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A SIMPLE SPREADSHEET SIMULATION MODEL OF THE ECONOMIC EFFECTS OF *NEOSPORA CANINUM* ABORTIONS IN DAIRY CATTLE IN NEW ZEALAND

Pfeiffer D.U.[1], Williamson N.B.[1], Thornton R.N.[1]

L'infection à Neospora est considérée comme une cause majeure d'avortements en élevage laitier dans un nombre important de pays dans le monde. La compréhension de l'épidémiologie de cette infection est encore très limitée. Grâce à un modèle simple utilisant un tableur informatisé, il a été possible d'identifier certaines zones où une information quantitative plus détaillée a été recueillie dans le but d'estimer les pertes économiques attendues lors de ce type d'avortements. En prenant en compte les données courantes, les pertes économiques annuelles de l'industrie laitière New-zélandaise peuvent être estimées à environ 16 millions de $ New-zélandais et les fermiers ayant des troupeaux infectés peuvent encourir des pertes de 2000 à 4000 $ New-zélandais chacun.

INTRODUCTION

Abortions caused by *Neospora caninum* infection are believed to result in major economic losses for dairy farmers in a number of countries around the world. These economic estimates are usually based on a number of assumptions and do not take account of any uncertainty. Computerised spreadsheets can be used to develop simple simulation models representing the factors influencing economic consequences of infection and abortion. This paper describes such a model which was developed to represent economic effects of *Neospora caninum* abortions for individual farmers as well as for New Zealand dairy farming on a national basis.

MATERIALS AND METHODS

The spreadsheet model consists of two functional components: one for infection dynamics at the herd level and the other representing the economic consequences of abortion losses at the individual herd and national level. Within-herd infection dynamics were simulated and taken up to a national scale based on estimates of the prevalence of infected herds. The within-herd model component of the simulation model uses existing information about individual herd size and infection prevalence in infected herds (see table I). The national herd model based on the same basic parameter settings is described in table II. The economic consequences of abortion were modelled taking into account milk production losses, loss of calves and replacement costs. The input parameters and the resulting economic calculations are presented in tables III and IV respectively. Assumptions regarding the actual risk of abortion in infected cows had to be made, as no quantitative data was available. It was decided to use the conservative estimate of 5%. The deterministic model described in tables I to IV was converted into a stochastic model by representing every parameter in the model, which was considered to be subject to variation, through an appropriate probability distribution. Normal distributions were used for parameters such as farm herd size, number of herds, within-herd prevalence, abortion and culling risk. Some of these parameters are possibly better approximated by other distributions. Events such as number of infected cows, abortions and cows culled was simulated using binomial distributions. Simulation runs based on 1000 iterations were conducted. The output from all iterations was used to generate probability distributions of expected annual economic loss for the dairy cattle industry in New Zealand dollars at a farm as well as at a national level. Sensitivity analyses were conducted to assess the importance of particular parameter estimates for the model output.

The spreadsheet software Microsoft Excel 97 (Microsoft Corporation, Redmond, WA, U.S.A.) in combination with the simulation add-in software @Risk version 3.5d (Palisade Corporation, Newfield, NY, U.S.A.) were used to develop the model.

Table I
Spreadsheet variables in within-herd model

Parameter	No. cows	Within-herd prevalence	Positive cows	Neospora abortion risk	Within-herd abortions	Proportion cows culled	Cows culled
Setting	200	0.35	70	0.05	4	0.6	2
Formula			=200*0.35		=70*0.05		=4*0.6

[1] Department of Veterinary Clinical Sciences, Massey University, Palmerston North, New Zealand

Table II
Spreadsheet variables for national dairy cattle herd

Parameter	No herds	Prevalence of infected Herds	No. infected herds	Cows at risk	Seropositive Cows	Total abortions	Total Cull Cows
Setting	15000	0.3	4500	900000	315000	15750	9450
Formula			=15000*0.3	=4500*200	=900000*0.35	=315000*0.05	=15750*0.6

Table III
Spreadsheet variables for economic input parameters

Milk payout		Animal values	
Fat	160.00 kg	Boner cow value	NZ$ 300.00
Price /kg	NZ$ 6.50	Replacement cow value	NZ$ 900.00
		Lost calf sales	NZ$ 64.00

