New Zealand Veterinary Journal

ISSN: 0048-0169 (Print) 1176-0710 (Online) Journal homepage: www.tandfonline.com/journals/tnzv20

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To cite this article: Gordon K.SweatmanPh.D. (1962) The importance of the New Zealand campaign against *Echinococcus granulosus* and *Taenia hydatigena* on the prevalence of *Taenia ovis* , New Zealand Veterinary Journal, 10:5, 93-98, DOI: 10.1080/00480169.1962.33468

To link to this article: https://doi.org/10.1080/00480169.1962.33468

Published online: 23 Feb 2011.

NEW ZEALAND VETERINARY JOURNAL

VOLUME 10 OCTOBER, 1962 NUMBER 5

THE IMPORTANCE OF THE NEW ZEALAND CAMPAIGN AGAINST *ECHINOCOCCUS GRANULOSUS* AND *TAENIA HYDATIGENA* ON THE PREVALENCE OF *TAENIA OVIS*

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AN IMPORTANT ASPECT of the campaign in New Zealand directed against *Echinococcus granulosus* and *Taenia hydatigena* is its possible effect on the prevalence of *Taenia ovis*. The burying of offal to eliminate *E. granulosus* and *T. hydatigena* is recommended as being preferable to cooking it and feeding it to dogs. The drastic reduction in the number of European rabbits (*Oryctolagus cuniculus*) in many districts has also virtually eliminated an important dog-food. Consequently, in addition to commercial products, many farmers are relying on more sheep carcass-meat than previously as a source of dog-food. Other things being equal, conditions would seem ideal for an increase in the prevalence of *T. ovis*. This is particularly significant to New Zealand which depends so much on a meat export trade. Damage to this on account of *T. ovis* could in turn prejudice a campaign directed against *E. granulosus* and *T. hydatigena*.

Hydatid control officers throughout the country dose almost all dogs with arecoline hydrobromide three times a year. This procedure removes many *T. ovis* worms which could conceivably offset the significance of new infections acquired from carcass-meat. This paper compares the changes in incidence of *T. ovis* and *T. hydatigena* in New Zealand dogs following their recurrent treatment with a taeniacide over a 16-month period of the current campaign against *E. granulosus* and *T. hydatigena*. Some observations are also included on natural infections of *T. ovis* cysts in New Zealand sheep.

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Materials and Methods

Each of the 84 regional hydatid control authorities (except urban areas) has been assigned to one of the three major types of farming in New Zealand according to which is predominant under that authority (Fig. 1). It will be appreciated, however, that no single type of farming occurs under any one authority to the exclusion of the other two. The three types are dairy farming, extensive sheep (wool and store) farming, and concentrated sheep (fat lamb) farming. Both types of sheep farms have usually four or five dogs, but dairy farms generally have one or two. Dairy farms almost always carry some sheep for home-slaughter and must dispose of offal and carcass trimmings.

Arecoline hydrobromide is given to dogs by hydatid control officers at the dosage rate of 2 mg/kg body weight, and all faecal samples are submitted to the National Hydatid Testing Station for diagnosis. Dogs given arecoline hydrobromide must pass a liquid or semi-solid faecal stool containing some intestinal mucus before worms, even if present, are excreted in it. This was demonstrated for *E. granulosus* by Batham (1946) and no doubt applies to other tapeworms as well. Forbes and Whitten (1961) demonstrated that the number of dogs which failed to pass a satisfactory sample under the conditions used by the hydatid control officers in New Zealand was 34 per cent. when arecoline hydrobromide tablets in gelatin capsules were used, and 19 per cent.

when this chemical was given as a drench with saccharin as a flavouring agent. For the first three-quarters of the current survey, the hydatid control officers used tablets, and drench was used in the last quarter. Faecal samples from dogs which failed to purge were obtained by soap and water enema (200 ml) or by arecoline hydrobromide enema (0·5 mg/kg body weight made up as a solution containing 3 mg arecoline hydrobromide per ml). The former was used during the initial period of this survey and the latter during the last quarter. According to Forbes (pers. comm.), the arecoline enema, when administered 45 minutes after oral drenching, induced the excretion of some mucus from the small intestine in 36 (75 per cent.) of 44 dogs. This could, therefore, conceivably enhance the chances of expelling tapeworms. The above critique suggests that the maximum number of faecal samples satisfactory for diagnosis would be between 66 per cent. and 81 per cent. Additionally, the efficiency of arecoline hydrobromide in the removal of *T. ovis* and *T. hydatigena* under different conditions has not been assessed, although in the laboratory Forbes (pers. comm.) observed 100 per cent. removal of both species of tapeworms in a few dogs given arecoline hydrobromide in a drench with saccharin. Furthermore, there were inevitable errors in diagnosis and some worms, for various reasons, were unidentifiable.

