of cattle provides a more receptive environment for introduction of knowledge-based interventions such as disease risk management for infectious diseases. Currently in Cambodia, intensive training programs for smallholder cattle farmers to improve knowledge of biosecurity and reduce risk behaviours best implement this. 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.

Knowledge Attitude and Practices survey 2012

Effect of interventions on smallholder farmer knowledge in 2012

Results for infectious disease and biosecurity questions demonstrated a significant effect of intervention level on farmer knowledge, with HI village farmers scoring much higher at 97.5% compared to LI village farmers at 47.2% ($P < 0.001$) (Figure 6). With internal parasites the LI villagers demonstrated almost no knowledge with only 0.3% of questions answered correctly, compared to HI village farmer knowledge of internal parasites at 99.7% ($P < 0.001$). When questioned on cattle nutrition, HI farmers had a significantly higher proportion of correct answers at 94.3% compared to 36.9% for LI villages ($P = 0.008$). Reproduction knowledge questions demonstrated HI villages had a significantly greater proportion of questions answered correctly compared to LI village scores at 97.7% and 48.7% respectively ($P < 0.001$) (Figure 6).

Figure 6. Comparison of LI and HI intervention farmer total knowledge scores on individual topics in 2012



Farmer knowledge on disease and biosecurity over time

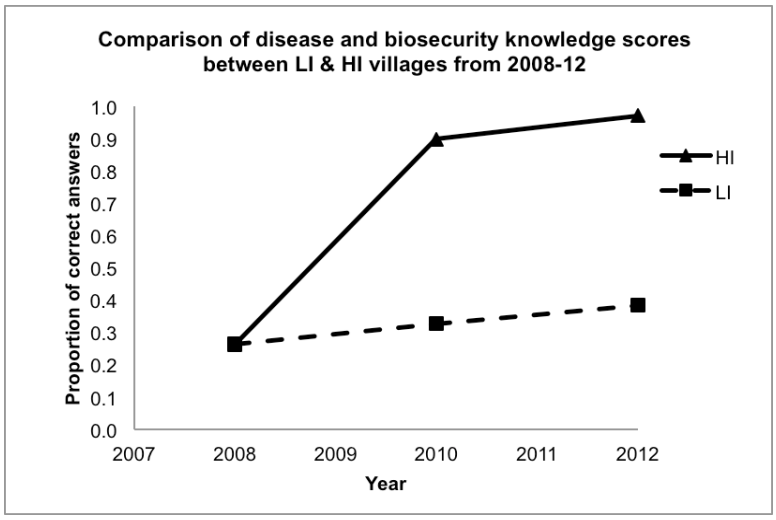
Comparing responses to questions on disease and biosecurity from knowledge surveys conducted in 2008, 2010 and 2012, there was a significant effect of intervention level and time on farmer knowledge ($P < 0.001$) (Figure 7). No significant difference in disease knowledge scores was determined between LI and HI villages at the commencement of the project in 2008, with 26.4% and 26.3% of questions answered correctly respectively. In 2010 HI farmer knowledge scores increased to 89.7% and was significantly higher than the LI farmers with 32.7% correct ($P = 0.004$). Knowledge scores for HI village farmers continued to increase and by 2012 were 97% correct, being significantly greater than the LI villages with 38.4% correct ($P < 0.001$). From 2008 to 2012, knowledge on disease and biosecurity in cattle significantly increased for both LI and HI village farmers although the LI village scores still remained low at 38% (Figure 7).

Comparison of farmer knowledge on nutrition over time

A comparison of responses to nutritional questions within the knowledge surveys conducted in 2008, 2010 and 2012 demonstrated significant effects of intervention level and time in both LI and HI nutritional knowledge. At the beginning of the project there was no significant difference between LI and HI farmer knowledge on cattle nutrition with 62.3% and 42.2% correct answers respectively ($P = 0.233$). In 2010 the nutritional knowledge of HI villagers had increased to 94% and was significantly greater than LI villagers at 58.9% ($P < 0.001$). The farmer knowledge on nutrition in HI villagers continued to increase in 2012 to 99.6%, with a

decrease in LI farmer knowledge of nutrition to 30%. The effect of intervention on LI and HI farmer nutritional knowledge scores in 2010 and 2012 were significant (P < 0.001). Over the life of the project from 2008 to 2012, HI farmer nutritional knowledge scores significantly improved from 57.4% to 99.6%, with a decline in LI villager nutritional scores by 28.9% (P < 0.001).

Figure 7. Comparison of disease and biosecurity knowledge scores between LI and HI villages from 2008-12



Attitudes and practices of LI and HI farmers on disease control and nutrition

To determine if interventions significantly affect attitudes and practices to vaccination of animals, a comparison was made between responses to several key questions by LI and HI farmers. In relation to FMD, 38% of LI village farmers identified symptoms of the disease in their animals since the vaccination programs were initiated at project start, being significantly higher than HI farmers with only 5% identifying symptoms in their cattle (P = 0.002). When asked whether they would continue to vaccinate if they had to pay for the vaccine themselves there was a high proportion of farmers indicating they would, with LI famers at 85% and HI farmers significantly higher at 98% (P = 0.021). When farmers were questioned on whether all their cattle over six months old were vaccinated for FMD, only 5% of LI farmers elected 'yes' while HI villages were significantly greater with 100% of famers selecting 'yes' (P = 0.004).

The effect of intervention level on farmer biosecurity practices was investigated with no significant differences recorded. When asked if they separate sick animals from the herd 77% of LI farmers and 100% of HI famers elected that they did (P = 0.773), with 100% of LI and HI groups removing manure from their cattle housing areas. When asked whether they treated newborn calves for *Toxocara vitulorum*, response rates were very low for both intervention levels with LI at 0.11% and HI significantly higher at 11% (P < 0.001). As the nutritional husbandry practice of target feeding selected animals in fattening pens has been encouraged

by the BPHH project, when farmers were asked if they built fattening pens for their animals there was a significant difference found between intervention groups; 82% of LI farmers and 98% of HI farmers responded that they used this practice (P = 0.017).

Marketing attitudes and practices in HI and LI villages

An assessment of marketing knowledge and practices was made by comparing responses from 2008 to 2012 and between intervention levels. Farmers were asked if they believed they knew the market price of their cattle before sale and no significant differences were found between HI and LI village farmer responses in 2008 (P = 0.121) with a marginally significant difference found in 2010 (P = 0.068). A significant effect of intervention level was found in 2012 with 90% of HI farmers electing that they did know the market price of their cattle compared to LI farmers with only 51.7% (P < 0.001). There was no significant change over time in LI village farmers but a marginally significant increase over time was found in HI farmers responses from 2010 to 2012 (P = 0.064).

When farmers were asked if they sought more than one quote from traders before the sale of their cattle a significant effect of intervention level and time were detected. At the beginning of the project there was no significant difference in the proportion of HI and LI village farmers seeking more than one quote from traders at 84.2% compared to 75% (P = 0.561). In 2010 there was no significant effect of intervention level on the numbers of farmers who sought more than one quote with 90.2% in LI villages and 92.3% in HI villages (P = 0.825). HI villages showed no significant change over time while in the LI villages there was a significant drop in farmer numbers of 30% seeking more than one quote from 2010 to 2012 (P = 0.046).

Photo: P Windsor

Sealing a plastic bag for silage making in Kampong Cham.

Information dissemination

Several questions were asked of farmers to determine where extension efforts should be targeted and what materials they rated to be most beneficial. When farmers in LI and HI villages were asked to nominate their primary source of information technologies significant differences were found between LI and HI villages. HI villages identified project staff as being their primary source of information with 100% of farmers selecting this choice, being significantly greater than LI with only 16% nominating project staff ($P < 0.001$). HI village farmers nominated the district veterinarian as their second choice at 36% and that was not significantly different to LI farmers ($P = 0.117$). The primary source of information as identified by LI village farmers was the village chief with 72% of farmers selecting this choice, being significantly greater than HI villages where only 9% of farmers chose this option ($P = 0.027$). In LI villages, after the village chief the VAHW was the next favoured option at 47% and was significantly greater than HI villages at 28% ($P = 0.044$). LI village farmers selected the district veterinarian as their third nomination at 23.3%. Interestingly nominations for 'other farmers' as a primary source of information was extremely low in both intervention villages with no significant differences found ($P = 0.821$).

Farmers in LI and HI villages were asked to rank extension materials and methods on a scale of 1 to 5 with 1 the most important and 5 the least important. The extension material rated most important was demonstrations for both LI and HI villages with scores of 1.52 and 1.08 respectively. HI villages ranked demonstrations as significantly more important than LI villages ($P < 0.001$). LI villagers ranked banners and village visits/meetings as their 2nd and 3rd preferences, compared to HI villagers ranking village visits/meetings and banners as their 2nd and 3rd preferences. In addition to demonstrations, HI villagers ranked village visits/meeting and leaflets as significantly more important than LI villagers ($P < 0.001$ and $P = 0.025$ respectively).

The link between VAHW's, government and farmers in FMD control

Using a 'guided group interview' technique, 445 Village Animal Health Workers (VAHW) from 19 provinces were interviewed early in the project to establish their current practices and knowledge. The aim was to identify the strengths and weaknesses of the VAHW resource in village level disease control, with a focus on FMD. As widespread improvement of farmer level knowledge of disease management will likely require intensive education and training programs, extension for improved disease control may be enhanced by improving VAHW skills. The study confirmed that VAHWs had good contact with farmers with 61.5% making more than one farm visit daily, plus high rates of disease reporting, with 72.5% reporting diseases immediately and 73.6% undertaking monthly reporting. FMD outbreaks were reported as being regular and widespread with 63.8% of surveyed VAHWs seeing FMD in

their village within the last year (2009). Vaccination was either unavailable or considered too expensive for smallholders according to 82.7% of VAHWs.

This study concluded that the VAHW system currently provides some field animal health services to smallholder farmers and has the potential to help fill the gap in delivering FMD control between government services and farmers. Although the VAHW system has potential to provide an improved nationwide government managed FMD vaccination programs, further research is required to test whether VAHWs can enhance the delivery of vaccine in the face of FMD outbreaks.

A SWOT analysis of the emerging smallholder cattle industry of Cambodia

Information emerging from the various sources of data collected during the project was grouped into the four categories of strengths, weaknesses, opportunities and threats for a SWOT analysis of the Cambodian cattle industry. Strengths and weaknesses constitute factors that enable or hinder the system from achieving further goals, with opportunities and threats reflecting external factors that facilitate or limit the emerging industry (Wasike et al., 2011). Through the development of an Analytical Hierarchy Process (Table 23) the two most important factors were considered as target forage growing to improve the value of cattle (strength), and the prevalence and associated risk of disease to smallholder cattle producers (threat).

Photo: P Windsor

Opening a bag of silage several months after sealing.

Table 23. SWOT factors identified for smallholder cattle farmers in Cambodia, 2012

Strengths	**Weaknesses**	**Opportunities**	**Threats**
S1: Base product (cattle) suited for tropical conditions – 90% of cattle owned by smallholders *S2:* Willingness amongst champion farmers to adopt new technologies *S3:* Technologies available are suitable for extension *S4:* Target forage growing can be implemented to increase the value of cattle *S5:* 80% of population from rural areas; comfortable and involved with rural practices	*W1:* Cattle not traditionally seen as source of protein *W2:* Cattle typically have low productivity *W3:* Low levels of education and literacy *W4:* Cattle underfed using low quality forages *W5:* Vaccinations and health care expensive *W6:* Producers are 'price-takers' rather than 'price-makers', and unaware of market trends *W7:* Social prestige associated with number of cattle owned, affecting willingness to sell	*O1:* Demand for animal products on rise in region *O2:* Domestic and international export avenues *O3:* Local traders expressing demand for quality product *O4:* International aid available for agriculture *O5:* Global push to eradicate FMD *O6:* Alleviate rural poverty by increasing ruminant production *O7:* Adoption of silage to cope with 'climate shocks' (drought, flood etc.) *O8:* Increased mechanisation of agriculture shifting importance of cattle as sources of draught power	*T1:* No market information system (MIS) *T2:* Transport and access to markets limited *T3:* High occurrence of illegal cattle movement (and trans-boundary disease) *T4:* Climate extremes *T5:* Other cattle producing countries seizing markets before Cambodian producers *T6:* Endemic disease (FMD & HS)

An introduced nutritious fodder source can improve the productivity of cattle through increased draught power, better quality meat and increased milk production for calf growth (Mureithi, 1998; Windsor, 2011). Further, the adoption of forage growing to target feed cattle is a potential ‘strength’ for smallholder cattle producers as improved nutrition enables farmers to be better positioned to cope with feed shortages that occur in both the wet and dry season or during floods, particularly if accompanied by forage conservation techniques such as silage. As demand for animal protein in the region continues to rise, traders will demand high quality animals and assuming the prices received for quality animals cover any increase in costs, farmers are well positioned to improve their livelihoods through increasing cattle productivity, potentially moving from a subsistence activity to a small to medium commercial enterprise.

Although rarely practiced in Cambodia, the growing of improved grass forage species as an alternative fodder source for cattle has achieved positive results when implemented (Stür et al., 2002). Grasses grown include Guinea grass (*P. maximum*), Atratum (*P. atratum*) and several *Brachiara* spp., all of which have moderate protein levels (Hare et al., 2009). Improving nutritional management of cattle emerged as a key intervention early in the BPHH

project as enthusiastic ‘champion’ farmers sought and willingly adopted forages plantations, encouraging the rapid spread of forages within and beyond the project. As smallholder farmers are often skeptical to new technologies, witnessing the benefits of forages and disease interventions implemented by the ‘champions’ ensured a rapid increase in the willingness of farmers to try these new technologies.

