Effect of Eprinomectin Treatment at Calving on Milk Production in Dairy Herds with Limited Outdoor Exposure

F. Sithole,¹ I. Dohoo,¹ K. Leslie,² L. DesCôteaux,³ S. Godden,⁴ J. Campbell,⁵
H. Stryhn,¹ and J. Sanchez¹

¹Department of Health Management, Atlantic Veterinary College, University of Prince Edward Island, 550 University Avenue, Charlottetown, Canada C1A 4P3

²Department of Population Medicine, Ontario Veterinary College, University of Guelph, Ontario, Canada N1G 2W1

³Département de sciences cliniques, Faculté de médecine vétérinaire, Université de Montréal, St-Hyacinthe, Quebec, Canada J2S 7C6

⁴University of Minnesota, College of Veterinary Medicine Large Animal Clinical Sciences, St. Paul, 55108

⁵Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, Canada S7N 5B4

ABSTRACT

The objective of this study was to determine the effect of anthelmintic treatment at calving in herds that were totally or semiconfined during the summer. In totally confined herds, lactating and dry cows were housed throughout the summer and had no access to pasture. In semiconfined herds, lactating and dry cows had limited outdoor exposure to a small pasture or paddock but were still fed a ration that met all their nutritional requirements. The study was carried out between February 2002 and February 2003 in 65 herds enrolled with DHI and distributed in 4 regions in Canada and 1 state in the United States. Cows were randomly allocated to receive eprinomectin or a placebo, with treatment being administered on or close to day of calving. In May and June 2002, 8 fecal samples were collected from each farm and fecal egg counts (FEC) were determined. Monthly bulk tank milk samples from each farm were tested with an indirect ELISA using a crude *Ostertagia ostertagi* antigen. Monthly test-day milk production data were recorded for 200 d after calving. In general, FEC were very low (mean = 1 egg per gram, range = 0 to 27). Mean herd bulk milk ELISA optical density ratio (ODR) values for the whole year ranged between 0.22 and 0.80. The ODR values were dichotomized into high and low using a threshold of 0.5. Treatment effects were analyzed using a linear mixed model with herd and cow as random effects. The analysis was restricted to 4789 cows (23,956 test-day records) treated between 21 d before and 7 d after calving. Overall, there was no significant effect of treatment. However, there was a tendency for an interaction between treatment and ODR, as illustrated by a larger numerical difference in

treated vs. untreated cows in high-ODR herds than in low-ODR herds. However, the confidence intervals for the treatment effects (kg/d of milk per cow) in high-ODR herds (−0.33 to 1.10) and in low-ODR herds (−0.53 to 0.14) were wide and included zero. Therefore, this study failed to show a beneficial effect of eprinomectin treatment in these totally or semiconfined herds.

(Key words: eprinomectin, milk production, ELISA, fecal egg count)

Abbreviation key: EPG = eggs per gram, FEC = fecal egg count, ODR = optical density ratio.

INTRODUCTION

Many studies have shown that deworming adult dairy cows has beneficial effects on milk production. A meta-analysis done by Sanchez et al. (2004) reported a mean increase of 0.46 kg of milk/cow per d in 75 clinical trials, although an adjustment to eliminate publication bias reduced this value to 0.35 kg of milk/cow per d.

Eprinomectin is a third-generation macrocyclic lactone dewormer that is suitable for use in dairy cows because the low milk partitioning coefficient (Shoop et al., 1996) associated with it alleviates the need for a milk withdrawal period. A recent study identified a 0.94-kg/d per cow increase in milk production when cows were treated at calving with eprinomectin pour-on, especially in dairy herds exposed to pasture (Nodtvedt et al., 2002). However, the effect of eprinomectin on milk production in herds with little or no exposure to pasture has not been investigated.

Fecal egg counts (FEC) have been used for a long time to measure parasite burden but are an inaccurate measure of worm burden in adult animals (Agneessens et al., 2000; Borgsteede et al., 2000). An ELISA test using a crude *Ostertagia ostertagi* antigen (Keus et al., 1981; Sanchez et al., 2002a,b) has been used to evaluate worm burden in several studies (Kloosterman et al.,

Received July 28, 2004.

