Final report

project

Development of a model for the control of fasciolosis in cattle and buffaloes in Cambodia

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1 Acknowledgments

The fasciolosis research team at the Department of Animal Health and Production (DAHP) in Cambodia are especially acknowledged for their work on this project. The farmers who participated in the study are thanked. The assistance of the Cambodian Agricultural Research and Development Institute (CARDI), the Cambodian Australian Agricultural Extension Project (CAAEP) and the Agricultural Extension Department (AED) was greatly appreciated. This project was initiated by the late Bruce Copeman and Dick Copland and we hope this work does justice to their foresight and aim to improve the economic situation of Cambodian farmers.

Table 1. List of acronyms.

Acronyms	Meaning
ACIAR	Australian Centre for International Agricultural Research
AED	Agricultural Extension Department
CAAEP	Cambodian Australian Agricultural Extension Project
CARDI	Cambodian Agricultural Research and Development Institute
DAHP	Department of Animal Health and Production
FMD	Foot and Mouth Disease
GIS	Geographical Information Systems
HS	Haemorrhagic Septicaemia
MAFF	Ministry of Agriculture, Forestry and Fisheries
NAHPIC	National Animal Health and Production Investigation Centre
OAHP	Office of Animal Health and Production
TIP	Technology Implementation Procedure

Figure 1. Farmer ploughing a rice field in Cambodia (fasciolosis affects draft capacity).

2 Executive summary

In Cambodia, around 87% of land cultivated by farmers is ploughed by draft cattle and water buffaloes and the rest by agricultural machinery. Cattle and buffaloes are also an import source of income for farmers when sold for slaughter or fattening. Therefore, the cattle industry is crucial to Cambodia like other neighbouring countries in the region. However, cattle and buffaloes have decreased draught capacity and lower calving rates and weight gain due to fasciolosis caused by infection with the giant liver fluke *Fasciola gigantica*. Humans can also be infected if they ingest intermediate stages of the parasite. Despite the importance of fasciolosis in Cambodia, the distribution of the disease is not known and control is not commonly practiced as most Cambodian farmers have minimal knowledge of fasciolosis.

Therefore this project aimed to develop a model for control that would determine the geographical risk of fasciolosis using geographical information systems (GIS) risk modelling, develop extension outputs that result in control methods being adopted by farmers, demonstrate the cost benefits of control and result in a national control strategy. We trained staff from the Department of Animal Health and Production (DAHP) and Office of Animal Health and Production (OAHP) Kandal Province in extension methodology, developed extension materials and conducted extension on the epidemiology of fasciolosis in two farming villages in Saang district in Kandal Province in Cambodia from 2004 until 2006. The effects and acceptance of this extension on farmer knowledge, understanding and control of fasciolosis were assessed by questionnaire from 2004-2007. Farmers were assessed and compared both before and after extension. They were also compared with farmers in a nearby control village where extension was not carried out. A cost benefit analysis was also carried out during this intervention study. A GIS risk model was updated and validated using prevalence data collected in Kampong Cham Province.

The project provided a validated accurate GIS risk based model that identifies areas most affected by fasciolosis for targeted control. It has provided an effective extension package that results in uptake of effective control of fasciolosis by farmers. This package also provides extension workers with the necessary training as well as tools to carry out extension. A technology implementation procedure (TIP) entitled “Fasciolosis of Cattle and Buffaloes and its Control Measures” was developed as a result of the project and is a significant impact. Use of the project outputs and TIP will result in significant economic benefits. A National Workshop held by the project disseminated the results of the project to key stakeholders with the expectation that it will lead to adoption of project outputs. There was a significant economic average net benefit of $60 USA/animal/yr in the first three years from the control of fasciolosis during the intervention study. This economic net benefit increases as animals get older. The project has maintained and improved the capacity of staff at the DAHP and the OAHP Kandal Province in a number of key areas such as extension, parasitology and research. This has led to a subsequent Australian Centre for International Agricultural Research (ACIAR) project on cattle health and production as well as capacity building for concurrent projects on trans-boundary diseases through transfer of staff. This project is likely to be used as a model for further research projects and control programmes designed to improve the management of diseases of livestock in Cambodia and neighbouring countries including the current ACIAR project on cattle health and production in Cambodia. The project will lead to a number of scientific publications in international journals with one already published in Veterinary Parasitology on the GIS risk model.

It is recommended that ACIAR monitor and facilitate the implementation of the National Control Strategy developed by the project. There needs to be an assessment of the impact of the project in a few years time. ACIAR should ensure that the outputs from this project are disseminated to neighbouring countries in the Mekong Delta and that similar projects and control strategies are developed in countries such as Laos and Vietnam.

3 Background

3.1 Origin of the project

This two year project (with one year extension) was recommended by reviewers of the Australian Centre for International Agricultural Research (ACIAR) project AS1/96/160 (Recommendation 2 of the review) to address two issues: 1. updating and validation of a Geographical Information Systems (GIS) risk model for fasciolosis in Cambodia and 2. Assess the cost/benefit of an extension programme to control fasciolosis in Cambodia.

3.2 A brief review of the issues

Tropical fasciolosis, caused by *Fasciola gigantica*, is one of the most widely distributed and socioeconomically important parasitic diseases in most humid tropical regions of Asia and Africa (Roberts and Suhadono, 1996). The loss from *F. gigantica* is due to reduced meat production, draught power and fertility in infected animals, and has been estimated to be AU$ 63 per animal per year (Spithill *et al.*, 1999). However, the impact of fasciolosis may not be recognised because the disease progresses slowly and clinically appears similar to chronic under nutrition, with which it may be confused. Therefore there is a need to predict the likely risk of fasciolosis which can be done relatively efficiently using GIS risk modelling. Furthermore, there is little knowledge amongst farmers and extension advisers about the potential benefits of control of fasciolosis in cattle and buffaloes and how to avoid re-infection following the use of an anthelmintic. The value of an extension programme to control fasciolosis needed to be evaluated.

The GIS risk map for fasciolosis in Cambodia produced in project AS1/96/160 was a preliminary attempt at modelling. The only available data on determinants of risk (such as land use and area under irrigation) were some years out of date, and only provincial statistics on animal numbers were available, which did not allow the model to take into account variation in distribution of animals within provinces. Recent data on agro-ecosystems were available for this project from the Mekong River Commission, Office of Council of Ministers and Ministry of Irrigation and Water Resources in Cambodia. Animal statistics at the district or commune level could be collected from provinces throughout the country. It was anticipated that incorporation of this new data would refine the output of the model and improve its usefulness as a tool for planning where control should be focused, both regionally and nationally. The extension programme planned would provide the opportunity to develop a model for extension for disease control using resources from within Cambodia. Cross-institutional sharing of expertise in extension has not previously been practiced in Cambodia but was expected to have benefits for all participating parties. It would also provide an opportunity to evaluate the acceptability, costs and benefits of the various options for control of fasciolosis.

3.3 Occurrence of fasciolosis in Cambodia and Australia

Information of the prevalence of fasciolosis in Cambodia is patchy and incomplete. The risk map produced in AS1/96/160 estimated that 28% of Cambodia was at risk of fasciolosis, mainly around Lake Tonle Sap and along the major rivers (especially the Mekong and Bassac). However, most of the cattle and buffaloes live in the areas at risk. *Fasciola gigantica* does not occur in Australia. Fasciolosis due to *F. hepatica* is an important disease of sheep and cattle in southern areas of Australia.

3.4 Size and value of the production system involved in Cambodia

The estimated loss from *F. gigantica* throughout Cambodia was approximately $23,000,000 US in 2001 from an estimated 10% prevalence (DAHP, Phnom Penh, 2001).

Losses to farmers are due to lower production of infected animals resulting from stunted growth, weigh loss, reduced production efficiency from poor feed conversion, liver condemnation at slaughter, and reduced reproduction and draught capacity.

3.5 Justification of the project based on priorities of ACIAR

The project was consistent with ACIAR's focus themes of "Meeting rising demand for Animal Protein" and geographical focus of supporting the livestock sector of countries in the Indo-China region.

3.6 Justification of the project based on the problem in Cambodia

A recent publication of the Cambodian DAHP "Domesticated Animal Genetic Resources in the Kingdom of Cambodia" listed fasciolosis as the most important parasitic disease of cattle and buffaloes in Cambodia.

