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# CONTROLLING TICK INFESTATIONS AND DISEASES IN SHEEP BY POUR-ON FORMULATIONS OF SYNTHETIC PYRETHROIDS. A FIELD STUDY

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ABSTRACT

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The use of synthetic pyrethroids in pour-on formulations reduced tick infestations and the incidence of tick-associated diseases in lambs more than dipping in organophosphate acaricides. Though the use of pyrethroids did not prevent the lambs from being infected with tick-borne fever (TBF), the incidence of lambs with lameness (tick pyaemia) or lambs suddenly found dead (*Pasteurella haemolytica* septicaemia), which often are seen in association with TBF, was reduced. The use of pyrethroids for three years did not seem to affect the prevalence of TBF.

*Keywords*: *Erlichia* (*Cytoecetes*) *phagocytophila*, insecticide, *Ixodes ricinus*, pour-on, pyrethroids, sheep, tick-borne fever

## INTRODUCTION

Tick-associated diseases are a major problem in coastal areas of southern Norway. The loss of lambs on *Ixodes ricinus*-infested pastures is significantly higher than that on tick-free pastures (Øverås *et al.*, 1985). This increased loss is associated with tick-borne fever (TBF), a disease which is known to predispose animals to secondary infections. In Norway, tick pyaemia (*Staphylococcus aureus*) is the most important of these but a close relationship is also observed between *I. ricinus* activity and septicaemia caused by *Pasteurella haemolytica* (Øverås, 1971, 1983).

The efficacy of prophylactic measures like dipping sheep in organophosphorus acaricides has been limited. However, synthetic pyrethroids have been reported to be effective in reducing and controlling tick infestations (Mitchell *et al.*, 1986; Taylor and Elliott, 1987).

This study was undertaken to examine the effects of synthetic pyrethroid treatment on tick-borne diseases and lamb losses in this part of Norway.

## MATERIALS AND METHODS

The ten flocks studied were kept on spring pastures infested with *I. ricinus* and all had a history of tick-borne diseases. Veterinarians attending these flocks had observed many cases of tick-pyaemia/polyarthritis (lameness) and septicaemic pasteurellosis (sudden death).

The flock size ranged from 20 to 60 ewes, with an average of 70 lambs in each flock. The breeds Dala, Rygja and Old Norse were represented. The lambs were born indoors, the average date of birth being 24 April. The flocks were put out onto tick-infested, bushy, hill pastures at the beginning of May, by which time the lambs were 2 to 6 weeks old. Some of the farmers moved their flocks to tick-free mountain pasture in the middle of June, while others had only tick-infested areas available for the whole grazing season.

The common practice was to treat the animals with acaricides once a year, prior to the flock being put out to graze on the tick-infested pasture.

In 1985 and 1986, dipping in the organophosphorus acaricide diazinon (Neocidol$^{R}$, 0.025% w/v; Ciba-Geigy) was used in all the flocks, only the lambs usually being treated. In 1987, some flocks were treated with pour-on pyrethroids instead of traditional dipping, and in 1988 and 1989 pyrethroids were used in all the flocks.

The pour-on preparations were applied to the skin along the midline of the back. The dosage was 5 ml for all formulations and animals, irrespective of age. Formulations used were 1% w/v flumethrin (Bayticol$^{R}$; Bayer) in flock A, 2% w/v cyhalothrin (Coopertix$^{R}$, Coopers) in flock B, and 1% w/v deltamethrin (Coopersect Spot-on$^{R}$; Coopers) in the eight flocks C to J (see also Table I).

Five flocks were on the register of the Norwegian Sheep Recording Scheme (NSR) in 1985 and all ten were registered by 1988 (see Figure 1). Farmers participating in this scheme are usually considered to be among the most professionally interested and active members of the sheep farming community.

The lambs were individually tagged and weighed at the end of May and again in September/October. Individual weights were corrected for several parameters: sex, age, and single or twin lambs (Eikje, 1971). In addition, NSR annually compute the average daily weight gain for each flock. The data available from NSR were obtained for the years 1985–1989.