Accepted November 22, 2004.

Corresponding author: Fortune Sithole; e-mail: fsithole@upe.ca.

1996; Sanchez et al., 2002a) and has been found to be a better measure of worm burden than FEC.

There have been claims in the past that cow-to-cow contamination of gastrointestinal nematode larvae occurs during housing (Carmel and Todd, 1979) but there has also been strong evidence refuting these claims (Herd et al., 1980). Two bulk tank milk ELISA optical density ratio (**ODR**) surveys conducted in Atlantic Canada showed that the ODR values found in some herds that were not exposed to pasture during summer were unexpectedly high (Guitian et al., 1999; Sanchez and Dohoo, 2002). This led to the question whether milk production in cows that had limited or no exposure to pasture would be increased by anthelmintic treatment.

The primary objective of this study was to determine if treatment of dairy cows with eprinomectin at the time of calving had any beneficial effect on milk production in herds that kept their adult cows in total confinement or provided limited outdoor exposure. The secondary objective was to determine if FEC or ELISA were able to identify herds in which a treatment effect would be expected.

MATERIALS AND METHODS

Herd Selection

The study was a randomized clinical trial performed in 65 herds between February 2002 and February 2003. There were 5, 9, 16, 12, and 11 dairy herds enrolled in the Canadian provinces of Prince Edward Island, Nova Scotia, Ontario, Quebec, and Saskatchewan, respectively. Another 12 dairy herds were enrolled in Minnesota, United States. Originally, 68 herds were recruited into the study, but 3 dropped out, 1 each in Ontario, Quebec, and Saskatchewan. The Ontario and Quebec herds dropped out at the beginning of the study. The Saskatchewan herd dropped out in the middle of the study after some bulk tank milk and fecal samples had been collected. Therefore, those data were included only in the assessment of parasite burdens and not in the analysis of milk production.

Cows in this study were Holsteins and classified as either totally or semiconfined. Totally confined herds were those in which lactating and dry cows were housed throughout the summer and had no outdoor exposure. Outdoor exposure for the lactating and dry cows in the semiconfined herds was limited to a yard or paddock; nevertheless, the cows were still fed a ration that met all of their nutritional requirements. In other words, the composition and quantity of stored feeds (components or TMR) fed to lactating or dry cows was not changed when the cows went outside. The herds had to be enrolled with the DHI organization and access to those data had to be available. They were also required

to provide monthly bulk tank milk samples through the dairy laboratory or through on-farm collection. No anthelmintics could have been administered to lactating-age cows during the summer of 2001. There were no restrictions on housing type for heifers in selected herds.

Selection of herds into the study was based on their proximity to a veterinary school or collaborating veterinary clinic. Five collaborating clinics were identified in the Atlantic provinces (Prince Edward Island and Nova Scotia), 2 in Saskatchewan, and 1 in each of the other 3 study sites. To detect a difference of 0.5 kg/cow per d of milk between eprinomectin- and placebo-treated cows in a study with 80% power, a sample size of 4688 cows was needed (half from each confinement group). Another goal was to balance the number of totally and semiconfined herds. The parameters ($SD = 6.17$ kg/d, within-cow correlation = 0.32) used in the sample size calculation were based on the results of the clinical trial by Nodtvedt et al. (2002). Because some attrition from the study was anticipated (given the low level of study technician supervision), a starting sample size of 6000 cows was planned. Based on the assumption that the average herd size was 100 cows, selecting 12 herds per study site ensured that the attrition-corrected sample size of 6000 cows was met. A minimum of 40 and a maximum of 300 milking cows per herd were set for participating herds. Within each study site, no more than 4 herds were to be >150 cows to avoid the influence of a small number of large herds on the study. During the study period, 4 follow-up visits and monthly phone calls were made to ensure that the study protocol was being followed. Data related to herd size, cow and heifer housing, and other management practices were recorded.