3.7 Potential beneficiaries

The project would benefit professional development of administrative, field and laboratory staff of the DAHP, and would involve extension personnel in the Cambodian Agricultural Research and Development Institute (CARDI), the Cambodian Australian Agricultural Extension Project (CAAEP) and the Agricultural Extension Department (AED), DAHP and OAHP Kandal Province. It was anticipated that the participating farmers would benefit through increased growth, draught ability and reproductive performance of their cattle and buffaloes and that this would translate to increased farm income. The project was also intended to act as a demonstration of the benefits of adopting measures to control fasciolosis, thus promoting the practice more widely with administrators, extension workers and farmers in other districts. An extension model for control of fasciolosis would be produced that could then be applied more widely for control of fasciolosis and, with modification, other diseases.

3.8 Balance between research, development and capacity building

This project presented a balance of research, development activities and capacity building. The research was mainly of an applied type to solve practical problems such as the most efficient method for determining prevalence of fasciolosis in the various zones at risk and production of a risk map for fasciolosis that would be a useful tool for focusing national and regional control extension activities. Cambodian farmers have little knowledge of diseases in their cattle and buffaloes or the extent to which disease control has the potential to lift production. This project worked directly with farmers to empower them to control diseases that may significantly reduce productivity and act as an example to other farmers (and also administrators and extension workers) of the value of adopting such controls. There was a substantial training component in the project, especially for extension officers, but also for the laboratory and field staff of National Animal Health and Production Investigation Centre (NAHPIC). This training built on a base provided in AS1/96/160 and had an excellent chance of success.

3.9 Project extension

A 12 month extension was granted to the project to assess sustainability of the control programme and to enable a national strategy for control to be developed. This variation would enable the project to assess the medium term impact of the project on the methods farmers used to control fasciolosis and provide key advice on the required frequency of extension to ensure maintenance of control methods for fasciolosis by farmers. This knowledge could also be used to determine the frequency of extension required for similar

agricultural issues. An added benefit of this variation to the project was it ensured skills and expertise gained by staff of the DAHP of Cambodia during the project were maintained within the Department.

3.10 List of related projects

AS1/9123: Control of fasciolosis in cattle and buffaloes in Indonesia

AS1/96/160: Control of fasciolosis in cattle and buffaloes in Indonesia, Cambodia and the Philippines

LWR1/2001/051: ACIAR project on use of GIS at CARDI

APIP/WB/IFAD: (Agricultural Productivity Improvement Project in Livestock sector, project loan funded by World Bank/IFAD)

4 Objectives

1. To evaluate the acceptance, costs and benefits of control of fasciolosis in Kandal Province
2. To train and mentor extension officers of the DAHP and provincial extension staff using experienced Cambodian extension staff
3. To develop an extension programme to control fasciolosis that is a model for control of fasciolosis.
4. To update, refine and validate a risk model for fasciolosis in Cambodia using GIS technology.

Project extension (12 months):

5. To assess sustainability of the control programme and to enable a national strategy for control to be developed.

5 Methodology

The study was conducted in two provinces namely Kandal and Kampong Cham. The study on implementation and evaluation of an extension programme for fasciolosis was conducted in Saang district, Kandal province, while the study on refinement and validation of a GIS-based risk model for fasciolosis in Cambodia was conducted in five districts of Kampong Cham (Batheay, Chheung Prey, Orang Ov, Chamcar Leu and Steung Trang). The 12 month project extension to assess sustainability of the control programme was conducted in the same villages in Saang district, Kandal province.

Objective 1: To evaluate the acceptance, costs and benefits of control of fasciolosis in Kandal Province.

The extension team from DAHP, CARDI and CAAEP assessed the acceptance of application of control recommendations through farmer interview and questionnaire each 3 months for 21 months. Kandal province was chosen because it has a high prevalence of fasciolosis and veterinary and extension staff within the province have knowledge of fasciolosis through the previous ACIAR project on fasciolosis AS1/96/160. We weighed animals and recorded data on additions, losses and reproduction, and draught use each 3 months. We calculated cash and social benefits of control by differences between groups using fasciolosis control and those with no control, with respect to weight gain and reproductive and draught performance. Resources required **w**ere electronic weigh scales, the existing ACIAR vehicle, a competent interviewer, and a record keeper**.** Major risks to success and management were a **l**arge loss of stock or participating farmers from those originally recruited. Participation for the duration was sought as a condition of involvement in the project. Sufficient animals were also recruited at the outset to offset an anticipated loss of up to 20% due to withdrawal and sale. Lack of appropriate questionnaire and extension material was overcome through the input of expertise from CARDI and CAAEP.

Use of anthelmintics - Levamisole Pour-on: This drug, with a dose rate of 2.5 ml per 50 Kg body weight was used in the two project sites both for control and non control groups for calves aged less than 1 year old for the treatment of *Toxocara* and other round worms. Genesis Pour-on: This drug was used only in the control group, with a dose rate of 1 ml per 50 Kg body weight to control helminths other than *Fasciola*. Genesis Ultra Pour-on or (Fasinex)/Fasinex 240: These drugs were used for the treatment and control against fasciolosis in the non control group, used at a dose rate of 2.5 ml per 50 Kg body weight. Genesis Ultra Pour-on also provided for control of other helminths.

Vaccination: Animals in the study at the two project sites, both control and non-control groups, were vaccinated against haemorrhagic septicaemia and foot and mouth disease. In addition, other cattle within these project sites and cattle from nearby villages were also vaccinated against these two infectious diseases to prevent the possibility of disease outbreaks in these areas. The vaccination was conducted annually for each disease.

Objective 2: To train and mentor extension officers of the DAHP and provincial extension staff using experienced Cambodian extension staff

A training workshop for extension officers from the DAHP and provincial extension staff participating in the project was held at the outset in Phnom Penh. The instructors were experienced extension staff of CARDI, AED and CAAEP. They oversaw extension methodology and supervised, monitored and evaluated the extension activities of field extension staff in DAHP and OAHP of Kandal Province throughout the project. Progress of the extension programme was reassessed 3 months after commencement, then each 6 months. It was intended that this extension-training workshop and the manuals produced in Khmer to support it, would be a model for training of other extension workers in the future. Resources required were equipment to produce manuals and other extension material and to display extension material (computer, printer, scanner, photocopier, data projector, video camera, digital camera). Major risks to success and management were

that the extension specialists from CARDI, AED, CAAEP did not have the desired level of extension expertise, or they would move on, or lose interest in this project during its course or that inter-institutional cooperation would break down. An undertaking was secured from specialists for their participation for the duration of the project.

Objective 3: To develop an extension programme to control fasciolosis that is a model for control of fasciolosis in Kandal Province and other regions.

Extension activities were implemented by extension staff from DAHP and OAHP of Kandal Province under the supervision of extension specialists in CARDI and AED/CAAEP. The following features were included:

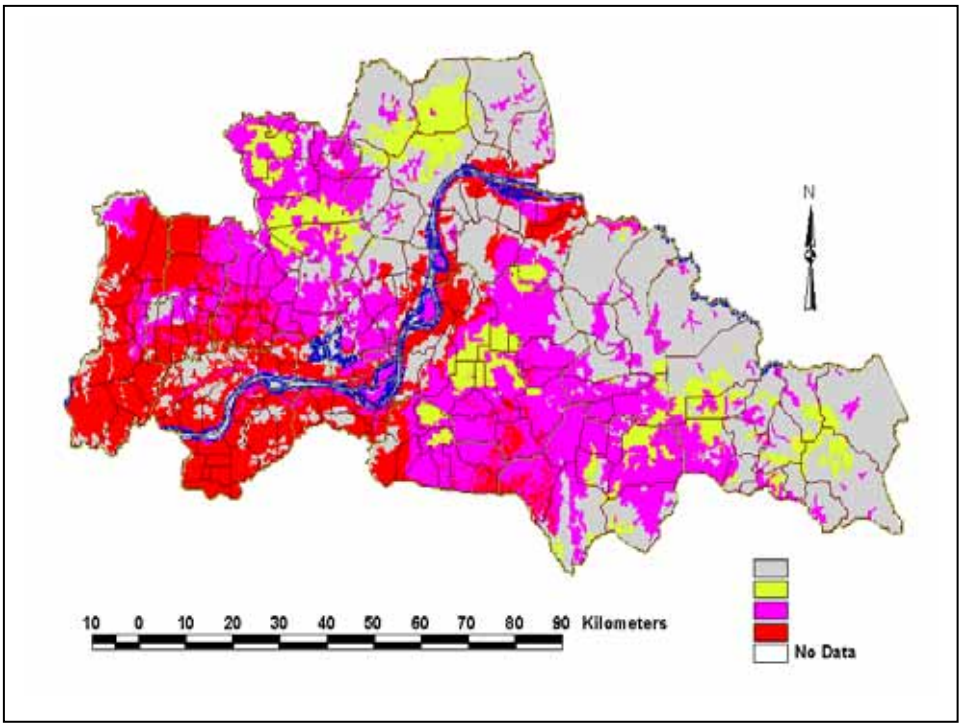
- Farmer meetings were held to explain the nature of the research and recruit participants.
- Two similar groups of farmer participants were selected; one was given information on control of fasciolosis and the other was a control group. Each study group would consist of farmers with about 150 animals in total. Control of Haemorrhagic Septicaemia (HS), Foot and Mouth Disease (FMD) and toxocarosis was applied in both groups.
- In addition, local authorities such as commune and village leaders, local veterinarians, school children over 13 years old were also invited for the education and extension course.
- Information was disseminated to farmers by discussion, printed and other visual material, radio, TV and videos.
- The most effective method of transmitting information was assessed through interview and questionnaire each 3 months for 21 months.

