Efficacy of Daily Oral Treatments of Ivermectin Administered to Cattle Infested with *Boophilus microplus* (Acari: Ixodidae)\(^1,2\)

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ABSTRACT

The efficacy of ivermectin administered orally to cattle infested with all parasitic stages of *Boophilus microplus* (Canestrini) ticks was evaluated. Ivermectin capsules were administered to two separate groups of cattle at a dose rate of either 25 or 50\(\mu\)g/kg for a period of 21 consecutive days. A third group of calves received a placebo capsule each day and served as a control. Although the overall control achieved at both doses of ivermectin was >99\% against all parasitic stages, the 50\(\mu\)g/kg/d dose was significantly more effective than the 25\(\mu\)g/kg/d dose against each developmental stage of the tick. Each ivermectin treatment dose produced a significantly higher percentage reduction in female tick numbers against ticks that were adults at the time of treatment onset than was observed against immature ticks (nymphs and larvae), however the 50\(\mu\)g/kg/d treatment was significantly more effective in reducing tick numbers, regardless of the developmental stage of the ticks. Both engorgement weight and egg mass weight of females were significantly lower in the ivermectin treated groups than were observed in the untreated group. The potential applicability for treating tick-infested cattle with different delivery systems, such as daily oral treatments, boluses, and medicated feed that contain ivermectin or other macrocyclic lactone compounds is also discussed.

KEY WORDS  ivermectin, *Boophilus microplus*, oral treatment, macrocyclic lactone, cattle tick, acaricidal activity

The discovery and development of avermectin endectocides, of which ivermectin is perhaps the foremost example (Hotson 1981), has provided the opportunity for evaluation of these compounds for the control and management of livestock ectoparasites. The avermectins offer the dual advantage of having broad spectrum activity and efficacy at extremely low concentrations (Putter et al. 1981). Numerous investigations with various tick species have been conducted which demonstrate that avermectins would be excellent candidates for use in programs

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The United States *Boophilus* Eradication Program has been in continuous operation in the continental U.S. since 1906. Presently *Boophilus* spp. ticks have been eradicated throughout the country, except for 8 counties that lie along the Texas-Mexico border, where a permanent quarantine is maintained by the U.S. Department of Agriculture, Animal Plant Health Inspection Service, Veterinary Services. Program operational procedures, as they are currently applied, rely solely on the use of an organophosphate (OP) acaricide, coumaphos, as the principal means of preventing the re-introduction of *Boophilus* ticks. Due to several factors associated with the reliance on this single acaricide, such as re-registration of the material and the widespread occurrence of OP resistance in tick populations in Mexico, there is a critical need to identify and develop alternative acaricides and treatment methods which may have potential for use in the Cattle Fever Tick Eradication Program in the United States.

In the current study, the primary objective was to determine whether the sustained application of ivermectin administered to tick-infested cattle provides a standard of control that would be acceptable in an eradication program. The secondary objective was to obtain data that can be used in the future development of sustained release technologies, such as boluses or medicated feed systems for use in a systematic treatment eradication program.

**Materials and Methods**

This study was conducted at the USDA, Agricultural Research Service, Cattle Fever Tick Research Laboratory in Mission, Texas, a certified quarantine facility where research on *Boophilus* spp. ticks is conducted in support of the eradication program.

**Experimental design.** Nine Hereford heifer calves weighing approximately 190 kg each were randomly assigned to three groups of three each. Throughout the study each calf was stanchioned individually in a 3.3 × 3.3 m stall in an open-sided barn under ambient conditions, except that no direct rainfall or sunlight reached the cattle. Fourteen days before the initiation of oral ivermectin treatments each calf was infested with ca. 5,000 *B. microplus* larvae that were 2–4 wk of age. Additional larval infestations of ca. 5,000 each were made at 7 d and before the beginning of oral treatments. This infestation regime provided the means for evaluating the effects of oral treatments against ticks that were in the early stages of adult development (14-d pretreatment infestation), nymphal development (7-d pretreatment infestation) and newly infesting larvae (0-d pre-treatment infestation) at the time oral treatments were initiated.

