LABORATORY EVALUATION OF INSECTICIDES FOR
CONTROL OF ADULT AND LARVAL HIDE BEETLES, ¹
DERMESTES MACULATUS DEGEER,
FROM Poultry HOUSES²,³

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Abstract: Twenty-three formulations and 40 insecticide treatments were screened in the
laboratory against hide beetle, Dermestes maculatus DeGeer, adults and larvae. Tetra­
chlorvinphos (Rabon 50 WP) and carbaryl (Sevin XLR), the products currently used for
litter beetle control in poultry houses, were found to be as effective as any of the materials
tested. Permethrin 0.25% dust (Ectiban), bendiocarb 1.0% dust, and microencapsulated
diazinon (Knox-Out 2FM) also provided good control. Carbamate and organophosphate
insecticides were more effective than pyrethroids at practical rates of application. Adults
were controlled more easily than larvae.

Key Words: Dermestes maculatus, hide beetles, pests of poultry, carbaryl, bendiocarb,
diazinon, dichlorvos, malathion, tetrachlorvinphos, cypermethrin, fenvalerate, permethrin.

The hide beetle, Dermestes maculatus DeGeer, has recently become a serious
problem in deep-pit, high-rise, environmentally controlled poultry houses in
Pennsylvania. The beetles live and develop within the accumulated manure and
litter of the pit, and when last instar larvae are ready to pupate, they migrate
throughout the house in search of protected pupational sites. Damage occurs as
these larvae bore into the wood and insulation of the house. The resulting damage
is similar to that caused by the lesser mealworm, Alphilobius diaperinus (Panzer)
(Gall 1980). While only Dunning et al. (1978) reported larval damage and assigned
economic importance to the hide beetle, surveys of poultry litter have found moderate
numbers of D. maculatus (Legner et al. 1975; Pfeiffer and Axtell 1980).

Despite the limited amount of information on the hide beetle in poultry houses,
similar structural damage has been reported in fertilizer mills and packing plants
(Robinson 1930; Brimblecombe 1938).

Because of the serious structural damage caused by this pest, poultrymen
desperately need an effective control strategy. At present, control is difficult to
achieve because there is an overlap of generations within a house and pupation
occurs within structural materials away from the breeding site. The large
accumulations of manure associated with high-rise, deep-pit houses further
complicate the situation by maintaining an environment favorable for reproduction
throughout most of the year. The houses are normally only cleaned once or twice a

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³ Where trade names are used, no discrimination is intended, and no endorsement by The Pennsylvania State University
Agricultural Experiment Station is implied.
year. Manure is stored until it can be used effectively to increase soil fertility and most poultry operations do not have available land to dispose of it regularly. While manure management and sanitation are important considerations in any control program, it appears that the industry will need to rely on efficacious insecticides to keep beetle populations below economic threshold levels.

There are only two insecticides currently registered for litter beetle control in poultry houses: Rabon® (tetrachlorvinphos) and Sevin® (carbaryl). Applications of dusts or sprays to the manure surface and house interior will suppress populations for a short period of time. Once a house becomes infested, a residual population often remains even after cleanout and treatment.

Despite the inability of the poultry industry to control the hide beetle, efficacious insecticides have been identified in the laboratory (Jensen and Holdaway 1946; Turner 1950; Lloyd and Dyte 1965; Wheatly 1971; and MacQuillan and Shipp 1975). A series of laboratory screening trials were performed to evaluate newer compounds and possibly find insecticides more efficacious against hide beetle adults and larvae.

MATERIALS AND METHODS

Tests were conducted at The Pennsylvania State University Poultry Research Farm Entomology Laboratory between 4 September 1981, and 26 June 1983. Insecticides being screened were prepared in 100 ml volumes and appropriate aliquots were applied to 20.3 × 30.5 cm sheets of Whatman no. 4 chromatography paper (see Tables 1 - 7 for specific application rates). Spray applications were made with a 250 ml chromatography sprayer (Fisher model 24/25) with air being supplied by an Arthur H. Thomas air pump (Model DOA-104-AA). After air drying, circular sections that completely covered the bottoms of 100 × 15 mm plastic petri dishes were cut from the treated papers. Similar circular sections were cut from untreated papers and used as controls. These treatment papers were then placed in the disposable plastic petri plates with the treated surface up. Pre-weighed quantities of dust and granular formulations were placed directly onto the bottom of the petri plates. Insecticides listed in the tables were obtained from the manufacturers. CGA-112913 (00-7899) was N-[4-(3-chloro-5-trifluoromethyl-2-pyridinyl-oxy)-3,5-dichloro-phenyl-aminocarbonyl]-2,6-difluoro-benzamide.

Each plate received either 10 lab-reared adults or mid to late instar larvae within 12 h of spray application. Each treatment was replicated six times except for the first two studies which were replicated four times. Adult and larval mortality counts were taken at 24, 72, and 168 h posttreatment and individuals were classified as normal, moribund, or dead. Adult mortality was not tested in studies two or four due to unavailability of beetles. Since prepupae are easily mistaken as dead larvae, larval mortality was checked again at 336 h posttreatment and adjusted. Adjustments also had to be made when treatment plates were missing larvae. Scoggin and Tauber (1949), and Roche and Smith (1973) reported that pupae are often cannibalized by larvae. In these tests it was assumed that missing larvae had pupated and these pupae were cannibalized by the remaining larvae. All pupae and missing larvae were classified as normal.