Resources required were audiovisual equipment suitable for use in the field (over head and data projectors, video player, PA system, and generator) and the existing ACIAR vehicle. Major risks to success and management were withdrawal of farmers from the project. This was managed through provision of incentives including vaccination against HS and FMD, treatment of toxocarosis in calves and helminths other than *Fasciola* in older animals and veterinary advice. Sufficient animals were also recruited at the outset to offset an anticipated loss of up to 20% due to withdrawal and sale.

Objective 4: To update, refine and validate a risk map for fasciolosis in Cambodia using GIS technology.

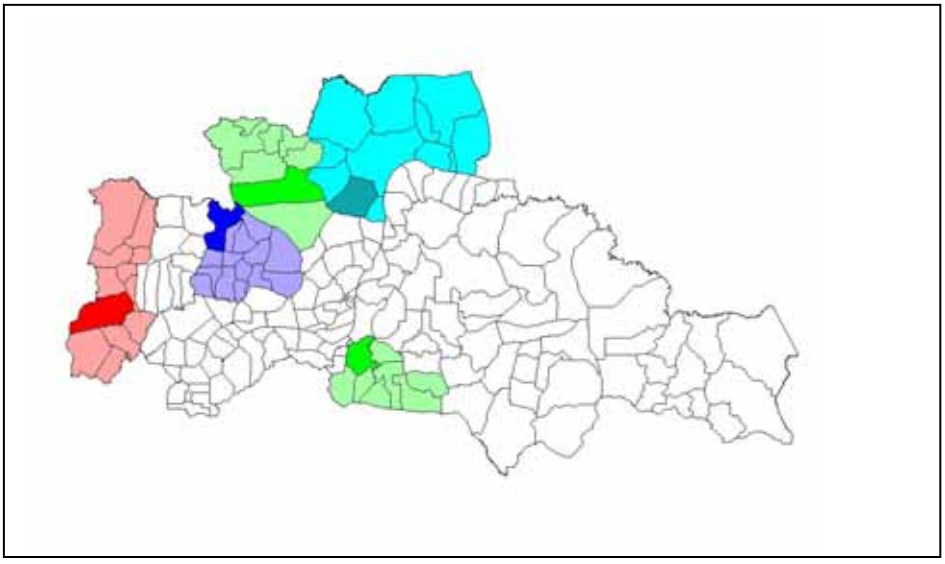
This aspect of the project was undertaken in conjunction with the John Allwright returnee fellowship grant of Tum Sothyra. He collected data on current land use, rainfall, ambient temperature and inundation from the Mekong River Commission, Office of Council of Ministers and Ministry of Irrigation and Water Resources in Cambodia. Animal statistics at the district or commune level was collected from records now held at DAHP in Phnom Penh. This information was then incorporated into the risk map for fasciolosis produced during AS1/96/160 by Tum Sothyra. The project also undertook the survey of prevalence of fasciolosis in cattle and buffaloes in regions chosen to represent the main risk categories in order to validate the GIS model.

Figure 2: Improved GIS risk model for fasciolosis in the Province of Kampong Cham.



Grey areas represent no risk, green low risk, pink medium risk and red high risk.

Figure 3: Areas selected representing different levels of risk to validate the improved GIS model in Kampong Cham.



Validation of the GIS model was achieved by faecal examination of animals chosen at random to estimate prevalence within 5% of its apparent value with 95% confidence. The weightings of determinants in the risk model could then be adjusted so that risk estimated by the model was a reliable indicator of likely prevalence. Random faecal sampling of stock was a major undertaking, as only one or two animals are owned per family and approximately a thousand samples were needed. Samples were examined by experienced parasitology staff in NAHPIC. Resources required use of the existing ACIAR vehicle and driver and technical assistance to collect and examine faecal samples. Major risks to success and management were managed through regular backup of data. A traffic accident was always a possibility and so the ACIAR vehicle was driven solely by a Cambodian driver, thus reducing the chances of an accident.

Project Extension

Objective 5: To assess sustainability of the control programme and to enable a national strategy for control to be developed.

The variation of the project carried out questionnaire surveys similar to those already used in the project to assess knowledge and the methods of control of fasciolosis used by farmers. The knowledge and understanding of farmers on control of fasciolosis was evaluated in August 2006 and May 2007 using the same questionnaire from the first two years of the project. A questionnaire on extension methods preferred and control methods used was given to the farmers in March 2007. Thirty farmers were randomly selected from each village for this latter questionnaire.

In addition the questionnaires identified any key bottle necks to effective control such as ready access to anthelminthics. The prevalence of fasciolosis was also determined to assess the effectiveness of control measures employed. The village that had not had extension acted as experimental controls. This village received extension and treatment for fasciolosis at the conclusion of the project. The national strategy for control was formulated from the discussions arising from the National Workshop on control of fasciolosis held in Phnom Penh in July 2006.

6 Achievements against activities and outputs/milestones

Objective 1: To evaluate the acceptance, costs and benefits of control of fasciolosis in Kandal Province.

no.	activity	outputs/ milestones	completion date	comments
1.1	Determine which methods of control farmers adopt and why others are rejected, through discussion and questionnaire at each 3 monthly meeting	Information on control methods most acceptable to farmers	August 2007	There is qualitative data suggesting that farmers are willing to use anthelminthics, composting of dung and grazing and drinking management.
1.2	Calculate benefits of control using cash value of improved weight gain and reproductive performance plus estimated value of improved draught performance and social benefits. Estimate costs from discussions with farmers in Y2, m11	Estimates of benefits and costs of implementing control	August 2007	There is good data suggesting a clear net economic benefit of controlling fasciolosis in high risk areas. This data requires a sensitivity analysis to determine whether the benefit would also occur in lower risk areas.

PC = partner country, A = Australia

Objective 2: To train extension officers of the DAHP and provincial extension staff using staff of CAAEP and CARDI.

no.	activity	outputs/ milestones	completion date	comments
2.1	Organise and conduct an extension training workshop	Extension training workshop completed	July 2004	The participants - extension staff from DAHP (8 persons): Pich Pituratha, Kea Pha, Hor Malin, Hieng Sarin, Hout Savuth, Thong Samnang and Loeng Vaneng, and OAHP of Kandal province (3 persons): Eng Sok Moy, Toung Hok and Ouk Sokun participated in the workshop
2.2	Produce extension material for extension workers	Production of a training manual and other material of extension methods, and information for decision makers and extension workers on epidemiology and control of fasciolosis	September 2004	A third draft of the 25-page Khmer language training manual entitled “Training manual for extension trainer on extension lessons and methods for the control and eradication of fasciolosis in cattle in Saang district, Kandal province” was produced.
2.3	Produce extension material for farmers	Production of leaflets, brochures, booklets, radio program, video on control of fasciolosis and questionnaire	September 2004	The DAHP, AED, OAHP extension team and extension officers in Saang district discussed and developed the extension materials for use to support the extension work on control of fasciolosis in the target areas. These extension materials were also approved by the DAHP before use.