Engorged female ticks were collected and counted daily beginning on the first d when they began to detach from the calves (21 d after the first pretreatment infestation and 7 d after the oral treatments were initiated). The daily tick collections were continued for 28 d after the last pretreatment infestation (7 d after the oral treatments were terminated). Random samples of up to 10 females
per day per calf (whenever possible) were saved to obtain data on the oviposition capability of the surviving ticks. Females within each sample (≤10) were weighed collectively, placed in a coded 25 × 95 mm (8-dram) shell vial with a cotton stopper and stored in an incubator at 27 ± 2°C, 92% RH, under a 12:12 [L:D]h photoperiod and allowed to oviposit for 20 d. After oviposition was complete females were discarded and the eggs produced by females in each sample were weighed and returned to the incubator. After 4 wk the percentage egg hatch of each sample group was visually estimated by observing the contents of the vial under a stereo microscope with a grid background and comparing the proportion of larvae to the proportion of unhatched eggs within the vial.

When all data on daily tick counts and engorgement weight, egg mass weight, and percentage egg hatch of saved females were complete, the daily index of fecundity (IF) of the ticks recovered from each calf in each of the three groups of animals was calculated. The IF is an estimate of the reproductive potential of the ticks that survived to repletion following the onset of oral ivermectin treatments, and is derived from the index of reproduction (IR) formula described by Drummond et al. (1967):

\[
\text{IF} = \frac{\text{No. of ♀ ♀ collected} \times \text{Weight of eggs (g)}}{\text{No. of ♀ ♀ saved} \times \text{Egg hatch (％)}}
\]

**Treatment procedures.** The efficacy of two different oral doses of ivermectin administered daily was evaluated in the study. Before initiation of the daily oral treatments each calf was weighed individually, so that the appropriate treatment dose could be calculated. Formulation of each treatment dose for each calf was conducted by weighing the appropriate amount of drug (ivermectin), based on the individual weight of each calf, then loading the ivermectin into a gelatin capsule with enough whole wheat flour to fill the remainder of the capsule. The formulated capsules were placed in prescription bottles marked for use on each individual calf. A sufficient number of capsules were made so that each calf could be treated for a period of 21 consecutive days. A standard balling gun was used to administer a single individual capsule to each animal for a period of 21 consecutive days following initiation of the oral treatments.

One group of cattle (n = 3) received a daily oral dose of 25 μg of ivermectin per kg of body weight. A second group of cattle (n = 3) received a dose of 50 μg/kg/d of ivermectin, and the third group of calves (n = 3) received a placebo containing only the whole wheat flour, thus serving as an untreated control group.

**Blood sample procedures.** Immediately before initiation of the daily oral treatments (day 0) and at 3, 7, 10, 14, 17, 21, 24, and 28 d after oral treatments began, blood samples were collected from the jugular vein of each calf. Whole blood samples were collected in 13-mL SST vacutainer tubes (Becton Dickinson, Franklin Lakes, New Jersey). Blood samples were allowed to clot for 1 h at room temperature, then centrifuged at 2,500 rpm for 30 min to separate the serum. The serum (5 mL) was poured into a coded plastic holding vial, sealed and frozen at −20°C for later analysis. Samples were analyzed for ivermectin concentration by placing 5 μL of serum in a liquid chromatography column and determining the absorption rate for ivermectin in an HPLC analyzer according to the technique described by Oehler & Miller (1989) that enables quantification of as little as 2 ppb of ivermectin in 5 μL of serum.
Data classification. The timing of pretreatment infestations (14, 7, and 0 d before onset of treatment), the interval between infestations (7 d), and the known parasitic development and detachment patterns of *B. microplus* (95% of all ticks infested at a given time detaching at 21–27 d following infestation (Hitchcock 1955)), provided a means for classifying and estimating the effect of the ivermectin treatments on tick numbers and the IF (index of fecundity) values by individual parasitic development stage. Using this information, a classification system was devised such that females collected 7–13 d after treatments began were considered to be adults at the time treatments were initiated. Females collected 14–20 d after treatments began were classified as nymphs at the time of treatment initiation; and females recovered 21–27 d after treatments began were classified as larvae at the time of treatment initiation.

