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RESEARCH PAPERS AND REPORTS IN ANIMAL HEALTH ECONOMICS

AN ACIAR THAI-AUSTRALIAN PROJECT

Working Paper No. 42

**Termination Report
Improved Methods in Diagnosis, Epidemiology,
Economics and Information Management in
Australia and Thailand**

Prepared by

Peter Black

November 1997



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**Improved Methods in Diagnosis, Epidemiology, Economics
and Information Management in Australia and Thailand**

Prepared by Peter Black²

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The Commissioned Organization is the Queensland Department of Primary Industries. Collaborating institutions in Australia are CSIRO-ANHL, Geelong, Victoria and the University of Queensland (Department of Economics; Department of Geographical Sciences and Planning). In Thailand, the collaborating institutions are the Department of Livestock Development (National Institute of Animal Health; Disease Control Division), Chiang Mai University (Department of Agricultural Economics; Department of Animal Husbandry) and Thammasat University (Faculty of Economics). The collaborating institution in Laos is the Department of Livestock and Veterinary Services. Dr F.C. Baldock, Senior Principal Epidemiologist, Queensland Department of Primary Industries is the Project Leader in Australia and Dr P. Chamnanpood, Senior Epidemiologist, Thai Department of Livestock Development is the Project Leader in Thailand. Professor Clem Tisdell and Dr Steve Harrison, Department of Economics, University of Queensland are responsible mainly for the economic component of this project.

'The overall goal of this project is to develop and evaluate the necessary tools to provide decision-makers with reliable animal health information which is placed in context and analysed appropriately in both Thailand and Australia. This goal will be achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a Geographical Information System (GIS); and providing a framework for the economic evaluation of the impact of animal diseases and their control.

A number of important diseases will be targeted in the project to test the systems being developed. In Thailand, the focus will be on smallholder livestock systems. In Australia, research will be directed at the northern beef industry as animal health information for this sector of livestock production is presently scarce.'

For more information on *Research Papers and Reports Animal Health Economics* write to Professor Clem Tisdell (c.tisdell@economics.uq.edu.au) or Dr Steve Harrison, (s.harrison@uq.edu.au) Department of Economics, University of Queensland, Brisbane, Australia, 4072.



Termination Report

ACIAR Project Number 9204

**Improved methods in diagnosis, epidemiology,
economics and information management in
Australia and Thailand**

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Abbreviations

AAHL	Australian Animal Health Laboratory
ACIAR	Australian Centre for International Research
AD	Aujeszky's disease
ADV	Aujeszky's disease Virus
BVDV	Bovine Viral Diarrhoea Virus
CBA	Cost Benefit Analysis
CGE	Closed General Equilibrium
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DLD	Department of Livestock Development
ELISA	Enzyme Linked Immunosorbant Assay
EMAI	Elizabeth MacArthur Agricultural Research Institute
FAO	Food and Agriculture Organisation
FMD	Foot and Mouth Disease
GIS	Geographic Information System
HC	Hog Cholera
HCV	Hog Cholera Virus
IBD	Infectious Bursal Disease
IBDV	Infectious Bursal Disease Virus
ISVEE	International Symposium on Veterinary Epidemiology and Economics
MOU	Memorandum of Understanding
NARIS	National Animal Health Information System
NIAH	National Institute of Animal Health
NSO	National Statistics Office
NVRDC	Northern Veterinary Research and Diagnostic Centre
OIE	Office International des Epizooties
QCEL	Quality Control for ELISA's
QDPI	Queensland Department of Primary Industries
RapiCAPS	Rapid, Computer-Assisted Prevalence Surveys
UQ	The University of Queensland

Executive Summary

Project: Improved methods in diagnosis, epidemiology, economics and information management in Australia and Thailand

Commissioned Organisation: Queensland Department of Primary Industries

Project Leaders:

i. Australia: Dr P Black, Principal Scientist
Formally Dr C Baldock

ii. Thailand: Dr P Chamnanpood, Senior Epidemiologist

Date of Commencement: 23 March 1994

Date of Completion: 30 June 1997.

Aims of Project:

The overall goal of this project was to develop and evaluate the necessary tools to provide decision makers with reliable animal health information placed in context and analysed appropriately in both Thailand and Australia. This goal was substantially achieved by improving laboratory diagnostic procedures; undertaking research to obtain cost-effective population referenced data; integrating data sets using modern information management technology, namely a GIS; and providing a framework for the economic evaluation of the impact of animal diseases and their control. The specific objectives for the project are listed below with an assessment of how well each was achieved.

Objective 1. To establish improved laboratory techniques and quality control procedures in Thailand for the diagnosis of hog cholera, Aujeszky's disease and infectious bursal disease.

Complete achievement.

Objective 2. To develop and use methods of population based research on animal health and production which will meet future international disease reporting requirements and provide information relevant to animal disease control.

95% achievement. The Australian portion of the study was complete for the wide area surveillance, but was only partially completed in the abattoir and longitudinal studies. The Thai portion of this objective was achieved.

Objective 3. To develop integrated data management systems within a GIS framework suitable for analysis and reporting of data both at a local and regional or national level.

105% achievement. The GIS framework outcomes clearly exceeded the project objectives.

Objective 4. To evaluate the economic implications of animal diseases and control options as well as the value of an animal health information system to Thailand.

80% achieved. Many difficulties were encountered, but the project still had a number of notable achievements in this area.

Description of Work:

Three new rapid antigen detection and three new serological tests for antibody detection were implemented at the NVRDC with full documentation in both Thai and English as well as quality control procedures to the international ISO 9000 specifications. These tests are in routine use in the virology laboratory.

Active surveillance methods were developed and evaluated in both Thailand and Australia. In Thailand, research towards this objective involved the development and testing of methodologies aimed at the collection of three core measures of disease: Seroprevalence, disease incidence and freedom from disease. The output of this work resulted in the development of the RapiCAPS computer program.