Treatment Protocol

The dose of eprinomectin pour-on (5 mg/mL) per cow was calculated based on a 725-kg cow, with the drug applied at 500 μ g/kg (1 mL/10 kg), resulting in a dose per cow of 72.5 mL. Individual doses of eprinomectin were dispensed into brown plastic bottles and an equal quantity of placebo (mineral oil) was dispensed in a similar way. The similarity in the bottles containing eprinomectin and placebo ensured that the producer would be unable to identify the contents of each bottle. The bottles were uniquely labeled with sequential numbers (alternating placebo and eprinomectin) and packed into compartmentalized cardboard boxes containing 18 bottles each. The boxes were then distributed to all the participating herds at the beginning of the trial and additional bottles provided if a herd ran low. Treatment of cows or heifers was to be done between 3 wk before

the expected calving date and 1 wk after calving. There was a label on the box of treatment bottles informing the producer to take the bottles in order from left to right of each row whenever treatment was due. Treatment was done by pouring the entire contents of the bottle along the dorsal midline of the animal. Cow name or number, treatment date, calving date, and bottle number were then recorded on a form provided to the producer.

Fecal Samples, Bulk Tank Milk, and Mange Scores

On the second farm visit (May to June, 2002), fecal samples were collected from 4 first-parity and 4 second- and above-parity milking cows that had not been treated at calving. Fecal egg counts in eggs per gram (EPG) were determined using the modified Wisconsin sugar flotation technique (Cox and Todd, 1962).

Monthly bulk tank milk samples from each herd were collected between March 2002 and February 2003. All milk samples were sent to the Atlantic Veterinary College where an indirect ELISA using a crude *Ostertagia ostertagi* antigen was performed (Sanchez et al., 2002b).

A mange score (0 to 3) for each cow was determined and recorded at the time of treatment by the producer according to a scoring chart (Leslie et al., 2000). Producers were trained in the use of the scoring system at the beginning of the study. Mange status was evaluated to determine if the milk production of cows with mange would benefit from eprinomectin treatment.

Milk Production Data

Individual test-day milk yield records for the Canadian sites were obtained from the Canadian Dairy Herd Management System database in Montreal. The records for the Minnesota herds were obtained from United States National DHI. This process of data collection ensured that the study was blinded because the technicians that measured milk yield were unaware of the treatment status of the cows. Test-day records were collected from February 2002 to August 2003 to ensure that cows that calved at the end of the treatment period (February 2003) had completed 200 d of lactation before data collection was stopped. Information on parity, DIM, SCC, and calving date were obtained from the same sources. Two herds in Quebec dropped out of DHI but were retained in the study, and farm-recorded milk production data were used in the analysis.

Descriptive Statistics

The FEC distribution across housing types and sites was summarized. In each herd, the percentage of cows

with an egg count greater than zero was determined and herds were classified into high- and low-FEC herds based on a threshold of $\geq 50\%$ of cows with a positive FEC. The temporal distribution of bulk tank milk ELISA ODR values was evaluated graphically. A mean 12-mo ODR was computed for each herd and dichotomized into high- and low-ODR using a threshold of 0.5. Mange scores were dichotomized into absent (score 0) or present (score ≥ 1). The study site prevalence of cows with any signs of mange was determined based on this dichotomized variable.

Equality in the distribution of cows treated with eprinomectin or with placebo was verified within herds, lactation groups, and calving seasons. Four categorical variables based on the housing of dry cows, lactating cows, bred heifers, and young heifers were generated with each variable having 3 categories (pasture/paddock, gravel yard, and confined). The distribution of herds according to dry- and lactating-cow housing and ODR was summarized.

The study period was divided into 4 calving seasons: winter (January–March), spring (April–June), summer (July–September), and fall (October–December). Parity was classified into 3 classes: first-, second-, or third-lactation and above.

Multi-Variable Methods

The analysis of FEC and their association with the predictors (parity, housing type, and study site) used generalized estimating equations with an exchangeable correlation structure to account for the correlation between cows in the same herd (Dohoo et al., 2003). A negative binomial distribution was assumed because it showed a significantly better fit than a Poisson distribution, and no improvements were obtained by adding a zero-inflation component (Dohoo et al., 2003).