Once the daily tick numbers and IF values for each calf within each treatment or control group over the entire study period were obtained, the numbers and values were summed across each of the classification categories described above to provide a mean total tick number and IF value for each treatment or control group. The percentage control afforded by each treatment against the various parasitic life stages of the tick were calculated by comparing the total IF value of each treated group with the total IF value of the untreated group within the same classification category using the following modified Abbott’s formula (Abbott 1925):

\[
\frac{\text{Total IF of untreated} - \text{Total IF of treated}}{\text{Total IF of untreated}} \times 100 = \% \text{ Control}
\]

Data analysis. Data obtained on concentration of ivermectin in blood serum in the two treated groups were subjected to *t*-test analysis on each day samples were taken (SPSS, Inc. 1997). Remaining data were subjected to a two-way analysis of variance with life stage and treatment dose as the main factors to determine differences. Differences among means was determined by Tukey’s test (SPSS, Inc. 1997). Arcsine transformation was applied to the data expressed as percentages (percentage reduction of the number of ticks per animal and percentage control of the IF) prior to analysis.

Results

The ivermectin concentration in the blood serum of cattle treated at 50 µg/kg/d was significantly higher (*t* = 4.3; df = 4; *P* = 0.02) than the 25 µg/kg/d treatment group at all sampling periods between 3-28 d after oral treatments were initiated, with the exception of the 21 d sample, which occurred on the day oral treatments were terminated (Fig. 1). However, even on this sampling day (21 d), although the difference was not significant between the two treatment groups (*t* = 2.5; df = 4; *P* = 0.07), it was substantial. At the 25 µg/kg/d treatment dose, the ivermectin concentration did not reach 6 ppb until 10 d following the initiation of oral treatments, which is the approximate concentration at which it remained through day 21. By day 28 (7 d after oral treatments were terminated), the ivermectin concentration decreased to undetectable levels (<2 ppb). At the 50 µg/kg/d treatment dose the ivermectin concentration in the blood reached 6 ppb at 3 d following the initiation of oral treatment and continued to increase to a
peak concentration of 13.3 ppb at 17 d after treatments began. The ivermectin concentration did not drop below 6 ppb until 24 d following the onset of treatment, and it was still at 4 ppb on day 28 (7 d after oral treatments were terminated) when the study ended.

Both the life stage of the ticks and the treatment dose responded independently of each other (no interaction effect; $F = 2.9; \text{df} = 2,12; \ P = 0.1$) in their effect on the percentage reduction of the number of ticks per animal that reached repletion following the onset of daily oral ivermectin treatment (Table 1). Comparison of three life stages within each treatment dose showed there was a significantly greater percentage reduction in tick numbers ($F = 20.6; \text{df} = 2,12; \ P < 0.01$) for ticks that were adults at the time treatments were initiated than was observed for ticks that were either nymphs or larvae at treatment initiation. Comparison of the two treatment doses within each life stage showed that 50 mg/kg/d of ivermectin provided significantly greater percentage reduction ($F = 118.2; \text{df} = 1,12; \ P < 0.01$) in the number of ticks per animal than the 25 mg/kg/d treatment, regardless of the stage the ticks were in when treatment began. Analysis showed that control was consistently high (no interaction effect; $F = 0.2; \text{df} = 2,12; \ P = 0.8$) against adults, nymphs, and larvae at both dosages.

Fig. 1. Mean and standard deviation of the ivermectin concentration in the blood serum of two groups of Hereford heifer calves administered daily oral treatments at dosages of 25 and 50 µg (active ingredient) per kg of body weight for 21 consecutive days.
Table 1. Mean ± standard deviation of the percentage reduction in ticks per animal, index of fecundity (IF), and percentage control of the IF obtained against *Boophilus microplus* females that were in different parasitic life stages at the time daily oral ivermectin treatments were initially administered to tick-infested cattle.

<table>
<thead>
<tr>
<th>Parasitic life stage</th>
<th>Treatment dose</th>
<th>Dose within life stage</th>
<th>Percentage reduction of number of ticks per animal recovered&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Stage × dose interaction:</th>
<th>Percentage control of the IF</th>
<th>Stage × dose interaction:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Untreated</td>
<td>25 μg/kg/d</td>
<td>50 μg/kg/d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>– (731)</td>
<td>92.4 ± 5.1 (56)</td>
<td>99.7 ± 0.3 (2)</td>
<td><em>F</em> = 118.2; <em>df</em> = 1, 12; <em>P</em> &lt; 0.001</td>
<td>Adult – 99.7 ± 0.2 &gt;99.9 ± 0.006</td>
<td>Adult – <em>F</em> = 0.5; <em>df</em> = 2, 12; <em>P</em> &gt; 0.06</td>
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<tr>
<td>Nymph</td>
<td>– (1327)</td>
<td>82.9 ± 3.7 (227)</td>
<td>97.6 ± 1.3 (32)</td>
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<tr>
<td>Larva</td>
<td>– (1151)</td>
<td>71.9 ± 6.2 (323)</td>
<td>96.9 ± 0.8 (36)</td>
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<tr>
<td>Life stage within dose</td>
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</table>