Each farmer was asked to estimate the number of ticks observed per lamb, and the number of diseased lambs. In particular, they were asked to provide details about lame lambs with arthritis and about the number of lambs found suddenly dead on spring pasture during the years in which traditional dipping was used as compared to the years when pour-on pyrethroids were employed.

These farmers' observations covered only the time during which the animals were exposed to ticks, whereas the NSR data covered the whole season.

In 1988, two groups of lambs in each of four flocks were closely observed. In these flocks, 10 lambs were treated with pour-on formulation (T-group), while 10 were left untreated (U-group). All the other sheep, approximately 40 ewes and the rest of the lambs, were treated. Flock A was treated with flumethrin, flock B with cyhalothrin and flocks C and D with deltamethrin (in flock D there were only six lambs in each group). The T- and U-groups were not separated from the rest of the flock but they wore ear-tags of different colours and were easily identifiable. The owners were instructed to count ticks of all stages on the head, axillae and inguinal regions on these lambs and were also offered free veterinary services if the lambs became ill. In the autumn, blood samples were taken from the lambs for serological investigation. Weights were obtained from NSR.

In order to ascertain the prevalence of TBF from year to year, serum samples were collected in 1987 (five flocks, in June and after tick exposure), 1988 (five flocks, in October) and 1989 (six flocks, in October and December). From 8 to 20 lambs in

each flock were sampled at random. The testing started in the year that pyrethroid treatment was introduced, and pyrethroids were used in subsequent years. Sera were examined for antibodies against *Ehrlichia* (*Cytoecetes*) *phagocytophila*, the causative agent of TBF, by the indirect immunofluorescent antibody test (IFA) (Paxton and Scott, 1989; Hardeng, 1991). Sera collected from September onwards were tested at a dilution of 1:128. To avoid positive reactions due to maternal antibodies, sera collected in June were tested at a dilution of 1:4096. At this titre, a positive sample would probably indicate an active infection (Hardeng, 1990).

Means and 95% confidence intervals for the years were computed from the data on the average daily weight gain and on the percentage of lambs lost during the season for each flock. For 1987, the calculations were done separately for the different regimes.

A personal computer program (Proprietary Software Release 6.03) (SAS, 1985) was used to perform a Wilcoxon rank-sum test on the live weights of the lambs in T- and U-groups.

## RESULTS

Figure 1 shows the average daily weight gain with 95% confidence intervals based on the annual results obtained from NSR. Some tendency towards better results can be seen for the years in which pyrethroids were used compared to traditional dipping.

The observations made by the farmers during the spring pasture period are listed in Table I. In the years in which dipping was used, ticks were usually found on the animals after 1 week. After the introduction of pour-on pyrethroids, the owners observed no ticks during the 4–6 week period on spring pasture. Also, with pyrethroid treatment, lameness was only observed in one case in each of two flocks, and sudden death in lambs was found in only one flock.

No ticks were observed in either the T- or U-groups on the spring pasture. Statistical analysis of the live weight differences between the T- and U-groups revealed no significant differences. There were lambs with antibodies against *E. phagocytophila* (TBF-positive) in all four flocks, and in both groups. In the pooled T-groups, 24 out of 34 treated lambs (two lambs missing) were TBF-positive, while in the pooled U-groups, 20 out of 31 untreated lambs (five lambs missing) were TBF-positive.

The results of testing for the prevalence of TBF in the years 1987–1989 are presented as annual means with 95% confidence intervals in Figure 2.

In the flock sampled in December 1989, 17 out of 21 lambs were positive 6 months after tick exposure. This indicates that at least 80% of naturally TBF-infected lambs can have antibodies 6 months after infection.

## DISCUSSION

Until recently, dipping in diazinon before exposure to tick-infested pasture has been the only prophylactic measure available but its effect on ticks in Norway has been reported to be doubtful (Berge and Søgnen, 1985). Our results indicate that prophylactic treatment with pour-on pyrethroid is superior to dipping in reducing

tick-borne diseases in lambs. Furthermore, dipping is laborious and local pollution from dips containing organophosphate acaricides presents an environmental problem. The cost of pour-on pyrethroids per individual equals about 0.1 kg of mutton, and the procedure is less time-consuming than the traditional dipping methods.