A GIS was successfully implemented in three provinces and subsequent research focussed on testing the system's ability to meet the information needs of the veterinary services. This was done through the development of specialist applications for disease control during an outbreak, development of improved reporting systems, and application of the system to research targeted at the development of new, more effective, disease control strategies.

In Australia, an active surveillance program was developed which aimed to satisfy a number of the criteria specified in the OIE Animal Health Code. The findings from the project have been one of the key determining factors in the establishment of an active surveillance system

by the Queensland Department of Primary Industries. It was also shown that a system of analysis involving simulation modelling (using the active surveillance data) could be used to improve animal health decision-making.

The project involved a comprehensive cost-benefit study of the economic impacts of FMD and the costs and benefits of eradication, in terms of the various impact categories. The economic evaluation of the Thai FMD control and eradication program indicated a number of factors which will help to assure success of the program. It is envisaged that these will be of assistance to Thai livestock authorities in disease control policy formulation. Dissemination of this CBA report as a monograph should provide useful methodology and insights into economic analysis of disease eradication for livestock authorities in South- East Asia.

Results, Conclusions and Assessments

This project has resulted in a high level of mutual respect among many participants and solid long term gains which will continue to spill over to many countries in the Southeast Asian region and other areas of the world for many years to come. Some outstanding achievements have been the development and verification of the RapiCAPS approach to animal health surveillance plus the development of low cost GIS systems and the demonstration of their usefulness as a framework for animal health information systems.

Components of RapiCAPS have been made freely available to animal health scientists throughout the world through the internet and it will be used by the OIE as the basis for a review of international standards for animal health surveillance techniques. In addition, FAO has asked that it be made available for a publication being prepared by that organisation on surveillance. It is also now gaining uptake in teaching of veterinary epidemiology.

On the laboratory side, there is potentially wide international application for the quality control software called QCEL developed through the project. Again, this software has been made freely available over the internet and is now being used in a number of veterinary laboratories throughout the world.

There were a number of logistical problems with the Australian field studies such as drought and closure of meatworks which meant that all work could not be completed. Nevertheless, this work has been the catalyst for the development of a new approach by QDPI to surveillance in extensive grazing areas of Queensland.

Cost-benefit aspects of FMD control and eradication in Thailand were explored. This analysis, prepared as a monograph for ACIAR, integrates findings of other components of the project, and develops and applies a methodology for estimation of the net present value and benefit-to-cost payoff of the current Thai FMD control and eradication program. Although major data problems arose, the analysis provides indicative results that the program has a positive net present value and a benefit-to-cost ratio exceeding unity. Provided current control measures are continued and adapted as necessary, the Thai FMD program appears to be well justified when all categories of benefits (including reduced animal health expenditure, trade gains, transport and draught and animal welfare benefits) are taken into account. The importance of FMD eradication in Thailand becomes greater when viewed within a program of eradication in South-East Asia. Such a program may take several decades to achieve its goal.

Publications:

A considerable number have been produced and are listed in the main document.

Follow-up

No patents, copyright or property rights are proposed. The RapiCAPS and QCEL software are shareware which give due recognition to the support of ACIAR in their development. There is clearly the potential for a number of the findings and products from this project, such as RapiCAPS and QCEL, to influence the future of animal health activities in many countries around the world. ACIAR should be involved in facilitating this dissemination of knowledge.

1. Background

This project evolved from discussions between Thai and Australian participants in ACIAR Project 8835: "The diagnosis and control of foot and mouth disease (FMD) in Thailand". During that project it became apparent that existing systems for FMD surveillance resulted in gross under-reporting of outbreaks. In addition, there was no system in place to reliably measure the effectiveness of the national FMD vaccination program, namely the level of herd immunity achieved on a population basis. Subsequent discussions led to the realisation that FMD was merely a specific example symptomatic of more generalised weaknesses in existing animal health information in both Thailand and Australia.

There is a growing recognition among veterinary administrators throughout the world of the need for more quantitative and reliable information on livestock production and disease. Better information is critical to efficient and effective disease control as well as becoming increasingly important in certification for international trade in livestock and livestock products. Some countries have, and many are moving towards developing national animal health information systems with data being derived from a number of sources. The problem with many existing data sources is that they are statistically biased and do not give a fair picture of the situation in the reference population. The need for additional, representative information obtained through active surveillance was recognised and methods developed in the human field should be adaptable to veterinary applications.

Animal industries are substantial and important in both Thailand and Australia. At the time of developing this project, neither country had a comprehensive, national animal health information system although the essential elements existed or were being considered in both countries. In Thailand, existing passively collected data from field and laboratory operations was being collated into a central database. In Australia, a national working party convened at the direction of Animal Health Committee made recommendations on the need and format of a NARIS but no progress has yet been made on implementation. Since that time, the recently formed Australian Animal Health Council Ltd has taken responsibility for the NARIS which is now operational.

Though scheduled to commence in January 1994, the MOU between ACIAR and QDPI was not signed until 23 March 1994 with funding available in May and the MSA (MOU) with

Thailand was not finalised until 7 December 1994. In addition, the Australian Project Leader suffered ill health in January 1994 and was not able to participate in a planned visit to Thailand in February 1994 to finalise plans for that country.

2. Objectives

The overall aim of this project was to develop integrated methods which will lead to improvements in the quality of animal health and production information available to decision makers. To meet this aim, it was necessary to improve laboratory diagnostic procedures; undertake population based research to gain a better understanding of the epidemiology and economic implications of important animal diseases and develop appropriate integrated data management, analysis and reporting methods through a GIS framework.

A small number of important diseases were targeted in the project to test the approaches being developed. In Thailand, the focus was on village and small commercial livestock systems. In Australia, research was directed at the northern beef industry as animal health information for this sector of export-oriented livestock production was scarce.

Specific objectives of the project were-

- To establish improved laboratory techniques and quality control procedures in Thailand for the diagnosis of hog cholera, Aujeszky's disease and infectious bursal disease.
- To develop and use methods of population based research on animal health and production which will meet future international disease reporting requirements and provide information relevant to animal disease control.
- To develop integrated data management systems within a GIS framework suitable for analysis and reporting of data both at a local and regional or national level.
- To evaluate the economic implications of animal diseases and control options as well as the value of an animal health information system to Thailand.

