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RESULTS

After inoculation, the lambs reacted with typical signs of infection with *A. phagocytophilum,* i.e. fever, cytoplasmatic inclusions in phagocytes, and neutropenia. Infected lambs developed a positive antibody titre to *E. equi* between D7 and D14 (post-inoculation). No clear differences between the groups in clinical manifestations were observed. The highest number of infected neutrophils of group 2 lambs (infected with a full dose of AF336220 and 1:1000 of the dose of M73220) was observed on D6, while on D3 in the other two groups. Only variant M73220 was found in acutely infected lambs, except on D2 in group 2 where variant AF336220 was detected. Preliminary results indicate that only variant M73220 survives in lambs simultaneously infected with the two variants.

DISCUSSION

The present trial confirms that exclusion of *A. phagocytophilum* genotypic variants occurs in infected lambs and suggests that exclusion of genotypes is unidirectional rather than dose dependent. The interaction between genetic variants in both acutely and persistently infected lambs and the epidemiological implication of this phenomenon will be discussed further at the meeting.

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CHANGES IN WORM CONTROL PRACTICES ON WESTERN AUSTRALIAN SHEEP FARMS 1981 - 2002

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INTRODUCTION

Surveys to assess the use of agricultural practices provide "point-in-time" snapshots of what farmers do on their farms. The results can then be compared across regions or over time. Often, comparisons over time allow an assessment to be made about the efficacy of extension campaigns to change such practices.

Gastro-intestinal nematodiasis is a serious production-limiting disease affecting Australian sheep and is further complicated by the widespread occurrence of anthelmintic resistance (1). Awareness of anthelmintic resistance has driven extension efforts to modify the worm control practices employed by farmers.

Surveys in the 1980's in Western Australia, estimated worm control practices and showed high levels of benzimidazole and levamisole resistance (3, 4). These findings initiated the "CRACK" campaign, which aimed to limit anthelmintic resistance. With the rising prevalence of ivermectin resistance detected in the 1990's, an extension campaign to modify summer drenching practices was commenced early in 2001-2002.

This paper compares five surveys of worm control practices conducted between 1981 and 2002 and discusses the changes against the extension campaigns waged.

MATERIALS AND METHODS

Data used in this paper from the surveys prior to 2002 have been published elsewhere. The surveys of 1981 (3), 2001 (5) and 2002 were conducted by mail questionnaire. The survey of 1982-84 (4) was conducted by personal interview with respondents on a randomly stratified basis. The survey of 1988 (2) was by telephone interview.

The survey of 2002 studied diarrhoea in sheep, by means of a questionnaire distributed by agribusinesses to their clients. Respondents were mainly from the Great Southern region. The questionnaire contained 25 questions regarding farm and enterprise descriptors, worm control practices and the incidence of diarrhoea and dag in sheep.

Statistical testing was by comparison of means and standard errors, or by Chi square tests for independence, with Bonferonni corrections for multiple tests.

RESULTS

The results of the 5 surveys being compared are shown in Tables 1 and 2. There was a significant difference between the number of flock anthelmintic treatments recorded in the survey of 2001 (5.07±0.25, range 2-21) and that of 2002 (4.17±0.16, range 0-8). There was also a difference in the number of summer flock treatments with only 2 of 132 respondents in the 2001 survey not conducting summer drenching, whereas 14 in the 2002 survey did not ($P=0.002$).

Table 1. Change in number of anthelmintic flock treatments by sheep class/age.

Number of flock treatments over a 12-month period		Ewes		Lambs		Weaners / Hoggets		Wethers	
1981 survey	Mean	3.41^{at}		3.70^{bu}		3.77^{cv}		2.39^{dtuv}	
n=584	SEM	0.11		0.15		0.21		0.11	
	Range	0-10		0-4		0-9		0-12	
2002 survey	Mean	1.02^{awx}		1.4^{bwy}		1.14^{cz}		1.78^{dxyz}	
	SEM	0.04		0.04		0.04		0.06	
	Range	0-2		0-4		0-3		0-3	
	n	133		133		127		99	
"Summer" treatments	No.	'81	'02	'81	'02	'81	'02	'81	'02
Farms (n) giving "Summer" treatments (Nov to Mar)	0	35^{e}	40^{e}	89^{g}	17^{g}	37^{i}	29^{i}	69^{k}	14^{k}
	1	145^{f}	91^{f}	75^{gh}	98^{gh}	82^{j}	94^{j}	142^{l}	99^{l}
	2+	181^{ef}	2^{ef}	174^{h}	18^{h}	183^{ij}	4^{ij}	92^{kl}	21^{kl}

Superscript letters indicate significant differences ($P<0.05$) between entries.

