Use of Dichlorvos in a Portable Automatic Sprayer-Mineral Station to Control Face Flies (Diptera: Muscidae) and Pyrethroid-Resistant Horn Flies (Diptera: Muscidae) on Beef Cattle

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ABSTRACT A portable automatic sprayer, actuated when cattle obtain mineral, was tested against face flies and pyrethroid-resistant horn flies using 0.5% Al dichlorvos in a water spray mixture. Horn fly populations were initially 48-fold resistant to permethrin with no resistance to diazinon. Horn fly control averaged 90.3 to 99.1% reduction. Resistance to permethrin decreased from 48-fold to 33-fold over 2 yr with no change in diazinon resistance. Face fly control averaged from 56.4 to 76.8% reduction. The cost for this system of fly control was approximately 33% the cost of effective insecticide ear tags (two/head).

KEY WORDS Face flies, horn flies, automatic sprayer, dichlorvos, resistance, cattle, Diptera, Muscidae, Haematobia irritans, Musca autumnalis.

Resistance of the horn fly, Haematobia irritans (L.), to pyrethroid insecticides, and the lack of satisfactory control of face flies, Musca autumnalis De Geer, has necessitated the search for new control strategies. Suggested strategies have included delaying control until horn flies build to an economic injury level, alternating types of insecticide ear tags, or reverting to back rubbers, oilers, dust bags or sprays. Research in fly control has demonstrated that low pressure sprays (Knapp 1962) and automatic spray systems (Eschle and Miller 1968, Knapp 1968, Miller et al. 1969) are effective against the horn fly and face fly on cattle, but with the advent of dust bags (Adkins and Seawright 1967) and ear tags (Knapp and Herald 1976), sprays had little widespread use. The current resistance of horn flies to permethrin however, has sparked a renewed interest in some of the earlier control methods. One such method is an automatic spray system. Recently, a new automatic spray system, incorporated into a mineral feeding apparatus (Wilson 1986), was evaluated in a three-state trial using dichlorvos, fenvalerate, and permethrin (Williams et al. 1986) Seasonal horn fly reduction exceeded 95%. Subsequent horn fly resistance to pyrethroids has increased to an extent that obtaining the same results today with pyrethroids would be unlikely. Also, the continued use of the pyrethroids would only increase horn fly resistance to this class of compound. Therefore, the use of dichlorvos as an alternative insecticide for the control of face flies and pyrethroid-resistant horn flies on beef cattle was evaluated using

1 Received for publication 26 April 1991; accepted 14 November 1991.
the Wilson sprayer, because no resistance to dichlorvos has been found. Reported herein are the results of a 2-yr study using 0.5% dichlorvos in the Wilson sprayer for the control of face flies and pyrethroid-resistant horn flies.

**Materials and Methods**

The Wilson sprayer is a self-contained automatic system consisting of a 12-volt wet cell battery that operates a time-delayed spray pump attached to a 114-liter insecticide reservoir. The sprayer is housed in a walk-in mineral station mounted on skids to facilitate transport. The mineral station, constructed of oak boards, is 1.6 m high and 3 m long with a metal roof. The location of the mineral box at one end of the station causes cattle to walk inside and lift a wooden lid to access the mineral. When an animal lifts the lid of the mineral box and holds it open for > 10 s, the timer is set and when the lid is lowered the sprayer is activated, spraying the animal for 3 s from two nozzles positioned above the shoulders and flanks. A fully charged 12-volt battery was installed in each sprayer and the insecticide reservoir tanks were filled with a 0.5% dichlorvos water emulsion made from a 43.2% EC formulation (Fermenta Animal Health, Kansas City, Missouri). The reservoirs were topped off every 3 wk with 0.5% dichlorvos, and trace mineralized salt was added to the mineral box as needed. Records were maintained on the liters of spray solution used and mineral consumed. Although the sprayers are portable they were not repositioned during this experiment.

In 1989, two separate herds of Charolais cattle were placed on 45-ha pastures located 2 km from each other. Herd I contained 58 cows with calves for weeks 1 through 4. At week four 15 cows with calves were removed and 12 other cows with calves added at week 5. Herd II contained 24 heifers. Herd I was used again in 1990 and contained 51 cows with calves. The sprayers were placed in operation during the first week of June both years. Both sprayers were located in the respective pastures 100 m from a water source in a partially shaded area free of undergrowth. Untreated control herds, varying between 20 and 40 adult animals, were located within 3 km of the treated herds.