<sup>a</sup>Numbers in parentheses are the actual mean number of ticks per animal recovered.
The engorgement weight of females recovered from untreated and ivermectin
treated cattle was significantly dependent (interaction effect; \( F = 9.9; \) df = 4, 17; 
\( P < 0.01 \)) on both life stage and treatment dose (Table 2). Analysis of the life stage
within each treatment dose showed that the engorgement weights of females
recovered from untreated cattle were similar, regardless of the life stage they
were in when ivermectin treatments were begun (\( F = 12.7; \) df = 2, 17; \( P < 0.001 \)).
However, in the 25 \( \mu \text{g/kg/d} \) treatment ticks that were adults at treatment onset
weighed more than larval ticks, whereas ticks in the nymphal stage at treatment
onset produced engorgement weights that were intermediate between that of
adults and larvae. At the 50 \( \mu \text{g/kg/d} \) treatment, ticks treated as adults weighed
more than immature ticks (nymphs or larvae), which had similar engorgement
weights. Comparison of the effects of the three treatment doses within the various
life stages showed that against ticks that were adults at treatment onset, en-
gorgement weight of untreated females was higher than either of the ivermectin
treated groups of females, which were similar (\( F = 1156.0; \) df = 2, 17; \( P < 0.001 \)).
Treatments initiated against both nymphs and larvae showed a dose response
with untreated females weighing more than females treated at 25 \( \mu \text{g/kg/d} \), which
in turn weighed more than ticks treated at 50 \( \mu \text{g/kg/d} \).

As with the engorgement weight of females, the egg mass weights produced by
females recovered from untreated and ivermectin treated cattle was significantly
dependent on both life stage and treatment dose (interaction effect; \( F = 4.1; \) df = 4, 17; 
\( P < 0.02 \)) (Table 2). The life stage of the ticks within each of the three
treatment groups had only a minimal effect on subsequent egg mass weights
(\( F = 1.7; \) df = 2, 17; \( P > 0.2 \)). The egg mass weights obtained from both untreated
females and females treated at 50 \( \mu \text{g/kg/d} \) were similar, regardless of the life
stage of the females at treatment onset. In the 25 \( \mu \text{g/kg/d} \) treatment group,
females that were adults at treatment onset produced egg masses that weighed
more than egg masses produced by females that were larvae at treatment initia-
tion, with egg masses of nymphal ticks being intermediate between that of adults
and larvae. Comparison of the effects of each treatment dose within each of the
three life stages showed that against ticks in the adult stage at treatment initia-
tion, there was a dose response, in which the weights of eggs produced by un-
treated females were higher than the 25 \( \mu \text{g/kg/d} \) group, which in turn were higher
than the 50 \( \mu \text{g/kg/d} \) group (\( F = 712.1; \) df = 2, 17; \( P < 0.001 \)). Against nymphal
and larval ticks, the subsequent egg mass weights of untreated females were
higher than either ivermectin treated group, which had similar egg mass weights.