PC = partner country, A = Australia

Objective 3: To develop an extension programme to control fasciolosis that is a model for control of fasciolosis.

no.	activity	outputs/ milestones	completion date	comments
3.1	Conduct meetings with farmers to gain their input and discuss the planned project in Kandal Province	Commitment by farmers to undertake the project	September 2004	There was a great amount of good will from farmers due to previous successful ACIAR projects in the province.
3.2	Allocate Fasciola-control and non control groups	Identification of two equivalent groups of about 150 animals each	September 2004	Cattle of different age groups on two project sites were selected for the study on fasciolosis prevalence, weight gain, condition rating, skin status, draught ability, animal sale and reproduction performance.
3.3	Identify (neck tag, tattoo) participating animals, record weight, reproductive status and condition score	An accurate identification and record of weight, and condition score of each participating animal	October 2004	Systematic collection and storage of data was learnt by the research team at the DAHP.
3.4	Provide education in Fasciola control through discussion, distribution of leaflets, booklets (to farmers, schools and community), radio and TV, during each 3 monthly interview	Distribution of printed, radio and TV material on control to control farmers	June 2006	
3.5	Assess the most effective method of transmitting information to farmers through discussion and questionnaire at each 3 monthly interview	Collated responses to questions on preferred extension material	June 2006	Extension workshops with farmers were the best approach for in depth extension although extension materials such as banners and leaflets were useful for raising general awareness of the control programme.
3.6	Assess knowledge of fasciolosis and methods of control through discussion and questionnaire at each 3 monthly meeting	Longitudinal information about effectiveness of farmer extension education		A total of 90 families (39.1%) out of 230 families on the two project sites participated in the survey.

PC = partner country, A = Australia

Objective 4: To update, refine and validate a risk model for fasciolosis in Cambodia using GIS technology

no.	activity	outputs/ milestones	completion date	comments
4.1	Establish sensitivity of the faecal egg counting test using faeces with low, medium and high egg counts of *F. gigantica*	Estimates of sensitivity and repeatability of the faecal egg counting technique	July 2004	

4.2	Collect faecal samples from cattle and buffaloes using randomised techniques in no, low, medium and high risk areas	Collection of sufficient faecal samples in each risk area to give an estimate of prevalence within 5% with 95% confidence	November 2004	A total of 1,132 faecal samples were collected from five districts in Kampong Cham province, which included 311 samples from high-risk areas, 301 samples from moderate-risk areas, 262 samples from low-risk areas and 262 samples from no-risk areas.
4.3	Estimate faecal *Fasciola* egg counts	Estimates of prevalence in each of the 4 categories of risk (nil, low, medium and high)	December 2004	The highest prevalence of fasciolosis was found in Batheay district - 24.44%, followed by Prey Chhor - 11.96%, Chamcar Leu and Orang Ov districts - 6.72%, and Stoeung Trang - 3.43%.
4.4	Adjust weightings in model to make estimated risk a reliable estimate of prevalence	When the GIS risk model reliably reflects prevalence	December 2004	The general agreement of the risk model with predicted prevalence in most districts surveyed suggests that the epidemiological determinants and weightings used to produce the model are appropriate.

PC = partner country, A = Australia

Objective 5: To assess sustainability of the control programme and to enable a national strategy for control to be developed.

no.	activity	outputs/ milestones	completion date	comments
5.1	Conduct questionnaire surveys of farmers to assess sustainability of the control program	Collated responses to questions on current control methods	August 2007	
5.2	Determine prevalence of fasciolosis.	Estimates of prevalence	August 2007	
5.3	Enable a national strategy for control to be developed	Conduct a national workshop on control of fasciolosis		This was discussed at a National Workshop on fasciolosis held in Cambodia in July 2006 as part of the project. Recommendations from that were developed into a national strategy in the third year of the project. Researchers and managers of fasciolosis from neighbouring countries, Vietnam, Laos and Indonesia attended.

PC = partner country, A = Australia

7 Key results and discussion

7.1 Acceptance, costs and benefits of control of fasciolosis in Kandal province

Cattle of different age groups in two project sites were selected for the study on the impact of the prevalence of fasciolosis on weight gain, condition score, skin status, draft ability, animal sale, and reproductive performance. This information was collected every three months from September 2004 (first time) until June 2006 (seventh time). The two project sites had similar farming systems and grazing management. Project site I was one village, Preak Thei of Saang district, Kandal province and was used as the control group. Project site II was two villages, Preak Kseav and Preak Trang of Saang district, Kandal province and was used as the non control group or treatment group.

Control group - Project site I (Preak Thei): Extension activity was not conducted. The selected animals were vaccinated against HS, FMD and given anthelmintic for helminths other than for fasciolosis.

Non control group - Project site II (Preak Kseav and Preak Trang): Extension activity was conducted and triclabendazole- the drug effective against fasciolosis was given in addition to the same treatments that were given to the control group.

Prevalence of fasciolosis: A total of 1,483 faecal samples from control and non control groups were examined. In the control group, the infection rate of fasciolosis at the start (September 2004) was 39.35% (n = 155), 40.25% in January 2005, 41.66% in April 2005, 42.85% in August 2005, 44.44% in November 2005, 46.42% in February 2006 and 45.45% in June 2006. In the non control group, the infection rate of fasciolosis at the start was 43.42% (n = 350), and then it dropped and remained low after treatment and extension activity at 1.80%, 5.19%, 3.77%, 4.34%, 4.08% and 3.12% in January 2005, April 2005, August 2005, November 2005, February 2006 and June 2006, respectively.

Extension activities were implemented by the extension team from DAHP and OAHP of Kandal province under the supervision of extension specialists from CARDI and AED/CAAEP. Extension was delivered as a series of three modules with the aim of increasing knowledge and understanding with each module. Attendance at these modules was 186 people in module I, 221 people in module II and 180 people in module III.

The farmers in the project sites were selected, interviewed and given questionnaires to evaluate their understanding on fasciolosis. The questionnaires included 25 questions related to the life-cycle for *Fasciola*, impact of the disease fasciolosis and control measures. A total of 90 families (39.1%) out of 230 families in the two project sites participated in the phase I survey and 113 families (49.1%) participated in the phase II survey.

Acceptance

At the beginning of the programme most farmers both in project site I and project site II had very poor knowledge on fasciolosis, its impacts and how to prevent the disease.

Results of the follow up surveys after extension activity had been carried out indicated that in project site I the average knowledge and understanding of *Fasciola* and fasciolosis was very low, while in project site II, 21.7% responded correctly to the survey questionnaire, 51.6% responded incorrectly and 26.4% admitted they did not know about fasciolosis, its impacts and how to control the disease.

Results of a second follow up survey after more extension activity had been carried out indicated farmers' knowledge and understanding between project site I and II differed greatly. It indicated that 74.8% farmers in project site II responded correctly to the

questionnaire, while the knowledge and understanding on fasciolosis and its control measures remained very low among farmers in project site I.

In conclusion, among farmers who received education and extension on fasciolosis and control measures, their knowledge and understanding was greatly enhanced.

Farmers were also interviewed to evaluate their opinion of the extension programme on control of fasciolosis and adoption of control methods in Saang district of Kandal province.

The activities were conducted from October 2005 with participation of 120 families where extension and education on fasciolosis was conducted. Results from the interview indicated the following:

- Farmers were satisfied with the extension programme on fasciolosis. It explained, demonstrated and helped farmers to understand the disease. In addition, it enabled them to address and discuss fasciolosis in groups
- Farmers were convinced of the economic impacts of fasciolosis as they became involved in the programme, due to the fact that infected cattle had slower weight gain, lower fertility among reproductive females, weaker draft ability, worse skin and condition scores and increased liver damage
- Extension materials such as sign boards, leaflets and banners drew farmers' attention to fasciolosis and the control programme
- Farmers suggested that the programme should be extended
- Extension workshops with farmers were the best approach for in depth extension although extension materials such as banners and leaflets were more useful for raising general awareness of the control programme
- Farmers were willing to use anthelminthics and composting of dung to control fasciolosis. However, farmers generally did not wish to treat pregnant animals with drugs despite assertions from project staff that the drug in question was safe.

A questionnaire on the preferred extension methods and control methods adopted by farmers including acceptance of grazing and drinking management techniques was conducted in the 12 month extension to the project and the results are reported further down.

Cost/Benefit Analysis

This was a deterministic analysis.