3. Description of Research

Objective 1. To establish improved laboratory techniques and quality control procedures in Thailand for the diagnosis of hog cholera, Aujeszky's disease and infectious bursal disease.

Improved laboratory techniques developed by AAHL for the diagnosis of animal diseases exotic to Australia but endemic in Thailand were adapted for use in Thai laboratories and used in field studies.

Simple and inexpensive quality control methods for laboratory tests which can be integrated into existing diagnostic systems were developed and introduced into Thai laboratories.

Objective 2. To develop and use methods of population based research on animal health and production which will meet future international disease reporting requirements and provide information relevant to animal disease control.

Active surveillance methods were developed and evaluated in both Thailand and Australia. In Thailand, research towards this objective involved the development and testing of methodologies aimed at the collection of three core measures of disease: Seroprevalence, disease incidence and freedom from disease. The approaches used to develop these methodologies involved:

- a systematic assessment of the information requirements of the veterinary services;
- an assessment of the current information collection capabilities and restraints faced by the veterinary services;
- a review of the literature with regards to techniques previously used for the collection of the three core disease information types;
- theoretical development of approaches to improved data collection;
- in some cases, stochastic simulation modelling to test the validity of the techniques;
- training of field staff and implementation of survey techniques to field test the methodologies;

- critical analysis of both the effectiveness of the methodology and the data collected.

In Australia, methods were developed for extensive beef raising areas of northern Australia where there was very poor and unreliable animal health information. An active surveillance program was developed which aimed to satisfy a number of the criteria specified in the OIE Animal Health Code. The program consisted of three components: the administration of a questionnaire to property owners/managers; on farm examination of a sample of cattle and collection of samples for serological testing for a range of diseases; and the storage of sera for retrospective analysis. The active surveillance methodology emphasised stratified random sampling of herds across the local government areas which formed the list frame of herds available in central Queensland. The results were therefore representative of the cattle population in central Queensland. In addition, more intensive longitudinal studies were undertaken to ascertain the effects of some infectious agents on production and enterprise economics.

In the Australian component of the project, because of the difficulties in collecting and interpreting data from longitudinal studies, modelling to ascertain the effects of some infectious agents on production and enterprise economics was carried out. The model developed includes methods to assess the benefits of disease control by vaccination and the benefits of additional information collected in Structured Animal Health Surveillance in Central Queensland on disease control decision-making and the likely distribution of those benefits.

Objective 3. To develop integrated data management systems within a GIS framework suitable for analysis and reporting of data both at a local and regional or national level.

Research on the GIS-based information system involved a preliminary assessment of the current information flows, and information requirements of different sectors of the veterinary authorities. This was followed by investigations into both the geographical information and attribute (animal health related) information that was already available, and identifying data that needed to be specially generated.

Subsequently, the pilot GIS was implemented in three provinces. This complex process involved staff training, hardware, software and data acquisition, conversion of base maps to digital form, and extensive manipulation of existing attribute data sources to check the quality

of the data and integrate them into the information system.

Following the successful implementation of the system, research focussed on testing the system's ability to meet the information needs of the veterinary services. This was done through the development of specialist applications for disease control during an outbreak, development of improved reporting systems, and application of the system to research targeted at the development of new, more effective, disease control strategies.

Objective 4. To evaluate the economic implications of animal diseases and control options as well as the value of an animal health information system to Thailand.

The research proceeded in two stages. Information was initially obtained from a visit to Thailand to attend a FMD workshop associated with the previous ACIAR FMD project in Lampang in 1992. This trip was supported by a pre-project grant. The project proper involved a number of trips to Thailand, as reported to ACIAR in the respective trip reports. The ISVEE conference in Paris was attended in July 1997, and four papers presented.

Economic analysis frameworks were developed for animal health economics. Data were collected from village surveys, discussions with Thai livestock officers, Thai official statistics (some of which had to be translated from Thai language), and computer modelling approaches. Costs of livestock diseases were examined at the producer level and aggregated to the national level, with the addition of wider socio-economic variables for policy making. Multistage sampling designs for active surveillance of seroprevalence levels against foot-and-mouth disease were evaluated in terms of cost-effectiveness using a simulation approach. The economics of information systems for animal health in extensive beef cattle grazing areas of central Queensland were examined.

Information about costs of FMD in Thailand, costs of vaccination and other control measures and potential benefits of FMD eradication were integrated in a cost-benefit evaluation of the current Thai control and eradication program.

4. Research Results

Objective 1: To establish improved laboratory techniques and quality control procedures in Thailand for the diagnosis of hog cholera, Aujeszky's disease and infectious bursal disease.

Three new rapid antigen detection and three new serological tests for antibody detection were implemented at the NVRDC with full documentation in both Thai and English as well as quality control procedures to the international ISO 9000 specifications. These tests are in routine use in the virology laboratory.

The antigen detection tests have considerable advantages over former technology including improved convenience, reduced cost, improved accuracy, and a dramatic reduction in time to diagnosis (for example, a reduction from 3-4 weeks to 3-8 hours in the case of AD and HC). This improvement in diagnostic ability means that diagnoses can now be provided in time to influence decisions on interventions rather than merely being an historical confirmation of a clinically suspect event. The new serological tests have similar advantages with the addition of a marked increase in capacity which is vital for animal health monitoring.

In the case of the HCV antibody test, some difficulties were initially experienced because of nonspecific reactions due to rheumatoid factor present in pig serum. This problem was overcome. An important feature of the diagnostic systems introduced to the NVRDC is that long term reagent supply is assured which was not the case previously. Most of the tests use commercially available reagents. Some reagents have been sourced from AAHL and EMAI in Australia and these will continue to be provided now that the project is completed.

A summary of the new diagnostic capabilities at the NVRDC is provided in the following tables.