Discussion

Results of the study demonstrated that daily oral treatments of ivermectin
were highly efficacious against \( B. \) microplus, regardless of the life stage the ticks
were in at the onset of treatment. Both treatment dosages (25 and 50 \( \mu \text{g/kg/d} \))
provided >99% control of ticks. However, the 50 \( \mu \text{g/kg/d} \) dose reached the maxi-
mum blood serum level achieved by the 25 \( \mu \text{g/kg/d} \) about three times faster, and
was significantly more effective. The greater effectiveness of the 50 \( \mu \text{g/kg/d} \) dos-
age was probably because the ivermectin concentration in the blood of calves
reached a lethal level more rapidly, was maintained at a higher level during
treatment, and remained at a lethal level for a longer interval after treatment
was terminated, thus providing more time for the chemical to produce adverse effects on the reproductive processes in the ticks. These results were consistent with other studies conducted with ivermectin against various tick species. In a similar study, it was reported that a daily oral dose of Merck MK-933 (ivermectin) administered to cattle at 50 μg/kg/d was 95% effective against the 1-host tick, *Dermacentor albipictus* (Packard), as well as numerous 3-host ticks (Drummond et al. 1981). In another study, dosages of 20–80 μg/kg/d of ivermectin administered to cattle intraruminally (similar to daily oral doses) provided >99% control against *Rhipicephalus appendiculatus* Newmann, *R. evertsi* Newmann, and *Hyalomma truncatum* Koch (Soll et al. 1989). When Spanish goats, *Capra hircus* (L.) were administered daily oral doses of ivermectin at 20–50 μg/kg/d the blood serum level remained at ≥2 ppb, resulting in >95% reduction of larvae in the 3-host tick *Amblyomma americanum* (L.) (Miller et al. 1989).

In the majority of studies conducted with ivermectin against various tick species it has been reported that perhaps the most important measure of control was associated with the reduction of the reproductive potential of the female ticks (Drummond et al. 1981, Lancaster et al. 1982, Cramer et al. 1988, Soil et al. 1989; 1990). While the results of our study were consistent with the observations of these investigators, it was also evident that mortality of ticks was also an important factor in the overall control achieved. Within each treatment dose, a higher percentage reduction in tick numbers was observed in ticks that were in the adult stage when treatments were initiated than was observed for ticks in either the nympha l or larval stage at treatment initiation (Table 1). However, even though a higher percentage of female ticks were subsequently able to reach repletion when treatments were initiated against ticks in the nymphal or larval develop-

<table>
<thead>
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<th>Dose within life stage</th>
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</thead>
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<tr>
<td></td>
<td>Untreated</td>
<td>25 μg/kg/d</td>
</tr>
<tr>
<td><strong>Engorged female weight (mg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>354 ± 9.5</td>
<td>130 ± 9.7</td>
</tr>
<tr>
<td>Nymph</td>
<td>368 ± 16.1</td>
<td>102 ± 21.3</td>
</tr>
<tr>
<td>Larva</td>
<td>376 ± 14.0</td>
<td>83 ± 10.5</td>
</tr>
<tr>
<td>Life Stage within Dose</td>
<td>F = 12.7; df = 2, 17; P &lt; 0.001</td>
<td></td>
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<tr>
<td><strong>Egg mass weight (mg)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adult</td>
<td>163 ± 15.3</td>
<td>45 ± 13.5</td>
</tr>
<tr>
<td>Nymph</td>
<td>176 ± 10.3</td>
<td>25 ± 11.5</td>
</tr>
<tr>
<td>Larva</td>
<td>181 ± 10.8</td>
<td>22 ± 6.0</td>
</tr>
<tr>
<td>Life Stage within Dose</td>
<td>F = 1.7; df = 2, 17; P &gt; 0.2</td>
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</table>