Table 2: The benefits of *Fasciola* control per animal per year. The gain values were derived from the intervention study in this project and the prices for those gains were provided by farmers in Kandal province.

Effect of Fasciola control	Gain/animal	Mean value (range) $ US
Improved pregnancy rate	10% over two year inter calf period in Cambodia	225 (150-300) /calf/year*
Reduced mating services	0.63-0.87 less services per animal (Swiss data) over two year inter calf period in Cambodia	3.0 (3.0-15.0) /service
Liver for sale	100%	3.0 (3.0-4.0) /liver
Improved strength	40%	2.5 /day for ploughing x 90 days
Weight gain	21.3kg for females or 42.1kg for males for first 3 years	2.5 (2.5 – 4.0)

**The average price of a calf sold after two years divided by the two years of investment, Male = $150/year and Female = $300/year. This did not take into account the potential improved birth weights associated with Fasciola control.*

The benefits of *Fasciola* control per animal per year were calculated by multiplying the gain by the price in the table above. Benefits for females and males were calculated separately as below.

Female sold for slaughter at 3 years of age:

Average benefit/female/yr from *Fasciola* control = improved pregnancy rate x value of a calf for 1 yr (because expect female to have calf at 2 yrs of age)/yr ($7.50/female/yr) + value of extra weight gain/yr ($53.25) + value of less services for one yr/yr ($0.87) + value of the liver/yr ($1.00) = $63/female/yr in first 3 years.

If the animal is sold at a younger age then *Fasciola* control is less profitable because there is no improved pregnancy rate gain. If the animal is sold at an age older than 3 years then there more gain from improved pregnancy rates but there is reduced weight gain/yr associated with older animals.

Sold at 2yrs $49/animal/annum, 4yrs $72/animal/annum, 5yrs $78/animal/annum

Male sold for slaughter at 3 years of age:

Average benefit/male/yr from *Fasciola* control = value of extra weight gain/yr ($105.25) + value of the liver/yr ($1.00) + value of improved strength for one year (because animal would be used for draught at 2 yrs of age/yr ($30.00)

= $136/male/yr in first 3 years

If the animal is sold at a younger age then *Fasciola* control is less profitable because the potential for gain from draught strength is lost. If the animal is sold at an age older than 3 years then there is more opportunity for profit from improved draught strength but there is reduced weight gain per year.

Sold at 2yrs $94/animal/annum, 4 yrs $143/animal/annum, 5 yrs $148/animal/annum.

Table 3. The costs of *Fasciola* control per animal per year.

Method of control	Maximum cost/animal/yr (range) $ US
Extension	
Train extension officers	1 (0.2-1) Calculation:200 (100-200)/200 (200-500)
Extension materials	5 (0.1-5) Calculation:5000 (1000-5000)/1000 (1000-10000) [a]
Extension labour	2 (0.2-2) Calculation:60 (10-60)/30 (30-60) [b]
Monitoring control through FEC of faeces	4 (2-4)
Farmer	
Lost income from attending extension days	7.5 (4-7.5)
Drug (Triclabendazole preferred)	5 (1.5-5) [c]
Management of faeces	5 (2-5)
Clean drinking water	5 (2-5)
Uninfected feed (grazing management)	5 (2-5)
Total	39.5 (14-39.5)

[a] *Extension materials = food and water and materials*
[b] *Extension labour = $1.25 paid to each farmer to attend + ($10 day/per extension officer x 5 extension officers + cost of a driver and vehicle)/25 farmers x four days (which includes delivery of two modules 1 and 2 on fasciolosis control).*
[c] *Calculation for cost of dose = 13L of Fasinex at $1683 Aus x .77 USA exchange rate at time of study from 2004-2006/No. of doses (866 doses for average weight of 251-300kg)*

The cost of control of faciolosis will decrease with time because extension training and extension is not needed every year.

Therefore there is a net benefit of a three year control programme for fasciolosis of at least $23 US/female/yr for an animal born at the start of the programme with maximum extension costs provided every year. The net benefit for males born at the start of the programme is $96/yr. An average net benefit for animals born at the start of the

programme will depend on the sex ratios but assuming a 1:1 sex ratio then the average net benefit is $60 US/animal/yr. The immediate benefit of a control programme will be greater for animals already alive at the start of the programme due to the greater value of control in older animals.

Therefore a control programme for fasciolosis even a relatively expensive one is economically viable in areas of high risk for fasciolosis.

Animal sale: In the control group, 70.96% (110 heads) of the 155 selected animals at the start of the study were sold, while in the non control group, 68.0% (238 heads) out of the 350 animals at the start of the study were sold by June 2006. Additional animals were recruited to offset these losses.

There were also benefits that were not costed such as increased knowledge of fasciolosis by farmers and increased extension capacity of DAHP staff.

7.2 To train and mentor extension officers of the DAHP and provincial extension staff using experienced Cambodian extension staff

An extension training workshop was organized by CARDI and AED. The workshop was held from 12 to 17 July 2004 at CARDI.

Objective of the training workshop: Train extension officers of the extension office of the DAHP and officers of the OAHP, Department of Agriculture of Kandal province as well as the extension officers of Saang district in Kandal province on basic applied knowledge of extension, using experienced Cambodian extension staff from CARDI and AED.

Methods: The extension officers from the extension office of the DAHP and OAHP, Saang district in Kandal province attended the extension training workshop organised by CARDI and AED. The instructors and experienced officers of CARDI and AED prepared the training programme and the course content was approved by the project leaders, Dr. Suon Sothoeun and Dr. Lee Skerratt.

Results: The participants - extension staff from DAHP (7 persons): Ms Pich Pituratha, Mr Kea Pha, Ms Hor Malin, Ms Hieng Sarin, Mr Hout Savuth, Mr Thong Samnang and Mr Loeng Vaneng, and OAHP of Kandal province (3 persons): Ms Eng Sok Moy, Mr Toung Hok and Mr Ouk Sokun participated in the workshop.

Workshop content - Theory and application of extension:

- Definition of extension
- Development objectives
- Approaches to extension
- External and internal factors for extension success
- Extension and educational methods
- Communication skills (definition, process, body language, hearing and listening, ten laws of communication, perception, communication barriers, presentation skills)
- Demonstrations (method and result of demonstrations)
  - Facilitation skills
  - Conducting a meeting
  - Role playing
  - Building a team

- Flip charts
- Flip chart presentations
- Posters

The participants who successfully completed the extension workshop received workshop certificates. Ongoing collaboration and mentoring occurred between the participants and extension experts from AED, CARDI and CAAEP. This resulted in a spin off from the project in the form of development of a technology implementation procedure (TIP) for fasciolosis (Suon, 2007) which will be very useful in terms of a national control programme for fasciolosis.

7.3 To develop an extension programme to control fasciolosis that is a model for control of fasciolosis.

A. Extension training workshop

See above

B. Production of an extension manual

A 44 page Khmer language training manual entitled “Training manual for extension trainer on extension lessons and methods for the control and eradication of fasciolosis in cattle in Saang district, Kandal province” was produced.

The content of the manual included:

- Objectives of the extension manual
- Extension program
- Methodology
  - Module I: Knowledge of fasciolosis (morphology, life cycle, final and intermediate hosts of *Fasciola*, disease signs, treatment etc.). The programme included both theory and practical exercises.
  - Module II: Control measures against fasciolosis I. (Revision on fasciolosis, control and prevention of fasciolosis: biological control, grazing management, treatment using anthelminthics). The programme included both theory and practical exercises.
  - Module III: Control measures against fasciolosis II. It addressed the cost and benefit of the fasciolosis control programme and filled the gaps of the farmers and stakeholders knowledge/understanding on fasciolosis control measures. The programme included both theory and practical exercises.
- Expected outputs
- Participation
- Materials for training and extension

C. Production and distribution of extension materials

The DAHP, AED, OAHP extension team and extension officers in Saang district discussed and developed the extension materials for use to support the extension work on control of fasciolosis in the target areas. These extension materials were also approved by the DAHP before use.

The extension materials produced were as follows:

- Fasciolosis T-shirt 500 units

- Leaflets 54,500 units
- Sign board 4 units
- Banner 28 units
- Photo books 4 sets
- Radio spot
- Video for extension
- Manual for extension

A total of 32 293 leaflets on fasciolosis were distributed to farmers, stakeholders, school children at school and Provincial Offices of Animal Health and Production. A total of 454 T-shirts were distributed to farmers and stakeholders.