Prior to testing the efficacy of the automatic spray system 500-700 horn flies were collected from the experimental cattle with a sweep net and assayed for resistance against permethrin and diazinon using the method of Cilek and Knapp (1986). Field-collected horn flies were compared to susceptible horn flies acquired from the Knipling-Bushland USDA Livestock Insects Research Laboratory, Kerrville, Texas.

Pretreatment counts of horn flies were estimated on one side of 10 animals, and face flies were counted on the head and face of the same animals. Using this method, the same person made counts between 11:00 AM - 3:00 PM at bimonthly intervals for the duration of the study. The results of the treated herds were compared to untreated controls of the same year within the same week by Student t-test (Goldstein 1964). When pretreatment populations of control and treated herds were found to be different in 1990, these populations were tested using analysis of covariance incorporating pretreatment fly counts as a concomitant variable (SAS Institute 1990).

Because dichlorvos rapidly hydrolyzes in water (Knapp and Ellis 1975), it was necessary to determine whether or not sufficient concentrations of dichlorvos
would remain in a water solution, under conditions used in this experiment, to control horn flies and face flies. Six liters of water were placed in a 7.6-liter polypropylene container containing 0.16 ml of a 1:100 dilution of 43.2% dichlorvos EC to make a concentration of 0.1 µg/ml. Four 10 ml aliquots were removed after stirring at 0, 4, 8, 24, and 30 h and at 2, 3, 6, 7, 9, 10, 12, 14, and 21 d. The aqueous samples were immediately extracted with an equal volume of hexane and 5 µl were injected into a gas chromatograph (Varian model 3700, 0.32 mm X 30 m DB-5 capillary column, 30 mm/min, 100 to 250°C @ 10°C/min) using an ion trap detector (Finnigan model 700). Aqueous standards were also extracted to determine the efficacy of removal of dichlorvos by the above method.

Results and Discussion

The use of dichlorvos in the Wilson sprayer was effective in controlling horn flies that exhibited a 48-fold resistance to permethrin. Calves were not noted activating the sprayer, although some were observed inside the sprayer box. All adult animals were observed activating the sprayer. Dichlorvos was effective against horn flies in 1989 (90.6 to 100% for herd I and II) and in 1990 (79.7 to 97.2% on herd I) while permethrin resistance decreased from 48-fold to 33-fold (Table 1). The decrease in control could not be attributed to less spray being applied because more spray was used per animal in 1990 than in 1989 (Table 2). The only difference between the two years was that in 1990 dichlorvos of a different lot number was used and the horn fly numbers had increased. It should be noted that the initial horn fly level of the treated herd in 1990 was significantly less than the control (Table 1). This is not considered unusual early in the fly season when populations of horn flies are beginning to emerge and populations on the animal are increasing daily. This is also the ideal time to initiate control procedures from a practical as well as economical perspective. Control was clearly exhibited in the treated herd by the reduction of average number of horn flies to 10/side after 8 wk. At the same time, the horn flies on the untreated herd increased to 359.5 horn flies/side.

Dichlorvos was stable in water up to 24 h; thereafter dissipation occurred with an 84% loss after 3 wk (Fig. 1). This equates to a 0.008% concentration after 3 wk from an initial 0.5% mixture. Thus, after the first 24 h the dichlorvos concentration in the sprayers was < 0.5%, but never reached the 0.008% level because the reservoirs were topped off with 0.5% dichlorvos solution every 3 wk. In earlier field tests performed with the Wilson sprayer, an initial starting concentration of 0.1% dichlorvos resulted in 100% reduction of horn flies for 21-28 d (Williams et al. 1986). Assuming that dichlorvos dissipated at a similar rate in William's field trial as it did in our laboratory studies, dichlorvos concentrations at 21 d in the earlier trials would have been approximately 0.002%. It was not determined if horn flies in William's test were resistant to permethrin, but it is doubtful, since pyrethroid resistance in horn flies was not reported in the area where the Wilson sprayer was tested until 1989 (unpublished data). Thus, the decrease in control of horn flies observed in 1989 and 1990, compared to the earlier test in 1984, may indicate some cross-resistance occurring between permethrin and dichlorvos or a change in the genetic composition of the population. However, to date there is no record of cross-resistance between a pyrethroid and an organophosphate insecticide. Because
Table 1. Mean number of horn flies per side (SEM) and percent reduction on cattle sprayed with 0.5% dichlorvos from an automatic sprayer.$^a$