The monthly bulk milk ELISA reading for ODR and the association of ODR with the predictors (testing season, housing type, and study site) were analyzed by linear mixed models to account for the repeated measurements on herds. Different within-herd correlation structures were examined and in order of increasing complexity, these are: compound symmetry, first-order auto-regressive, auto-regressive moving average, and stationary (or Toeplitz). The best model was selected based on Akaike's information criterion and likelihood-ratio tests.

Individual cow milk production for the first 200 DIM was analyzed by linear mixed models with herd random effects and correlated errors of observations on the same cow to account for the repeated measurements. The highest level in the hierarchy, study site, was included in the model as a fixed effect (predictor). In a

Table 1. Mean, range, and SD values of fecal egg counts (FEC) and bulk tank milk ELISA optical density ratio (ODR) values obtained from 66 herds according to study site, housing type, and season (for ODR) in a clinical trial on the effect of eprinomectin on milk production in confined and semiconfined dairy herds.

	FEC (eggs per gram)		Bulk milk ODR	
	Mean (range)	SD	Mean (range)	SD
Site (no. of herds)				
Atlantic (14)	1 (0–26)	4	0.41 (0.18–0.74)	0.14
Minnesota (12)	0 (0–10)	1	0.36 (0.19–0.66)	0.09
Ontario (16)	1 (0–27)	3	0.36 (0.14–0.89)	0.14
Quebec (12)	0 (0–6)	1	0.37 (0.10–0.56)	0.10
Saskatchewan (12)	0 (0–6)	1	0.55 (0.18–0.86)	0.17
Housing				
Confined (34)	0 (0–6)	1	0.38 (0.10–0.81)	0.13
Semiconfined (32)	1 (0–27)	3	0.44 (0.18–0.89)	0.17
Season				
Winter	—	—	0.38 (0.14–0.69)	0.13
Spring	—	—	0.38 (0.10–0.89)	0.17
Summer	—	—	0.45 (0.22–0.86)	0.15
Fall	—	—	0.42 (0.18–0.81)	0.14

¹FEC distribution was right-skewed and all median values were zero.

linear mixed model, it is assumed that all random effects follow a normal distribution, and with only 5 study sites it was difficult to make this assumption. Other predictors included were eprinomectin treatment, DIM, parity, lnSCC, calving season, calendar month of test, housing type, mange status, and gastrointestinal tract nematode parasite burden indicators. As the housing type for milking and dry cows could be expected to have a more direct effect on milk production than the housing type for heifers, both dry- and lactating-cow housing variables were included in the model. The associations of the 2 parasite burden indicators, FEC and herd-level ODR status, with milk production and treatment response were examined by including interaction terms with treatment in separate models. Calendar month of test was included in the model to account for seasonal variation. Days in milk was included as Wilmink's function (Schaeffer et al., 2000) consisting of a linear term (DIM) and a power term ($\text{DIM}^{-0.05}$). Main effects of interest were kept in regardless of their *P* value, as was the interaction between treatment and ODR. The within-cow correlation structure was explored in a similar fashion as in the linear mixed model for bulk milk ELISA ODR. Pairwise correlation coefficients of all parameter estimates were determined to investigate any problems of collinearity between predictors.

The Proc Mixed procedure of SAS, version 8.2 (SAS Institute, 1999) was used to fit the linear mixed models and Stata version 8 (Stata Corporation, 2003) was used for data editing and all other statistical procedures. For all analyses, the significance level was set at $P < 0.05$. Linear mixed model analyses used the Satterthwaite method to approximate the degrees of freedom for significance tests.

RESULTS

Parasite Burden

In general, FEC (Table 1) were very low (mean = 1, range = 0 to 27, SD = 2). In the study by Borgsteede et al. (2000) that was conducted on adult dairy cattle, 30% of the cows had FEC higher than 25 EPG, whereas in this study, only 2 out of 556 cows had FEC higher than 25. Six hundred seventy-seven monthly bulk tank milk samples (Figure 1) were tested from the 66 herds. The herd average bulk milk ODR values had a mean of 0.41, a standard deviation of 0.13, and a range of 0.22 to 0.80.