Table 2. Mean ± standard deviation of female weight and egg mass weight of *Boophilus microplus* that were in different parasitic life stages at the time daily oral ivermectin treatments were initially administered to tick-infected cattle.
ment stage, these females had lower engorgement and egg mass weights as compared to ticks that were adults at treatment initiation (Table 2). Thus, although the overall control achieved was essentially the same during each parasitic stage, the level of control at different stages was apparently obtained by a different effect. When daily ivermectin treatments were initiated against ticks that were in the early stage of adult development, high mortality of the females occurred. This high mortality of early stage adult ticks may have been because these ticks were imbibing relatively large volumes of ivermectin in their blood meal as they underwent rapid engorgement at approximately the same time that ivermectin blood serum levels in the animals were at peak levels. On the other hand, it is possible that since immature ticks underwent one or two molts after ivermectin treatments were initiated (a time during which little or no blood is taken (Tatchell & Moorhouse 1968, Seifert et al. 1968)), a higher percentage of the ticks were able to survive because they did not imbibe enough ivermectin contaminated blood to cause death. By the time these ticks reached the adult stage, during which relatively large volumes of blood would have been taken in, it is possible that the ivermectin blood serum level in the animals was either constant or declining (Fig. 1), which allowed a greater percentage of ticks to reach repletion. However, the reduction in reproductive potential of these ticks suggests that although they may not have imbibed enough ivermectin contaminated blood to kill them, they were subjected to a sublethal level of the drug over a long enough period of time to cause a dramatic adverse effect on engorgement, fecundity, and fertility of the females. Our results seem to contrast with a study in which it was reported that there was no difference in death of adult female *Ixodes ricinus* (L.) on ivermectin treated cattle, as compared to untreated cattle (Taylor & Kenny 1990). Other research with *B. microplus* reported that either the adult ticks were less susceptible to ivermectin or there was a lag phase after treatment, during which the drug did not reach the engorging adult ticks in lethal amounts (Nolan et al. 1981). Our results stand in stark contrast to the first part of this statement, as adult ticks in our study were highly susceptible to ivermectin. Our findings neither confirm or refute that there is a lag phase that allows engorging adults to survive, but our results clearly show that high mortality will occur when early stage adult ticks are exposed to ivermectin. Our findings of lower reproductive capacity associated with ticks that were in the nymphal and larval stage of development at treatment initiation appeared to be in agreement with other studies regarding immature stages of ticks. Soll et al. (1990) reported that a reduction in the percentage of nymphs of the 2-host tick, *R. evertsi* was probably a result of having the two immature stages exposed to ivermectin over a prolonged period. Similarly, it was reported that efficacy of ivermectin against the 1-host tick, *B. decoloratus* (Koch) was at least partially due to the effect against the immature stages of the tick, which were exposed to the drug for an extended period of time (Horak et al. 1983).

As stated previously, the highly positive aspect of this study is that it clearly demonstrated that sustained daily oral treatments of ivermectin produced a very high degree of control against *Boophilus* ticks. On the other hand, the fact that even small numbers of viable ticks in all stages of development at the initiation of treatments were able to survive indicated that there could be a potentially serious negative impact with this treatment regime. There is little doubt that ivermectin levels in the blood serum of the animals acted to produce a very strong
selective pressure on the ticks that survived. Consequently, the use of this type of sustained release treatment method has the distinct possibility of initiating the emergence and future development of acaricide resistance in the surviving tick population. If a large enough segment of the tick population in a given area or region were subjected to this type of selection pressure for an extended period of time, it could result in the elimination of ivermectin or other avermectins from consideration as candidates for use in tick control programs in treatment regimes that might otherwise be successful. Thus, serious forethought should be given before using these potent endectocides in a manner that could induce the development of resistance in a short time.

Aside from the concern over development of acaricide resistance, the results of the study otherwise provide encouraging possibilities for the potential use of ivermectin and other macrocyclic lactone compounds in the Cattle Fever Tick Eradication Program as a means of eliminating Boophilus ticks on infested cattle. However, the potential use of this specific sustained release treatment (daily oral treatments) is unlikely to ever achieve wide acceptability in the program because of the necessity for treating the animals on a daily basis for such an extended period of time. It is possible that future circumstances could occur that would necessitate the consideration of this type of treatment regime (daily oral treatment) as a potential candidate for use on cattle within an infested premises to achieve eradication of the ticks.

Perhaps the most important aspect of this study is that it provides a model for the development of other sustained release delivery systems using macrocyclic lactone compounds. Treatment methods, such as pour-on, bolus, and injectable formulations, some of which provide sustained release of ivermectin, have produced good results in the control of Boophilus ticks (Pegram & Lemche 1985, Cramer et al. 1988, Taylor & Kenny 1990, Soll et al. 1990, Miller et al. 1997, 1999). However, only one of these studies (Miller et al. 1999) has demonstrated the total elimination of ticks in the field. The success of these studies has not resulted in a commercial registration of the drug or the various treatment methods for use in the U.S. eradication program. But if sustained release systems, such as long-term boluses, medicated feed systems, or medicated baits can be designed to provide a dosage level of at least 50 µg/kg/d for an extended period of time, then perhaps macrocyclic lactones or specifically ivermectin can be used to achieve eradication of a Boophilus population, as evidenced by this study. Thus, these acaricidal compounds show considerable potential for future applicability in an eradication program, and additional studies are warranted to provide the data necessary for obtaining a commercial registration for their use.

References Cited