Results of the extension programme indicated that training in extension methods is an important component of control. The project has confirmed the need for extension training of extension officers prior to any implementation of a national control programme for fasciolosis. Control methods that require a good level of understanding of the epidemiology of fasciolosis by farmers such as prevention of infection may take significantly longer to implement compared with simple control measures such as anthelminthics depending on the background knowledge of the farmer. This has a significant impact because it means that benefits of some control methods may take some time to be realised. Therefore a sustained extension and control programme is needed.

7.4 To update, refine and validate a risk model for fasciolosis in Cambodia using GIS technology.

Figure 4: GIS risk model for fasciolosis in Cambodia. This model was updated with improved information and validated (see table below). Categorical level of risk is indicated by colour.

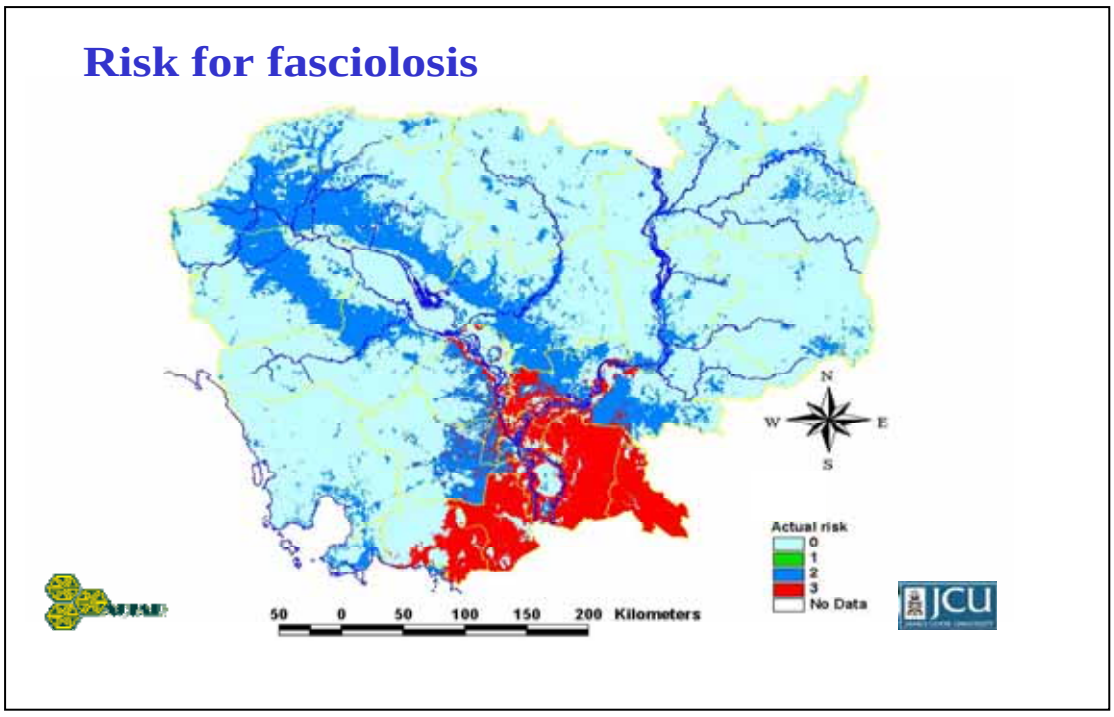


Table 4: Faecal examination results from different districts and risk classification in the province of Kampong Cham in Cambodia.

Districts	Samples	Cases	Prevalence (%)	Risk rating
Batheay	311	76	24.44	High
Prey Chhor	301	36	11.96	Moderate
Orang Ov and Chamcar Leu	268	18	6.72	Low
Stoeung Trang	262	9	3.43	No risk

The levels of prevalence of fasciolosis found in the field survey were generally in accord with predictions from the risk model, except in Stoeung Trang where the prevalence was higher than predicted. This mismatch between the GIS model and field survey results may be due to the distribution of animals and their use of the land within districts, which is unlikely to be uniform (some animals may be grazed in the areas where the risk of fasciolosis is higher), as is implied by the model. However, the general agreement of the risk model with predicted prevalence in most districts surveyed suggests that the epidemiological determinants and weightings used to produce the model are appropriate.

Project extension (12 months):

7.5 To assess sustainability of the control programme and to enable a national strategy for control to be developed

This aspect of the project involved two questionnaire studies and development of a national strategy for control. The first questionnaire aimed to evaluate the knowledge and understanding of farmers on control of fasciolosis at 6 and 11 months after extension had finished, December 2006 and May 2007, using the questionnaire used in the first two years of this project. The second questionnaire aimed to assess the extension methods preferred and control measures employed by farmers once the extension and control programme had finished. It was conducted in March 2007, 9 months after the two year intervention study had finished.

In December 2006, 90 families answered the same questionnaire survey used in the first two years of the study to assess the level of understanding and knowledge of fasciolosis, its impacts and control of fasciolosis. The last time these villages received extension was in June 2006. Of these families, 30 occurred in project site I, Preak Thei, where extension on fasciolosis had not been introduced and 60 families in project site II, Preak Kseav and Preak Trang, where the extension on fasciolosis was introduced (30 families in Preak Kseav and another 30 families in Preak Trang). In project site I (Preak Thai, where extension on fasciolosis had not been introduced) the level of understanding and knowledge of fasciolosis, disease impacts and fasciolosis control was very low in the first survey. Among the attendees, 77% had not heard of fasciolosis, 100% had no idea about the survival of *Fasciola* eggs in dung kept in storage or the survival of metacecaria on cut grass or rice straw. The majority did not know of any control measures against fasciolosis. The second round of questionnaires conducted in May 2007 in this selected site also indicated a low level of understanding on fasciolosis, its impacts and control measures against fasciolosis.

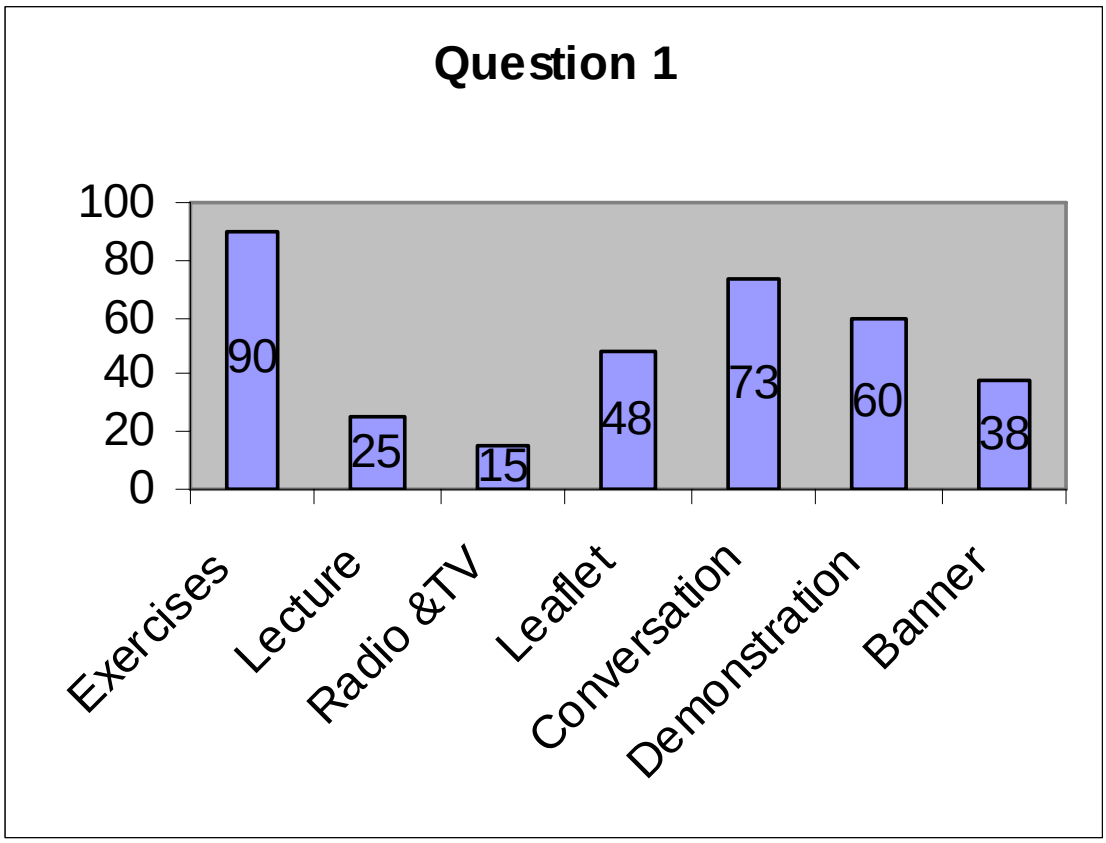
In the first survey at project site II (Preak Kseav and Preak Trang, where the extension on fasciolosis was introduced) 21.7% responded correctly to the survey questionnaire, 51.6% responded incorrectly and 26.4% admitted that they did not know about fasciolosis, its impacts and how to control the disease. Results of a second follow up survey after more extension activity had been carried out in this project site indicated farmers' knowledge and understanding improved greatly. It indicated that 74.8% of farmers in project site II responded correctly to the questionnaire, while the knowledge and understanding on fasciolosis and its control measures remained very low among farmers in project site I

