Efficacy of Topically Applied Pyrethroids Against Eggs of *Boophilus microplus* (Canestrini) (Acari: Ixodidae)

Ronald B. Davey

USDA, ARS, SPA, Cattle Fever Tick Research Laboratory
P. O. Box 969
Mission, TX 78572 USA

ABSTRACT Efficacy of three pyrethroid acaricides (permethrin, cypermethrin, and cyfluthrin) at concentrations of 0.1, 0.05, 0.01 and 0.005% active ingredient (AI) applied topically to *Boophilus microplus* (Canestrini) eggs of three different age classes was determined. At the rate of 0.1% AI, permethrin provided ≥ 94% reduction of hatch in all age classes of eggs. However, at the two lower concentrations (0.01 and 0.005% AI) reduction of hatch was ≤ 35% except against 1-d-old eggs at the 0.01% AI concentration; thus permethrin was less effective at the lower concentrations than the other materials tested. Cypermethrin provided ≥ 93% reduction of hatch at concentrations of ≥ 0.01% AI, but was not effective against 10- and 21-d-old eggs at 0.005% AI (71.1 and 75.9% reduction, respectively). Based on the effect of concentration and age class, cyfluthrin provided ≥ 96% reduction of hatch against all ages at all concentrations. It was concluded that all three compounds applied at manufacturers’ recommended concentration (0.1% AI for permethrin and 0.05% AI for cypermethrin and cyfluthrin) would be excellent candidates in the cleaning and disinfesting of premises to eliminate *B. microplus* eggs.

KEY WORDS Acari, Ixodidae, ovicides, *Boophilus microplus*, pyrethroids

Although *Boophilus* ticks have been eradicated from all but eight South Texas counties along the Texas-Mexico border, occasional outbreaks still occur in livestock originating from Mexico where these ticks are endemic. Among the regulation procedures required are those to be followed when infested animals are detected at livestock sale barns and feedlot facilities. Aside from acaricidal treatment of the infested animals, regulations also require treatment of facility grounds with an approved acaricide. Treatment of facility grounds is known as cleaning and disinfecting (C & D) the premises. Replete females have been reported to begin oviposition in as few as two d after detachment (Davey et al. 1980 a,b); thus if there is a time lapse of this magnitude between the discovery of the infestation and the initiation of C & D procedures, it is possible that treatment may be aimed at eggs, as well as engorged females.

1 Accepted for publication 14 November 1994.
At the present time, when C & D operations are warranted, the eradication program specifies the use of either of two organophosphorus (OP) acaricides that are registered for premise application against ticks (chlorpyrifos and diazinon). While chlorpyrifos and diazinon are highly effective against engorged females and larvae of *Boophilus microplus* (Canestrini) (Rawlins & Mansingh 1977, 1978, 1981; Drummond & Davey 1981), neither has been shown to be particularly effective as an ovicidal agent (Davey et al. 1989). In addition, numerous studies have documented the existence of OP-resistant *B. microplus* strains (Shaw 1966; Baker et al. 1978; Roulston et al. 1981; Stone & Youlton 1982; Harris et al. 1988). Another critical concern to the continued use of OP compounds relates to environmental safety. In recent years in the United States, concerns over environmental safety have resulted in a number of OP compounds being removed from the public marketplace with many more having a precarious future.

During the past 15 yrs, a number of non-OP classes of pesticides have been developed that are effective against target arthropod pests, environmentally safe, and relatively less toxic to mammals and other nontarget organisms than OP compounds. Among the most prominent of these pesticides is a wide array of pyrethroids. Some of these pyrethroids have good to excellent activity against several tick species, including *Boophilus* spp. (Rupes et al. 1980; Stubbs et al. 1983; Visvanathan et al. 1983; Davey & Ahrens 1984; de Leon et al. 1987; Solberg et al. 1992). Although some pyrethroid-resistant tick strains have been reported in Africa and Australia (Coetzee et al. 1987; Nolan et al. 1989), none have been reported from the Americas.

The purpose of the present study was to determine the ovicidal activity of several pyrethroids applied topically to *B. microplus* eggs of different age classes. Information from the study could be of great value to the U.S. Eradication Program because, if effective, these materials would provide viable alternatives to the use of OP acaricides, thus ensuring continued success of C & D operations in the elimination of *Boophilus* ticks within the U.S. borders.