Table 1: Antigen Detection Tests

Disease	Test & sample	Advantages	Capacity	Reagents from
Hog Cholera	HCV Antigen Capture ELISA using spleen homogenate or leucocyte preparation	8 hrs vs 3-4 wks for previous test Specific - no BVDV cross-reaction Leucocyte testing for carrier status	200/day	CSIRO-AAHL EMAI, Aust
Aujeszky's Disease	ADV Monoclonal Indirect Fluorescent Antibody using brain tissue smears	3 hrs vs 3-4 wks for virus isolation Monoclonal specificity for ADV	20/day	TropBio PL
Infectious Bursal Disease	IBDV Antigen Capture ELISA using bursa homogenate	4 hrs vs 48 hrs for previous test Much more sensitive than AGID No egg inoculation required Less expensive	200/day	TropBio PL

Table 2: Serological Tests

Disease	Test & sample	Advantages	Capacity	Reagents from
Hog Cholera	HCV Complex Trapping Blocking LP ELISA	8 hrs vs 5 days for previous test Specific - no BVDV cross-reaction	400/day	CSIRO-AAHL EMAI, Aust
Aujeszky's Disease	ADV Latex Agglutination Test	Rapid (10 minutes) Simple Sensitive & specific using recombinant ADV technology	400/day	Viral Antigens Inc
Infectious Bursal Disease	IBDV Indirect ELISA	4 hrs vs 48 hrs for previous test Much more sensitive than AGID	400/day	CSIRO-AAHL

A quality control process for laboratory assays has been put in place and is now in routine use in the virology laboratory at the NVRDC and has also been introduced to the other regional laboratories. This process was based on previous work done by Mr Stewart Blacksell and involved writing a specific computer program by the Australian Project Scientist, Dr Angus Cameron. The system is called QCEL and has the following features:

- meets ISO 9000 specifications for quality control;
- runs on any IBM compatible computer;

- provides the user with an independent assessment on unacceptable trends in ELISA performance;
- provides individual operator performance data;
- requires no assumed knowledge of statistics;
- gives easy-to-interpret graphical summaries of Quality Control data;
- uses international standard methods (Shewart-CUSUM);
- inexpensive, and simple to implement and use.

In addition to development of the new tests, Mr. Blacksell has been able to assist in producing a volume of FMD reagents sufficient to service the needs of all the regional laboratories in Thailand until 1999.

Objective 2: To develop and use methods of population based research on animal health and production which will meet future international disease reporting requirements and provide information relevant to animal disease control.

Thailand

Cross-sectional studies

Seroprevalence surveys

Research initially concentrated on the development of techniques for FMD surveillance and serological monitoring of the official vaccination program. The new techniques are now in routine use in the Northern Region

Features of the technique include:

- A flexible methodology for serosurveillance applicable to virtually any developing country situation. This is achieved through the use of a two-stage sampling approach, in which the first-stage (selection of villages or herds) can be modified according to the sampling frame available (ranging from a good quality sampling frame with reliable livestock population data, through to no sampling frame at all).

- A new approach to first stage random sampling using random geographic coordinate sampling which allows the selection of a true random sample (of villages or herds) in the absence of a sampling frame. The new technique achieves greater accuracy at a lower cost than previously used techniques. The benefits of use of remotely sensed data (satellite images or aerial photographs to further improve the efficiency of the technique were also demonstrated).
- Compilation (and testing through simulation) of formulae for minimum sample size estimation, tailored to the variance structures of different livestock populations (resulting in significant cost savings for routine surveys run as part of a monitoring programme).
- A practical approach to the random selection of individual animals at the village level, effectively removing the danger errors due to selection bias.

These techniques were successfully field tested in Northern Thailand, and have since been implemented in other developing countries.

Disease incidence estimation

Prevalence data only provides some of the information relevant to animal disease control. The other key measure of disease required to monitor control programme progress, and for international reporting is disease incidence. Two approaches to the estimation of disease incidence were developed. Both are based on the use of village interviews to collect reliable retrospective disease outbreak data quickly and inexpensively. A number of methods developed in the area of participatory rural appraisal were modified and adopted to ensure the quality of data recalled by livestock owners is the best possible.

The first technique applies backwards recurrence time analysis, an analytical technique akin to survival analysis borrowed from sociology, to calculate measures of disease occurrence. The second technique uses capture/recapture techniques (developed in the field of ecology) to calculate incidence estimates based on two data sources (combining, for example, laboratory submissions or disease reports, with survey results).

Freedom from disease

In order to reap the full benefits at the completion of disease eradication programmes, developing countries must be able to demonstrate their freedom from disease. All trading countries are now required to provide soundly based evidence for their disease status. To support this, a new formula and survey approach was developed. The new probability formula is free from previous restrictive assumptions of a perfect diagnostic test or infinite population.

RapiCAPS (Rapid Computer-Assisted Prevalence Surveys)

The techniques developed have proven their value to developing countries through extensive field testing. One of the most significant outcomes of the work in this part of the project has been the development of a package which aims to bring the benefits of this research to the developing country veterinary services that most need them. The package, known as RapiCAPS and still under development, is a combination of computer software and a methodological manual. The software incorporates the entire complex statistical and data manipulation routines required to successfully conduct the disease surveys developed, freeing developing country veterinarians from the need for access to high-level statistical consultants. The planned manual will contain simple descriptions of the techniques, and will be suitable for use as part of epidemiology and surveillance training programmes.

Effective extension of the benefits of this research to other developing countries depends on the completion, publication and distribution of this package.