TABLE I

Farmers' observations of the number of ticks on each lamb and the percentage of lameness and sudden deaths in the flocks for the years before and after the introduction of pour-on pyrethroids. Treatment: Dip = dipping in diazinon. Pour-on: F = flumethrin, D = deltamethrin, C = cyhalothrin

| FLOCK | Before / After | Number of ticks | Lame-ness % | Sudden death % |
|---|---|---|---|---|
| A | Dip | 5-10 | 1-2 | 0 |
| | F | 0-1 | 0 | 0 |
| B | Dip | 5-10 | 2-5 | 0 |
| | C | 0-1 | 0 | 0 |
| C | Dip | 5-10 | >20 | 2-5 |
| | D | 0-1 | 1-2 | 0 |
| D | Dip | 10-20 | 5-10 | 0 |
| | D | 0-1 | 0 | 0 |
| E | Dip | 2-5 | >20 | 5-10 |
| | D | 0-1 | 0 | 0 |
| F | Dip | 5-10 | 1-2 | 1-2 |
| | D | 0-1 | 0 | 0 |
| G | Dip | >20 | 5-10 | 2-5 |
| | D | 0-1 | 0 | 0 |
| H | Dip | >20 | 5-10 | 5-10 |
| | D | 0-1 | 0 | 0 |
| I | Dip | >20 | >20 | 5-10 |
| | D | 0-1 | 0 | 1-2 |
| J | Dip | 10-20 | >20 | 1-2 |
| | D | 0-1 | 1-2 | 0 |

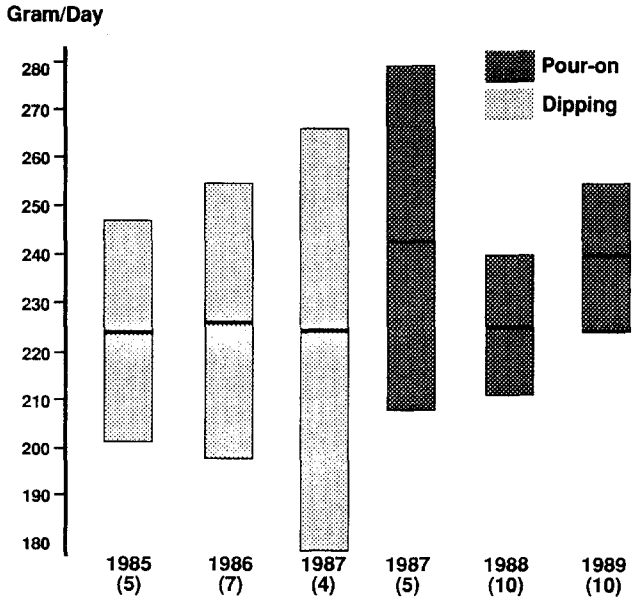


Figure 1. Average daily weight gain in grams for each flock. Means with 95% confidence interval. Based on NSR data. (Number of flocks in brackets below)

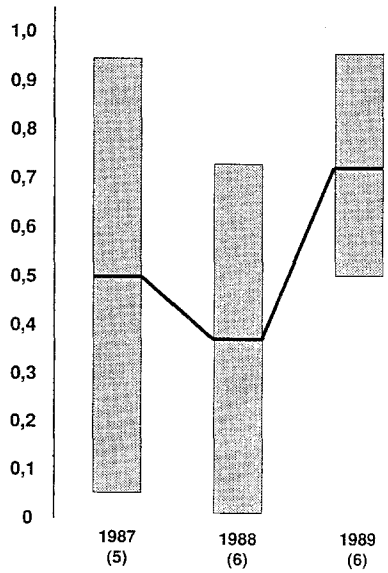


Figure 2. Prevalence of TBF in the flocks. Means with 95% confidence intervals. (Number of flocks in brackets below)

Synthetic pyrethroids in pour-on formulations have been reported to be active against ticks for 3–6 weeks (Mitchell *et al.*, 1986; Taylor and Elliott, 1987).