(see above). Above 90% knew about fasciolosis and the impacts caused by *Fasciola*. Most of them knew how to control the disease as well as what control techniques could be applied. People had difficulty answering questions which referred to detailed aspects of the epidemiology of fasciolosis such as how long *Fasciola* could survive in the environment.

In conclusion, among farmers who received education and extension on fasciolosis and control measures, their knowledge and understanding was greatly enhanced although appeared to be generally short term. Follow up extension resulted in significant recall of this knowledge and understanding.

In March 2007 the extension methods preferred and control methods used by farmers once extension had finished were evaluated by questionnaire after randomly selecting 30 farmers from each village where extension was carried out.

Figure 5. Results from question 1 in Preak Kseav and Preak Trang showing percentage of 60 farmers which regarded the extension method as worthwhile.



All extension methods were regarded as useful. Interactive learning through exercises such as games were the preferred method of extension followed by practical demonstrations such as necropsy of infected livers, one on one conversations, information leaflets, banners displayed in public places, lectures and lastly radio and TV spots (Fig. 5).

Most farmers (90%) used drugs to control fasciolosis. The preferred drug was triclabendazole with 77% of farmers using it, 18% used nitroxinil and 8% albendazole. The use of drug was mostly determined by the veterinarian and their access to importers of drugs. Triclabendazole was the drug used in the intervention study however it was not available in Cambodia at the start of the study. Interestingly, farmers were able to get access to the drug once there was a reasonable demand for it created by the extension project. The cost of the drug for farmers could be reduced if it were to be imported in bulk into Cambodia. To date no pharmaceutical companies have expressed interest but this may change once control of fasciolosis becomes a national program. Farmers either used

drugs once in May or twice, once in May and the other treatment in July at the end of the dry season. This prevents contamination of the environment during times favourable for snails, the intermediate host and it ensures cattle are relatively free of the parasite until the dry season rice farming when exposure is at its greatest.

Most farmers (93%) practised collection and composting of faeces to reduce environmental contamination with *Fasciola*. All farmers prevented their cattle from drinking potentially contaminated water and provided drinking water from a river or well. Most (77%) also managed the feeding of their animals to reduce exposure to contaminated areas or feed either by preventing feeding in contaminated areas or treating feed to kill the larval stage of the parasite, metacercaria, in the environment. Farmers were satisfied with the control methods believing they were effective in controlling fasciolosis. This was confirmed by faecal examination which showed that the prevalence of fasciolosis was low whereas it remained high where extension had not been carried out in Preak Thai.

National Control Strategy

This strategy emerged after conducting a National Workshop on fasciolosis held in Phnom Penh in Cambodia in July 2006 as part of the project. Recommendations came from stakeholders, project staff and experts on fasciolosis from South East Asia and Australia, extension and management of agricultural issues including disease control. These recommendations were developed into a national strategy in the third year of the project.

Steps to be undertaken in a national control strategy:

Firstly it is important to identify areas for control and then secondly establish control programs in those areas. Therefore two key steps are listed below.

1. Use of the geographical information system (GIS) predictive model for fasciolosis in Cambodia to target moderate and high risk areas (i.e. provinces, districts and villages) initially. There will need to be some additional validation of the model in provinces and districts identified as moderate to high risk.

   The model has been validated in Kampong Cham and was generated using specific knowledge from epidemiological studies in Kandal Province and general knowledge on the epidemiology of fasciolosis. However, it still needs some validation in other areas especially at fine geographical scales (Sothyra et al., 2003, 2007). Approximate validation could be done cheaply at local abattoirs by confirming high prevalence's of flukes in livers of slaughtered cattle. Alternatively, a potentially more accurate validation method would be to conduct faecal egg counts for evidence of fluke infection and clinical examination of cattle for signs of fasciolosis. Faecal analysis can be conducted through the Department of Animal Health and Production and their parasitology laboratory within the National Animal Health and Production Investigation Centre (see Appendix 1 for contact details). Sampling should be representative of the population of interest if possible and take into account the seasonal nature of fasciolosis. The GIS model was developed by Mr Tum Sothyra with guidance from Dr Mari Puotinen and is available from the Department of Animal Health and Production (see Appendix 1 for contact details).

2. Plan and implement a control programme within each province, district and village identified as high to moderate risk by the GIS model.

   Once a high or moderate risk area has been identified then planning a control programme needs to be undertaken. This should involve all stakeholders such as farmers, village leaders, village animal health workers (VAHW), local veterinarians and local and provincial veterinary and extension authorities. Experts in extension and control of fasciolosis also need to be partners. This expertise currently resides only in the central office of the Department of Animal Health and Production (DAHP) and in the Office of Animal Health and Production in Saang District where extension work has been carried out (see Appendix 1 for contact details). National veterinary

authorities also need to be present to coordinate control programs on the national scale. The experts from the DAHP could act in this role. There is a technology implementation procedure (TIP) entitled “Fasciolosis of Cattle and Buffaloes and its Control Measures” that can be used as a guide to planning a control programme (Suon, 2007). This was developed as a result of the National Workshop on the Control of Fasciolosis in 2006 and is an invaluable document for planning and implementing a control program.

One key aspect of this control programme will be the budget. The TIP recommends co-funding from farmers and provincial government. It is recommended that farmers pay for the cost of control such as anthelminthic treatment, dung management and feeding management. Government will cover the costs of planning and establishing a control programme and providing extension to farmers. This funding is expected to come from provincial funds in the long term to ensure sustainability. In order to achieve co-investment from farmers, they may need to be taken to demonstration villages where the benefits of control are readily visible. Another key aspect will be facilitating the access to anthelminthics by farmers through VAHW and local veterinarians. The supply chain from overseas pharmaceutical companies to VAHW and local veterinarians are not clear and need to be developed for the drug of choice by farmers, triclabendazole. Triclabendazole is sold in a number of forms such as a drench and a pour on with brand names Fasinex (Novartis, Sydney, Australia), Genesis Pour-On (Ancare, Kingsgrove, Australia) and Genesis Ultra Pour-On (Ancare, Kingsgrove, Australia) which are currently unavailable in Cambodia. Currently large suppliers of veterinary drugs in Cambodia do not appear to be interested in this developing market and it may require small local veterinary businesses to develop supply chains in the short term until the market is large enough to attract a bulk importer. It may be necessary for government to ensure supply by importing, distributing and selling triclabendazole as happens in Thailand at the moment.

3. This strategy and the TIP will need to be reviewed and updated at least every five years to take into account new research findings and the changing use and management of cattle and buffaloes in Cambodia as mechanisation is gradually replacing animals for draught and beef production is increasing.

   Research currently needed is further validation of the GIS model and determining the success of extension and control of fasciolosis and economic benefits of control in other areas of Cambodia (as discussed above). This could be funded by non government international organisations in the short term to decrease the initial financial burden on farmers and the Cambodian government as significant investment is needed at the start of this national control program.

8 Impacts

8.1 Scientific impacts – now and in 5 years

The scientific impact of the study in terms of fasciolosis is that other researchers will use GIS risk mapping to predict risk of fasciolosis. It is also likely that researchers will study extension methods and control practices adopted by farmers in order to design appropriate control programs. Although this is not the first cost benefit study on fasciolosis it is likely that it will lead to more. It is also likely that studies will be designed with multiple concurrent objectives such as occurred in this one. In five years time it is possible that this project will have led to similar projects especially within the region as it is the first to demonstrate the benefits of research on control whereas most research in the region on fasciolosis is on the biology of the disease. It is also possible that there will be further research on control once a national strategy for control of fasciolosis has been adopted in Cambodia due to the scientific success of this project.

