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MODELLING THE EFFECT OF MATERNAL TARGETED CULLING STRATEGIES ON THE FUTURE COURSE OF THE BSE EPIDEMIC IN BRITISH DAIRY HERDS

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Cet article décrit un modèle stochastique de troupeau qui a été utilisé pour prédire le développement de l'épidémie de l'encéphalopathie spongiforme bovine (ESB) dans les troupeaux de bovins laitiers du Royaume Uni. Il a été considéré que 10% des veaux nés de mères infectées dans l'année précédant l'apparition des signes cliniques ont été infectés. Trois scénarios différents ont été simulés, chacun avec 1000 itérations. Le scénario 1 n'impliquait aucune élimination sélective des veaux nés des mères cliniquement atteintes. Le scénario 2 considérait que tous les veaux nés des cas cliniques apparus à partir de 1987 seraient retrouvés et abattus. Le scénario 3 tenait compte seulement d'un abattage des veaux des cas cliniques diagnostiqués à partir de 1997. Les résultats montrent que chaque stratégie d'abattage serait associée à une réduction du nombre de cas maternels apparaissant après 1997. Toutefois ces stratégies auraient une influence faible sur le nombre total de cas d'ESB car la plupart des cas apparaissant après l'an 2000 continueraient d'être attribués à une contamination par l'affouragement. Des simulations complémentaires sont nécessaires pour évaluer la probabilité de cas occasionnels pouvant apparaître par suite de la contamination de veaux par des mères qui auraient été aussi contaminées par voie verticale.

INTRODUCTION

Stochastic herd models enable the simulation of disease within discrete groups of animals. These models also can take into account the influence of chance on the occurrence of disease. This approach offers a number of advantages over deterministic models in predicting the future course of the BSE epidemic in the United Kingdom. This paper describes a stochastic model that has been developed to describe the occurrence of clinical BSE in British dairy herds.

The recent announcement by the Spongiform Encephalopathy Advisory Committee (SEAC, 1997) that BSE may be transmitted maternally raises questions about the future course of the disease in the UK. SEAC estimated that maternal transmission probably occurs in less than 10% of calves born to dams which go on to develop clinical BSE. However, it is still unclear whether there is a variation in risk of infection depending on the interval between calving and the onset of clinical disease.

The United Kingdom is currently engaged in tracing and slaughtering birth cohorts of clinical cases with the intention of eradicating BSE at the earliest possible date. The effectiveness of this eradication policy may affect the length of time that the beef export ban imposed by the European Union remains in force. It is therefore important to determine the influence of maternal transmission on the duration of the BSE epidemic and to investigate the benefit of alternative eradication strategies which can prevent maternally derived clinical cases occurring in the future.

METHODOLOGY

A stochastic model was developed to describe the herd structure of a typical UK dairy herd (Tsutsui *et al.*, 1997). A disease model was superimposed on the herd model to represent a BSE infected dairy herd. The model relied on herd production parameters derived from the UK Holstein Friesan Society and the DAISY herd database (DAISY, University of Reading). Disease incidence figures were taken from MAFF data of actual clinical incidence rates in home bred UK dairy herds (MAFF, 1996).

It was assumed that maternal transmission occurred at a 10% transmission rate from infected dam to calf in the year prior to dams developing clinical disease. This assumption was based on the SEAC estimates and sensitivity analysis conducted with different transmission rates in the model (Tsutsui *et al.*, 1997).

The model was run for a 29 year period from 1987 to 2015. This enabled a validation of the model outputs against clinical incidence data available from MAFF for 1995. The model was then run 1,000 times to simulate the range of outcomes that might be expected in 1,000 dairy herds given the assumptions incorporated into the model and taking into account the effects of chance. This simulation is described as scenario 1 in the results.

The simulation was then repeated to examine the influence of two different maternally targeted culling strategies. Scenario 2 assumed that any animal in the herd which was found to have been born to a dam that had developed clinical BSE in the past 10 years would be culled in 1997. In addition offspring of any future cases of BSE in the herd would also be culled from 1997 onwards. Scenario 3 assumed that only future offspring of BSE cases in the herd would be culled. Both scenarios were simulated by running the modified model 1,000 times.