Mange Score Prevalence

The prevalence of mange was generally low. No cases of mange were recorded in 19 herds and only 4 herds had a mange prevalence >40%. Across herds within region, percentages of cows with mange were 6 (Atlantic study site), 8 (Quebec), 16 (Ontario), 12 (Saskatchewan), and 13% (Minnesota).

Test Animals

Every effort was made to link records in the treatment file with those in the production data file. Of 6162 cows that were treated in the trial, 5477 (89%) had production records. Treated cows without production records consisted of cows with inconsistent identification or cows that were removed from the herd before any production data were recorded for the lactation. Restriction of the analysis to cows treated between 21 d before and 7 d after the day of calving was the main reason for the drop from 5477 to 4789 cows (78% of

Figure 1. Frequency distribution of 677 monthly bulk tank milk optical density ratio (ODR) values obtained from 66 confined and semiconfined dairy herds that participated in a clinical trial on the effect of eprinomectin on milk production.

treated cows). One herd with 75 cows did not have SCC records, so it was excluded from the statistical models where SCC was a predictor (leaving a total of 64 herds in the milk production analyses).

Of the 4789 cows with production records and treated within the allotted time, 50.37% were treated with eprinomectin and the remainder with placebo. The equality in the distribution of eprinomectin- and placebo-treated cows within the lactation groups provided evidence that random allocation of treatment to cows had been achieved. Equality of treatment groups within regions and calving seasons provided a good indication that the exclusion of cows did not introduce any selection bias.

The parity distribution of the third- and higher-parity group was as follows: 44% third parity, 27% fourth-parity, 15% fifth-parity, 7% sixth-parity, and the rest was composed of parities 7 to 13.

Cow Housing and Herd Parasite Burden

Table 2 shows that 9 of the 13 (69%) high-ODR herds had lactating cows that had some degree of outdoor exposure compared with 12 of the 51 (24%) low-ODR herds. None of the high-ODR herds and 20 (39%) of the low-ODR herds confined both their lactating and dry cows indoors.

Multi-Variable Models

Parasite burden. The bulk milk ELISA ODR model that assumed a Toeplitz correlation structure fit much better than the models that assumed other structures. This model showed that ODR was significantly related to season ($P < 0.001$) and study site ($P < 0.001$). Bulk milk ODR values in the winter were 0.03 (SE = 0.02) less than in the fall, whereas those in the summer were

Table 2. Distribution of 64 herds by parasite burden [high/low optical density ratios (ODR)], and dry and lactating cow housing in a clinical trial on the effect of eprinomectin on milk production in confined and semiconfined dairy herds.

Lactation cow housing/ODR status	Dry cow housing			
	Paddock/pasture	Yard	Indoors	Total
Low ODR				
Paddock/pasture	6	0	2	8
Yard	2	1	1	4
Indoors	14	5	20	39
Total	22	6	23	51
High ODR				
Paddock/pasture	4	0	1	5
Yard	1	3	0	4
Indoors	2	2	0	4
Total	7	5	1	13

Figure 2. Temporal distribution of the monthly average bulk milk ELISA optical density ratio (ODR) values according to housing type (March 2002 to August 2002) in 66 confined and semiconfined dairy herds that participated in a clinical trial on the effect of eprinomectin on milk production.

0.04 (SE = 0.01) higher than in the fall. Figure 2 shows that ODR values peaked during the warmer months. There was no significant relationship between ODR and housing type ($P = 0.16$) although semiconfined herds had slightly higher numerical ODR values than did confined herds (Figure 2). Six hundred seventy-two observations from 66 herds were used in this analysis.

Out of 556 cows (from 66 herds) whose fecal samples were collected, 411 were used in the analysis; the parity status of the rest was not recorded. The negative binomial regression model showed that parity ($P = 0.047$) and housing type ($P < 0.001$) were significantly related to $\ln$ FEC. Mean $\ln$ FEC in cows that were in their second parity and above was 0.72 (SE = 0.36) less than that from first-parity cows. The mean $\ln$ FEC of semiconfined cows was 2.24 (SE = 0.52) higher than that in totally confined cows. The effect of study site on $\ln$ FEC was marginally significant ($P = 0.063$). Cows in Ontario had the highest $\ln$ FEC, and cows in Quebec and Saskatchewan had the lowest.