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Flies/side</th>
<th>S.E.M.</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1989</td>
<td></td>
<td>152.5</td>
<td>185.0</td>
<td>157.5</td>
<td>197.5</td>
<td>210.0</td>
<td>158.5</td>
<td>151.0</td>
<td>185.0</td>
<td>195.0</td>
<td>215.0</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td></td>
<td>(7.4)</td>
<td>(12.4)</td>
<td>(10.0)</td>
<td>(12.5)</td>
<td>(9.5)</td>
<td>(9.2)</td>
<td>(8.0)</td>
<td>(8.1)</td>
<td>(11.1)</td>
<td>(9.5)</td>
</tr>
<tr>
<td>Herd I</td>
<td>1989</td>
<td></td>
<td>118.6</td>
<td>4.5</td>
<td>2.5</td>
<td>18.5</td>
<td>7.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td></td>
<td>(2.5)</td>
<td>(1.3)</td>
<td>(1.1)</td>
<td>(5.9)</td>
<td>(2.0)</td>
<td>(0.0)</td>
<td>(0.0)</td>
<td>(0.0)</td>
<td>(2.1)</td>
<td>(3.2)</td>
</tr>
<tr>
<td>% Reduct.</td>
<td></td>
<td></td>
<td>–</td>
<td>97.6</td>
<td>98.4</td>
<td>90.6</td>
<td>96.7</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>97.4</td>
<td>97.7</td>
</tr>
<tr>
<td>Herd II</td>
<td>1989</td>
<td></td>
<td>119.5</td>
<td>3.2</td>
<td>0.9</td>
<td>6.0</td>
<td>2.5</td>
<td>0.5</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td></td>
<td>(3.1)</td>
<td>(2.3)</td>
<td>(0.5)</td>
<td>(2.0)</td>
<td>(1.3)</td>
<td>(0.5)</td>
<td>(0.0)</td>
<td>(0.0)</td>
<td>(1.3)</td>
<td>(0.0)</td>
</tr>
<tr>
<td>% Reduct.</td>
<td></td>
<td></td>
<td>–</td>
<td>98.3</td>
<td>99.4</td>
<td>97.0</td>
<td>98.8</td>
<td>99.7</td>
<td>100.0</td>
<td>100.0</td>
<td>99.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Control</td>
<td>1990</td>
<td></td>
<td>100.0</td>
<td>190.0</td>
<td>210.0</td>
<td>311.5</td>
<td>359.5</td>
<td>387.5</td>
<td>375.0</td>
<td>330.0</td>
<td>197.5</td>
<td>127.5</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td></td>
<td>(7.1)</td>
<td>(9.5)</td>
<td>(13.8)</td>
<td>(12.5)</td>
<td>(45.3)</td>
<td>(24.3)</td>
<td>(16.2)</td>
<td>(20.3)</td>
<td>(9.0)</td>
<td>(6.6)</td>
</tr>
<tr>
<td>Herd I</td>
<td>1990</td>
<td></td>
<td>58.5</td>
<td>38.5</td>
<td>21.9</td>
<td>38.0</td>
<td>10.0</td>
<td>30.0</td>
<td>17.5</td>
<td>25.0</td>
<td>15.0</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td></td>
<td>(6.1)</td>
<td>(7.5)</td>
<td>(10.0)</td>
<td>(19.9)</td>
<td>(6.3)</td>
<td>(12.7)</td>
<td>(11.2)</td>
<td>(16.2)</td>
<td>(9.5)</td>
<td>(8.7)</td>
</tr>
<tr>
<td>% Reduct.</td>
<td></td>
<td></td>
<td>–</td>
<td>79.7</td>
<td>89.6</td>
<td>87.8</td>
<td>97.2</td>
<td>92.3</td>
<td>95.3</td>
<td>92.4</td>
<td>92.4</td>
<td>86.3</td>
</tr>
</tbody>
</table>

$^a$ Horn flies were counted on one side of animal only. N = 10.