Table 3: RapiCAPS programs data input and output

Program	Inputs	Outputs
Two-stage sampling prevalence survey sample size calculator	Estimate of variance Estimate of prevalence Required accuracy Cost per animal Cost per village	Number of villages to be sampled Number of animals per village to be sampled
Village Random Selection from a sampling frame	Data file with villages (with or without size measure) Number of villages to be selected Simple Random Sampling or Probability proportional to size sampling	List of village identifiers and names, in the order they were selected
Random Geographic Coordinate sampling (with a paper map)	Latitude/Longitude of lines bounding the study area Number of points to select	List of random coordinates
Random Geographic Coordinate sampling (with a GIS)	Digitised map of study area, with any internal subdivisions used for stratification Number of points to select Radius of anticipated selection area	Table of random coordinates Map of random points Circles marking selection radius
Individual animal random sampling within a village Input	Total livestock owned by each village livestock owner Number or percent to be selected	List of owner IDs and animals to be selected
Prevalence survey analysis	Data file containing survey results, with animal ID, village ID, stratum ID, weight Number of animals in study area, Number of villages in study area,	Village and stratum proportions Total estimated proportion, Variance Confidence limits
Apparent to true prevalence calculator	Apparent prevalence Sensitivity Specificity Sample size	True prevalence Confidence interval
<hr/>		
Program	Inputs	Outputs
Survival analysis for comparison of disease occurrence	Data file containing village ID, time since last outbreak, censoring indicator, stratum ID, group, weight	Kaplein-Meier survival curves for two groups Logrank test value and p-value Hazard ratio and confidence interval
Design and analysis of surveys to prove freedom from disease (Sample size calculation)	Test sensitivity and specificity Population size Minimum expected prevalence Type I and type II error rate	Sample size
Design and analysis of surveys to prove freedom from disease (Survey analysis)	Test sensitivity and specificity Population size Minimum expected prevalence Type I and type II error rate Sample size Number of reactors	Probability that the population is free from disease

Longitudinal Studies

Because there is an emerging small commercial sector particularly in pigs, longitudinal studies of selected diseases to measure their biological impact and identify critical factors relevant to control were undertaken in representative herds.

Four small commercial piggeries and five poultry farms were enrolled in these studies. Blood samples collected during these studies were used to further evaluate the new diagnostic assays introduced to the NVRDC as part of the project. Analyses of the serological data confirmed the HC ELISA and AD Latex Agglutination tests were working well.

In addition, serology was used to evaluate vaccination programs which were found to be deficient in some instances and corrective actions were taken.

Australia

The severe drought in Queensland caused problems in the form of a delayed start up because of unwillingness of owners to muster cattle for both wide area surveillance and the longitudinal studies. In addition, four exotic animal disease outbreaks occurred in Queensland between September 1994 and December 1996. These incidents required the full time attention of the Drs. Baldock and Black for extended periods with some adverse effects on the project.

Wide area surveillance

The wide area surveillance studies commenced in 1994 and continued during 1995 and 1996. A total of 165 herds in Central Queensland were selected from the QDPI property list during this three year period using a stratified random sampling process with probability proportional to size of stratum. Because of the severe drought conditions, it was possible to sample only 129 of these herds from 14 shires by the end of 1996. Serological testing was completed for a range of diseases including Akabane, Pestivirus, Ephemeral Fever,

Bluetongue, Anaplasmosis, Babesiosis, Leptospirosis, Infectious Bovine Rhinotracheitis, Johne's Disease, Brucellosis and Enzootic Bovine Leucosis. Most diseases were not tested for in every year.

The results demonstrated that an active surveillance program is capable of collecting data

about a number of intrinsic and extrinsic host factors which may influence or be associated with disease occurrence in Queensland. The serological data provided more accurate measures of herd prevalence on a area basis than had been obtained from passively collected surveillance information in the past.

The findings from the project have been one of the key determining factors in the establishment of an active surveillance system by the Queensland Department of Primary Industries.

The additional information produced from the data collected in the active surveillance system can be used to improve animal health decision-making and the efficiency of beef production in the extensive grazing system in Central Queensland. In order for the active surveillance data to be used in decision making, a system of analysis involving simulation modelling was developed in Dr Ramsay's thesis.

It was found that in some cases it was not economic for producers to collect additional animal health information before making a decision to vaccinate their cattle for *Babesia bovis*. In other situations it was economic for producers to collect additional information.

The benefits from improved decision making were predicted to be distributed to several groups within society. If free trade were to take place, producers in Central Queensland would be expected to benefit but consumers would not. However, where quotas are in place consumers and the holders of quotas are also predicted to receive benefits.

Serum specimens collected on properties provided the most useful animal health information where they could be used to determine age specific seroprevalence. Serum samples collected from female cattle at slaughter could not be used to determine age specific seroprevalence. This was because most cows slaughtered had full sets of permanent teeth and their age could not be determined accurately. The passive data being collected in the Department of Primary Industries laboratory database were found to provide little information on the level of disease in beef cattle in Central Queensland.

Longitudinal Studies

Again, because of severe drought, only 3 herds were enrolled in the longitudinal study. These herds were located at Rockhampton, Blackwater and Rolleston in Central Queensland.

Cohorts of maiden heifers were identified in each herd and were sampled on four occasions over a period of up to two years. Heifers from two herds were artificially inseminated in December 1994 while those in the third herd were naturally bred in January 1995. Incidence density rates and cumulative incidence for Akabane virus, Bovine ephemeral fever virus, bluetongue virus and pestivirus were calculated for the three herds. Incidence density rates are shown in table 4.

Table 4: Incident Density Rates for seroconversions to four viral diseases of cattle in three herds in Central Queensland in 1994-1996

	Incidence density rates per 100 cattle years at risk			
	Akabane virus	Bluetongue virus	Bovine ephemeral fever virus	Pestivirus
Herd 1	36.23	37.31	63.40	92.55
Time at risk in cattle years	88.33	152.78	123.03	65.91
Herd 2	0	0	10.26	Not tested
Time at risk in cattle years	125.03	125.03	126.70	
Herd 3	0.70	1.13	13.31	3.64
Time at risk in cattle years	143.34	176.44	120.17	82.36

The low rates of seroconversion in two of the herds meant that the study lacked even more power than anticipated in investigating potential associations between seroconversion and reproductive performance in these herds. The analysis of data in herd 1 is continuing.

Data from both the wide area surveillance and the longitudinal studies was managed in a specially designed database. This database was developed at the QDPI Rockhampton laboratory using Microsoft Access. The procedure developed to extract data from the laboratory database for aggregation and further analysis has been used for a number of other projects in the QDPI.