Milk production. The auto-regressive moving average correlation structure was chosen because it fit the data better than the auto-regressive structure, which has been used in the past for such test-day models. The Toeplitz correlation structure produced a slightly better

fit (as determined by both the Akaike's information criteria and likelihood-ratio test) than the auto-regressive moving average, but it is a more complicated model, which requires the estimation of many more correlation parameters.

Results of the final model are shown in Table 3. Overall, there was no significant effect of treatment ($P = 0.291$). However, there was a slight tendency ($P = 0.149$) for an interaction between treatment and ODR, which suggested the possibility of a larger treatment effect (kg/d of milk per cow) in high-ODR herds (0.38 kg) than in low-ODR herds (−0.20 kg). The confidence intervals for the treatment effects in high-ODR herds (−0.33 to 1.1) and in low-ODR herds (−0.53 to 0.14) were both wide and included zero. Cows in low-ODR herds that received the placebo produced 2.8 kg of milk more than cows in high-ODR herds that received placebo.

In a model in which ODR was replaced by FEC as an indicator of herd parasite burden, the interaction of FEC and treatment ($P = 0.37$) was not significant. This model was not considered any further and details have not been presented.

Lactating-cow housing and dry-cow housing were not significantly associated with milk production. Study site was statistically insignificant ($P = 0.342$) and was

Table 3. Coefficients, standard errors (SE), and *P* values from a linear mixed effects model (with a herd random effect and an auto-regressive moving average within-cow correlation structure) of the effect of eprinomectin on test-day milk production (kg/d per cow) within the first 200 d after calving (4789 cows from 64 herds).

Variable	Category	Coefficient	SE	<i>P</i>
Constant		167.830	2.472	<0.001
Eprinomectin	Yes	0.385	0.366	0.291 ^a
	No	0		
ODR	Low	2.819	1.234	0.037 ^a
	High	0		
Eprino × ODR	Yes, Low	-0.584	0.405	0.149
Lactating cow housing	Pasture	-0.908	1.197	0.719 ^b
	Yard	0.177	1.420	
	Indoor	0		
Dry cow housing	Pasture	0.426	0.988	0.398 ^b
	Yard	1.887	1.386	
	Indoor	0		
Parity	1	-8.207	0.187	<0.001 ^b
	2	-1.421	0.196	
	3+	0		
ln SCC		-1.075	0.033	<0.001
DIM		-0.110	0.002	<0.001
DIM ^{-0.05}		-145.290	2.344	<0.001
Calving season	Winter	0.380	0.223	<0.001 ^b
	Spring	-0.071	0.235	
	Summer	-0.947	0.217	
	Fall	0		
Test month, ¹				<0.001 ^b

^aTest includes both the main effect and interaction terms.

^bFor categorical variables, *P* value reflects test of overall significance, not individual levels of the variable.

¹Dummy variables for each of the 12 mo not shown.

removed from the model. Parity, DIM, month of test, calving season, and ln SCC were all statistically significant (Table 3). Interaction terms between treatment and all the other variables were tested and found to be nonsignificant. There was no indication of collinearity because the pairwise correlations between the parameter estimates of all predictors were low.

The effect of mange at the time of treatment was evaluated in a model together with the other predictors and was found not to have a significant effect on milk production nor was there any interaction of treatment by mange.

DISCUSSION

Consistent with other studies (Agneessens et al., 2000; Borgsteede et al., 2000), the ODR values reached a peak in the warmer months and declined in colder months. Consistent with a study done in Canada (Nodtvedt et al., 2002), FEC were higher in younger cows than in older ones. The older cows are more likely to have developed enough immunity to keep the FEC low. The FEC of cows in semiconfined herds were higher than those in totally confined herds most likely because of some pasture exposure in the former group.

Nine of the 13 (69%) high-ODR herds had lactating cows with some degree of outdoor exposure compared

with 12 of the 51 (24%) low-ODR herds. None of the high-ODR herds and 20 (39%) of the low-ODR herds confined both their lactating and dry cows indoors. This distribution is consistent with expectations because cows with outdoor exposure have a higher probability of consuming parasite larvae and being infected than cows kept indoors.