The prevalence of FMD in the region has been identified as perhaps the strongest threat to the emerging beef industry, with high frequency of movements of cattle, lack of knowledge of biosecurity plus the relatively high costs and inaccessibility of FMD vaccines, contributing to the rapid spread of disease outbreaks and compromising control efforts. The uncontrolled mixing of cattle from different herds, especially at the point of sale where disease may be introduced to healthy animals through the activities of traders is considered to contribute to a high prevalence of FMD (Bronsvoort et al., 2004). When traders demand cattle of higher BCS and improved disease status, opportunities emerge to significantly advance the smallholder cattle industry if market demand continues to grow. This has been occurring in Cambodia and traders are seek ‘premium’ cattle and offering higher returns for these animals. If farmers are provided with knowledge on how to prepare these animals, they will be more likely to ‘invest’ in improvement of their cattle.

The benefits to farmers of improving their cattle production system include reduced mortality and morbidity from disease, better body condition scores (BCS) (especially if farmers adopt target forage growing) and increased time savings for farmers in feeding their animals (Maxwell et al., 2012). The benefits of time savings can enable 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.

Progressing from subsistence to commercial cattle production in Cambodia presents many challenges to smallholder farmers and other stakeholders, with further work required to understand how to many these challenges. Survey questionnaires that require stakeholders to rank factors affecting the smallholder industry, with the responses potentially guiding the allocation of future resources, is suggested as a future study method as it has been employed in similar smallholder cattle production systems in developing countries (Latif et al., 2002; Wasike et al., 2011, Bronsvoort et al., 2004). The results of such a study can then assist with long-term planning for the Cambodian beef industry, enabling strategies and policy to be developed that address these factors.

8.5 Theme 5: Financial and socioeconomic impacts

As described, smallholder beef cattle productivity in rural Cambodia is constrained by a range of factors including inadequate nutrition and high susceptibility of cattle to infectious diseases. Until recently the financial impact of FMD on smallholder households has not been quantified, despite numerous aid projects aimed at improving animal health and husbandry having yielded promising results with the socio-economic benefits of these improvements now being investigated. During the project investigations covering this theme included:

- socioeconomic impacts of the best practice program in project villages;
- socioeconomic case studies of 6 smallholder farmers;
- the financial impact of FMD on smallholder cattle farmers; and
- the financial impact of HS on smallholder cattle and buffalo farmers.

Socioeconomic impacts of the 'best practice' program

DAHP staff and UoS students travelled to project villages in March 2012 and conducted interviews with 20 farmers from each project village on-site (120 in total). When asked "As a consequence of this project, do you believe your annual income from cattle has increased?" a total of 52 out of 60 HI farmers agreed with the statement including all 20 farmers in Nor Mo, 18 out of 20 in Senson Tbong and 14 out of 20 in Preak Por. The remaining 8 farmers in the HI villages did not agree nor disagree with the statement, as a response of 'I don't know' was recorded. This also applied to the majority of farmers interviewed in the LI villages where 14 out of 20 farmers in Dem Pdet, 18 out of 20 in Veal and 17 out of 20 in Koh Kor said that they did not know if their annual income from cattle had increased as a consequence of the project. The remaining 10 farmers in the LI villages said that they did not believe their annual income had increased and therefore did not agree with the statement whilst one farmer in the LI village of Koh Kor agreed with the statement.

Of the 52 farmers in the HI villages and the one farmer in the LI village who believed their annual income from cattle had increased, a follow-up question sought to determine the extent of the increase. When asked to nominate whether they believed their income had less than doubled, doubled or more than doubled, one-third (20/52) of these HI farmers selected 'less than doubled' whilst more than half (32/52) estimated it had either doubled or more than doubled. The sole farmer in the LI village of Koh Kor stating their annual income had increased by less than double.

In response to the question 'Does growing forages save time that would otherwise be spent feeding the cattle', all 20 farmers interviewed in the HI village of Nor Mo in Takeo province and 19 out of 20 farmers interviewed in the HI village of Senson Tbong in Kampong Cham

province agreed with the statement. In contrast to these results, none of the 20 farmers in the HI village of Preak Por in Kandal province agreed with the statement. This result in Preak Por was similar to the responses recorded for the farmers interviewed in the LI villages, with all 60 farmers interviewed answering no when asked if growing forages saved time that would otherwise be spent feeding the cattle.

The farmers who indicated that forages led to time savings were asked to record how they used their extra time. Of the 33 farmers indicating they benefited directly from the time savings, all 33 stated that they directed these time savings towards other employment, with 11 to farming activities and 8 spending this time on household activities. Of the 19 farmers stating that the women in their family gained time savings as a result of forage growing, all 19 said that the women allocated their time savings to household activities, 9 to other employment and 6 to farming activities. Unlike these men and women who distributed their time savings across different activities, the 15 farmers stating their children saved time from growing forages indicated that the children devoted it solely to school work.

Socioeconomic case studies

When asked if growing forages had enabled farmers to expand their farm, all 6 farmers agreed that it had allowed them to expand their farm by being able to both increase the numbers of livestock (cattle, pigs and chickens) and the amount of crops grown. For one farmer interviewed, involvement enabled expansion from 5 cattle, 20-30 chickens and 2 pigs to 11 cattle, over 200 chickens and 7 pigs after the fifth year. Another farmer had expanded his farm livestock from 3 cattle, no pigs and 15 chickens prior to project, to cattle, 2 pigs and 40 chickens at the time of interview.

In addition to farm expansion, all 6 interviewed farmers reported at least a doubling of their annual income from the time before the project to the time of interview, with one farmer reporting an increase in annual income from US$ 2,000 pre-project to US$ 5,000 and another farmer from US$ 1,000 to US$ 5,000 at the time of interview. This information highlights the considerable increases in earnings that are possible from both involvement in this project and from future adoption of the strategies that were developed and tested.

In addition to expansion of the farm and increasing annual income, the 6 farmers in these socio-economic case studies were also asked to discuss other ways in which the project had provided benefits to themselves and their family. One farmer stated that as a result of his increased income, he had been able to better support his family financially through paying for the study expenses of family members. Another farmer stated that he had been able to purchase a new car, a new motorbike and rice milling machine and another that the project had allowed him to upgrade his standard of living and allow his children to attend school more frequently. In the most exceptional case, the project had facilitated one farmer to participate in

the National Farmer Competition. He was placed 1st and received a new motorbike, a new hand-tractor and a sum of money that allowed him to import a Braham bull that he used for breeding, charging his neighbours for servicing their cows, further increasing his income.

These interviewed farmers also highlighted the benefits to cattle health and husbandry as a result of their involvement in the project. One farmer stated that his participation had resulted in an improvement in his knowledge of cattle husbandry, in particular the best practices to follow to ensure that cattle are kept in the best condition and receive a good price at the time of sale. Another farmer mentioned that his cattle had not suffered from FMD or HS since they started receiving vaccinations as part of the project and recognised the benefits to the overall productivity of his farm.

These case studies suggested that farmers that practised forage growing and feeding, vaccinated their cattle and actively expanded their animal health and husbandry knowledge, may more than double their annual income and realise a time saving of at least 2 hours per day. This increased income was directed towards the purchase of vehicles, motorbikes and/or farm equipment as well as payment for the education of children. Time savings were distributed amongst the family and directed towards other employment such as teaching in the local commune, farm enterprise expansion and household activities, as well as improved educational opportunities for children. These findings confirm the importance of forages and animal health knowledge in improving the quality of life for potential smallholder beef producers. This provides important lessons for future development projects with evidence that improving livestock production reduces rural poverty and increases food security in this part of the developing world.

The financial impacts of FMD on smallholder farmers

The financial impact of an outbreak of FMD in 2010 on 62 smallholder cattle farmers located in the four villages of Preak Taprum and Kompongous in Kandal Province, and Meemang and Tang Tpang in Kampong Cham Province in southern Cambodia was investigated by a financial impact survey questionnaire. Financial losses associated with FMD infection were severe with variation depending on whether the animal survived or died or was used for draught (Table 24, Figure 8). 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.

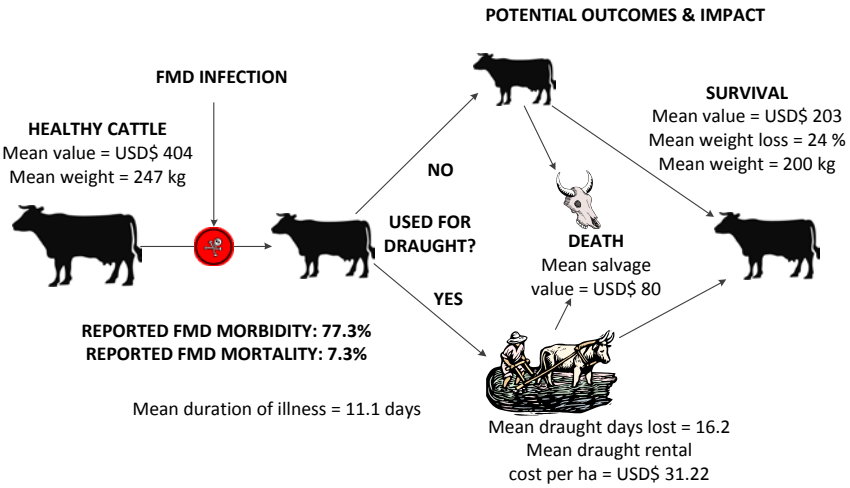
Partial budget analysis identified a strongly positive incentive for cattle to be vaccinated biannually for FMD, providing US$ 31.48 per animal for each animal owned. However the current low vaccination rates suggest that farmers are mostly unaware of the need or are averse to the practice of vaccinating their cattle for FMD. This may be due to poor

understanding of preventative disease strategies such as vaccination, unavailable disposable income for purchase of vaccines, failure to recognise the full costs that are incurred when the disease occurs, but importantly, an expectation that such a task should be provided free by government services.

Table 24. Outcome cost of FMD and proportion of initial animal value

Outcome cost	Total cost (US$)	Proportion of initial value
1. Animal survives + treatment	216.32	54%
2. Animal survives + treatment + draught replacement	247.54	61%
3. Animal dies + treatment	339.32	84%
4. Animal dies + treatment + draught replacement	370.54	92%

Figure 8. Outcome diagram of possible scenarios of FMD infection



Enhancing smallholder cattle productivity through the introduction of forage growing systems has been suggested as a pathway for alleviating rural poverty in the GMS (Windsor, 2011). This financial analysis in an endemic FMD area in Cambodia indicates a substantial net benefit of vaccination for smallholder farmer enterprises. It is considered important that both regional livestock policy development and livestock development project design, include FMD control, with public and farmer awareness strategies acknowledging this information on the financial benefits of FMD vaccination.

Provision of both access to vaccine and training in preventative disease risk management that can improve biosecurity practices in Cambodia are clearly important strategies for development of a regional beef industry.

The financial impact of HS on smallholder farmers

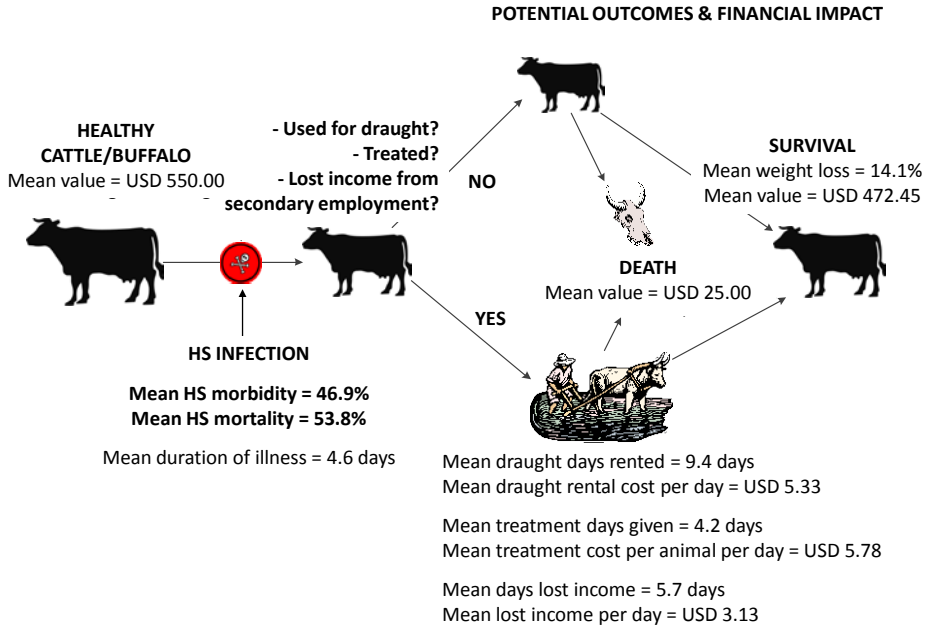
The study of the impacts of HS found that the overall outcome costs of an outbreak in 2011 varied greatly between households, from a low of only 2.0% to a high of 2426.3% of annual household income. Approximately 40% of the interviewed farmers experienced financial losses greater than 100% of their annual household income. Such variations resulted from a number of factors including whether: the affected animals died, treatment was given, draught replacement was required, and the household lost income from secondary employment during the outbreak. The average outcome costs per affected animal experienced by the interviewed farmers were US$ 375.84, or 66.1% of pre-HS values. This varied from US$ 101.83, or 18.5% of pre-HS value if an affected animal survived with treatment, to US$ 617.22, or 112.2% of pre-HS value if an affected animal was treated, died, draught replacement was rented and income from secondary employment was lost (Table 25, Figure 9).