Objective 3: To develop integrated data management systems within a GIS framework suitable for analysis and reporting of data both at a local and regional or national level.

GIS Development

A model system was developed at the NVRDC based on the 3 pilot provinces in northern Thailand, namely Lampang, Lamphun and Chiang Mai provinces. This model system provided the basis for the further development of information technology for animal health information management by the DLD. The information system was based on mainstream GIS technology with pcARC/INFO as the central software package. The database manager for pcARC/INFO is dBASE IV although it is possible to read any application files created in a compatible package such as FOXBASE which is presently used by the DLD for animal health information management.

A computer system of sufficient capacity and performance with map digitisation and GIS capabilities is now functional at the NVRDC. The system comprises an ACER brand IBM compatible computer using a Pentium processor running at 90 MHz speed and a 17 inch high resolution colour monitor. The machine is configured with 16 Mbytes RAM and a 540 Mbyte hard disc. It is linked to an A1 digitiser, A3 Roland colour plotter and A3 Hewlett

Packard colour ink-jet printer. The GIS package, pcARC/INFO is installed and running on the machine through the Windows operating system.

This computer system, when linked to the existing disease database at the NVRDC, provided the capability of producing computerised maps of disease distributions in the 3 provinces comprising the pilot area to assist with the evaluation of the need for such technology in the DLD. Initial difficulties in obtaining existing spatial datasets and hard copy maps for digitisation were overcome. Digitisation of the pilot study area is complete and several staff members at the NVRDC have been trained in map digitisation and data management. Once basic computerised mapping capabilities had been established at the NVRDC, more sophisticated spatial analysis techniques for animal health data were developed.

Two powerful Pentium computers with associated software and peripherals have been installed at the NVRDC. Base 1:50,000 maps have been used to digitise administrative boundaries, village locations and roads for the study area using the PC ArcInfo software package. Village attribute data have been obtained in electronic format from the NSO and Department of Interior (from surveys conducted by Thammasat University) village level censuses and incorporated into the GIS along with laboratory accession data using the software package dBase for Windows. Additional attribute data on land use has been

obtained from the United Nations Environment Program global environmental resource database (GRID). Output maps from the system are generated using the program ArcView 2.

Several of the staff at the NVRDC have been trained in using the system and Dr Yodyot Meepeuch from NIAH has had advanced training in GIS at the Department of Geographical Sciences and Planning, University of Queensland.

Development of the pilot GIS demonstrated that incorporation of this technology into the DLD's animal health information system was quite feasible. The focus of the GIS component of the project in the latter part of the project shifted to making the system more sustainable after completion of the current project. More DLD staff were trained in the use of GIS to give them the capacity, if required, to expand the coverage from the present three provinces to the whole of Regions 5, 6, 8 and 9. This expansion meant that both the NVRDC and SVRDC would have a fully operational GIS capability in addition to expertise and facilities within the epidemiology unit at NIAH for integration of the system at a national level.

The GIS studies have also shown that the accuracy of the existing laboratory accession database could be enhanced through use of predefined codes and some drop-down menu systems. This enhancement has been developed through existing project resources.

An additional focus of the GIS component of the project was the development of output formats of maps and reports (both on screen and in hardcopy relevant to DLD needs. These included the production of different map formats for displaying the distribution of livestock diseases, spatio-temporal visualisation of disease occurrence, disease outbreak management, use of the GIS for producing village random samples for active surveillance of livestock diseases of interest.

Database Development. The following data sources were identified and obtained: computerised laboratory submissions database from the NVRDC; computerised data from National Statistics Office for the three target provinces (village level data); UNEP land use data for Thailand; cross sectional village survey (round 1), special surveys carried out by the DLD Thammasat University village level survey; submission data from other Thai regional laboratories; meteorological data from the meteorological office.

Objective 4: To evaluate the economic implications of animal diseases and control options as well as the value of an animal health information system to Thailand.

A number of lines of inquiry were conducted in the economics component of the project, which may be grouped as follows:

Theoretical models of animal health economics

1. Optimal disease control effort: The earlier analyses of Mcinerney and others based on a loss-expenditure tradeoff appear to be inappropriate for infectious diseases where a threshold expenditure is needed to make progress in disease control. This implies that the optimal control expenditure on a disease may be zero or a very high level, rather than some intermediate point such as may be optimal with a disease such as mastitis. This reasoning would appear to apply to FMD control in Thailand.
2. Models of economic benefits (economic surplus) for disease control programs. Traditional economic models have been extended to take account of not only producer benefits, but impacts on traders, consumers of livestock products, government fiscal impacts, and trade gains from expanded foreign markets. The theoretical conditions for maximizing economic gain (e.g. in terms of demand elasticities) have been explored and identified. This conceptual analysis has been incorporated into a cost-benefit analysis of FMD control in Thailand.

Thai livestock industry studies

Data has been collected from various sources to develop profiles of livestock industries in Thailand, as a background to investigating production benefits and trade opportunities from improved animal health. Reports have been prepared for the meat cattle and buffalo, dairy, and pig and poultry industries. These reports have examined livestock numbers, management systems and disease status. Unlike cattle and buffaloes, the pig and poultry industries have clearly defined commercial and village sectors, and disease control in the latter presents considerable difficulty. The cyclical nature of village pig production raises difficulty for regular vaccination against FMD.

Socio-economic and environmental studies

The economics group has participated in surveys of Thai villages, and used cross-sectional survey data to carry out a socio-economic analysis of the role of livestock in villages. An understanding of socio-economic aspects is important in predicting the success of animal health intervention measures by government. The roles of women and of common property resources in the management of Thai village livestock production systems were also examined.

Macroeconomic analysis of livestock industries

A CGE model was applied to examine the relationship between output of the livestock sector (as influenced by disease control measures) and other Thai industries.

FMD global status

A review has been undertaken of the global status of foot-and-mouth disease in bovines. The prevalence of this disease in Asia and the need for a coordinated control program is notable.