Overall, there was no significant effect of treatment. These results are consistent with a study conducted in the United States that evaluated whether the milk production of confined cows benefited from anthelmintic treatment (Glenn et al., 1982). The numerical difference between treated and nontreated cows was 0.58 kg/d of milk per cow higher in high-ODR than in low-ODR herds, perhaps indicating a tendency for ODR to be predictive of treatment response. On the other hand, there was no evidence that the effect of treatment depended on whether the herd was low-FEC or high-FEC based on just 8 fecal samples per herd. Therefore, this study did provide some indication that the ELISA test of a composite bulk tank milk sample might be better than FEC from a small sample of cows to identify herds in which a positive treatment effect might be expected. The study by Sanchez et al. (2002a) showed that ODR values of late-lactation cow milk samples had a marginally significant effect (*P* = 0.07) on treatment response

in the subsequent lactation, suggesting that high-ODR cows responded better to the anthelmintic treatment.

Cows in low-ODR herds that received the placebo produced 2.8 kg of milk more than cows in high-ODR herds that received the placebo. This provides evidence that high-ODR herds were associated with lower production. Despite controlling for the type of housing (confinement, yard, or paddock) that lactating and dry cows had, it was impossible to tell if the effect was entirely due to parasites or partially due to outdoor exposure. If it were entirely due to parasites, we would have expected a larger treatment effect.

There was no evidence that mange status at calving had any influence on milk production nor was there evidence that the effect of eprinomectin depended on the mange status. This may be attributed to the generally low prevalence observed in the study herds. Mange scoring was done by the producers. To standardize the reporting of mange lesions, a mange scoring system was used (Leslie et al., 2000). Despite the fact that the system was evaluated and found to be useful, it does have some shortcomings. It is subject to misclassification bias especially when the lesions were mild (level 1) as was the case in the majority of the mange cases in the study. Cows that have few lesions are likely to be missed and classified as noncases. On the other hand, noncases could be wrongly classified as mange cases especially in thin cows as they tend to lose hair around the bony prominences of the lumbosacral area. Encrusted dry dung and dirt around the lumbosacral area may be mistaken for mange lesions. Given the large number of herds in the study, and their wide geographic distribution, it was impossible to have study personnel visit the farms sufficiently often to do the mange scoring.

Interpretation of all the significant predictors of milk production (DIM, parity, month of test, ln SCC, and calving season) was consistent with the findings of other studies. First- and second-parity cows produced 8 and 1.4 kg less milk respectively, than the third- and higher-parity cows. The linear mixed effects model showed that test-day milk production was generally highest in the winter and spring and lowest in the summer and fall. The results of a study by Ray et al. (1992) on the effect of season and parity on milk production are consistent with the results of the present study. A unit increase in ln SCC resulted in a decrease of 1 kg of milk. Many previous studies have shown that increased SCC values were associated with reduced milk production. Cows calving in winter produced 0.4 kg/d more milk than did those calving in the fall. Milk production of cows calving in spring and summer was 0.07 and 1 kg/cow per d less, respectively, than ones calving in the fall. The study by Nodtvedt et al. (2002) that evaluated the effect of

eprinomectin in pastured herds did not have enough power to detect a significant association between calving season and milk production.

CONCLUSIONS

Overall, this study failed to show a beneficial effect of eprinomectin treatment in totally or semiconfined herds. However, this study did provide evidence that the ELISA test used on a composite milk sample might be more effective than fecal egg counts from a few animals in identifying herds in which a positive treatment effect might be expected.

ACKNOWLEDGMENTS

The authors would like to thank the following people for their valuable technical assistance: Theresa Andrews (Atlantic Veterinary College), Judy Sheppard (Atlantic Veterinary College), Chris McLaren (Ontario Veterinary College), Isabelle Dutil (University of Montreal), and François Dubois (University of Montreal). We would also like to extend our gratitude to the producers that participated in the study. The study was funded by Merial, Canada.

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