Partial budget analysis revealed that smallholder farmers receive a significant benefit from biannual HS vaccinations to their cattle and buffalo, with the maximum of US$ 912.32 when a household owns a total of five cattle or buffaloes, the average number of livestock owned by the interviewed farmers prior to the outbreak. A net positive benefit remained even if market values of cattle and buffalo, vaccination costs, outcome costs, and outbreak incidence rates were to change. A relatively high proportion of the interviewed farmers were identified to have vaccinated their animals against HS, suggesting that many farmers are aware of the need or importance of vaccination to reduce risk of HS. However not all of them vaccinated all of their cattle and buffalo, lowering the actual vaccination rate. This occurred due to difficulties in bringing working draught animals back for vaccination, or of more concern, misunderstanding of the side effects of vaccination leading to reluctance of some farmers to vaccinate certain group of animals, such as pregnant cows. Other possible reasons for less than optimal vaccination rates include: poor understanding of effective vaccination practices; financial limitations in vaccinating all the animals in a household; and underestimation of the full costs that occur in an outbreak. As with FMD, it is important to improve farmer knowledge of effective preventative disease risk management practices through education plus enhancing accessibility to vaccines by farmers. As the financial losses associated with an HS are considerably higher than the costs of biannual vaccinations, encouraging vaccination and other strategies to improve cattle health and productivity, will improve livelihoods in HS endemic areas in Cambodia and should be prioritised in both policy and project design.

Table 25. Summary of estimated outcome costs per animal affected with different scenarios and proportion of healthy animal value.

Outcome scenario						
	Animal Survival	Treatment	Draught replacement	Lost income	Total Cost (US$)	% Healthy value
1.	Yes	Yes	No	No	101.83	18.5
2.	Yes	Yes	Yes	No	151.93	27.6
3.	Yes	Yes	Yes	Yes	169.77	30.9
4.	No	No	No	No	525.00	95.5
5.	No	No	Yes	No	575.10	104.6
6.	No	Yes	No	No	549.28	99.9
7.	No	Yes	Yes	No	599.38	109.0
8.	No	Yes	Yes	Yes	617.22	112.2

Figure 9. Summary of possible outcome scenarios and associated costs of HS



9 Impacts

9.1 Scientific impacts – now and in 5 years

The scientific impacts have been summarised into a table based on the four key questions of: (1) what we didn't know; (2) what we know now; (3) what it means; and (4) who needs to know?

What we didn't know?	What we know now?	What it means?	Who needs to know?
Are farmers willing to implement interventions in health, biosecurity and production?	Results from the KAP survey indicate that farmers that now grow forages and been educated on vaccination, biosecurity and nutrition, wish to continue with these interventions.	The interventions used in this project have successfully led to increased cattle production & improved health.	Project outcomes being documented & disseminated do provide an excellent resource for future studies and programs.
What are baseline cattle production metrics in Cambodia?	Smallholders mostly own less than 5 cattle, usually a crossbreed of Haryana & the local breed or the local yellow breed, with 24% of farmers using cattle for draught, providing an important asset for households. Productivity is low, with mean weights between 180-240 kg for local and crossbreds, with low BCS at 1-2/4, & weight gains low at approximately 50 grams per day on an annual basis; growing faster in the wet season. Female reproductive parameters are poor & inter-calving intervals long at 20+ months; an important issue considering demand exceeding supply.	A significant opportunity exists for improving the production of cattle, offering a pathway to improving smallholder incomes to help alleviate rural poverty. Baseline data can be used in a number of research areas including improving the large ruminant trade, poverty reduction, food security, and climate change.	This research is a benchmark for future projects on ruminant health & production, including economic analyses, of use to policy makers, donor agencies, extension workers, traders & smallholder who should all value this information.

What we didn't know?	What we know now?	What it means?	Who needs to know?
Could the best practice systems approach lead to measurable gains in cattle production?	Analysis of cattle weights showed that after a 2.5 year lag period when forages are being established, mean weights were statistically higher in the HI sites, with average daily gains 2.4 times higher (P = 0.009) compared to LI sites across the project duration. This evidence is that the best practice program of multiple interventions leads to higher cattle productivity that is incremental but very likely to be exponential.	The delivery of a best practice program based on farmer education, broad stakeholder engagement and addressing disease control and nutrition together, can relatively rapidly improve cattle productivity & household incomes.	This information needs dissemination to smallholder farmers, research & extension workers plus many other stakeholders including livestock project designers and policy makers.
Can forage technology be implemented in a sustainable manner into smallholder farm systems?	Rapid forage uptake by project and non-project farmers occurred & far exceeded expectations with over 1,170 farmers developed forage plots with an average of 356m^2. That 422 farmers developed forage plots outside the project sites provides evidence of the demand for this technology and that this intervention may now have a life of its own.	Improvements in cattle nutrition drives better production and socioeconomic outcomes, with forage offering an 'entry point' for delivery of improved animal health management. The savings of time by farmers growing forages for cattle feeding is a major driver for the uptake & adoption of forage. Increasing farmer access to forage seeds & seedlings plus education in forage growth & management, enables ongoing improvements in cattle production, and offers an entry point for engaging farmers in animal health interventions to manage disease risk, especially FMD and HS.	Researchers, extension workers and policy makers aiming to improve productivity of livestock should consider this important linkage between animal health & nutrition interventions to improve productivity.

What we didn't know?	What we know now?	What it means?	Who needs to know?
Can we improve cattle production through increasing smallholder knowledge on forage technology and biosecurity?	The results from farmer knowledge surveys & the longitudinal studies shows statistically valid improvements in both knowledge and cattle live weights does occur with the systems strategies used in this project.	Significant improvements in cattle productivity that increase rural household profitability occurs rapidly, providing clear extension messages to be delivered at the village level. Improving production & disease control increases animal value, saving time & allowing families to pursue other interests, employment and education. Thus interventions contribute to 'public good' through improved incomes & trading opportunities as trans-boundary disease is controlled.	Smallholder farmers, extension workers and policy makers.
Has biosecurity training and FMD/HS vaccine use limited infectious disease in project villages?	Biosecurity education and vaccine use combined, resulted in no outbreaks in High Intervention villages of FMD or HS despite widespread occurrence of these in surrounding villages.	Vaccine use without biosecurity education has an impact on disease on disease control, but is limited, as was evident in the LI site of Veal where despite FMD vaccination, an outbreak occurred in 2010 associated with introductions of unvaccinated animals. Vaccine delivery requires biosecurity education for sustainable impact on disease management.	Policy makers and donors need to understand the importance when supplying vaccine to smallholder farmers, that this should be combined with biosecurity education for maximum impact and sustainability.
How do cattle supply chains & trading systems work & are there opportunities to improve these for smallholder farmers?	There is a large network of traders operating in rural Cambodia without an organised marketing system. There is evidence of significant increases in prices of large ruminants driven by consistent demand for beef for Vietnam and China and a dwindling supply requiring an increased focus on improving reproductive efficiency.	Smallholder farmers need greater access to market information systems, knowledge of improving large ruminant quality to meet market demands & maximise profits, plus expertise in estimating animal weights & values.	Policy makers, industry stakeholders including exporters and smallholder farmers.
Do productivity and health interventions lead to increased value of livestock?	The feeding trial conducted in 2012 with 8% body weight of forage increased the value of cattle by US$ 61.29 more than control cattle fed at 5% over a 3 month period.	Smallholder farmers can see financial benefits from implementing nutrition, health and husbandry interventions.	Extension workers, donor agencies, policy makers, smallholder farmers.

What we didn't know?	What we know now?	What it means?	Who needs to know?
What is the financial impact of FMD on smallholder livestock farmers?	FMD induces severe financial impacts on smallholders with average losses (both direct and indirect) between US$ 216.32 & $ 370.54 or 54-92% of the initial animal value, depending on the outcome. Partial budget showed a net benefit of US$ 31.48 for biannual use of FMD vaccination.	The results challenge the dogma that FMD is a 'trade disease' with minimal impact on smallholders on the assumption that animals fully recover. Financial evidence from partial budgets can be used to promote biosecurity and FMD vaccine use by smallholder farmers.	Vaccine use is economically justified and should be made to increase availability of vaccine to farmers through commercial suppliers, accompanied by education in vaccine use and importance of biosecurity.
What is the financial impact of HS on smallholder livestock farmers?	The financial impact of HS on smallholders is severe. The average outcome costs per affected animal experienced by the interviewed farmers were US$ 375.84 USD, or 66.1% of pre-HS values. Depending on the outcome, these were as high as $ 617.22 or 112% of the initial animal value.	HS causes a significant financial impact at the household level. This provides financial justification for biosecurity interventions including regular vaccination.	Vaccine use is economically justified and efforts should be made to increase availability of vaccine to farmers through commercial suppliers, accompanied by biosecurity education.
What are the impacts of chronic FMD infection?	A survey of district veterinarians indicated that some animals suffer chronic effects after clinical FMD and become unproductive.	The effects of FMD are not limited to the acute phase of infection, and losses may be underestimated if chronic effects are ignored.	Researchers, animal health authorities, smallholder farmers.

9.2 Capacity impacts – now and in 5 years

Leadership, People & Organisations & Project Management training for Cambodian Project Leader

An AusAID Australian Leadership Award Fellowship program round 7 in 2009 entitled 'Strengthening Animal Health and Production Capacities, Cambodia and Lao PDR' was obtained and both fellows (Dr Suon Sothoeun and Dr Syseng Khounsy) completed a program that included studies in the Leadership and Project Management units in the UoS VPHMgmt program (Veterinary Public Health Management) and visited many sites including UoS and CSU, providing exposure to adult teaching/learning techniques. Visits with professionals at DAFF, NSW DPI, Menangle Veterinary Laboratory, Animal Health Australia, Australian Veterinary Association and ACIAR plus several mixed private veterinary practices and farms, provided broad experience in disease surveillance and diagnostics at local, state and national level as well as insights into animal health and production policy, research and organisational structures and management. Further placements included a cattle feedlot, export abattoir,

dairy farms and saleyards providing knowledge on marketing and processing as well as large scale farming practices.

Cambodian Project Staff

During the project the UoS team strongly focused on training project staff and district partners in animal health and biosecurity management plus applied animal production principles, encouraging these staff to implement project interventions and train farmers in HI villages. The central DAHP project team was responsible for project implementation and farmer training with the district staff responsible for coordination and extension at local level.

During the first year, training related to animal health, forage production and nutrition involved only the DAHP project team and district partners, but the following 3 training courses on ruminant nutrition, reproduction and cattle nutrition (3 days each) included other provincial and district staff, students from the Royal Academy of Agriculture and partners of the ACIAR project 'Improved feeding systems for more efficient beef cattle production in Cambodia'. A workshop on Biosecurity was held in May 2012 and delivered to District Veterinarians and Project Staff. Two project staff Mr Kea Pha and Mr Van Irng, received English language training in the first two years of the project.

As well as attending project workshops, project staff members Mr Kea Pha and Mr Van Irng visited Lao PDR in December 2010 and presented in English, the farmer training program implemented in Cambodia at a workshop for the Lao district and provincial project staff. This assisted the development of the Lao farmer-training program. The four DAHP project staff members, Mr Kea Pha, Mr Van Irng, Mr Thong Samnang & and Mr Hout Savouth led by Dr Suon Sothoeun are co-authors on papers on their research that has been documented and currently being published as an ACIAR Cambodian Cattle Proceedings following a successful workshop in Phnom Penh in June 2011 that gathered together the work of the three cattle projects funded by ACIAR that have been recently completed.

Two RAC students completed their PhD projects in close association with the ACIAR project, contributing to increased local research capacity. They were:

- Mr. Mong Seang Ngim - research on Forage thesis (completed);
- Mr. Tiang Sin - research on FMD epidemiology (completed); and
- Mr. Ieng Savoeurn - research on HS epidemiology (deceased prior to completion).

The project team were often reminded of the significant contribution of the late Mr Ieng Savoeurn, RAC PhD student who undertook and presented research on Haemorrhagic Septicaemia at the June 2011 joint three project workshop. His paper on HS was completed by the project leaders and will be published with a tribute to Mr Savoeurn in the ACIAR Cambodian Cattle Proceedings 138 currently in print.

Future impacts

The close collaboration between Cambodian and Australian staff is likely to provide on-going impacts over the next five years. Both Australian and Cambodian staff and students have

increased skillsets in agricultural development and extension and research. It is predicted that the students, project staff and leadership, as well as VAHWs, District and Provincial veterinarians, and lastly but most importantly the smallholder farmers, will continue to use and develop the skills obtained during the course of the project.

9.3 Community impacts – now and in 5 years

9.3.1 Economic impacts

FMD & HS impact and vaccine partial budget analysis

A financial impact study of FMD on smallholder farmers was completed that identified that this disease has significant economic impacts that are generally not well recognised by stakeholders working with smallholder farmers. This challenges the widely held assumption that because of low mortality, FMD has minimal impacts on smallholder farmers. Interviewed farmers that are keen to improve their cattle productivity and profitability have identified that this assumption is false.

This outcome encouraged a similar study to investigate the financial impact of HS in 2012. These household impact studies provide important evidence of impacts that can be used in further economic analyses and justification for investment in disease prevention and control.

The 'cattle feeding forage industry'

Some farmers in the project villages established small forage nurseries and are now selling seedlings to other farmers to assist them adopt forage technology. One farmer reported selling seedlings to farmers to establish a 10 m x 10 m plot for US$ 10. Assistance was also provided to the farmers in site selection, cultivation and feeding management.

A number of farmers established dams for irrigation to enable production of forage in the dry season. It is now common to see fresh forages for sale for large ruminant feeding in Cambodia on the roadside in the wet season, but increasingly also in the dry season when such feed is scarce.

These examples provide an indication that the demand for large ruminant feed will provide opportunities for innovative smallholders beyond feeding their own cattle. The apparent development of the 'cattle feeding forage industry' has become an additional driver for the successful adoption of this forage intervention and is attributable to the excellent work of the Cambodian team in promoting this intervention in the early to mid-phase of the project when farmers were mostly sceptical of the benefits of forage technology.

Project financial impacts

The recent KAP survey conducted in March 2013 included questions on the financial impact of the project. Preliminary analysis of this data on impacts of the project on households indicates that in HI villages, of the 60 farmers surveyed, 86% consider the project increased their

household income, with 62% indicating that this increase doubled or more than doubled their usual household income.