The scientific impact of the project in terms of cattle health is that it has led to further scientific study in Cambodia in the field of cattle health and production. This is because the project demonstrated that significant improvements in understanding constraints and better ways of managing the health and production of extensive animal farming in Cambodia can be made through research. In particular there is an ACIAR project AH/2005/086 currently underway to examine “Best Practice Health and Husbandry of Cattle in Cambodia”. This latest project builds on the scientific work of the project reported here and previous projects on fasciolosis.

The scientific impact of the study in a broad sense is that it is likely that future research on extensive animal farming systems will use this project as a model as has occurred above.

The scientific impact of the study at the DAHP is that it significantly stimulated its research environment and commitment.

8.2 Capacity impacts – now and in 5 years

The project has led to a subsequent project on cattle health and production which will use the scientific and extension skills that staff gained at the DAHP and OAHP during this project. The IT equipment and software and vehicle from this project will also be utilised by the subsequent project on cattle health and production. There has been a transfer of staff from this project to other programs on important trans-boundary diseases such as avian influenza and foot and mouth disease within the DAHP which will use the skills acquired during this project such as GIS risk modeling. Staff at the DAHP now have sufficient capacity to undertake additional scientific intervention studies on fasciolosis or other important production diseases and associated extension methods. This capacity is likely to be used within the next five years given the lack of knowledge of health and production constraints of extensive animal systems in Cambodia.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

A key current impact is ongoing control of fasciolosis in the Saang district of Kandal Province by farmers. This was demonstrated in the 12 month project extension which measured the impact of the two year project in terms of control methods adopted by farmers. This will result in higher disposable income to farmers and greater protein availability for the general public of Cambodia and neighbouring countries through trade.

The second major economic impact was development of the technology implementation procedure (TIP) entitled “Fasciolosis of Cattle and Buffaloes and its Control Measures” that can be used as a guide to planning a control programme by other provinces in Cambodia (Suon, 2007). This empowers other provinces to improve economically if they consider fasciolosis to be a significant problem. Use of a National Control Strategy for fasciolosis by MAFF in Cambodia will ensure adequate resources are available to provinces to use the TIP on fasciolosis.

8.3.2 Social impacts

This project has a social impact on farmers who have a higher status and take great pride in having healthier, stronger and bigger animals through control of fasciolosis. Although undocumented it is likely that there are a number of cases of human fasciolosis in Cambodia each year. The disease is emerging in neighbouring countries such as Vietnam. Humans are dead end hosts and therefore cattle are the reservoir for infection. Therefore this project is likely to lead to improved human health through the control of the disease in cattle.

8.3.3 Environmental impacts

There are no obvious impacts other than making the farming system more efficient and therefore potentially reducing its impact on the environment.

8.4 Communication and dissemination activities

The project held a national workshop on the control of fasciolosis in July 2006 in Phnom Penh which presented the project outputs and results. Directors from each provincial OAHP attended as well as senior staff from the MAFF. This was followed up with dissemination of the TIP on fasciolosis to each province along with other extension materials such as leaflets. This will potentially lead to uptake of the project’s findings by other provinces within Cambodia.

Results from the project have also been disseminated via international journal publications, ACIAR publications and international conference presentations (please see the list below).

9 Conclusions and recommendations

9.1 Conclusions

The project has been very successful in providing a model for the control of fasciolosis in Cambodia. It has provided a GIS risk based model that identifies areas most affected by fasciolosis for targeted control. It has provided an effective extension package that aims to control fasciolosis. This package provides extension workers with the necessary training and tools to carry out extension. In addition the extension methods have been adapted to have the highest impact on farmers based on feedback from farmers. This extension package can be adopted on a national scale to implement effective control measures for fasciolosis. The mechanism for doing this has been realised through development of a technology implementation procedure entitled “Fasciolosis of Cattle and Buffaloes and its Control Measures” which has been distributed to all provinces which is a significant impact of the project. The other is development of a National Control Strategy after consultation with stakeholders, project staff and experts at a National Workshop on Control of Fasciolosis. The sustainability of control is feasible as all the methods of control recommended are currently available and have been shown to be adopted by Cambodian farmers. For example anthelminthics such as nitroxinil and albendazole are available and the market for triclabendazole is emerging and these drugs are used by farmers along with other methods such as grazing management to control fasciolosis. The project has also carried out a benefit analysis for control of fasciolosis. Analysis indicates that control of fasciolosis results in an average financial benefit of $136 US/year for a 3yr old male and $63 US/year for a 3yr old female cow. These returns increase with age. The costs of control are significantly less even with a large amount of extension in the first year ($40 US/animal) and ongoing intermittent extension. In addition, once farmers are shown the benefits of control of fasciolosis they readily adopt and finance their own control.

The project has maintained and improved the capacity of staff at the DAHP and the OAHP Kandal Province in a number of key areas such as extension, parasitology and research. This has led to a subsequent ACIAR project on cattle health and production as well as capacity building for concurrent projects on trans-boundary diseases through transfer of staff. This current study and subsequent control programme is likely to be used as a model for further research projects and control programs designed to improve the management of diseases of livestock in Cambodia and neighbouring countries including the current ACIAR project on cattle health and production. The project will lead to a number of scientific publications in international journals with one already published in Veterinary Parasitology on the GIS model.

9.2 Recommendations

It is recommended that ACIAR monitor the implementation of the National Control Strategy and technology implementation procedure for fasciolosis in Cambodia. ACIAR should facilitate implementation of these where necessary. There needs to be an assessment of the impact of the project in a few years time. ACIAR should ensure that the outputs from this project are disseminated to neighbouring countries in the Mekong delta and that similar projects and control strategies are developed in countries such as Laos and Vietnam.

Language barriers and lack of research training of Cambodian project staff were significant impediments to the progress of the project. It is recommended that English language training be adopted in government departments especially those that collaborate internationally such as the DAHP. Departments undertaking research should adopt training in research methodology, data analysis and scientific writing. This training could

occur in country and be undertaken by resident scientists and volunteers or alternatively through placement of staff or students in courses in overseas institutes.

Research to refine the GIS model of 2007 needs to be undertaken and a cost benefit analysis for control of fasciolosis needs to be done in areas where the disease has a low to moderate prevalence. Lastly research should be undertaken on the National Control Strategy to improve its effectiveness.

10 References

10.1 References cited in report

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Spithill, T.W., Smooker, P.M. and Copeman, D.B. (1999) Fasciola gigantica: epidemiology, control, immunology and molecular biology. In: J.P. Dalton (Ed), Fasciolosis. CAB International. pp 465-525.

Suon, S. (2007) Technology Implementation Procedure: Fasciolosis of Cattle and Buffaloes and its Control Measures. Ministry of Agriculture, Forestry and Fisheries, Phnom Penh, Cambodia. Pp 22.

10.2 List of publications produced by project

Department of Animal Health and Production of Cambodia. 2004. Training manual for extension trainer on extension lessons and methods for the control and eradication of fasciolosis in cattle in Saang district, Kandal province. Phnom Penh.

Tum, S., Puotinen, M.L., and Copeman, D.B. 2004. A geographic information systems model for mapping risk of fasciolosis in cattle and buffaloes in Cambodia, *Veterinary Parasitology* 122: 141.

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Tum, S., Puotinen, M.L., Skerratt, L.F., Chan, B. and S. Sothoeun. 2007. Validation of a geographic information system model for mapping the risk of fasciolosis in cattle and buffaloes in Cambodia. *Veterinary Parasitology* 143: 364-367.

Several further publications on the intervention study such as the effectiveness of extension and the cost benefits of control of fasciolosis are anticipated and are in the process of being drafted. ACIAR is also publishing a monograph on fasciolosis which refers to some preliminary results of this study. The TIP is regarded as an impact of the project because the project staff were involved in its production and ACIAR financially supported its publication. This is because the TIP was produced based on recommendations of the National Workshop and was not an original project objective.

11 Appendixes

11.1 Appendix 1 Contacts

Contacts for further information on project results and outputs.

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