Table 2. Frequency of conducting ancillary worm control practices.

	1982-84	1988	2001	2002
Conduct resistance tests		39/300^{a}		52/134^{a}
Use WECs to monitor worms		39/300^{bc}	101/126^{bd}	109/135^{cd}
Rotate drenches annually	19/75		44/114	
Practice quarantine drenching		146/216	54/118	36/83
Dose based on heaviest in mob	28/116^{ef}	210/300^{eg}	104/114^{fg}	
Weigh sheep before drenching		171/300^{h}	97/119^{h}	
Calibration of drench gun		240/300	66/80	

Superscript letters indicate significant differences ($P<0.05$) between entries.

DISCUSSION

The number of flock anthelmintic treatments ('drenches') has been significantly reduced. Drenching frequency was considered to be the main cause of anthelmintic resistance in 1981 and the major thrust of the "CRACK" extension campaign of the 1980's was to implement summer drenching, in order to reduce the need for winter treatments. With the rising prevalence of ivermectin resistance, came an understanding that strategic summer treatments in a Mediterranean climate reduce "refugia" for winter active worm species. Thus, an extension campaign to modify summer drenching commenced in Western Australia in 2001. The aim was to reduce the number of summer treatments and move the timing of them to either end of the summer period (1). Table 1 does not show the change the "CRACK" campaign made in summer drenching practices, although the results of the 2001 survey do indicate its impact. The results of the revised campaign are already seen in the 2002 survey, with the increase in the number of farmers not practicing summer drenching.

In 1981, wethers received less drenches than other sheep classes, whereas in 2002 they received more, when a larger proportion of farmers gave two summer drenchings to wethers. This may be because the extension campaign to modify summer drenching has focused on the other classes (ewes, weaners and hoggets).

There has been a steady increase in the proportion of farmers testing for worms in sheep. This may be overstated, as in the 2001 survey, of all farmers having conducted anthelmintic resistance testing in the past 3 years, this proportion was approximately 3% of the state's sheep producers (5).

Ensuring that sheep were administered the correct dose was a substantial part of the "CRACK" campaign. There has been an increase in the proportion of farmers performing these practices over the study period.

There has been no change in the use of quarantine drenching or of annual rotation of drench classes, probably reflecting the lack of emphasis on these aspects of controlling anthelmintic resistance in extension campaigns.

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A COMPUTER SIMULATION MODEL FOR THE CONTROL OF PARASITIC GASTROENTERITIS IN SHEEP

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INTRODUCTION

The complex epidemiology of parasitic gastroenteritis (PGE) in sheep is directly influenced by a number of factors, which in turn influence the development of immunity and the selection pressures that increase the potential for anthelmintic resistance (AR) to develop. The development of sheep nematodes with resistance to one or more anthelmintic groups is increasingly reported worldwide (8). In temperate climates, including the UK, AR has been slower to develop, but nevertheless threatens effective European sheep productivity. Several recommendations have been made to limit the development of AR (2, 7); there have been however, few studies to monitor their efficacy in the field under temperate European conditions. A number of computer models have been developed to predict the efficacy of nematode control strategies and the rate of development of AR (1, 3, 4, 5). As these models have been developed for use in sheep parasite control strategies in southern hemisphere countries, few relate to northern, temperate climates, where there is considerable variation in management and husbandry systems and differing patterns of anthelmintic usage. The aim of the project was to develop a user-friendly computer model for use in the design of integrated control strategies for sheep PGE and to predict the potential for such strategies to select for AR.

MATERIALS AND METHODS

Model Design. The model is programmed in STELLA, a software system, which uses a multi-level hierarchical environment for model construction. The software provides two major layers, a high-level mapping layer and a model construction layer. Layering within the software system allows complex interactions and repeat generic model structuring with the ability to create high level maps that facilitate user interaction.

Model Validation. Data for model validation was derived from on-farm monitoring of sentinel farms in different regions within the UK. This work is ongoing, but provides information on PGE through monitoring of pasture larval levels and faecal egg counts in both ewes and lambs (6). Nematode populations were screened for the presence of anthelmintic resistance using either faecal egg reduction or larval development (8).

RESULTS

A computer model has been developed that describes the population dynamics and epidemiology of PGE nematodes of sheep, based on literature reviews with data incorporated into equations that drive information around the model. In the model, the parasite life cycles have been built to interact with a sector describing flock dynamics relevant to UK farms. For ease of use, a user-friendly interface has been