An issue of considerable concern identified by the project remains the relative unavailability of vaccines through commercial suppliers in Cambodia. The project observed that there was often the ready provision of therapies such as expensive antibiotics to treat ill animals, with anecdotal reports of very expensive treatment costs for FMD, a viral disease that rarely requires such therapy, presumably due to the widespread lack of distinction between FMD and HS outbreaks where such therapies are indicated. The practise of promotion of antibiotics for treatment rather than the inexpensive option of providing vaccines for disease prevention needs to be addressed. Ongoing and widespread public awareness of this important distinction is urgently needed in Cambodia, Laos and other Mekong countries.

9.3.2 Social impacts

Many project farmers experienced significant savings in time for household members with forages due to reduced need for supervised grazing and searching for native grasses for cut-and-carry feeding. Increasingly, reports are that some farmers have experienced improved live weight gain and sale value of cattle. The analysis of cattle weight data in the longitudinal study confirmed that cattle in HI villages (particularly in Takeo) had significantly improved growth rates compared to cattle in the LI villages, although overall growth rates were still poor.

The visits by the project team to the 6 project villages continues to strengthen the awareness and knowledge amongst village farmers on animal disease, nutrition, reproduction and husbandry issues, with efforts in the final year introducing the interventions successfully used in the HI villages, into the LI villages.

Substantial areas of land have been allocated to forage growing in the project villages, with approximate plantation sizes of: Takeo province 141,000 m^2; Kampong Cham 120,000 m^2; and Kandal province 21,000 m^2. In the latter half of 2011 a further 23,900 m^2 of forage plots were established by 195 smallholder farmers although the rate of increase slowed in 2012 due to severe flooding. It is anticipated that expansion of cattle fodder production will result in significant savings of time for household members as captured by the KAP survey, enabling other agricultural enterprises to be developed.

An important question at the end of this project is, will project farmers be willing and able to pay for the interventions that were provided for free or at least subsidised in the project villages? It is very likely that improved farmer knowledge and changes in attitudes and practices (e.g. pen hygiene, cattle fattening, disease control) will remain with the farmers in HI villages and potentially with the LI villages following the insertion of key interventions into LI sites towards the end of the project. KAP survey assessments taken in 2012 support the notion that many of the interventions are very likely to be sustainable in the long term.

9.3.3 Environmental impacts

Changes of land use resulting from forage plantations is likely to result in some environmental impacts although analysis of this issue was not an objective of this project. Insertion of dams for dry season irrigation and replacement of rice straw with fresh fodder will have some minor local environmental impacts as will conversion of some rice growing areas into forage plantations.

Of interest has been the increasing adoption in the project sites of the household bio-digester, using manure and other wastes to generate methane for cooking and lighting. Cattle and forages are important component of the successful extension of this very sustainable energy initiative. Longer-term impacts of the project depend on both the sustainability of the introduced interventions and the extent of uptake of these interventions beyond the project area.

9.4 Communication and dissemination activities

Scientific papers accepted in a peer-reviewed journal:

Formal publication in Conference Proceedings or Scientific Journal	**Outputs described in the publication and their significance to project outcomes**
Windsor PA. (2011). Review: Perspectives on Australian animal health aid projects. Editor invited paper. *Transboundary and Emerging Diseases*: 58: 375–386	This invited review paper by the Project Leader offers perspectives on issues involved in Australian aid projects addressing regional animal health research and development, with a checklist of strategies to consider when designing and managing such projects. The paper supports the need for animal health aid projects to improve livestock productivity, minimize risk to trade and human health and enhance the capacities of countries where there are significant gaps in the provision of veterinary services. Improving large ruminant production, particularly through forages technology and infectious disease risk management including village-level biosecurity, provides a potential driver of FMD control and eventual eradication in the region.
Nampanya S., Suon, S, Rast, L, Windsor P.A. (2012) Improvement of Farmer Knowledge of Cattle Production, Health and Biosecurity in Southern Cambodia between 2008 and 2010. *Transboundary and Emerging Diseases.* 59: 117-127	This research provides evidence for knowledge based interventions leading to improved farmer knowledge of livestock productivity and health. Using participatory knowledge training through a range of formats, a participatory learning environment encourages implementation of livestock disease risk management and production strategies, technologies and techniques.

Windsor, P.A, Khounsy, S., Sothoeun S., Nampanya, S., Young, J., Rast, L., Henry, L.A., Bush, R.D. (2012) Comparison of smallholder large ruminant systems and health and productivity interventions in southern Cambodia and northern Lao PDR. *The 15th Asian-Australian Association of Animal Production Animal Science Congress*. Bangkok, November 26-30, p 144	This paper compared smallholder large ruminant systems and key drivers for health and productivity interventions in southern Cambodia and northern Lao PDR, identifying that whilst forages were an entry point in Cambodia due to year round energy deficits, health interventions were more important in northern Laos where FMD vaccination and treatment for Toxocara vitulorum was most appreciated by farmers that had reasonable grazing options for much of the year.
Windsor, P.A., Khounsy, S., Sothoeun, S., Nampanya, S., Stratton, J., Rast, L. Henry, L., & Bush, R.D. (2012) 'Village-based approaches to biosecurity in the Mekong region', In: Animal Biosecurity in the Mekong: Future Directions for Research and Development, ACIAR Proceedings 137, pp. 97-100	This paper describes the opportunities and challenges of village-based approaches to biosecurity in the Mekong region. The research suggests attention to 'bottom-up' approaches to disease control to facilitate sustainable adaptive change in the disease risk behaviours of livestock owners and other stakeholders to assist disease control program. Key steps include: development of a readily adopted village-level biosecurity program; testing of the village-level biosecurity program in FMD hot spots; promotion of the successful aspects of the program through strategic public awareness; assessing the extent to which improved smallholder farmer knowledge of disease and biosecurity can deliver widespread reduction and elimination of FMD and other diseases in rural communities of the Mekong.
Formal publication in Conference Proceedings or Scientific Journal in In press or submitted	**Outputs described in the publication and their significance to project outcomes**
Young, J. R., Suon, S., Andrews, C. J., Henry, L. A. and Windsor, P. A. (2013), Assessment of Financial Impact of Foot and Mouth Disease on Smallholder Cattle Farmers in Southern Cambodia. *Transboundary and Emerging Diseases.* 60:166-174 This research was presented as a poster at the FAO/OIE 2nd Global Conference on Foot-and-Mouth Disease Bangkok, June 2012 (see Appendix 1 for abstract).	This research challenges the dogma that FMD has minimal impacts on smallholder farmers with a financial impact survey questionnaire indicating that due to loss of weight of cattle, farmers are subject to an acute severe financial shock when FMD occurs, particularly if a draught animal. The partial budget provides economic evidence that biannual FMD vaccination is justified. Presenting this research at the Global FMD Conference helps communicate and disseminate project outputs.
Windsor P.A., Young, J. (2013) Workshop Summary. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print	This paper provides a summary of this workshop held in Phnom Penh in 2011 that collated findings of 3 ACIAR funded projects working on cattle in Cambodia and were nearing completion, including the Forages for Beef, Best Practice Health & Husbandry, and Movement Control for Transboundary Diseases.

Young, J., Rast, L., Sothoeun, S., Van Irng, L., Samnang, T., Windsor, P.A. (2013) A longitudinal study on cattle health & production. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print.	This paper documents the longitudinal research that compared HI and LI villages as interventions were introduced over time, identifying a lag phase as forages were established and then differences in weight gain of project cattle at the village level.
Sothoeun, S., Young, J., Windsor, P.A. (2013) Livestock infectious disease status in Cambodia. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print.	This paper documents the trends in livestock disease from official reports to DAHP during the course of the project.
Savoeurn, I., Sothoeun, S., Windsor, P.A. (2013) The epidemiology, diagnosis and control of haemorrhagic septicaemia of cattle and buffalo in Cambodia. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print.	This paper documents the a study of HS including a post-vaccination serological survey that identified high levels of persistent antibody titres even at 6 months post-vaccination, suggestive of good immune protection.
Young, J., Sothoeun, S., Van Irng, L., Pha, K., Savouth, H., Rast, L., Windsor, P.A. (2013) Parasitic infections of large ruminants in Cambodia. . In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print.	This paper documents the various studies conducted on parasitism in cattle in the projects sites, with Fascioliasis control being the main intervention required in Kandal but not in other provinces.
Rast, L., Nampanya, S., Khounsy, S., Toribio, J-A., Windsor, P.A. 92013) Liver Fluke in large ruminants in northern Lao PDR. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print	This paper compares the findings on Fascioliasis in Cambodia which is now well studied, with the recent data from northern Laos where this disease is poorly recognised yet found to be widespread and of potential concern to cattle and buffalo productivity in some areas, particularly in Xieng Khouang province.
O'Connell, J., Young,J., Henry, L., Rast,L., Sothoeun,S., Bush, R., Windsor, P.A.(2013) Assessment of current trends in smallholder cattle trade in Cambodia. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print.	This paper describes surveys conducted with traders in and beyond the project sites that document trends in their practices and desires for marketing improvements, plus the significant increases in cattle prices that occurred during the project period.
Nampanya, S., Sothoeun,S., Rast, L., Windsor, P.A. (2013) Improvement in smallholder farmer knowledge of cattle production, health and biosecurity in southern Cambodia between 2008 and 2010. In: Best Practice Cattle Health Production and Marketing for Cambodia. ACIAR Proceedings TBA, in print	This paper documents the success of the smallholder farmer education program in Cambodia and compares the impacts of the 3 different extension strategies used, offering suggestions for future R&D programs that can more rapidly motivate farmers to adopt improved practices. A similar study is nearing completion in Laos offering interesting comparisons between the two countries.

Publications for Smallholder Farmers and Extension Workers

1. Khmer Forage booklet publication

A 51 page Khmer language booklet publication was prepared and published in early 2012 by the Cambodian Project team, with 3,000 copies printed. A number of meetings were conducted to increase awareness and distribute these materials in both project sites and surrounding areas.

Publication title: **Forages and Forage Cultivation Techniques**

Language: Khmer (only)

Publication contents

Contents

Preface

Acknowledgements

1. Forages for cattle
    a. Importance of forages for cattle
    b. Types of forage species
    c. Forage cultivation techniques
    d. Selection of areas for forage cultivation
    e. Land preparation
    f. Seed selection and preparation
    g. Cultivation techniques
    h. Caring and management of forages
2. Silage production
    a. What is silage?
    b. How to make silage
    c. Silage packaging
    d. Silage storage
    e. How to feed silage to cattle
3. Rice straw urea treatment

References

Example of booklet distribution. On 14 June 2012 Project Team members led by Dr. Suon Sothoeun attended a meeting of 16 Village Leaders to discuss forage technology and cattle feeding on Thursday morning in the Office of the Cheang Tong commune in Takeo province. The purpose of the meeting was to alert Village Leaders that the No Mor forage nursery would soon be available for farmers to obtain forages, and that those wishing to do so should begin land preparation. A new booklet, titled ‘Forages and forage cultivation techniques’ produced by the ‘Best practice health and husbandry of cattle, Cambodia’ Project Team was also distributed by staff and reviewed. This 51-page Khmer language publication contains

information and guides farmers on feeding forages for cattle, forage cultivation techniques from seeds and seedlings, as well as silage production. This will be an important resource for farmers, and contains multiple photos to demonstrate points were applicable.

2. Smallholder cattle Best Practice Manual – a guide for smallholder farmers

An English draft document was prepared and supplied to the DAHP in March 2013 for translation and inclusion of photos for publication and distribution to smallholder farmers. This manual draws information from research conducted during the project and contains simple messages associated with cattle production and animal health. It includes basic biosecurity and disease information. The final page of the manual contains a basic body condition score (BCS) chart. The draft English version will be populated with photos when in print. It is expected to be in print by mid-2013. A copy of the draft manual is provided (Appendix 6).

Irrigation tank for dry season forage growing in Kampong Cham.

10 Conclusions and recommendations

10.1 Conclusions

This project has provided evidence that the delivery of animal health and production focused interventions through a systems approach can lead to improved cattle growth and reduced trans-boundary disease impacts. Coupling animal health with production interventions provides farmers with incentives to protect their increasingly valued livestock, offering improved socioeconomic outcomes for smallholders and offering an 'entry point' for farmer engagement and collaboration in livestock development.

The project sought to improve farmer knowledge on husbandry techniques that would both improve cattle growth through improved nutrition and limit infectious TADs that otherwise severely constrain cattle productivity and trade. The project engaged multiple level stakeholders including government veterinarians and extension workers, VAHWs, village chiefs, multi-national students in addition to smallholder farmers to maximise awareness of the projects outcomes. This approach enabled dissemination of project information across village, district, provincial, national and international level communities.

Cattle are extremely important resource for smallholder rural households, particularly as an asset for storing wealth. Increasing smallholder cattle productivity offers opportunities to increase household incomes, improve the national supply of beef, and contribute to regional food security through development of local export markets that aim to meet the consistent demand for meat in the GMS. Enhancing this system clearly offers a pathway for smallholders to improve their livelihoods and therefore offers a pathway to help alleviate regional rural poverty.

Smallholder farmers and VAHWs lack knowledge of basic husbandry and animal health issues that are currently constraining production, including the control of TADs. With a low level of knowledge, interventions that fail to include a strong educational component run the risk of being unstainable beyond the life and duration of aid projects. The overall aims of such research should be to provide policy makers with clearer understanding of how farmers can benefit from information that empowers them to make sound evidence-based decisions that are suitable for their household needs. While this project can claim a range of important and successful research outcomes, it recognises that these need to be translated into wider rural community KAP outcomes to have a significant societal impact and that this requires a substantial amount of development work and commitment.

10.2 Recommendations

A key recommendation is that future aid programs involving livestock research and development with cattle in developing countries include alignment of both production and

animal health interventions through knowledge and marketing using a 'systems approach'. This is highly desirable if the ultimate aim is to provide sustainable improvements to animal productivity and profitability and address food security and rural poverty concerns.