Because of the carrier, the mode of spread of pour-on formulations over the skin

may differ from that of dips. Moreover, the spread of flumethrin pour-on formulations has been shown to be markedly increased by the animal's own movements (Hamel and Van Amelsfoort, 1986; Stendel, 1986) and contact spread from animal to animal will probably take place. McEwan Jenkinson and colleagues (1986) found that one pyrethroid, cypermethrin pour-on (Barricade; Shell), spread in the stratum corneum. They suggested that the active ingredient is transported in an emulsion of sebum and sweat in the intercellular channels. The compatibility of the active ingredient and its carrier medium to the sweat/sebum emulsion may be better in the oily pour-on formulations than in traditional dips.

A radical reduction of ticks on the animals after the use of pour-on pyrethroid was observed by the farmers in this study. Since such a reduction was also observed in the untreated groups in 1988, this may have been due to an absolute reduction in the tick population on the pastures caused by the adverse local climate. Nevertheless, other flocks in the same area still suffered heavy tick infestations and we consider that the 10 'untreated' lambs in the flock were in fact 'treated' by the transfer of active substance owing to the close physical contact with treated lambs. Furthermore, we did not find any difference in weight gain between T- and U-groups. This is in contrast to Watson *et al.* (1966), who found weight differences in twins when one twin was dipped and the other left as an untreated control. This lack of difference in weight may also be due to smearing of pyrethroids from treated to untreated lambs. Foster (1968) showed reduced tick infestation after dipping, coinciding with reduced severity of TBF. He found dead and moribund ticks on the dipped lambs and suggested that the reduced quantity of *E. phagocytophila* inoculated or an inoculum of diminished virulence could explain the milder symptoms. We consider that a reduction in the number of feeding ticks leads to fewer ticks inoculating the agent, thus reducing the infective dose of *E. phagocytophila*.

Webster and Mitchell (1989a) have shown that *I. ricinus* may be a mechanical vector of *S. aureus*. The reduction in cases of tick pyaemia seen in the present study may thus have been due to decreased inoculation of *S. aureus* by a smaller number of ticks.

The examination of TBF-antibodies confirmed that *E. phagocytophila* was present in the area. None of the formulations used in this trial prevented the transmission of *E. phagocytophila*, as the treated lambs also appeared to have been infected. Even though the owners did not observe any ticks on the sheep, some ticks able to transmit TBF must have been present. In some of the flocks most lambs had seroconverted after 3 weeks of tick exposure, including those treated with pyrethroid, suggesting that the transmission of infection was high. Similar observations have been reported by other authors. Webster (1987) concluded that use of the pyrethroid cyhalothrin had no effect on the incidence of TBF, and Foster (1968) found that all the lambs dipped with organophosphate acaricide were also infected with TBF.

Although there was a drop in the prevalence of TBF from the first to the second year of treatment, the mean prevalence during the third year of treatment was higher than in the first year (Figure 2). Thus, after 3 years of treatment there was no apparent trend. However, if transmission of *E. phagocytophila* is to be avoided, the control of ticks must be extremely efficient, preventing any ticks from attaching for more than 24 hours. MacLeod (1936) reported that two female ticks attached for 24–48 hours are sufficient to transmit TBF. Webster and Mitchell (1989b) found a high prevalence of TBF infection in ticks captured on pastures in Scotland, *E.*

*phagocytophila* being demonstrable in about one-third of unfed nymphs and adults.

Thus TBF is easily transmitted, young lambs are infected after a few days on pasture, and the infection rate in ticks is probably high. Hence the effect of acaricides on the prevalence of TBF is minor, a situation confirmed by our findings.

The apparent reduction in clinical disease observed by the owners, together with the continuing high rate of seroconversion, indicate that, while the animals were infected with TBF, few cases of secondary disease occur. The high infection rate of TBF in ticks makes it virtually impossible to eradicate the disease but treatment with pyrethroid pour-on formulations seems to be a reasonable way to reduce losses.

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