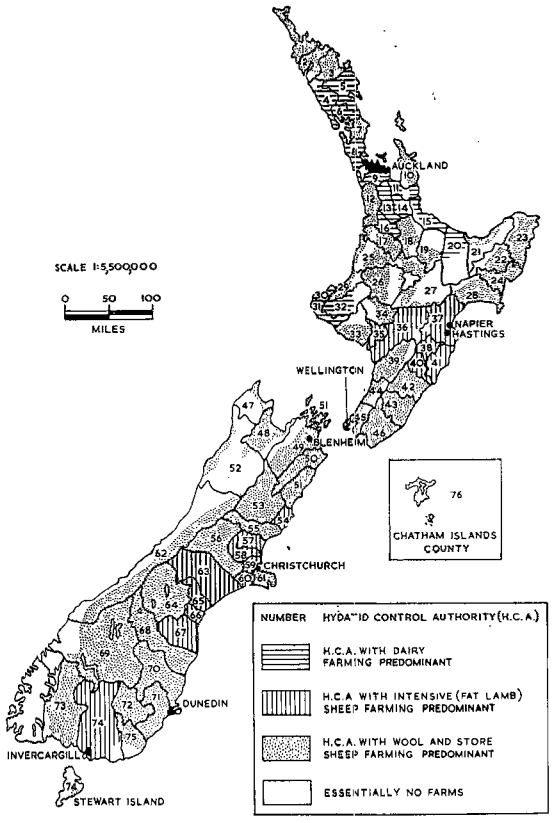

FIG. 1: *Distribution of the hydatid control authorities and the type of farming which predominates in each.*

The long taeniid tapeworms in New Zealand dogs include *T. ovis, T. hydatigena, T. pisiformis* and rarely *Multiceps* spp., which, as a group, are separated initially by the diagnostic technician from E. *granulosus* and *Dipylidium caninum*. Although *E. granulosus* would demonstrate the ingestion of raw offal by a dog, it was thought to be less desirable than *T. hydatigena* for this purpose in the case of the present survey because *T. hydatigena* was more common, and even a single adult worm would be seen by the diagnostic technician, whereas a light infection of *E. granulosus* could be overlooked.

If more than a single long taeniid tapeworm was present, the diagnostician examined only one worm when there may have been a mixed infection. The criteria used to separate the long tapeworms from one another were rostellar hook length, prominence of the genital pore, and sometimes the number of uterine branches in the gravid proglottid*. Rostellar hook length separated *T. pisiformis* from the rest. There was overlap, however, in the hook length of *T. hydatigena* and *T. ovis* at one end of the scale and between *T. ovis* and *Multiceps* spp. at the other. *T. ovis* was distinguished from the other two by the very conspicuous genital pore which, from experimental infections, appeared reliable (Sweatman and Henshall, unpublished data). By contrast, the

*In the survey papers by Gemmell (1958) and Forbes (1961) for the South and North Islands respectively, hook length was primarily used to separate the various tapeworms (pers. comm. from authors) so that their figures for *T. ovis* and *T. hydatigea* may have been lower and higher respectively than they should have been.

genital pore was only rarely prominent in *T. hydatigena* and *Multiceps* spp. Sometimes use was made of the number of uterine branches in the gravid proglottid since only half as many occurred in *T. hydatigena* as in *T. ovis* and *Multiceps* spp. During the period of this survey, the identification of *T. ovis* and *Multiceps* spp. was confirmed by the present writer following their initial identification by the staff of the National Hydatid Testing Station. It was deemed unnecessary to check the identification of *T. hydatigena*.

A total of 636,661 faecal examinations were made during the 16-month period beginning June 1, 1960. The hydatid control authorities were in different stages of organization and their hydatid control officers were on different dosing rounds during the period. The data, however, have been compiled according to the dosing round number. A dosing round extended over a 4-month period and, ideally, included all dogs in a district. In practice, the second round almost always included more dogs than the first, but thereafter the numbers fluctuated within fairly small limits.

Results

NATURAL INCIDENCE OF *T. ovis* CYSTS IN NEW ZEALAND SHEEP

Observations on *T. ovis* cysts in sheep were made at a freezing works for two weeks in June, 1960. The animals were raised in intensive sheep (fat lamb) areas on the plains of Canterbury Province. Routine meat inspection procedures were used which included an examination of the heart, although cardiac infections were not referred to the carcass from which they came. The muscular part of the diaphragm was inspected together with a cursory examination of the carcass. Masseter muscles were not examined.