Economics of animal health information systems

This research focussed on cost-effective multistage sampling designs for active surveillance of FMD protection status. The World Health Organisation recommended design of 30 villages and 7 subjects (in this case, animals) from each was found to be quite robust to variations in population protection status and sampling cost parameters. In active surveillance for FMD (tests of seroprevalence), there was a tendency for "natural" optima to arise with respect to sampling designs, due to cost discontinuities, e.g. where a maximum number of blood specimens can be collected per day.

No economic evaluation was carried out of the prototype GIS system which has been developed for three Northern provinces in Thailand. While this GIS work has demonstrated how to overcome various obstacles in development of a modern information system for animal health, the expenditure incurred on it would bear little resemblance to that on a national "production" system of animal health information, and Thai cooperators were not prepared to make available details of information system costs.

Collaboration in studies conducted through Chiang Mai University

Two small collaborative projects were established at the University of Chiang Mai, in the Departments of Agricultural Economics and Livestock Science and the Multiple Cropping Unit, with funding from Project 9204 and in collaboration with the UQ Economics Dept. These studies involved a survey of village livestock producers in Chiang Mai province (to be published as a discussion paper), and an intensive survey of animal health in dairy production.

Economic studies of animal health in Australia

The Australian component of the project has involved two studies.

1. Economics of animal health information in extensive cattle grazing systems. This formed the basis of Dr Gavin Ramsay's Ph.D. thesis.
2. Modelling of multi-species economic pest control. This work, which is a spin-off from ACIAR project 9204 rather than a direct component of it, has been conducted by Mr Rex Davis, and is continuing. Two discussion papers have been produced.

Cost-benefit aspects of FMD control and eradication in Thailand

This analysis, prepared as a monograph for ACIAR, integrates findings of other components of the project, and develops and applies a methodology for estimation of the net present value and benefit-to-cost payoff of the current Thai FMD control and eradication program. Although major data problems arose, the analysis provides indicative results that the program has a positive net present value and a benefit-to-cost ratio exceeding unity. However, it is doubtful that the rate of return on public funds is nearly as high as estimated in an earlier evaluation by Bartholomew and Culpitt (in 1993). The producer benefits appear to be smaller than would be anticipated on FMD eradication from a European perspective. As well, the potential for increased livestock and meat exports from Thailand as a result of FMD eradication appears rather limited. However, provided current control measures are continued and adapted as necessary, the Thai FMD program appears to be well justified when all categories of benefits (including reduced animal health expenditure, trade gains, transport and draught and animal welfare benefits) are taken into account. The importance of FMD eradication in Thailand becomes greater when viewed within a program of eradication in South-East Asia. Such a program may take several decades to achieve its goal.

Some lessons from the project

From the viewpoint of the economics component, this project faced a number of difficulties. While a project such as this would not be expected to be all "plain sailing", and language difficulties and data scarcity were inevitable, the difficulties were somewhat greater than anticipated. Important amongst these were:

- delay in signing the MOU in Thailand reducing the effective project duration and creating prolonged uncertainty as to whether funding would be extended into 1997 (in particular to allow Dr Ramsay to complete his Ph.D.).
- lack of biological data on FMD impacts in a village livestock sector where the disease is endemic (e.g. impact on reproduction rates and effect of compensatory weight gains).
- absence of staff in Thai livestock agencies with economics training, hence lack of understanding of the data needs for economic analysis.
- political sensitivity in Thailand about animal health issues. This led to unwillingness to disclose information about livestock disease incidence and expenditure on animal health programs, and to a period during the project where it was deemed inadvisable to make field trips to Thailand for project purposes.
- early termination of some of the data collection activities in Thailand, hence reduced access to survey data, associated with political sensitivities referred to above.
- unavailability of Thai postgraduate agricultural economics students to participate in field work in Thailand.

Persistent efforts at data collection were continued, and given the circumstances it is considered that reasonably representative data were obtained for economic assessment purposes.

ACIAR should be aware of the political difficulties facing economists when some of the issues they are investigating are sensitive internationally. Trade opportunities are closely linked to animal health status. A continuing political issue has been import of Thai poultry meat to Australia, where Australian producers have argued against imports on the grounds of risk of disease transfer. Thailand also faces scrutiny concerning animal health with regard to

live cattle exports to Malaysia. In these circumstances, there is naturally sensitivity in Thailand about foreigners obtaining information concerning disease cases. Estimation of the benefits of animal health programs requires detail on disease incidence. Underestimation and under reporting of disease incidence appears to be a universal phenomenon, and not confined to developing countries, due to various practical data collection constraints as well as political reasons. It is not surprising that Thailand would be loath to provide information for economic analysis, which could be inimical to trade prospects. Political sensitivity to data disclosure compounds the normal problems of data collection for diseases, the production impacts of which are not well understood in developing countries.

5. Use of Results

The main use of the results are summarised below:

- Diagnostic times have been reduced from weeks to hours for some important livestock diseases in Thailand.
- The QCEL computer program for quality control of ELISA systems has been developed and is in routine use at the NVRDC and transfer to other regional laboratories has begun.
- Improved sampling designs have been devised for serological surveillance and these are now being used routinely at the NVRDC for disease surveillance.
- The laboratory methods are now in routine use in Thailand and this will facilitate spillover to other countries in the region.
- The RapiCAPS system is being considered by OIE and FAO for general use in livestock disease surveillance throughout the world.
- Through associated training programs, there is a much better understanding of the integrated use of laboratory and field expertise in both surveillance and disease control right throughout the South East Asian region. This will contribute to a fundamental change in how livestock health agencies operate.
- The GIS system is in use in Thailand and provides a low-cost model for other countries in the region. The ACIAR project has provided core expertise in GIS in Thailand and laid the foundations for the further development of GIS in the DLD.
- In Australia, the approach to disease surveillance and substantiation of disease freedom has been challenged and this has led to a great deal of interest and further development of the issues. In Queensland, as already mentioned, active surveillance is now a formal component of disease surveillance.
- The disease prediction/vaccination model developed in this project has gained acceptance and is now being used by workers in the area of tick-borne disease control. Examples of this are the use of the model by the Tick Fever Research Centre in its

project "Assessment of the risk of tick fever mortalities in the northern Queensland beef industry" (de Vos, 1996) and by the Caribbean Amblyomma Program run by the FAO. The model developed in the project is also being evaluated for use in Zimbabwe by Charles Katsande of the Veterinary Research Laboratories, Harare, as part of his Masters research project at the University of Queensland.