Use of participatory education in development projects

Sustainable change through uptake and adoption of new technology requires farmers to internalise new practices. In order to achieve this level of commitment beyond simple participation and compliance during the project, largely illiterate farmers need substantial participatory education in the broad range of relevant topics from production through health and marketing, with clear demonstrations of the benefits of adopting such interventions. It is recommended that projects aiming to improve profitability through increasing productivity and animal health should include a significant education and capacity building component to enable farmers to make suitable decisions that meet their own production objectives in a sustainable manner.

Reinforce the need for biosecurity measures

Current behaviours and practices of smallholder farmers and traders pose very high risks for transmission of TADs and impair regional marketing of livestock. Multiple interventions that combine productivity and health interventions profit improvements with greater biosecurity should be a priority, particularly as there is a widespread tendency to 'vaccinate and forget' when approaching disease control, ignoring the reality that sustainable disease control requires improved disease risk management.

An emergency management approach for TAD control

The lack of rapid detection, recognition, investigation and reporting of TADs, accompanied by regular virus isolation to ensure 'vaccine matching', remains a significant issue in Cambodia. Reasons for delays or failure of reporting and a rapid response need to be addressed and where appropriate, resource and capacity deficits improved, with encouragement that an FMD Task Force be established at the DAHP in Phnom Penh. Improving the availability, cost and reporting of laboratory tests needs investigation.

Improved marketing of cattle

The project established a standard BCS chart on a scale of 1-5 (1= Emaciated and 5 = Fat) for distribution within a Smallholder Farmer Manual in Khmer to smallholders, VAHWs, traders, and official veterinarians, that will be of benefit the industry (Appendix 6). Standardised grading of live cattle is needed to reduce the current ambiguity at the point of sale from smallholder to trader, plus help define market requirements to meet quality and standards demanded for each market segment (domestic consumption, export etc.). The manual can continue to be improved and developed with future use. The development of a girth weight tape should be encouraged as should the development of a Market Information System available to smallholder farmers providing information of current demands and prices to help farmers with decisions that can maximise profits.

Scaling out of the Best Practice Program

The leaders of this project believe that this Best Practice project has very strong potential to be ‘scaled out’ to other villages and communities in Cambodia, at least through provision of information and resources to current and future livestock development projects.

Cattle fed forages in pens under the house in Takeo province November 2011.

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Windsor PA, Khounsy S, Sothoeun S, Nampanya S, Young J, Rast L, Henry LA, Bush RD. (2012) Comparison of smallholder large ruminant systems and health and productivity interventions in southern Cambodia and northern Lao PDR. The 15th Asian-Australian Association of Animal Production Animal Science Congress. Bangkok, November 26-30,p 144, 2012

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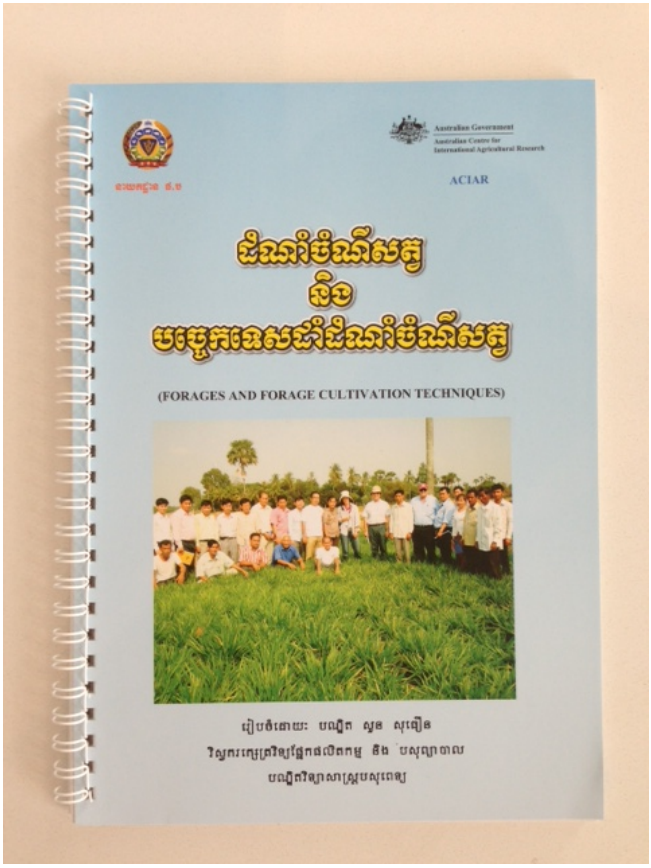
Conference posters

Young JR, Sothoeun S, Andrews CJ, Henry LA, Windsor PA.. (2012) Assessment of financial impact of FMD on smallholder cattle farmers in southern Cambodia. FAO OIE 2nd Global Conference on FMD, Bangkok, Thailand, June 27-29, 2012

Smallholder farmer Resource Booklets

Forages and Forage Cultivation Techniques

Smallholder Cattle Best Practice Manual – a guide for smallholder farmers (Appendix 6)



Project Websites

The projects ACIAR website can be found at:

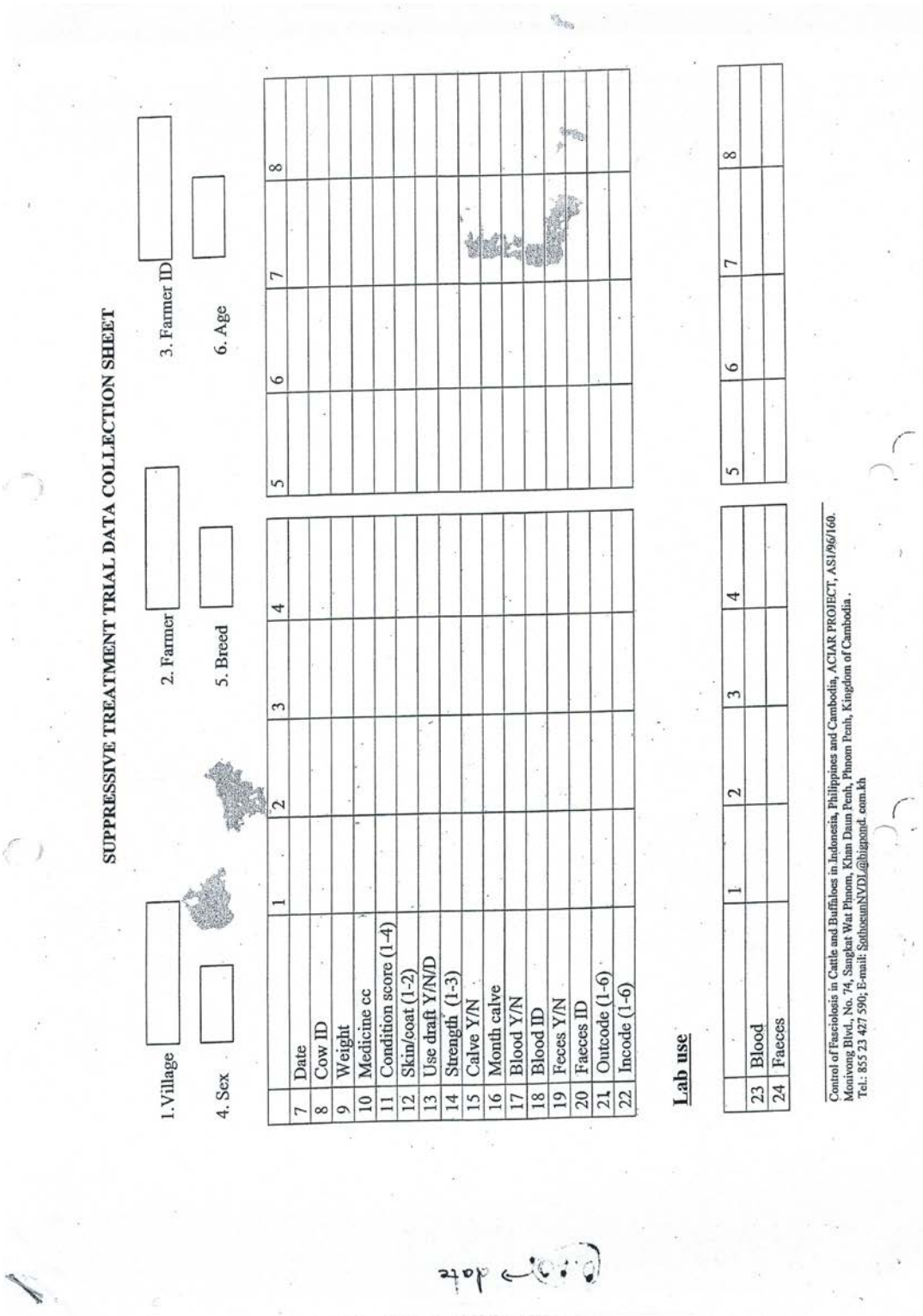
http://aciar.gov.au/project/AH/2005/086

The Cambodian developed project website can be found at:

http://www.2005086-dahp-aciar.com/

12 Appendices

12.1 Appendix 1: Longitudinal Survey data collection



SUPPRESSIVE TREATMENT TRIAL DATA COLLECTION SHEET

1. Village ____ 2. Farmer ____ 3. Farmer ID ____

4. Sex ____ 5. Breed ____ 6. Age ____

		1	2	3	4	5	6	7	8
7	Date								
8	Cow ID								
9	Weight								
10	Medicine cc								
11	Condition score (1-4)								
12	Skin/coat (1-2)								
13	Use draft Y/N/D								
14	Strength (1-3)								
15	Calve Y/N								
16	Month calve								
17	Blood Y/N								
18	Blood ID								
19	Feces Y/N								
20	Faeces ID								
21	Outcode (1-6)								
22	Incode (1-6)								

Lab use

		1	2	3	4	5	6	7	8
23	Blood								
24	Faeces								

Control of Fasciolosis in Cattle and Buffaloes in Indonesia, Philippines and Cambodia, ACIAR PROJECT, AS1/96/160.
Monivong Blvd., No. 74, Sangkat Wat Phnom, Khan Daun Penh, Phnom Penh, Kingdom of Cambodia .
Tel.: 855 23 427 590; E-mail: SothoeunNVDI@bigpond. com.kh

Explanation of terms :

1. Village	Name of village
2.Farmer	Name of farmer
3.Farmer ID	ID number of farmer
4.Sex	1= male castrate, 2= female, 3= young entire male, 4= bull for breeding
5.Breed	1= Haryana, 2= Local, 3= Crossbred, 4= Brahman
6.Age	In years and half years e.g. 0.5, 1.0, 1.5, 2.0, 2.5... etc
7.Date	Day month year
8.Cow ID	Number of neck tag
9.Weight	Kilograms according to scales
10.Medicine cc	Amount of medicine given in cc
11.Condition score (1-4)	1= fat, 2= medium, 3= skinny, 4= very skinny
12.Skin/coat (1-2)	1= bright, 2= dull
13.Use draft Y/N/D	Y= used since last treatment, N= not used since last treatment D= don't know. If first time: ask if used in last three months
14.Strength (1-3)	1= strong, 2= same, 3= weaker. Compared to strength 3 months before
15.Calve Y/N	Y= has calved since last treatment, N= not calved since last treatment
16.Month calve	Month that calved
17.Blood Y/N	Y= took blood, N= did not take blood
18.Blood ID	ID written on blood tube
19.Faeces Y/N	Y= took feces, N= did not take feces
20.Faeces ID	ID written on feces sample
21.Outcode (1-6)	1= sold, 2= dead, 3= loan, 4= stolen, 5= don't know, 6= same
22.Incode (1-6)	1= buy, 2= born, 3= borrow, 4= rent, 5= don't know, 6=same

Lab use :

23.Blood	PCV (%)
24.Faeces	Number of eggs per 3 gram

Control of Fasciolosis in Cattle and Buffaloes in Indonesia, Philippines and Cambodia, ACIAR PROJECT, AS1/96/160.
Monivong Blvd., No. 74, Sangkat Wat Phnom, Khan Daun Penh, Phnom Penh, Kingdom of Cambodia .
Tel.: 855 23 427 590; E-mail: SothoeunNVDL@bigpond. com.kh

12.2 Appendix 2: TRADER SURVEY 2008

Aim: To interview as many traders as possible associated with the six project villages

Preferably interviews to be conducted with each trader individually. If this is not possible, then interview groups of traders (max 5 per group) associated with each village.

Name of trader: ……

Address: ……

Contact details: (phone/email) ……

Operating location: (villages/district/province) ……

Number of years trading: ……

Sole business/other businesses:……

Interviewer: ……

Date: ……

1. Please fill in the following tables indicating the number of animals you bought in the last 12 months based on their breed, age and season.

Indigenous:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Haryana:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Buffalo:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

2. Please indicate in the following tables the average price you paid for the animals you bought in the last 12 months based on their age and season.

Indigenous:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Haryana:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Buffalo:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

3. Do you purchase:

Directly from farmer ……..

Other trader……..

Other ……..

What percentage does this represent?

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

Phone ……

SMS ……

Spotter ……

Other ……

b) Are you ever contacted by the farmer?

Yes……

No ……

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

a) If so from where? ……

b) What percentage? ……

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

R sold for reuse for breeding or draft

X exported – if known to where

D sold for slaughter – if known to where

C sold to Yuvak Peanek

Indigenous:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Haryana:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

Buffalo:

MALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

FEMALE	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

BULLS	0-2 years		2-4 years		4-10 years		over 10 years	
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry
poor condition (skinny)								
medium condition								
good condition (fat)								

7. How do you transport your cattle or buffalo to their final destination? Please indicate the percentage

Walk ……

Truck ……

Boat ……

Other ……

8. What costs do you incur per head?

Transport ……

Slaughter costs ……

Marketing costs ……

Levies ……

Quarantine/health ……

Other ……

9. Do you own a slaughter house (partly or fully owned)?

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

Month	Indigenous			Haryana			Buffalo		
	Male	Female	Bulls	Male	Female	Bulls	Male	Female	Bulls
January									
February									
March									
April									
May									
June									
July									
August									
September									
October									
November									
December									

10. How do you assess/determine the value of the animals you are purchasing?

Weight: ……

Condition Score……

General Appearance ……..