A total of 16,662 lambs were examined, of which only two were condemned because of the presence of more than two cysts in the carcass, while one or two cysts were seen in the hearts of 258 (1·6 per cent.) and/or in the carcasses (including diaphragms) of 251 (1·5 per cent.). Only a single adult sheep among 4,178 was condemned, while infections were seen in the hearts of 57 (1·4 per cent.) and/or carcasses (including diaphragms) of 117 (2·8 per cent.) of these. These results suggest that standard meat inspection procedures show the incidence of *T. ovis* in lambs and sheep under conditions of farming, where infections by this parasite might be highest in New Zealand, to be less than 3 per cent. even in adult animals.

Wide fluctuations occurred in the incidence of *T. ovis* in lambs from different properties. One farmer sent in 115 lambs of which 32 (28 per cent.) were infected and seven (6 per cent.) condemned. Thirty-six lambs from another property had 18 (50 per cent.) infected and two (6 per cent.) condemned.

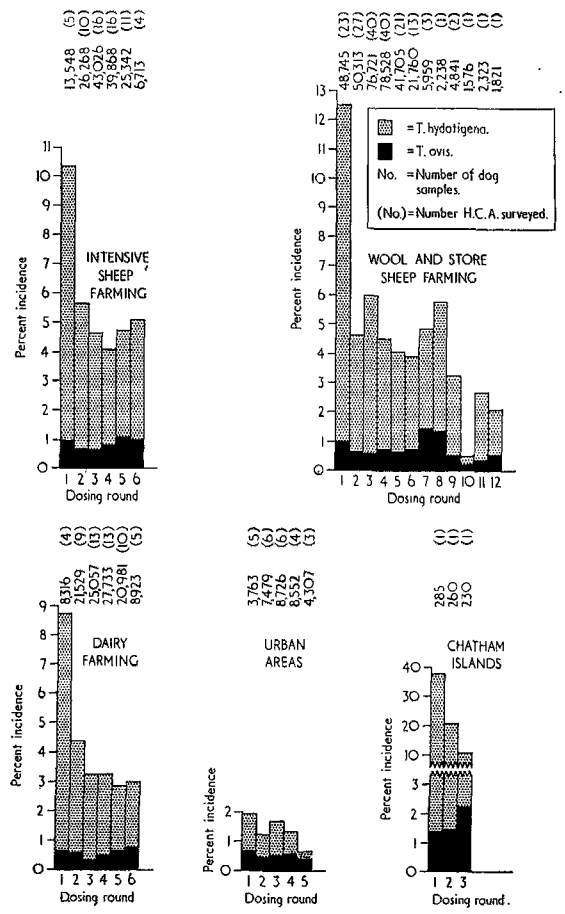

FIG. 2: *The comparative change in incidence of* T. hydatigena *and* T. ovis *in dogs seen at 4-monthly intervals in the different hydatid control authorities.*

RELATIVE INCIDENCE AND GEOGRAPHIC DISTRIBUTION OF THE STROBILATE STAGE OF *T. ovis* AND *T. hydatigena*

Taenia hydatigena and *T. ovis* were seen throughout New Zealand. Figure 2 shows that the highest initial incidence of *T. hydatigena* was 38 per cent. and occurred on the Chatham Islands. The initial incidence of this tapeworm was lower (9 to 12 per cent.) in the farming districts of the North and South Islands, presumably because of different local conditions and also on account of the activities of voluntary workers and individual farmers before the first visit of the hydatid control officer. All three types of farming districts throughout New Zealand showed a marked drop in the overall incidence of *T. hydatigena* from the first to the second round. The Chatham Islands showed a further drop in incidence with the third visit of the hydatid control officer, but, on the two main islands, the overall incidence of *T. hydatigena* in all farming regions fluctuated irregularly after the first dosing round between 6 per cent. and less than 1 per cent. The same dogs or farms were not necessarily incriminated from one dosing round to the next.

The overall incidence of *T. ovis* for the three farming types from round to round never fluctuated to any extent and was never more than 3 per cent. Only on the Chatham Islands was there a slight rise in the overall incidence of *T. ovis* concomitant with a drop in the incidence of *T. hydatigena* from one dosing round to the next.

