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Working Paper No. 6

The Use of Serology to Produce Disease Information for the Economic Analysis of Disease in Extensively Grazed Cattle

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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.

The Use of Serology to Produce Disease Information for the Economic Analysis of Disease in Extensively Grazed Cattle

ABSTRACT

Economic studies require accessible accurate data on the occurrence of the disease being examined. In areas where this data is difficult to obtain, serological studies can provide considerable information. Serological data alone does not provide information on the number of cases of disease that have occurred. However, the annual incidence of seroconversion can be calculated from seroprevalence and, using knowledge of the disease dynamics, the number of cases of disease can be estimated. Where significant mortality due to disease occurs, additional techniques must be used to estimate the numbers that have died. This paper describes the development and application of a method to quantify disease effects from serological data.

Keywords: livestock disease, animal health, serology,

JEL Codes: Q160

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1. Introduction

Economic analysis of animal health data should provide public and private decision makers with easily understood information on the costs of disease and the benefits of disease control. To perform an economic analysis, in a cost effective manner, the data used in the analysis must be readily available. However, appropriate information may be difficult to obtain in areas where disease data is sparse, for example, where cattle are grazed extensively. In Australia a significant proportion of beef herds are pasture based. In the northern cattle raising areas, property management varies from very large extensive properties, where cattle are mustered annually and occasionally examined in the paddock, to smaller extensive herds, where cattle are mustered several times a year and examined more often in the paddock. In these areas, clinical disease is rarely detected and if seen is not always recorded and is rarely reported.

A system to collect animal health information, known as structured surveillance, is being set up in Queensland. Structured surveillance includes the collection of serum samples from young animals whose ages are estimated and the testing of these samples for antibodies to a variety of disease agents, including *Babesia bovis*, *Anaplasma marginale*, bovine ephemeral fever, bovine pestivirus, leptospirosis and Akabane virus.

Additional information, on disease occurrence, disease control activities and herd structure is collected from the producer. While the principal aim of structured surveillance is to provide a more accurate indication of the disease status of extensively grazed herds, to enable disease certification for trade purposes, this information can also be used to assist producers in defining disease control priorities.

Serological results alone do not provide sufficient data on which to base economic studies. This is because serological data does not provide information on the incidence or severity of clinical disease. In addition, any animals which may have died are not counted. However, serological data can be used, in association with pre-existing knowledge of age and breed susceptibility of cattle to overt disease following infection with a specific disease agent, to

estimate past losses, and to predict future losses, from the infection.

This paper outlines the development of a method which enables the use of serological data to provide information on disease occurrence that can be used in economic analysis.

2. Interpreting serological test results

2.1 Diagnostic Test Parameters

Serological data collected in a cross sectional study provides an estimate of the point prevalence of antibody positive animals within a population known as the apparent prevalence (AP). The apparent prevalence is a function of the true prevalence and the sensitivity (Se) and specificity (Sp) of the test being used (Martin 1984). If the sensitivity and specificity of the test are known, the true prevalence can be calculated using the following formula (Martin 1984):

$$\text{True Prevalence} = (AP + Sp - 1) / (Sp + Se - 1) \quad (1)$$

Provided that a test has a relatively high sensitivity and specificity and the prevalence of antibody titres is greater than 10% the apparent prevalence provides a useful estimate of the true prevalence (Martin 1984).

2.2 Calculating Incidence From Prevalence

As the effect of a disease on production can vary considerably with the age, physical condition, and reproductive status of the affected animal, it is necessary to convert the prevalence data to annual incidence.

Lilienfeld and Lilienfeld (1980) provided the following formula to calculate annual incidence from age specific prevalence:

$$\text{Incidence} = 1 - (10^{(\log(1-Pn)/n)}) \quad (2)$$

Where $\underline{Pn}$ is the prevalence in cattle aged n years.

This formula provides a reasonable estimate of annual incidence if: the risk of infection is constant over time and at all ages; immunity to infection is lifelong and always detectable; and mortality due to infection is negligible. McGowan et al (1992) used this formula to estimate annual incidence from seroprevalence data in a study of the economic loss

associated with bovine pestivirus infection.

It is important to note that this formula calculates the incidence of seroconversion and where significant mortalities occur, as for example, may be the case with *B. bovis* infection, additional methods must be used to estimate the number of animals that have died from the disease. In addition, if mortality due to the disease is high and varies significantly between age groups this formula may not be an appropriate estimator of the incidence of seroconversion.