$^b$ All treated means are significantly different from untreated control means of same year within the same week ($P < 0.05$) according to Student $t$-test (Goldstein 1964).

$^c$ All treated means are significantly different from control using covariance of analysis incorporating pretreatment fly count values as a covariant ($F = 17.71$; d.f. = 1.18; $P = 0.05$).
Table 2. Spray usage and cost analysis using dichlorvos at $40.50/gallon (43.2%) in a 0.5% water mixture in an automatic spray apparatus.

<table>
<thead>
<tr>
<th>Weeks after initiation of treatment</th>
<th>1</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herd I (1989)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># animals using spray</td>
<td>58a</td>
<td>43</td>
<td>55</td>
<td>55</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Amt. spray used (liter)</td>
<td>34</td>
<td>15</td>
<td>15</td>
<td>15</td>
<td>23</td>
<td>23</td>
</tr>
<tr>
<td>cum. cost/animal</td>
<td>$ 0.063</td>
<td>$ 0.17</td>
<td>$ 0.30</td>
<td>$ 0.43</td>
<td>$ 0.59</td>
<td>$ 0.76</td>
</tr>
<tr>
<td>total cum. cost</td>
<td>$ 3.65</td>
<td>$ 8.10</td>
<td>$14.58</td>
<td>$21.87</td>
<td>$30.78</td>
<td>$40.10</td>
</tr>
<tr>
<td>cost/animal/day</td>
<td>$ 0.009</td>
<td>$ 0.007</td>
<td>$ 0.005</td>
<td>$ 0.005</td>
<td>$ 0.005</td>
<td>$ 0.005</td>
</tr>
<tr>
<td>Herd II (1989)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># animals access to spray</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Amt. spray used (liter)</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>8</td>
<td>8</td>
<td>12</td>
</tr>
<tr>
<td>cum. cost/animal</td>
<td>$ 0.068</td>
<td>$ 0.22</td>
<td>$ 0.46</td>
<td>$ 0.68</td>
<td>$ 0.89</td>
<td>$ 1.10</td>
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<tr>
<td>total cum. cost</td>
<td>$ 1.62</td>
<td>$ 5.27</td>
<td>$10.94</td>
<td>$16.20</td>
<td>$21.47</td>
<td>$26.33</td>
</tr>
<tr>
<td>cost/animal/day</td>
<td>$ 0.010</td>
<td>$ 0.008</td>
<td>$ 0.008</td>
<td>$ 0.008</td>
<td>$ 0.008</td>
<td>$ 0.008</td>
</tr>
<tr>
<td>Herd I (1990)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td># animals access to spray</td>
<td>51</td>
<td>51</td>
<td>51</td>
<td>51</td>
<td>51</td>
<td>51b</td>
</tr>
<tr>
<td>Amt. spray used (liter)</td>
<td>23</td>
<td>15</td>
<td>19</td>
<td>23</td>
<td>19</td>
<td>23</td>
</tr>
<tr>
<td>cum. cost/animal</td>
<td>$ 0.048</td>
<td>$ 0.17</td>
<td>$ 0.34</td>
<td>$ 0.53</td>
<td>$ 0.71</td>
<td>$ 0.75</td>
</tr>
<tr>
<td>total cum. cost</td>
<td>$ 2.43</td>
<td>$ 8.91</td>
<td>$17.42</td>
<td>$27.14</td>
<td>$36.05</td>
<td>$38.48</td>
</tr>
<tr>
<td>cost/animal/day</td>
<td>$ 0.007</td>
<td>$ 0.006</td>
<td>$ 0.0061</td>
<td>$ 0.006</td>
<td>$ 0.006</td>
<td>$ 0.006</td>
</tr>
</tbody>
</table>

*a Fifteen cows with calves were removed at week 4 and 12 replacement cows with calves at week 5.  
*b Test terminated at week 18 due to cold weather.

dichlorvos acts as a fumigant in an enclosed system we were not able to test it for resistance, since the volatility of the compound made it incompatible with our resistance testing procedure.