Other ……

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

Market	List of problems encountered: Purchase	List of problems encountered: Sale
Provincial		
Domestic		
International		

12. What do you think might help to overcome these problems?

13. Do you have any ideas that would assist for the future of marketing of cattle and buffalo in Cambodia?

14. Do you have any other comments?

12.3 Appendix 3: Farmer Baseline Knowledge Survey of Cattle Farmer Participants 2008

INTERVIEW DETAILS

Sampling Guidelines

A minimum of 20 % of households (farmers) will be selected randomly from all the project participants in each project village to undertake the survey.

In each of the three intervention villages all the households (farmers) selected for the initial round of forage growing (4-7 in each village) will be automatically selected to participate in the farmer baseline knowledge survey, in addition to the 20 % of the other farmers (households) randomly selected there. They will be treated as a separate group given they have already received project training, and are no longer considered “baseline”.

Interviewer…….

Province……..

District……..

Commune…….

Village…….

Date……..

Farmer name……..

1. Forage Grower (Yes/No).....

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

3. Area of land owned/leased by farmer:…….acres or square meters (circle units used)

4. Area of land used for forages:……..acres or square meters (circle units used)

GENERAL

1. List the following, from 1 (most important) to 5 (least important), in order of importance to your livelihood?

    a) rice growing
    b) cattle raising
    c) pig raising
    d) chicken and/or duck raising
    e) Chamkar (non rice crop, vegetable or fruit growing)

2. Rate the following, from 1(most skills/knowledge) to 5 (least skills/knowledge), in order of the farming enterprises you think you have the most skills and knowledge in?

    a) rice growing
    b) cattle raising
    c) pig raising
    d) chicken and/or duck raising
    e) Chamkar

3. How did you obtain your skills/knowledge in **cattle** raising? Indicate the following sources of knowledge in order of amount of knowledge you have gained from them: 1(source where most knowledge has been learned from) to 7 (source where least knowledge learned)

    a) From family/household member
    b) From other farmers in village
    c) From farmers from neighboring villages
    d) From government staff
    e) From project staff
    f) From schools
    g) From VLA
    h) other-specify

4. What is your main objective in keeping cattle? (list in order of priority, 1 most important 5 least important)

    a) For security if I need money suddenly
    b) For draught power
    c) For breeding calves
    d) For sale for meat
    e) Other (specify)…....

5. Put the following in order, from 1 (most common) to 5 (least common), in terms of the main reason you normally sell your cattle?
    a) need the money
    b) good price available
    c) have too many cattle to care for
    d) a cow cannot have calves
    e) cattle are too old or sick

6. What age do you generally sell your cattle?
    a. 0-2 years
    b. 2-6 years
    c. 6-10 years
    d. over 10 years
    e. whatever age they are when I need the money

7. Do you usually obtain a quote from more than one trader before you sell your cattle? (Yes, No)

8. Do you know the market price of your cattle before you decide to sell your cattle? (Yes, No)

9. Do you know which market your cattle are going to when you sell them (yes, no), and if yes where? (can circle more than one answer)
    a. export to foreign country
    b. local slaughter
    c. Phnom Penh
    d. other

10. Do you **always** call the VAHW to visit when your cattle are sick? (Yes, No)

Circle either true, false or I do not know for each of the remaining questions

ANIMAL HEALTH (INTERNAL PARASITES)

11. Liver fluke and roundworm are parasites that can occur in cattle True- False- I do not know

12. Liver fluke can make my cattle sick and loose weight True- False- I do not know

13. Liver fluke cannot kill my cattle True- False- I do not know

14. Round worms can make cattle scour and loose weight True- False- I do not know

15. It is more important to treat adult cattle than calves for roundworm True- False- I do not know

16. Worms and liver fluke can be treated with medication given one or two time per year True- False- I do not know

17. Cattle cannot become infected with worms or fluke when grazing True- False- I do not know

18. My cattle have internal parasites (round worms or liver fluke) True- False- I do not know

19. I have treated my cattle for worms in the last 6 months True- False- I do not know

ANIMAL HEALTH (INFECTIOUS DISEASES)

20. a(*Basic description symptoms of FMD)* What disease is this? (name the disease) – I don't know

b(Basic description symptoms of HS) What disease is this? (name the disease) – I don't know

c(Basic description symptoms of Blackleg) What disease is this? (name the disease) – I don't know

21. A single vaccination protects my cattle from getting both HS and FMD for 12 months True-False- I do not know

22. An antibiotic injection protects cattle from getting new diseases True-False- I do not know

23. FMD vaccination is good to give as a treatment for animals with FMD True-False- I do not know

24. My cattle can get FMD or HS if I mix them with newly bought cattle straight away True- False- I do not know

25. FMD virus can survive in the soil and can infect another cow at a later time True-False- I do not know

26. Pigs with FMD can give FMD to cattle in the same village True-False- I do not know

27. Calling the Village Animal Health Worker for assistance when my cattle are sick is important to minimize the impact of illness True-False- I do not know

28. I have vaccinated my cattle against FMD in the last six months True-False- I do not know

29. I have vaccinated my cattle against HS in the last six months True-False- I do not know

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

31. Keeping my sick cattle away from other animals helps ensure other cattle in the village do not get sick True-False- I do not know

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

33. Which is most efficient method to protect cattle for FMD

. a. treat with AB

B vaccinate for FMD

C stop animal movement

D B+C

E improve feed

NUTRITION

34. A cow with a suckling calf needs more than twice the amount of food than a cow without a suckling calf True- False- I do not know

35. An adult cow needs about 10 kg of fresh grass per day to keep its weight True- False- I do not know

36. The condition score of cattle can be used to assess their Nutritional status True- False- I do not know

37. Cattle need about 20 liters of water once a day True- False- I do not know

38. Weighing cattle is a useful tool to measure my progress in cattle raising True-False- I do not know

REPRODUCTION

39. It is possible for adult cows to have a calf every single year True-False- I do not know

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

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

42. The amount and type of food fed to cows during pregnancy Will affect the health of the calf when born True-False- I do not know

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

EXTENSION

44. What kind of extension materials would you find the most effective in providing information about cattle health and production? (rate the following from 1 most to 5 least)
    a. TV or radio spots
    b. posters
    c. leaflets/handouts
    d. demonstration
    e. sign boards

45. What kind of extension methods would you find most effective in teaching you about cattle health and production? (rate the following from 1most to 5 least)
    a. demonstrations
    b. meetings
    c. advise by project staff
    d. teaching by direct extension
    e. farmer cross visits

12.4 Appendix 4: SMALLHOLDER FARMER KAP SURVEY – CAMBODIA 2012

Final copy- This copy was reviewed by the project team in Phnom Penh on the 29 March

The KAP survey is being undertaken to assess the impact of the interventions on the project village farmers. The KAP stands for Knowledge (K), Attitudes (A) and Practices (P). This means that it is used to assess what the farmer 'knows', 'believes', and 'does'. The KAP survey is different to the Farmer Knowledge (FK) surveys conducted in 2008 and 2010, in that it is now K + AP. The target survey population will be 20 farmers per project village, for a total of 120 farmers.

Interviewer Name:		**Date:**		
Farmer Name:				
Province:		**Commune:**		
District:		**Village:**		
Household members:				
Farm area (ha):				
1. Total cultivated area	Rice	Garden	Forage	Other
Area in ha				
2. Number of cattle owned at present	Bull	Castrated	Female	Calf (<6mo)
Number (head)				
Number (head) fed forages				
3. Number of cattle were bought in the last year	Bull	Castrated	Female	Calf (<6mo)
Number (head)				
Average age (year)				
Average price (Riel)				
4. Number of cattle sold in the last year	Bull	Castrated	Female	Calf (<6mo)
Number (head)				
Average age (year)				
Average price (Riel)				

5. Number of calves born in the last year				
6. Number of cattle died in the last year	Bull	Castrated	Female	Calf (<6mo)
Number (head)				
Average price (Riel)				
Suspected disease if known				

Knowledge – These questions are used to assess what the farmer 'knows'

Animal health & Biosecurity *(circle answer which applies)*

7. Liver fluke can infect cattle in my village Yes No I don't know

8. Liver fluke can kill my cattle Yes No I don't know

9. The intestinal worm, Toxocara, can kill many cattle calves Yes No I don't know

10. Cattle can become infected with worms or liver fluke while grazing Yes No I don't know

11. Toxocara can be treated by giving medication to calves once Yes No I don't know

12. What disease gives the signs of illness listed below to cattle?

Sores on mouth/tongue, Sores on feet, Sores on udder, Loss of strength, Many cattle affected at one time

(Choose one)

- HS
- FMD
- Blackleg
- I don't know

13. What disease gives the signs of illness listed below to cattle?

Swelling in neck area, Quick and difficult breathing, Sudden death, Many cattle or buffalo affected at one time

(Choose one)

- HS
- FMD
- Blackleg
- I don't know

14. What disease gives the signs of illness listed below to cattle?

Lameness, Swelling in hips, shoulder, chest, Found dead or rapid death, Usually young cattle

(Choose one)

- HS
- FMD
- Blackleg
- I don't know

15. FMD and HS can be stopped by selling affected (sick) cattle Yes No I don't know

16. Regular vaccination can stop my cattle getting FMD & HS Yes No I don't know

17. Vaccination and antibiotic injection are the same Yes No I don't know

18. My cattle can get FMD or HS if I mix them with newly bought cattle or buffalo.

Yes No I don't know

19. Giving a vaccination to pregnant cows harms them Yes No I don't know

20. Keeping my sick cattle away from other healthy animals help to ensure other cattle in the village do not get sick Yes No I don't know

21. Using the same food and water buckets for sick and healthy cattle can spread infection

Yes No I don't know

22. If I buy cattle from a village where there are many sick cattle there is potential to introduce disease into my village Yes No I don't know

Nutrition

23. A pregnant cow or buffalo needs as much as twice as much feed as a cow that is not pregnant

Yes No I don't know

24. A cow with a suckling calf needs more than twice the amount of food than an animal without a calf

Yes No I don't know

25. There is enough grass around the village and on my land to give enough food for my cattle all year around Yes No I don't know

26. A 200kg adult cow needs about 30 kg (15% of it's body weight) of fresh grass each day to maintain (keep) its weight Yes No I don't know

27. The condition score of cattle can be used to assess their health, nutritional status, and value

Yes No I don't know

28. Cattle need at least 20 liters of water throughout the day to drink Yes No I don't know

Reproduction

29. A cow can have its first calf when it is two years old Yes No I don't know

30. A cow can have a calf every year Yes No I don't know

31. Bull and cow selection can produce better calves Yes No I don't know

32. The amount and type of food fed to cows during pregnancy will effect the health of the calf

Yes No I don't know

33. If my cow is being mounted and is very vocal she is not yet ready for breeding

Yes No I don't know

Attitudes – These questions assess what the farmer 'believes'

34. Who was your primary source of information on project technologies? *(Circle one)*

- Project staff
- VAHW
- District Vet
- Farmer
- Village Chief
- Other

35. Do you know the market price of your cattle before you decide to sell your animals? Yes No

36. Do you know where your cattle go when you sell? Yes No

Other farmer Other province Other country (export) Local slaughter Other (specify)….

37. Did any of your vaccinated cattle have signs of FMD infection since you started vaccinating?

Yes No I don't know

38. Did any of your vaccinated cattle have signs of HS infection since you started vaccinating?

Yes No I don't know

39. Would you continue to vaccinate your cattle for HS if you have to pay the vaccine cost yourself?

Yes No I don't know

40. Would you continue vaccinate your cattle for FMD if you have to pay the vaccine cost yourself?

Yes No I don't know

41. Rate the following, from 1 (least important) to 5 (most important), in order of the benefits of feeding forages to your cattle?

	Least Important (1)				Most Important (5)
My cattle grow faster and are more valuable (fattening)	1	2	3	4	5
My cattle can have more calves	1	2	3	4	5

My cattle have more feed when there is limited wild grasses available 1 2 3 4 5

Feeding forages saves time to tend to my cattle 1 2 3 4 5

My cattle are healthier and stronger 1 2 3 4 5

42. Do you think that cattle that are fed forages obtain a higher sale price? Yes No I don't know

43. Does growing forages save time that would otherwise be spent feeding the cattle?

Yes No

If Yes, how many hours per day for men, women and children?

Men .....hours/day

Women .....hours/day

Children .....hours/day

How is this extra time spent? (*Please tick box*)

Tick answer	Other employment	Farming activities	Household activities	School work	Other (specify)
Men					
Women					
Children					

44. As a consequence of this project, do you believe your annual income from cattle has increased?

Yes No Don't know

If yes, by how much?

Less than doubled Doubled More than doubled

45. To extend the message of this project to other farmers, rate the extension methods (1 least important, 5 most important).

	Least Important (1)				Most Important (5)
Information leaflet	1	2	3	4	5
Village visit and meeting	1	2	3	4	5
Digital storybook	1	2	3	4	5
Posters	1	2	3	4	5
Farmer and village cross-visits	1	2	3	4	5
Radio message	1	2	3	4	5

Practices – These questions assess what the farmer 'does'

46. What education type or project activities did you attend? *(Circle one or more)*

- Participating in project data collections and weighing's (applied field research)
- Working with project staff implementing new techniques (on the job training)
- Formal training sessions with VAHWs and project extension officers
- Cross visits to other farms and/or villages
- None of these

47. What is your main reason for keeping cattle? List in order of priority (1 least important, 5 most important)

	Least Important (1)				Most Important (5)
For fattening and sale	1	2	3	4	5
For cash asset storage	1	2	3	4	5
For draught power	1	2	3	4	5
For breeding calves	1	2	3	4	5
For manure for biogas and/or fertilizer	1	2	3	4	5

48. Do you usually obtain a quote from more than one trader before you sell your cattle? Yes No

49. Were ALL your cattle over 6 months vaccinated against FMD? Yes No I don't know

50. Were ALL of your cattle over 6 months vaccinated against HS? Yes No I don't know

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

Yes No I don't know

52. When any of my cattle becomes sick I separate the sick animals from the herd

Yes No I don't know

53. I give treatment for Toxocara for my new born calf (less than 4 weeks) Yes No

If yes, what kind of medicine…….