As the annual incidence is the proportion of susceptible animals which seroconvert in a year, and the number of susceptible animals decreases each year, the proportion of animals in any age group which seroconvert in relation to the total number of animals in the age group will decrease with increasing age. The proportion of animals in an age group which seroconvert in a year can be calculated as (Houe and Meyling 1991,McGowan et al 1992):

Proportion seroconverting in nth year of life = $P_n - P_{n-t}$ (3)

Alternatively using probability theory it can be calculated as:

Proportion seroconverting in nth year of life = $(1 - P_{n-l})$ x annual incidence. (4)

2.3 Determining the Amount and Severity of Disease

In order to calculate the amount of disease that has occurred it is necessary to determine the clinical syndromes which follow infection with the disease agent and the proportion of infected animals which suffered from each of the clinical syndromes.

In order to make these calculations more clear an example using infection with *Babesia bovis* is used for the rest of the paper. The clinical syndromes following infection with *B. bovis* were placed into four categories, namely:

Category 1. Acute disease and death

Category 2. Chronic disease and death

Category 3. Subclinical disease with seroconversion

Category 4. Clinical disease with recovery and seroconversion

with p1 being the proportion of animals in Category 1, p2 the proportion in Category 2 and so on.

The annual incidence of seroconversion, calculated using the formula in the previous section, therefore, estimates the incidence in Categories 3 and 4 combined and the total number of animals in the age group that were exposed to *B. bovis* in the past year can be calculated as:

Total exposed = (p seroconvert x no. in age)/(p3 + p4) (5)

where p seroconvert is the proportion of all animals, in that age group, which seroconvert in a year, calculated using Formula (3) or (4), and no. in age is the number in the age group at the time of serum sampling.

If the proportion of animals, in each of the categories above following *B. bovis* infection is known, the number of animals, in a specific age group, in each disease category in the past year can be calculated using the following formula:

Number in category = total exposed x proportion in category (6)

Expert estimates of the proportion of cattle which would be in each of the four disease categories following infection with *B. bovis* were collected. Opinion was sought for two age classes: less than one year old and older than one year for each of three different types of cattle: *Bos taurus*, *Bos indicus* and *Bos taurus* cross *Bos indicus*.

A spreadsheet has been developed using the above techniques and Tables 1-4 provides an example of the use of these methods.

Table 1 Example: Assumptions

Seroprevalence:	50%	Age in Years:	2

Annual incidence (calculated from seroprevalence using Formula 2): 0.29

Table 2 Estimated age specific prevalences (calculated using Formula 3)

Age	Seroprevalence	Proportion seroconverting
1year	0.29	0.29
2 years	0.50	0.21
3 years	0.65	0.15
4 years	0.75	0.10
5 years	0.82	0.07
6 years	0.88	0.04

Table 3 Experts estimates of proportions of animals in each age group (used in Formula 5)

Less than 1year old	Bos taurus	Bos indicus	Bos tX Bos i
Subclinical	0.1	0.8	0.3
Clinical & recover	0.7	0.15	0.6
Acute die	0.2	0.05	0.1
Chronic die	0	0	0
Greater than 1year old			
Subclinical	0.1	0.8	0.3
Clinical & recover	0.5	0.15	0.55
Acute die	0.35	0.05	0.15
Chronic die	**0.05**	**0**	0

Table 4 Estimated numbers affected by different severities of disease in the past year (Calculated using Formula 6)

Bos taurus	Number in age group at	Subclinical disease	Clinical diseas	Acute disease and die	Chronic disease and die
Bos taurus					
1vear	100	3.66	25.63	7.32	0.00
2 years	100	3.45	17.26	12.08	1.73
3 years	100	2.44	12.20	8.54	1.22
4 years	100	1.73	8.63	6.04	0.86
5 years	100	1.22	6.10	4.27	0.61
6 years	100	0.86	4.31	3.02	0.43
Bos indicus					
1year	100	24.66	4.62	1.54	0.00
2 years	100	17.44	3.27	1.09	0.00
3 years	100	12.33	2.31	0.77	0.00
4 years	100	8.72	1.64	0.55	0.00
5 years	100	6.17	1.16	0.39	0.00
6 years	100	4.36	0.82	0.27	0.00
Cross bred					
1 year	100	9.76	19.53	3.25	0.00
2 years	100	7.31	13.40	3.65	0.00
3 years	100	5.17	9.48	2.58	0.00
4 years	100	3.65	6.70	1.83	0.00
5 years	100	2.58	4.74	1.29	0.00
6 years	100	1.83	3.35	0.91	0.00

As these figures are calculated retrospectively there will be more animals present in the herd 12 months before samples were collected than were present at sampling.

3. Further development

The spreadsheet is being expanded to predict future disease occurrence from serological data and to enable the effects of control measures on disease occurrence to be estimated. This will include the ability to allow for variations in the incidence of infection between years and to overcome difficulties associated with variations in mortality between different age groups.

The disease information produced will be linked with the production effects of the diseases and subsequently with economic models, such as those described by Tisdell and Ramsay (1995).

Validation of the outputs is being carried out.

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