Control of the face fly was not as effective as that for the horn fly (Table 3). This is not surprising because face flies, unlike horn flies, do not remain on the animals when they enter the Wilson sprayer and therefore did not receive direct spray. Face fly reduction averaged 77 and 70%, respectively with the exception of week 4 in herd I and week 12 in herd II. The low value in herd II at week 12 in 1989 was caused by a spray nozzle diaphragm failure which allowed the system to lose its prime, resulting in a shorter spray period at each application. This malfunction did not appear to affect horn fly reduction (Table 1), indicating significant dichlorvos was available to kill horn flies. In 1990, with the face fly population on untreated animals approximately double that of 1989, face fly reduction only averaged 56.4% with range from 32.1 to 83.4%. Still, the face fly control achieved with dichlorvos in the Wilson sprayer was comparable to control achieved with dust bags (Adkins and Seawright 1967, Poindexter and Adkins 1970, Knapp 1972) and with ear tags (Webb and Knapp 1990).
Fig. 1. Hydrolysis of dichlorvos in water from an initial concentration of 0.1 µg/ml.

It may be possible to improve face fly control by increasing the concentration of dichlorvos or by adding an attractant to draw face flies to the sprayed animal. Sugar in the spray mixture has shown some increase in face fly reduction (unpublished data). Since face flies leave the animal as the animal enters the sprayer and rest on the sprayer housing, positioning spray nozzles on the outside perimeter of the spray apparatus may expose the face flies to the spray mist.

One of the advantages of the Wilson spray system is the cost of treatment. In 1989 and 1990 with herd I the cost of the insecticide for the season was $40.10 and $38.48, per herd respectively. This averaged $0.76 per adult animal for the season (Table 2). In herd II (1989) the seasonal cost was $0.98 per adult animal. These costs were less than the approximately $3.00 to place insecticide ear tags on animals at the recommended rate of two per adult animal. The cost of loose trace mineralized salt, priced at $320/ton, was $1.89 and $2.12 per adult animal in herd I in 1989 and 1990, respectively and $2.32 per animal for herd II in 1989 (Table 4). This cost of mineral is a necessary expense regardless of the type of fly control. The use of more insecticide per animal by the smaller herd of 24 heifers (herd II) may be attributed to fewer animals having more freedom of use of the sprayer or young heifers being more active. The herds of cows and calves used less insecticide spray per adult than did the herd of 24 heifers even though calves were occasionally noted inside the sprayer during the latter weeks of the experiment. In all three groups the amount of trace mineral consumed averaged 44.8 to 58.8 g per animal per day which is a sufficient amount for pastured cattle (Cullison 1979).
Table 3. Mean number of face flies per face (SEM) and percent reduction on cattle sprayed with 0.5% dichlorvos from an automatic sprayer.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Weeks after initiation of spray treatment&lt;sup&gt;b&lt;/sup&gt;</th>
<th>0</th>
<th>2</th>
<th>4</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control 1989</td>
<td>Flies/face</td>
<td>1.1</td>
<td>1.3</td>
<td>4.7</td>
<td>10.6</td>
<td>14.7</td>
<td>19.0</td>
<td>14.0</td>
<td>28.0</td>
<td>21.5</td>
<td>17.0</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td>(0.2)</td>
<td>(0.2)</td>
<td>(0.6)</td>
<td>(1.5)</td>
<td>(1.4)</td>
<td>(1.2)</td>
<td>(1.7)</td>
<td>(2.9)</td>
<td>(1.0)</td>
<td>(1.8)</td>
</tr>
<tr>
<td></td>
<td>% Reduct.</td>
<td>-</td>
<td>69.2</td>
<td>93.6</td>
<td>3.8</td>
<td>72.1</td>
<td>80.5</td>
<td>68.6</td>
<td>69.6</td>
<td>84.7</td>
<td>77.7</td>
</tr>
<tr>
<td>Herd I 1989</td>
<td>Flies/face</td>
<td>1.3</td>
<td>0.4</td>
<td>0.3</td>
<td>10.2</td>
<td>4.1</td>
<td>3.7</td>
<td>4.4</td>
<td>8.5</td>
<td>3.3</td>
<td>3.8</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td>(0.2)</td>
<td>(0.2)</td>
<td>(0.1)</td>
<td>(0.9)</td>
<td>(1.0)</td>
<td>(0.8)</td>
<td>(2.7)</td>
<td>(0.9)</td>
<td>(1.0)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>% Reduct.</td>
<td>-</td>
<td>69.2</td>
<td>93.6</td>
<td>3.8</td>
<td>72.1</td>
<td>80.5</td>
<td>68.6</td>
<td>69.6</td>
<td>84.7</td>
<td>77.7</td>
</tr>
<tr>
<td>Herd II 1989</td>
<td>Flies/face</td>
<td>1.0</td>
<td>0.3</td>
<td>0.5</td>
<td>2.7</td>
<td>6.0</td>
<td>4.7</td>
<td>7.0</td>
<td>25.5</td>
<td>6.8</td>
<td>4.5</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td>(0.2)</td>
<td>(0.1)</td>
<td>(0.2)</td>
<td>(0.8)</td>
<td>(1.0)</td>
<td>(1.3)</td>
<td>(1.8)</td>
<td>(2.3)</td>
<td>(0.7)</td>
<td>(1.1)</td>
</tr>
<tr>
<td></td>
<td>% Reduct.</td>
<td>-</td>
<td>76.9</td>
<td>89.4</td>
<td>74.5</td>
<td>59.2</td>
<td>75.3</td>
<td>50.0</td>
<td>8.9</td>
<td>68.4</td>
<td>73.5</td>
</tr>
<tr>
<td>Control 1990</td>
<td>Flies/face</td>
<td>4.5</td>
<td>9.0</td>
<td>23.5</td>
<td>23.0</td>
<td>47.0</td>
<td>39.5</td>
<td>43.0</td>
<td>28.5</td>
<td>11.3</td>
<td>4.6</td>
</tr>
<tr>
<td></td>
<td>S.E.M.</td>
<td>(0.6)</td>
<td>(1.5)</td>
<td>(0.0)</td>
<td>(2.7)</td>
<td>(3.3)</td>
<td>(3.8)</td>
<td>(2.8)</td>
<td>(1.9)</td>
<td>(1.2)</td>
<td>(0.5)</td>
</tr>
<tr>
<td></td>
<td>% Reduct.</td>
<td>-</td>
<td>25.6</td>
<td>42.6</td>
<td>65.2</td>
<td>83.4</td>
<td>36.7</td>
<td>59.3</td>
<td>71.9</td>
<td>68.1</td>
<td>47.8</td>
</tr>
</tbody>
</table>