- The village socio-economic survey has generated information of relevance to Thai livestock authorities in designing animal health programs and securing cooperation of livestock owners. This study found that villagers do not seek information concerning livestock diseases from DLD officers but rather approach village leaders, hence extension programs need to target these village leaders. The better educated livestock owners are more likely to take advantage of assistance available from DLD officers.
- The project has involved a comprehensive cost-benefit study of the economic impacts of FMD and the costs and benefits of eradication, in terms of the various impact categories. The economic evaluation of the Thai FMD control and eradication program indicates a number of factors which will help to assure success of the program. It is envisaged that these will be of assistance to Thai livestock authorities in disease control policy formulation. ACIAR have indicated an interest in producing this CBA report as a monograph. Dissemination of this report should provide useful methodology and insights into economic analysis of disease eradication for livestock authorities in South-East Asia.
- A computer simulation model was developed to evaluate alternative two-stage probability-proportional-to-size sampling plans for a range of disease incidence and sampling cost parameters. This research has been reported in a discussion paper, a condensed version of which was provided at the ISVEE conference in Paris in 1997, and a report is to be included in an ACIAR monograph being edited by Drs Sharma and Baldock. The model and findings from a number of simulation experiments should be of assistance in designing expensive active surveillance surveys.
- Dr Paul Riethmuller, UQ Dept. of Economics and Dr Gavin Ramsay have undertaken a research consultancy for the Food and Agriculture Organisation in South East Asia, and there are prospects of an edited book being commissioned by FAO on this work, with benefits to livestock agencies in the region.

- A training workshop was held in Lampang in January 1995, comprised of a CBA component provided by Dr Harrison and GIS component provided by Dr Sharma. About 15 Thai veterinary epidemiologists attended this workshop. A range of issues in economic analysis were covered over the week. This workshop was designed for capability building in Thailand with respect to economic evaluation of animal health programs. In that there appear to have been no Thai economic evaluations of the FMD control and eradication program, the workshop has hopefully raised skills levels and awareness with respect to economic evaluation of public sector programs in livestock industries in Thailand. The CBA component was documented in the form of a series of six discussion papers mentioned above.
- Staff at Chiang Mai University in Thailand have indicated that participation in the project changed the focus of their research to a greater emphasis on livestock economics, and that other research funds have subsequently been obtained in this research area.
- Training of students. Tom Murphy, who undertook his M. Agr. Econ. Studs. thesis as part of the project, was subsequently accepted as an M.Phil. student at Cambridge University, UK. Gavin Ramsay, who completed his Ph.D. thesis (supervisors Tisdell, Harrison and Baldock) has subsequently gained a number of national and international consultancies, and has been appointed as Principal Veterinary Officer in the Qld. Department of Primary Industries, in Rockhampton.

6. Publications

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7. Follow Up

Substantial follow-up has already occurred. A follow-up small one year project (ACIAR I PN 9683) in Lao PDR has carried over many of the findings from 9204. In addition, the experience and understanding of animal health information systems has led to the implementation of a low cost national animal health information system in Lao PDR.

As mentioned previously, discussions have been held with OIE staff in Paris and this may well result in widespread adoption of the new surveillance techniques developed during the project.

The surveillance techniques developed are already being implemented in the FMD eradication program underway in the Philippines with AUSAID support. This is being effected through the project manager, Dr Chris Baldock, who is the epidemiology consultant to the Philippines project.

It is intended to make revisions to the cost-benefit analysis of the Thai FMD control and eradication program once comments are received from Dr Lal, to bring the report to a publishable standard.

Five papers from the economic component of Project 9204 are being prepared for *Understanding Animal Health in Southeast Asia*, being edited by Drs Sharma and Baldock.

Work for FAO in South-East Asia by Dr Riethmuller drawing on outputs of this project is continuing.

The publication of an ACIAR monograph to be edited by Drs Sharma and Baldock is planned.

8. Other Activities

Four people were temporarily engaged for the project, three working in Thailand and one in Australia. In Thailand, an Australian, Dr Angus Cameron has been engaged as the Project Scientist in Thailand working under the auspices of the Australian Overseas Service Bureau as an Australian Volunteer Abroad. Dr Cameron is a veterinarian with a Masters degree and skills in computer science who is responsible for undertaking the field studies to collect epidemiological and economic data and for establishing the GIS at the NVRDC. His position description is attached in Appendix 6. Also in Thailand, two Thais were temporarily engaged, Mr Somsak Parisuttikul to assist in the virology laboratory with use of the new diagnostic assays and quality control and Ms Amnuay to assist Dr Cameron with data entry and map digitisation and Dr Chamnanpood with project administration.

In Australia, Dr Gavin Ramsay was engaged as the Project Scientist in Australia working as a Research Officer in the Department of Economics at the University of Queensland. He was responsible for assisting with the epidemiological studies in Australia and his position description is attached in Appendix 6.

Both Australians engaged in the project were enrolled in PhD studies at the University of Queensland. The advantage of this to the project was that they were more likely to stay for the duration of the project and not seek employment elsewhere in the final year which would have been disastrous. Dr Cameron is enrolled in the Department of Geographical Sciences and Planning supervised by Drs Shanna, Baldock and Chamnanpood and his work on the use of GIS in animal health forms the basis of his PhD studies. Dr Ramsay was enrolled in the Department of Economics supervised by Prof Tisdell and Drs Harrison and Baldock. His work on the value of information obtained from wide area surveillance and longitudinal studies formed the basis of his PhD studies.

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