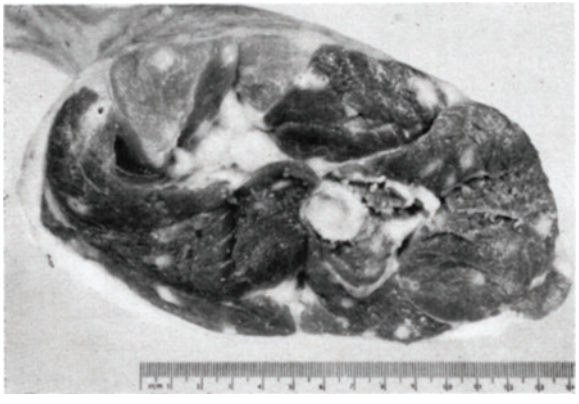

FIG. 3: *Cross-section of the hind leg of a sheep with a generalized* T. ovis *infection.*

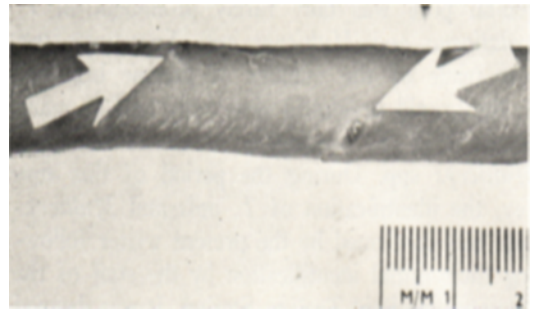

FIG. 4: *Two* T. ovis *cysts in the oesophagus of a sheep which had a heavy general infection.*

Some urban control authorities (Fig. 2) include a few farms (Metropolitan Auckland, 30 farms; South Auckland City, 245; Wellington, 4; Christchurch, 8; Dunedin, 174; Invercargill, 43) while others have no farms (Napier, Hastings, Blenheim, Picton). However, as no differences in the results occurred between the two, the results for both are combined in Fig. 2. The incidence of both *T. hydatigena* and *T. ovis* in dogs remained about the same from one dosing round to the next and was less than 2 per cent.

The above results demonstrate no clear interrelationship between the incidence of *T. ovis* and *T. hydatigena* in dogs in any rural or urban hydatid control authority during a 16-month period of the current New Zealand campaign directed against *E. granulosus* and *T. hydatigena*.

INCIDENCE OF *T. ovis* IN RABBIT-DOGS AND PIG-DOGS

In New Zealand, there are 204 rabbit destruction boards. These occur in 46 of the 84 hydatid control authorities. Under the control of each board, there are between one and 23 packs of rabbit-dogs with an average of 8 dogs in a pack. The dogs operate on farmland and their diet frequently includes raw sheep carcass-meat (Sweatman and Williams, unpublished data). In spite of this, only 15 of more than 2,000 rabbit-dogs were found infected with *T. ovis* as demonstrated following their purgation with arecoline hydrobromide.

Dogs are used for hunting pigs in widely separated parts of New Zealand and they traverse many different properties during the course of the hunt. Many of these also ingest raw sheep

carcass-meat. *Taenia ovis* was seen, however, in only two of 233 pig-dogs after their treatment with a vermifuge by hydatid control officers.

It seems clear that, since both rabbit-dogs and pig-dogs are infrequently infected with *T. ovis,* the part these animals play in the continuity of this tapeworm cycle is only a minor one.

Discussion

The drop in incidence of *T. hydatigena* (Fig. 2) in farm dogs following the first dosing round of the hydatid control officer suggested that more raw offal was eaten by New Zealand dogs before his first visit. Subsequently, however, the overall decline in the incidence of *T. hydatigena* was only barely detectable and there was no way to determine whether these small differences were attributable to the ingestion by the dogs of less raw offal or to the direct effects of recurrent treatment with a taeniacide. The incidence of *T. ovis* fluctuated within low limits regardless of the type of farming that predominated in the various hydatid control authorities. If it is assumed that increasing amounts of carcass-meat are being fed to dogs as the campaign against *E. granulosus* and *T. hydatigena* progresses, this has not as yet increased the incidence of *T. ovis* in dogs, perhaps because of the periodic vermifuging of the dogs by the hydatid control officers. In urban areas, where only a few dogs were infected in the first place, there was no suggestion that the campaign was having any overall detectable effect. This survey indicates that the campaign as it now operates has greater difficulty in reducing the incidence of infection when only a few dogs are initially infected than when the initial incidence is high.