<sup>a</sup> Face flies were counted on head and face of animal. N = 10.

<sup>b</sup> All treated means significantly different than untreated control means of same year within the same week (P < 0.05) using Student t-test (Goldstein 1964).
Table 4. Trace mineralized salt usage and cost.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of animals access to spray</td>
<td>55</td>
<td>24</td>
<td>51</td>
</tr>
<tr>
<td>Kg trace mineral (total)</td>
<td>360</td>
<td>182</td>
<td>296</td>
</tr>
<tr>
<td>Cost @ $320.00/ton</td>
<td>$128.00</td>
<td>$64.00</td>
<td>$104.00</td>
</tr>
<tr>
<td>Average cost/animal</td>
<td>$1.89</td>
<td>$2.32</td>
<td>$2.12</td>
</tr>
<tr>
<td>Consumption (g/day/animal)</td>
<td>51.5</td>
<td>58.8</td>
<td>44.8</td>
</tr>
</tbody>
</table>

Another advantage of this sprayer is that it operates on battery power and therefore is portable. The sprayer can easily be moved from field to field with a tractor or truck. Usually one fully charged battery lasts one season. However, if the battery should become discharged it can be replaced with a 12-volt automotive battery found in cars, trucks, and many farm implements. The sprayer is also versatile in that the concentration of insecticide or the type of insecticide can be changed any time during the fly season.

One disadvantage to the automatic sprayer is that a basic understanding of spray systems and a certain amount of maintenance is required to keep them functioning. In our tests, the sprayers were checked weekly and minor maintenance to the pump system or electrical systems were required. Another disadvantage to this system would be the initial cost of the sprayer (ca. $600.00), although this can be recouped after several seasons of use.

Acknowledgment

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References Cited