54. I built fattening pens for cattle fattening Yes No

55. Do you remove manure from the cattle housing? Yes No

56. Do you use target-feeding practices (for example, do you feed forages to individual cattle to gain weight faster?) Yes No

57. Do you use manure for use in a biodigester? Yes No

58. For what purposes are the products of the biodigester used for?

Biogas (heat and electricity) Fertilizer Sale Other (specify).....

ONLY ANSWER THE FOLLOWING QUESTIONS IF YOU GROW FORAGES

59. What type of forages do you grow?

Mulato II Murando Stylo Paspalum Simong

Other (specify).....

60. Do you make silage? Yes No If Yes.....Quantity =..... (How many 15kg bags/year?)

61. Do you sell silage? Yes No If Yes.....Quantity =..... (How many 15kg bags/year?)

How much Riel per bag?.....

62. How long did it take from planting the forage until you could cut for feeding?

1 month 2 months 3 months Other (specify) ……..months

63. How many kilos of forage do you yield per m^2 in the *dry* season?

1 kg 2 kg 3 kg 4 kg 5 kg 6 kg 7 kg 8 kg Other (specify).....kg

64. How many kilos of forage do you yield per m^2 in the *wet* season?

1 kg 2 kg 3 kg 4 kg 5 kg 6 kg 7 kg 8 kg Other (specify).....kg

65. Do you irrigate forages in the dry season? Yes No

66. Did you sell forages for cattle feeding in the last year? Yes No

If yes, what was your income from forages over the last year?.....

67. Did you sell forage seeds or seedlings for forage planting in the last year? Yes No

If yes, what was your income from selling these over the last year?.....

68. Did you sell forages to other cattle farmers who were affected by the floods that occurred in 2011?

Yes No

If Yes....Quantity = ...kg (estimate) at $...../kg

THANK YOU FOR YOUR TIME

12.5 Appendix 5: Large Ruminant FISQ 2012

Interviewer: ……

Date of interview conducted:……/……/……..

Village ……, Commune …….

District ……, Province……

General information

1. Farmer Name ……
2. Farmer Age ……..
3. Farmer Sex ……..
4. Number of people in household ……..
5. When were your animals affected?
    a. 1-2 weeks ago (in December)
    b. 3-6 weeks ago (in November)
    c. 7-9 weeks ago (in October)
    d. More than 10 weeks ago (before September)
6. Number of cattle/buffalo in household before outbreak
    a. Cattle ……
    b. Buffalo ……
7. Number of cattle/buffalo in household after outbreak
    a. Cattle ……
    b. Buffalo ……
8. Did you introduce any animals into the household before outbreak? - Yes/No

    If yes,

    a. When? ……
    b. What species? ……
    c. How many? ……
9. What is your estimated annual income in the last year? ……..(riels)
10. What are the major source of income in the household? (circle each source and indicate relative importance in percentage)
    a. Rice/vegetables……(riel or %)
    b. Cattle/buffalo……(riel or %)
    c. Other animals e.g. pig, chicken ……..(riel or %)
    d. Fishing ……..(riel or %)
    e. Secondary employment (please specify e.g. delivery……)
    ……(riel or %)

General husbandry practice

11. Did your cattle or buffalo graze in communal groups (in last 3 months)? - Yes/No
12. Have you ever vaccinated your animals for FMD before? - Yes/No/I don't know

    If yes,

    a. When was the last vaccination?.....
    b. How many of your animals have you vaccinated?.....
    c. How much did it cost per animal? ……..(riels/animal)
13. Have you ever vaccinated your animals for HS before? - Yes/No/I don't know

    If yes,

    a. When was the last vaccination?.....
    b. How many of your animals have you vaccinated?.....
    c. How much did it cost per animal? ……..(riels/animal)

Recent disease outbreak investigation

14. For each cattle/buffalo you owned before outbreak (number of animals = Q6) (*fill/circle one in the table below*)

ID	Species/Breed	Age	Sex	Use of animal (maximum 3)	FMD Vaccinations	HS Vaccination	Condition of animal
	a. Cattle (local breed) b. Cattle (crossbreed) c. Buffalo	……years	a. Male (uncastrated) b. Male (castrated) c. Female	a. Draught b. Transport c. Fattening d. Breeding e. Cash asset storage f. Other?.....	a. Yes b. No c. I don't know	a. Yes b. No c. I don't know	a. Unaffected (healthy) b. Affected

If animal was affected;

Outcome of the disease	Any symptoms observed?	If yes, what symptoms?	Duration of illness	Changes in body weight	Market value of animals
a. Recovered b. Sick c. Died Or Sold during the outbreak - …….(riels)	a. Yes b. No. c. I don't remember	a. Heavy breathing b. Reduced appetite c. Increased salivation d. Nasal discharge e. Ulcers/vesicles in mouth f. Feet sores g. Lameness h. Fever i. Swelling of neck j. Diarrhoea k. Others……..	……days	a. Before disease: .....…….kg b. After disease: .....…….kgor % weight lost ……...%	a. Before outbreak (healthy) ……..riels b. After outbreak (recovered) ……riels c. After outbreak (died) ……..riels

Impact of disease outbreak

15. Who in the household cared for the sick animals? (*circle*)- Men/Women/Children
16. How many hours per day did treatment and management require? ……..(hours)
17. Any treatment given? - Yes/No/I don't know

    If yes;

    a. What kind of treatment? …….
    b. How many days of treatment? ……(days)
    c. How much did it cost in total? ……(riels)
18. Did you purchase feed for sick cattle/buffalo? - Yes/No

    If yes,

    a. How many days of feed did you buy? ……..(days)
    b. How much did it cost in total? ……..(riels)
19. Were there any other costs associated with management/caring of affected animals? - Yes/No/I don't know

    If yes;

    a. What kind of cost?.....
    b. How many days?.....(days)
    c. How much did it cost in total?.....(riels)
20. Loss of draught powers? – Yes/No

    If yes;

    a. How many days? ……(days)
21. Rented alternative draught power? - Yes/No

    If yes;

    a. How many days rental were required? ……(days)
    b. How much did it cost per day? ……(riels)
22. Loss of reproductive opportunities? – Yes/No/I don't know

    If yes, what type of losses did you experienced?

    a. Abortion (loss of foetus)
    b. Loss of pregnant animals (Pregnant animals died)
    c. Failure of conception after mating
    d. Others……
23. Did you lose any days of employment in a secondary job? – Yes/No

    If yes;

    a. How many days? ……(days)
    b. What was the lost income per day? ……(riels)

THANK YOU FOR YOUR TIME AND PARTICIPATION TO THE SURVEY.

12.6 Appendix 6: Smallholder Cattle Best Practice Manual

A guide for smallholder cattle farmers

(Revised English draft 25 March 2013)

This manual was prepared by Peter Windsor, Suon Sothoeun, Russell Bush and James Young as part of the 'Best practice health and husbandry of cattle, Cambodia' project conducted between 2007-12 (Project number AH/2005/086). The Australian Centre for International Research (ACIAR) funded this project to which the support is gratefully acknowledged.

Table of Contents

Introduction - How better cattle raising system can benefit smallholder farmers?

As many smallholder Cambodian farmers own cattle, increasing the production and hence profitability of these animals is a potential path to improve smallholder household income. This manual is designed to provide smallholder farmers with some basic information on cattle husbandry including production, optimising health, disease prevention, biosecurity, breeding, nutrition, and accessing markets. The ultimate aim is to produce quality cattle, which can obtain the best market price and monetary return to the smallholder beef producer. This information is provided in brief, and smallholder farmers seeking more advice and details should seek out further information from their Village Animal Health Worker or District Veterinarian for further advice.

Social and financial benefits of better feeding, disease prevention and better cattle

Cattle are an increasingly important resource for smallholder farmers in Cambodia, providing a store of wealth, use for income generation by sale, availability for draught, plus are increasingly important for supply of manure for fertiliser or household through bio-digestion. It is very important to understand how to best manage this important asset, enabling the value of the animals to grow as quickly as possible and protect this value. This means attention to improving nutrition and providing disease risk management, resulting in more calves produced and more meat on animals for sale, resulting in higher prices and more income for the family for health, education and other needs.

It is widely accepted that the demand for red meat and particularly from cattle and buffalo in SE Asia will continue to grow quickly for many years, as neighbouring counties become wealthier. This means re-investing in improving cattle health and production is a sound approach for smallholder farmers. Forages provide better quality nutrition for cattle for fattening and improving reproductive rates. They also reduce the time required for 'cut and carry', so enabling other income generation activities to be explored and providing children with more time to attend to educational needs.

Extension services: finding information

Dr. Sothoeun - may wish to provide details on how farmers should access more information?
Contact your Village Animal Health Worker or District Veterinarian.

Farmer Learning & Community Benefits

Developing and improving farmer knowledge and skills will help increase livestock productivity, improve efficiency and lead to higher smallholder farmer profitability. The key areas of farmer knowledge to achieve these goals are;

Knowledge topic	Techniques	Outcomes
Improving cattle nutrition	Developing forage cultivation, targeted feeding, selective feed types, and stock separation	Achieving higher cattle body weights and receiving a premium purchase price and higher income for farmers
Improving cattle health	Protecting from disease using strategic parasite treatments and vaccination, disease knowledge and protection strategies	Reduced impact of endemic diseases protecting farmer asset value
Improving biosecurity	Reducing exposure of cattle to infectious diseases, through reduced movement, reduced cattle-to-cattle contact, reduced fomite contact	Reduced impact of endemic diseases protecting farmer asset value
Improving reproduction	Targeted bull selection, preferred mating timing, feeding the pregnant and lactating cow, calf feeding and management, strategic weaning	Increasing calf production will result in higher income for farmers

Improving cattle health and production can have wide reaching benefits across the community, which include;

Community benefits of improved health	Community benefits of increased production
Reduced endemic disease occurrence	Trader preference for heavier and healthier cattle
Reduced cattle weight loss and death	Steady supply of cattle for trader
Increased cattle production	Higher price for cattle sold
Reduced labour	Reduced labour
More calves produced	Market development, value added products, business development

Production

To increase income from cattle, farmers need to increase production. Increasing production can be achieved by:
Improving general husbandry practices
Growing cattle faster through feeding higher quantity and quality feeds such as forages
Preventing infectious diseases and parasites
Target-feeding cattle for sale
Selecting higher value breeds that maintain environment suitability
Improving breeding management to increase reproduction and calves born

Housing versus free grazing

Cattle are commonly housed in Cambodia, often in pens under the family house or in purpose built pens adjacent to the house. These animals are usually tethered on the rice paddies in the dry season for grazing or by the roadside in the wet season where they may be given access to rice straw. It is also still a common practice in some areas to take cattle to forest lands for free-grazing. Whatever system is used for housing, animal's need an abundance of nutrition, access to a plentiful supply of clean water, shade or shelter and an ability to move about and interact with each other socially, so normal behaviours such as 'heat' can occur. What is apparent is that for many large ruminants in Cambodia both systems do not provide the animals with sufficient opportunities to forage to meet their energy needs. Planting of forages is usually needed to provide the nutritional needs of cattle, particularly in rice growing areas where there is energy deficiencies is present all year and the majority of the cattle remain continuously in poor condition.

Breeds

So-called local cattle or *gor srok* are small early maturing generally quiet animals growing to a mature weight of 250-350kg, with a small hump suggesting *Bos indicus* origin. They are commonly found in rice-producing areas and are well adapted to lower energy diets.

The Haryana breed and their crosses predominate in Cambodia as they are a larger *Bos indicus* animal, weighing up to 500kg if fed well, so are more suited to draught than local cattle. They are not as quiet as the local cattle and require feed for maintenance.

Brahman cattle and their crosses are another *Bos indicus* type that are increasingly common but have higher feed requirements, walk slowly and may have poor breeding ability, so are less adapted to Cambodia.

Swamp buffalo weigh 350-600+kg at maturity and are more adapted to low-lying conditions, as they need access to shade and water for temperature regulation. They are suited for draught in heavy, wet soils and can utilise poor nutrients but are decreasing in number due partly to low reproductive rates.

Breeding Basics

Breeding is often from matings of free-roaming animals where bulls are not selected. The preferred breeding approach is to use selected hopefully superior bulls with a fee for service, the cost relating to the quality of the bull. Heat should occur every 21 days in healthy mature non-pregnant female cattle although the signs may only be present for a few hours and can easily be missed, especially in buffalo and where animals are tethered and unable to display herd behaviours. Signs include restlessness, bellowing, mounting behaviour and vaginal discharge of mucous. It is important to note that it is the cow 'standing' for the mounting by other cows or a bull that is in heat.

Artificial insemination is becoming increasingly common and enables access to superior genetics. However it requires a skilled, trained and experienced technician who understands the care needed with semen storage and thawing, plus able to place the semen correctly in the reproductive tract. Farmers need to have excellent heat detection ability and ready access to the technician to ensure that a viable ovum (egg) is present in the tract when the semen is inserted.

Gestation is generally 9 months and as 2/3rds of the foetal growth occurs in the last 3 months of pregnancy, care of the cow during gestation and particularly approaching, during and after birth is very important to ensure calf survival, a good lactation and improve the chances of her cycling again and becoming pregnant. This means feeding the animal very well in late gestation and throughout lactation as the cow will need 2-2.5 times the energy required for maintenance at this stage of her cycle. Failure to provide this will mean the cow will not come back into heat (commence her oestrous cycle), often until the calf is weaned, so delaying pregnancies and reducing the number of calves per lifetime of the cow. For this reason, using a pregnant or lactating cow for draught is not recommended.