Table IV
Spreadsheet variables for summary economic calculations

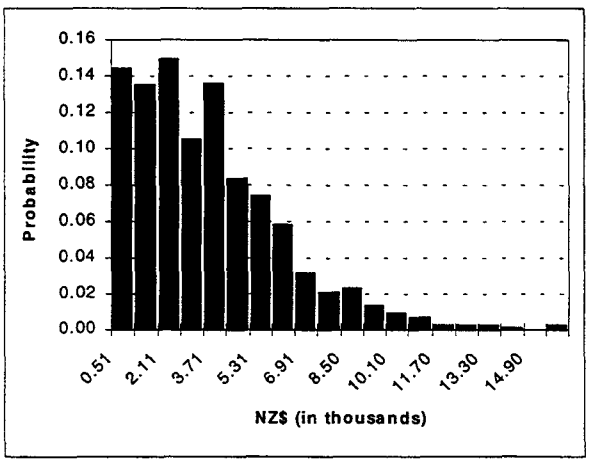
Proportion of cows		National		Farm	Formulas for farm
Full season lost	40%	NZ$	6,552,000.00	NZ$ 1,664.00	=0.4*4*160*6.5
Third of season lost	60%	NZ$	3,243,240.00	NZ$ 823.68	=0.6*4*160*6.5*0.33
	Cost culls	NZ$	8,505,000.00	NZ$ 1,800.00	=900*2
	Value culls	NZ$	2,835,000.00	NZ$ 600.00	=300*2
	Lost calves	NZ$	1,008,000.00	NZ$ 256.00	=64*4
	Total Loss	NZ$	16,473,240.00	NZ$ 3,943.68	

RESULTS

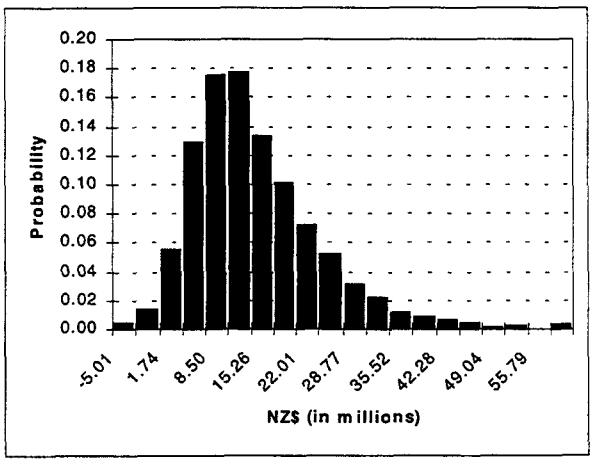
The deterministic version of the simulation model estimated an average annual loss of about NZ$ 16.5 million at a national and NZ$ 3900 at the farm level, based on the input parameters defined in tables I to IV. Introduction of stochastic parameters resulted in a predicted average annual economic loss for the dairy industry of about NZ$15 million with a maximum of about 60 million dollars (see figure 1b). At the farm level, losses were expected to vary between NZ$ 500 and NZ$ 17000 averaging about NZ$ 3900 (see figure 1a). A model sensitivity analysis revealed that model output was strongly influenced by the probability of an abortion given *Neospora* infection and the probability of a cow being culled as a result of an abortion as well as size of the cow herd (see figure 2). The first parameter was uncertain as no field data was available and the second is a management decision by farmers.

Figure 1
Probability distributions for expected economic losses from Neospora abortions

A: Farm level



B: National level



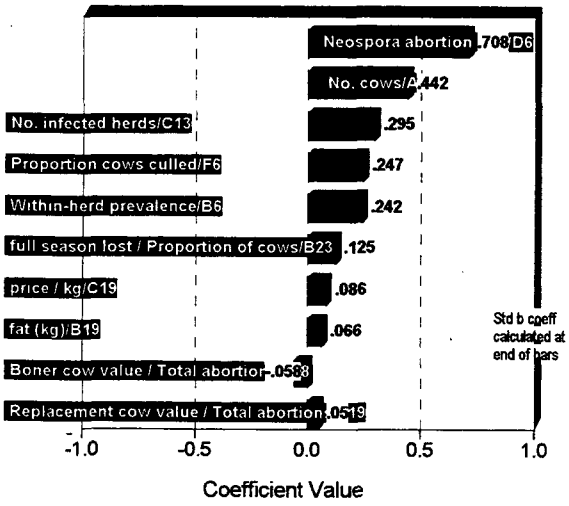


Figure 2
Results of sensitivity analysis for national herd presented as a tornado graph

DISCUSSION

The design phase of the model was extremely useful, as it was possible to define areas in the epidemiology of *Neospora caninum* infection/abortions where additional field studies were required. Once these studies have been conducted the model will be used to generate more accurate predictions of economic losses, and to evaluate the benefits of implementing particular control methods.

The results of the simulations strongly support the common belief that *Neospora caninum* abortions are very costly for dairy farming in New Zealand. This was the case although many model parameters were based on conservative estimates. The model can be used to produce output based on different input parameters, reflecting different views of the current understanding as to the correct quantitative estimates.

The development of this model demonstrates the usefulness of computerised spreadsheets for designing simple and effective epidemiological models without the need to develop advanced computer-programming skills. Given its simple structure and the use of meaningful input parameters / distributions it was also possible to discuss the model mechanisms and parameters with a group of experienced veterinarians who had only limited computer modelling skills. The model also shows that summarising expected outcome values using single values such as averages can be quite misleading, specifically if they are derived on the basis of a series of input values for whom the true value is unknown.