**Materials and Methods**

The study was conducted at the USDA, ARS, Cattle Fever Tick Research Laboratory, Mission, TX. Commercial formulations of permethrin (Atroban® 11% Emulsifiable Concentrate, Coopers Animal Health, Kansas City, KS), cypermethrin (5% Emulsifiable Concentrate, Y-Tex Corp., Cody, WY), and cyfluthrin (Tempo® 20% Wettable Powder, Miles Laboratories, Kansas City, MO) were evaluated in the study. Concentrations of 0.1, 0.05, 0.01, and 0.005% active ingredient (AI) of each compound were selected for evaluation because 0.1% AI (permethrin) and 0.05% AI (cypermethrin and cyfluthrin) are the manufacturers' recommended dosage for premise application, while 0.01 and 0.005% AI represented a 10-fold decrease in the recommended dosage of each compound, respectively. Appropriate concentrations of each compound were diluted in water immediately prior to each evaluation to ensure the use of fresh material in all treatments.
A single Hereford heifer was infested with ca. 10,000 larval *B. microplus* 2-3 wk of age. As engorged females began detaching from the host, 400 females were collected on the day of maximum detachment (24 d after infestation) and placed in an incubator at 25 ± 2°C, 92.5% RH using a saturated solution of KNO₃ (Winston & Bates 1960), and a 12:12 photoperiod (L:D). After 5 d, females were separated from the eggs they had deposited and the eggs were discarded. The females were returned to the incubator and allowed to oviposit for 24 h, after which all eggs were collected for use in the study. This procedure provided eggs that were a known age (≤ 24-h-old) at the time of treatment. A portion of 1-d-old eggs was tested to determine the ovicidal activity of the three pyrethroids. The remainder of the eggs was returned to the incubator until they were 10- and 21-d-old, at which time a portion of the eggs of each age group was subjected to the three pyrethroids at the four concentrations.

Eggs from each age class (1-, 10-, and 21-d-old eggs) were weighed into 20 mg lots (ca. 400 eggs) and placed on 9 cm diameter filter paper. Four replicates were prepared for each of the three pyrethroid formulations at the four concentrations (0.1, 0.05, 0.01, and 0.005% AI), as well as four replicates which were treated with water only to serve as untreated controls. A microsyringe applicator containing sufficient volume to ensure complete coverage of all eggs (2 ml) was used to topically apply the water and each of the four appropriate pyrethroid concentrations. After treatment each egg sample was allowed to air-dry and was placed in a clean, coded 15 × 45 mm shell vial (1-dram) stoppered with a cotton plug and then was placed in an incubator until hatching was complete (ca. 4 wks). The percentage larval hatch of all treatment and control groups was determined by counting the number of larvae in proportion to the number of unhatched eggs in the sample.

To determine the percentage reduction of larval hatch afforded by each treatment, the larval hatch within each replicate for each treatment (pesticide, concentration, and age class of eggs) was subjected to the following formula (Abbott 1925):

\[
\text{Percent Reduction} = 100 \times \frac{\text{Hatch in Control Group} - \text{Hatch in Treated Group}}{\text{Hatch in Control Group}}
\]

Once the percentage reduction of larval hatch was established, the data were subjected to a two-way analysis of variance (ANOVA) using a general linear model (GLM) to determine differences between concentrations and age class of eggs (SAS Institute Inc. 1987). A Fisher's Least Significant Difference (LSD) was calculated to determine differences among means. Arcsine transformation was applied to the data prior to analysis.
Results

The mean larval hatch (± SE) of 1-, 10-, and 21-d-old eggs treated with water only (untreated control group) was 80.3 ± 3.2, 83.7 ± 1.7, and 82.0 ± 2.3%, respectively. Results of the studies of the efficacy of the pyrethroids against B. microplus eggs are presented in Table 1. For eggs treated with permethrin, there was a significant interaction between the concentrations and age classes of eggs ($F = 7.7; \text{df} = 6.36; P < 0.01; \text{LSD} = 15.1$) indicating that reduction of larval hatch in the three age classes of treated eggs was not constant across the four concentrations. At the 0.1% AI concentration, there was no difference in reduction of larval hatch across the three age classes of treated eggs. At the 0.05% AI concentration, 21-d-old treated eggs were significantly less sensitive to the material than 1- or 10-d-old treated eggs. At the two lowest concentrations (0.01 and 0.005% AI), there were no differences across age classes within either concentration, except in 1-d-old eggs treated at 0.01% AI, there was significantly higher reduction of larval hatch than eggs in the older age classes (10- and 21-d-old eggs). Reduction of larval hatch at the two lower concentrations (0.005 and 0.01% AI) was significantly lower than at the two high concentrations (0.1 and 0.05% AI). Based on the effects of all concentrations upon all age classes of treated eggs, permethrin was less effective than the other materials tested.

Cyp permethrin was highly effective in controlling larval hatchability at the 0.1, 0.05, and 0.01% AI concentrations (Table 1). ANOVA for cypermethrin showed a significant interaction between age classes and concentrations ($F = 7.1; \text{df} = 6.36; P < 0.01; \text{LSD} = 6.8$) indicating that reduction in larval hatch in the age classes was not constant across the four concentrations. At concentrations of 0.1, 0.05, and 0.01% AI, there were no differences in reduction of larval hatch across the age classes. However, at the lowest concentration (0.005% AI) larval hatch reduction was high in 1-d-old treated eggs (97.1%) and then diminished significantly in 10- and 21-d-old treated eggs (<76%).