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RESULTS

The model predicted that with no culling policy targeted at offspring of clinical cases (scenario 1), the maximum number of cases would occur in 1992 and that the last case would be in the year 2005 (Figure 1). The model predicted there would be a total of 768 cases in a 1,000 herds from the year 1997 of which 40 were maternal infections (Table 1). With the scenario 2 culling policy, the number of clinical cases would decline to 687 with only three of these cases being maternal infections. Scenario 3 predicted a smaller decline in clinical cases to 752 of which 21 were maternal infections. Only scenario 2 succeeded in reducing the length of the epidemic with the last case occurring in 2004.

Figure 1
number of cases by year as a result of 1000 simulations with scenario 1

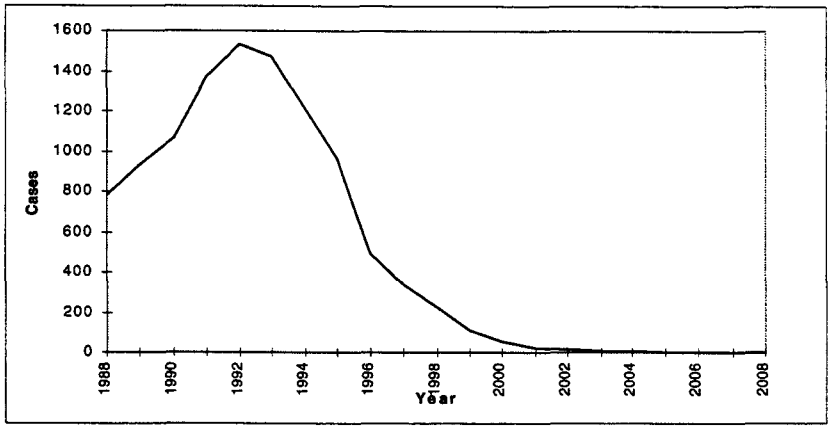

Table I
Summary results of 1000 simulations with different culling scenarios

	Scenario 1	Scenario 2	Scenario 3
Number of cases since 1997	768	687	752
Number of maternally derived cases since 1997	40	3	21
Year of last clinical case	2005	2004	2005
Number of cases saved since 1997	-	81	16
Number of animals culled per herd	-	4.23	0.72
Number of animals culled per case saved	-	52.2	44.8

Scenarios 2 and 3 did succeed in reducing the number of maternal derived clinical cases. However the cases saved represents only a small proportion of the total number of clinical cases because the cases derived from feed based transmission still accounted for the majority of cases after 1997. Small number of maternally derived cases were slipped though maternal targeted culling due to infected animals born to dams which were then culled from the herd before developing BSE.

The total number of animals that were culled in an average herd of about 80 adult cattle was 4.23 and 0.72 for scenario 2 and 3 respectively. The number of animals that had to be culled Scenario 3 was slightly more efficient at removing potential cases with 44.8 animals culled for each case saved as compared to 52.2 for scenario 2.

DISCUSSION

Predicting the future course of the BSE epidemic in the UK relies on a number of key assumptions concerning the epidemiology of the disease. Our results are based on the assumption that feed based and maternal transmission were the only routes of infection. Sensitivity analysis of the impact of maternal suggests that a 10% transmission rate would have a small effect on the duration of the epidemic (Tsutsui *et al.*, 1997). Anderson *et al.* (1996) also suggested that maternal transmission was unlikely to have any major influence on the number of future cases or the duration of the epidemic. However, our findings suggest that there will continue to be a few cases in the next century and these are likely to be of considerable political and trade significance. Stochastic herd modelling lends itself to the prediction of when these cases will occur and how best to limit their number by means of disease control strategies.

Our results indicate that only about 5% of cases that occur after 1997 are likely to be as a result of maternal infection. For this reason culling offspring of clinical cases only had a small influence on the total number of cases that could be expected after the year 2000. Slaughtering all offspring of clinical BSE dams both retrospectively and prospectively (scenario 2) reduced the number of maternal cases significantly but was less efficient in terms of animals culled per case saved than slaughtering offspring of infected cases that occurred from 1997 onwards (scenario 2).

Our initial findings represent the results of simulating 1,000 infected dairy herds. However, it is important to remember that in fact more than 30,000 UK herds have reported clinical cases of BSE. Given the stochastic nature of the model, it would therefore be necessary to conduct many more simulations to determine if

occasional cases, as a result of maternally infected dams infecting their own calves, were likely to occur after the main epidemic had disappeared. It would be useful to see whether maternal targeted culling policies might be an effective means of reducing the risk of these sporadic cases occurring after the main epidemic had been eradicated.

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