Husbandry practices

Calves depend on milk for growth for several months and this means feeding the mother with a plentiful supply of good quality forages, either by cut and carry or grazing. Inadequate feed for the cow will mean a rapid decline in supply of milk and the calf will be early weaned and lack the protein required for growth, meaning late maturity, late onset of puberty and potentially poor performance for life. If forages are plentiful, it is possible to early wean a calf (say after 10 weeks of age) provided high quality nutrition is provided to the calf (e.g. Stylo forage high in protein), enabling the cow to potentially 'return to service' more quickly.

Most male calves should be castrated unless the animal has potential as a superior bull. There are a number of techniques available to do this (surgical removal of testes, Burdizzo clamps, rubber rings etc.) but it should only be done an experienced operator with adequate after care to prevent infection.

Female calves kept as replacement heifers must be fed well for optimal growth as poor nutrition affects their life-time production.

Calves are very susceptible to *Toxocara vitulorum,* a roundworm parasite that can cause mortalities. Poor doing calves should be investigated with faecal samples taken and examined under a microscope for worm eggs by an experienced laboratory technician. Treatment within the first 3 weeks of life with an appropriate anthelmintic will manage worm infestations.

In certain areas, calves over 6 months of age, like adult cattle, are susceptible to *Fasciola gigantica* infestation, a fluke parasite that migrates in the liver causing hepatitis and then maturing in the bile ducts where it produces eggs. Again faecal samples are useful to diagnose the problem although tissue damage in the liver at slaughter and the presence of the flukes (often described as 'leaves') can assist. Very few of the commonly available anthelmintics can be used to treat 'liver fluke disease' so help from a veterinarian is advised.

A number of external parasites including lice and ticks can cause 'worry' for cattle and may transmit blood-borne parasites, so are best controlled if they are prevalent. A number

of commonly available acaricides can be used to treat external parasites but again, help from a veterinarian is advised.

Monitoring animals

A very useful technique to evaluate the productive state of an animal is body condition scoring (BCS). This involves simply rating the appearance or even better the body condition by palpation, on a scale from a low of 1 (emaciated) through 2 (poor) and 3 (medium) then 4 (good) to a high of 5 (fat). The best sites to determine the rating include the ribs, the brisket, the backline and the prominence of the hips. Healthy animals should have a covering of flesh over bony prominences. Animals for breeding should be at least BCS 2 and preferably 2.5 to 3. Animals less than 1.5 are in poor health and need to be investigated. They are either starving such as a lactating cow not receiving sufficient quality forage to feed the calf and maintain her condition, or have a disease that needs to be managed. Unfortunately there are many animals in Cambodia with a BCS of 1.5 or less.

Feeding Forages to Cattle

Five forage species are recommended including four grasses and one legume. These are Simuang, Mulato II, Marandu, Terenos and Stylo 184 (legume). The grass forages are typically ready for harvest two months after planting to yield 6.2-7.4 kg/m^2 for fresh grasses and 3.2 kg/m^2 for fresh legume.

Target feeding cattle

Farmers may wish to ‘target feed’ cattle to achieve rapid weight gain and body condition score improvement. Key ‘target feeding’ points include:
Farmers should allow for a target feeding time period of approximately 3 months to achieve results
Cattle weighing approximately 130 kg fed 21 kg of fresh forages per day may achieve weight gains of between 0.33-0.52 kg/day
Farmers should aim to feed cattle 15% of the cattle body weight (BW) per day
Therefore a 200 kg animal would need 30 kg fresh forage per day to achieve optimum rapid growth
Farmers should aim to grow approximately 1000 m^2 of forage for each animal to be target fed 15 % BW per day

Benefits of feeding forages to cattle

Benefits of target feeding forage crops to cattle and the smallholder farmer and family:

Cattle	Improved health & production	Improved weight gain
		Improved body condition score
		Improved reproduction
		Higher immunity to resist disease
		Improved draft performance
Farmer & Family	Time	Reduced time sourcing cattle feed
		More time for other employment
		Children spend less time tending to cattle, and have more time for school and study
	Income generation	Higher prices achieved for cattle sale
		Income through sale of forages
		Income through sale of forage seeds

Dr Sothoeun - it may be valuable to cross-reference your ‘Forage manual’ here for farmers seeking further forage-growing information

Animal Health

Poor health of cattle through infectious disease, parasitism or poor nutrition will severely limit production and any potential income from cattle. Poor health may lead to loss of body condition or even death that may cause a significant financial shock to the farmer and household, particularly if cattle are used to store household wealth.
Cattle health can be maintained through:
Rapid recognition of disease and seeking appropriate treatment
Farmer education in disease and biosecurity
Actively practicing biosecurity including regular vaccination
Maintaining cattle in a higher body condition score (3+) to maximise immunity

Disease Recognition and Reporting

Why are recognising and reporting animal diseases important?
Recognising animal diseases as soon as they start and reporting them to village veterinary workers immediately means disease can be controlled early and limit the impact and economic loss. Early intervention when animals get sick prevents negative impact on animals (prolonged sickness or death) and reduces financial losses to farmer, village, region and possibly country.

Animals show different signs when sick. Some signs like fever or not eating occur with many different diseases and some sings like blisters in the mouth with FMD are very specific for one disease only.

Some common disease signs are:

- Stop eating and drinking
- Lie down a lot
- Keep separate from other animals
- Excretions from eyes, nose or mouth
- Diarrhoea or stop urinating/defecating
- Loss of body condition and/or weight
- Coat looks rough
- Fever (breathing fast, seeking cool areas)
- Sudden death

Rapid identification of sick animals and early diagnosis and treatment can reduce the impact of disease and reduce spread. Obtaining professional expertise from your VAHW (village veterinary worker; department of animal health and production officer) to investigate, take samples, and advise on treatment can be very beneficial.

Dr. Sothoeun – May wish to add another small paragraph outlining the local disease control laws/practices, what are legal/regulatory requirements for Farmers to report sick animals?
The disease hotline for reporting infectious disease including FMD and HS is: XXXX

Disease prevention methods

Biosecurity

Biosecurity is management practices that can be applied by individual farmer or better by groups of farmers or villages to reduce the risk of introducing diseases into their herds or village (or commune or district). Practicing good biosecurity measures are a powerful disease preventative measure and often can be undertaken at minimal cost to the farmer.

Some simple Biosecurity measures are;

- Regular vaccination of animals for important and high impact diseases such as FMD, HS, & Blackleg
- Not introduce unvaccinated new animals into the village or herd without quarantine
- Quarantine newly introduced livestock (even if they are vaccinated) in an area separate from any other animals for 2-4 weeks and observe daily for disease signs
- Isolate all sick animals from healthy animals and ensure that they are fed last, using different equipment and avoid mixing in any way with healthy animals
- Observe your livestock daily for good health, and where possible do not allow contact with other animals which have unknown health status
- Ensure your breeding cattle only mix with bulls and cows that have no history disease
- Where possible, avoid your animals congregating with groups of other animals from different areas and of unknown health status
- Stay alert to the status of disease in your area and change practices if a disease is threatening your area, discuss preventative options with your VAHW or District Veterinarian

Vaccination

Vaccination for protecting cattle or buffalo against viral diseases (i.e. FMD) and bacterial disease (HS, Anthrax, Blackleg) are available. Vaccine produces immunity in the animal once administered. This means that if the animal is exposed to a disease at a later stage it is immune or protected and will not become infected, or may be less affected than unvaccinated animals.

Important points to know about vaccines are;

- Storage at fridge (not freeze) temperature all the time until given to animal is necessary, vaccines which are not chilled may be ineffective
- Most vaccines are applied by injection under the skin
- Initial and ‘booster’ vaccination about 2-4 months apart then annual vaccination is necessary for best protection
- All animals in a herd (or village) need to be vaccinated to provide the best infectious disease protection
- Vaccine is cheap (especially for diseases that cause large outbreaks and many deaths such as FMD and HS)
- Good hygiene and correct injection technique (under skin) prevents large swelling at injection site.

<u>Reasons for vaccine sometimes not working</u>
Sometimes animals that are vaccinated against certain diseases can still become infected. Reasons for this can be:

- Incorrect dosing; not enough vaccine is given or no ‘booster’ is given
- Using time-expired vaccine
- Vaccine having been subjected to high temperatures during storage or transportation
- Not all animals in a herd are vaccinated
- The vaccine type did not accurately match the disease type

Foot-and-mouth Disease (FMD)

What causes FMD infection?	A virus which spreads to cattle from other cattle, buffaloes and pigs
	Infected animals shed the virus in milk, faeces, urine and saliva
	The virus can also be spread on vehicles, shoes, clothing, peoples hands, dogs and equipment
What are the signs in cattle?	High temperature
	Mouth sores and salivation
	Foot sores and lameness
	Teat sores
	Difficulty eating and Weight Loss
	Abortion
	Calves may lose weight
	Cattle usually recover in 2-3 weeks (however may be thin and weak)
How do I treat infected animals?	Alert your village animal health worker
	Isolate to limit disease spread
	Provide shelter, hand feeding, and water
	Clean feet sores and apply blue metalin spray
How can I avoid my cattle becoming infected?	Vaccinate all your cattle every six months
	Avoid all contact with sick animals (cattle & pigs)
	Avoid contact with potentially contaminated material such as cattle trucks, manure, mud, and feed
	Isolate your animals when an outbreak is occurring
	Avoid trading cattle during an outbreak
	Avoid transport of cattle during an outbreak
	Keep people who have had contact with infected animals away from your cattle
	Ask about the disease history of any animals before you buy, and don't purchase infected or recently infected animals

Haemorrhagic Septicaemia (HS)

What causes HS infection?	The disease is caused by a bacteria
	The disease is spread usually from affected cattle and buffalo
	Outbreaks often occur when there is close herding, or at the start of the rainy season
What are the signs in cattle and buffalo?	Sudden death (may be many cattle & buffalo)
	Fever
	Loss of appetite
	Discharge from nose
	Increased salivation
	Laboured breathing
	Swelling in neck area and under jaw
How do I treat infected animals?	Alert your village animal health worker
	Isolate your animals to prevent disease spread
	Provide shelter, hand feeding, and water
	Antibiotic medicines may be useful if provided very early and used correctly
How can I avoid my cattle and buffalo becoming infected?	Vaccinate your cattle every 6 months, aiming to vaccinate 1 month before the rainy season
	Avoid all contact with sick animals
	Isolate your animals when an outbreak is occurring - don't mix cattle
	Avoid trading cattle during an outbreak, and ensure the cattle you purchase have no history of disease
	Avoid transport during an outbreak

Blackleg

What causes Blackleg infection?	The disease is caused by a bacteria
	The bacteria live in cattle intestines, and are shed onto the soil; other animals may ingest the bacteria while eating
	The disease is not spread from one animal to another by contact alone
	Outbreaks with multiple cattle affected may occur
What are the signs in cattle?	Most often young, well fed cattle
	Lameness, rapid breathing, depression
	Fever
	Loss of appetite
	Swelling of hip, shoulder and chest
	Swelling becomes hot, painful spongy
	The animal usually dies within 12-48 hours
How do I treat infected animals?	Alert your village animal health worker
	Treatment with antibiotics may be warranted, however this is rarely successful and the focus should be on prevention
How can I avoid my cattle and becoming infected?	Use a Blackleg vaccination and vaccinate your calves twice, at 2-6 months of age. In high risk areas revaccinate at 1 year and 5 years of age
	In the event of an outbreak, can vaccinate all susceptible cattle and provide prophylactic penicillin

Marketing and Trade of Cattle

The most important part of trading cattle is planning. Cattle that are targeted for sale should be identified at least three months before the planned sale so feeding can be used to maximise body weight and body condition. Heavier cattle will achieve a higher price. Key aspects of cattle sale include:
Obtain multiple quotes from traders when planning to sell cattle to achieve the highest price
If possible, seek cattle weigh scales or weight tape to clarify cattle weight
Target feed cattle prior to sale to maximise body condition, weight and therefore value of animal

Targeting markets (local, domestic, & export)

When considering sale of cattle, farmers can consider three main markets. These are the ‘local’, ‘domestic’ and ‘export’. It is important to differentiate the ‘product’ to account for different meat markets. There may also be a need for a ‘store’ market for sale of excess stock.
Farmers need to consider each market’s requirements before selling as each market has a different requirement. These requirements may include the age of animal, body condition score (BCS), sex, and weight. Knowledge of BCS is important to maintain sale

of a consistent product and to guarantee that the animal bought and sold is on a comparable basis and ensure a fair price is being received. Some trader's buy for specific markets – linking the animal being sold with trader as well as the market is important. Consideration should be given to 'value adding' the animal to the specific use e.g. fatten before selling or sell to a feedlot on the border. It is important to ensure consistent quality and quantity to sustain the market.

When to sell

Animals should be sold when they are 'market ready' and not just as a cash source – value adding the animal will increase their asset value.

Farmers may benefit and obtain a higher price by aiming to target specific markets and plan for festivals such as the New Year when prices are higher. By using forage technology, farmers may be able to maintain a high BCS beyond the wet season – essentially extending the beef season by making use of silage and irrigation techniques.

Coordinate the sale of animals so as to improve farmers' market power and reduce the dominance of the middleman/trader whilst simultaneously increasing returns to producers.

Establish defined market or selling days/times – both at local and regional levels.

Smallholder Farmer Body Condition Scores of Cattle in Cambodia

1. EMACIATED

No palpable fat is detectable over pin bones, tailhead or ribs, which are all prominent.

Minimal sale value

Needs urgent feeding improvement and is at a high risk of infectious disease and reproductive failure

2. POOR

The animal is still emaciated however pin bones, tailhead or ribs are slightly less prominent.

Low sale value

Needs feeding improvement, good candidate for target feeding

3. MEDIUM

The ribs are still slightly identifiable as are hip bones and pin bones.

Medium sale value that could be improved with target feeding

4. GOOD

Overall appearance is good. Fat is palpable over the ribs. Fat cover is present on either side of the tailhead and hip bones are rounded.

Good sale value

5. FAT

Considerable fat cover is present. The ribs are not visible. There is a smooth rounded fat layer over the hip and pin bones and the tailhead.

High sale value