Cyfluthrin was more effective than the other pyrethroids tested when all concentrations and age classes of treated eggs were considered (Table 1). The larval hatch reduction was ≥96% in all age classes at all four concentrations. Unlike the results obtained for permethrin and cypermethrin, ANOVA of the cyfluthrin data showed no significant interaction between concentration and age class of treated eggs ($F = 1.3; \text{df} = 6.36; P = 0.3$). This indicated that reduction of larval hatch in the three age classes of treated eggs was consistently high across all four concentrations tested. Although ANOVA showed that there were statistical differences within both concentration ($F = 11; \text{df} = 3,36; P < 0.04$) and age class of treated eggs ($F = 3.7; \text{df} = 2.36; P < 0.01; \text{LSD} = 1.4$), it should be noted that the difference between the lowest reduction of hatch (96.4%) and the highest level of reduction (99.9%) was equivalent to the hatch of only 12 larvae.
Table 1. Percent reduction of hatch of *Boophilus microplus* larvae after treatment of eggs of various age classes with three pyrethroids at four concentrations.

<table>
<thead>
<tr>
<th>Acaricide</th>
<th>Concentration (% AI)</th>
<th>Percent reduction at indicated age of eggs (± SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1-d-old</td>
</tr>
<tr>
<td>Permethrin</td>
<td>0.005</td>
<td>30.8 (7.6)</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>89.7 (3.6)</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>98.8 (0.4)</td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>99.9 (0.1)</td>
</tr>
<tr>
<td>(LSD² = 15.1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cypermethrin</td>
<td>0.005</td>
<td>97.1 (0.7)</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>98.6 (0.3)</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>99.7 (0.1)</td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>99.9 (0.1)</td>
</tr>
<tr>
<td>(LSD - 6.8)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cyfluthrin</td>
<td>0.005</td>
<td>97.6 (0.7)</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>97.7 (0.6)</td>
</tr>
<tr>
<td></td>
<td>0.05</td>
<td>99.1 (0.1)</td>
</tr>
<tr>
<td></td>
<td>0.1</td>
<td>99.5 (0.1)</td>
</tr>
<tr>
<td>(LSD = 1.4)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* LSD = Fisher's Least Significant Difference; P < 0.05 for all concentrations with the same acaricide.

Discussion

Because egg laying is a dynamic process, C & D treatments applied under natural field conditions might be applied to eggs of any age. Thus, to be effective, an acaricide must prevent hatch regardless of the age of eggs to which it is applied. Therefore, the lowest acceptable concentration for C & D treatments would be dictated by the age of eggs which still result in a high level of hatch reduction (i.e. ≥90%).

While the OP acaricides traditionally used in C & D operations have excellent activity against engorged females and larvae of *B. microplus* (Rawlins & Mansingh 1977, 1978, 1981; Drummond & Davey 1981), they do not possess the ovicidal activity needed to prevent hatching of eggs that may be present when treatments are applied (Davey et al. 1989). In contrast, the pyrethroids evaluated in this study have not only been shown to be highly...
effective against the parasitic stages (adults, nymphs, and larvae) of a number of ixodid species, including *B. microplus* (Rupes et al. 1980; Roberts et al. 1980; Heller-Haupt & Varma 1982; Khan & Srivastava 1988; Deblinger & Rimmer 1991; Stafford 1991; Solberg et al. 1992), but were shown to have excellent ovicidal properties as well.

Permethrin provided excellent ovicidal activity against *B. microplus* eggs of all age classes at the manufacturer’s recommended concentration for premises application (0.1% AI), but efficacy diminished sharply as the concentration was reduced, particularly when older eggs were treated. Cypermethrin and cyfluthrin were also highly effective against all treated eggs at manufacturers’ recommended concentration for premises treatment (0.05% AI); however, in contrast to permethrin, cypermethrin remained highly effective at a dosage that was 5-fold below the recommended level (0.01% AI), while cyfluthrin was highly effective at a dosage that was 10-fold below the recommended level (0.005% AI).

Results of the study indicated that each of the pyrethroids would be an excellent candidate for use in C & D treatment applications against *B. microplus*. The three pyrethroids evaluated in this study certainly appear to have much higher ovicidal activity than any of the OP compounds that are presently used (Davey et al. 1989). Even under practical application situations in the field, where conditions are often less than ideal, as was the case in this laboratory study, it is likely that if manufacturers’ recommended concentrations for premises application are maintained, the hatch reduction of treated *B. microplus* eggs could be expected to be high.

**References Cited**


1978. Acaricidal susceptibility of five strains of Boophilus microplus from four Caribbean countries. J. Econ. Entomol. 71: 142-144.