FIG. 5: T. ovis *in a sheep's heart.*

The more or less constant low incidence of *T. ovis* throughout New Zealand should not detract from controlling the parasite on individual farms or in local areas which have a *T. ovis* problem. Many of these are known, in so far as lamb and sheep infections are concerned, mainly because rejected carcasses cause considerable economic loss, selling at about 2d. per pound compared with the export lamb price of about 24d. Where there is a problem, a simple procedure of inspection could be followed by the farmer without the necessity of boiling all carcass-meat before feeding it to dogs. Sweatman and Williams (unpublished data) demonstrated that, in very heavy infections, the cysts of *T. ovis* were distributed throughout the muscular system (Fig. 3), sometimes even occurring in the oesophagus (Fig. 4). In heavy infections (more than 70 cysts), some cysts always occurred in the heart (Fig. 5), diaphragm (Fig. 6), and the external masseter muscles. In light infections, cysts almost always occurred in one or more of the above muscle groups. If these three muscles were examined at the time of home-slaughter, it might well be that almost all infected carcasses would be detected.

The observations of Sweatman and Williams (unpublished data) showed also that it was unnecessary to cut the heart since, when there was

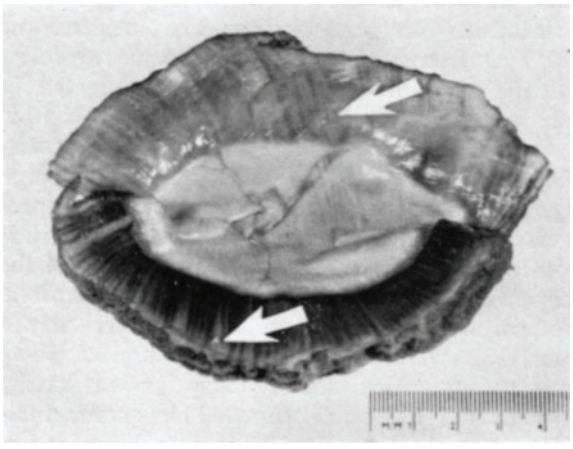

FIG. 6: *Two* T. ovis *cysts in the diaphragm of a sheep.*

only a single cyst in this organ, it occurred on the surface. In practice, however, cutting the heart would be desirable if for no other reason than to ensure that the heart was handled adequately for examination and removed from the pericardium. The muscular part of the diaphragm, which is generally left attached to the carcass after the entrails have been removed, could be readily examined. The only change that most farmers would need to adopt would be to remove the skin from the external masseter muscles (both sides) in order to incise them. There is no problem in differential diagnosis. *Sarcocystis* spp., the only possible cause of misidentification in New Zealand is readily distinguished by its thin, elongate lesion from the larger, more rounded *T. ovis* lesion. For practical purposes, carcass-meat from a sheep could be fed raw to dogs in which the heart, diaphragm and external masseter muscles were found negative for *T. ovis*. Their inspection on the farm would probably reduce the prevalence of *T. ovis* and at the same time would not prejudice the campaign against *E. granulosus* and *T. hydatigena*.

Summary

The incidence of *Taenia ovis* cysts in more than 20,000 sheep and lambs detected by the standard New Zealand meat inspection procedures showed an overall incidence of less than 3 per cent. The incidence on individual farms, however, reached as high as 50 per cent.

The adult stages of *T. ovis* and *T. hydatigena* were seen in dogs in all parts of New Zealand following taeniacidal treatment. There was a drop in the incidence of the strobilate stage of *T. hydatigena* following the first dog-dosing round of the hydatid control officers in the hydatid control authorities covering all farming districts. Subsequent taeniacidal treatment at 4-monthly intervals, however, demonstrated no change in the overall incidence of this tapeworm. In urban authorities, the incidence of *T. hydatigena* was always low and did not display the initial drop of the farm authorities. The overall incidence of *T. ovis* in dogs did not change during the period of observation, being consistently below 3 per cent.

The possible effect of the New Zealand campaign against *Echinococcus granulosus* and *T. hydatigena* on the prevalence of *T. ovis* is discussed, and a simple method is proposed for carcass inspection to detect *T. ovis* on farms.

Acknowledgements

Appreciation is extended to M. A. Gemmell, Hydatid Research Unit, New Zealand Medical Research Council, A. D. M. G. Laing, Chief Executive Officer, National Hydatids Council, and G. Cardoza, National Hydatid Testing Station, for making available the parasites and records used in this survey. Hydatid control officers throughout New Zealand made the original collections and submissions to the National Hydatid Testing Station. Technical assistance was provided by Mrs B. R. Clarke, Miss L. A. Duncan and D. Weston.

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