The insects remained in contact with the insecticides for the duration of the study and were not provided food or water during this time. The test plates were housed in an environmentally controlled chamber at 25°C, 70% RH, and no light.
RESULTS AND DISCUSSION

Various formulations and dosages of permethrin and fenvalerate tested in study one did not give satisfactory levels of control (Table 1). Larval mortality levels did not differ significantly from the controls until 168 h posttreatment. Only the two highest concentrations of Atroban 25 WP and highest concentration of Ectiban 25 WP were significantly higher than the controls. Adult mortality levels were slightly higher but similar trends were observed (Table 1).

In the second study, two carbaryl and two malathion (Cythion®) formulations were compared to the highest rate of permethrin (Atroban® 25 WP) tested in study one (Table 2). At 118 h Sevin XLR resulted in significantly better larval control than all other treatments except for Atroban 25 WP, but mortality comparisons between Atroban and Cythion 25 WP treatments were not significantly different. Significant efficacy differences between formulations were seen with both carbaryl and malathion.

Several concentrations of tetrachlorvinphos (Rabon 50 WP), carbaryl (Sevin XLR), and microencapsulated diazinon (Knox-Out® 2FM) were evaluated in study three (Table 3). Tetrachlorvinphos and carbaryl, the pesticides currently used for litter beetle control in poultry houses, performed equally well against larvae. Mortality of larvae treated with the microencapsulated formulation of diazinon was not significantly different from tetrachlorvinphos and carbaryl, but is not currently registered for use in poultry houses. All treatments, except the lower concentration of carbaryl (Sevin XLR), provided complete adult control after 72 h (Table 3).

In study four cypermethrin, two formulations of bendiocarb, and carbaryl (Sevimol® 4) did not result in adequate larval control (Table 4).

Several livestock dusts were evaluated in the fifth study (Table 5). Permethrin and bendiocarb dusts provided complete larval control and resulted in significantly higher mortality than coumaphos and tetrachlorvinphos dusts. All dusts achieved excellent adult control after 72 h (Table 5).

Higher concentrations of permethrin (Ectiban® 25 WP) than previously tested, along with chlorpyrifos (Dursban® 4E), were evaluated in the sixth study. The highest concentration of permethrin did not provide complete control, but did achieve high larval mortality. Both rates of permethrin resulted in significantly higher mortality than chlorpyrifos. These two pesticides produced complete adult mortality with chlorpyrifos achieving control after a shorter exposure time (Table 6).

Two additional formulations of diazinon (Spectracide® 2G and AG500) were tested in study seven (Table 7). Both formulations were less effective than the microencapsulated formulation (Knox-Out 2FM) tested in study three (Table 3). RaVap treatment results did not show any greater mortality than the diazinon formulations, and CGA 112913 did not produce significantly greater larval mortality than the control. CGA 112913 was not evaluated against adults. All other treatments provided complete adult mortality after 72 h (Table 7).

Adult mortality levels from insecticide treatments were slightly higher than larval mortality. With the exception of study one, adult mortality in the control was extremely high at 168 h posttreatment (Tables 3, 5, 6, and 7), probably due to lack of water.
Table 1. Laboratory evaluation of pyrethroid insecticides for the control of hide beetle, *Dermestes maculatus*, late instar larvae and adults.*

<table>
<thead>
<tr>
<th>Treatment†</th>
<th>mg ai/m²</th>
<th>% Mortality‡</th>
<th>% Mortality‡</th>
<th>% Mortality‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
</tr>
<tr>
<td></td>
<td></td>
<td>24</td>
<td>72</td>
<td>168</td>
</tr>
<tr>
<td>Atroban 25 WP</td>
<td>66.7</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>5.0 a</td>
</tr>
<tr>
<td>(permethrin)</td>
<td>133.4</td>
<td>2.5 a</td>
<td>0.0 a</td>
<td>15.0 a</td>
</tr>
<tr>
<td></td>
<td>266.8</td>
<td>2.5 a</td>
<td>0.0 a</td>
<td>10.0 a</td>
</tr>
<tr>
<td>Ectiban 25 WP</td>
<td>53.4</td>
<td>2.5 a</td>
<td>0.0 a</td>
<td>2.5 a</td>
</tr>
<tr>
<td>(permethrin)</td>
<td>133.4</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>15.0 a</td>
</tr>
<tr>
<td>Ectiban 5.7 EC</td>
<td>54.2</td>
<td>2.5 a</td>
<td>0.0 a</td>
<td>2.5 a</td>
</tr>
<tr>
<td>(permethrin)</td>
<td>135.3</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>2.5 a</td>
</tr>
<tr>
<td>Ectrin 13.76 WP</td>
<td>40.0</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
<tr>
<td>(fenvalerate)</td>
<td>100.1</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>5.0 a</td>
</tr>
<tr>
<td>Permetrin 10 EC</td>
<td>40.7</td>
<td>2.5 a</td>
<td>0.0 a</td>
<td>7.5 a</td>
</tr>
<tr>
<td>(permethrin)</td>
<td>101.4</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>5.0 a</td>
</tr>
<tr>
<td>Control</td>
<td>–</td>
<td>0.0 a</td>
<td>0.0 a</td>
<td>0.0 a</td>
</tr>
</tbody>
</table>

*Means within columns followed by the same letter are not significantly different by Waller-Duncan's k-ratio t-test with k-ratio = 100 (Steel and Torrie 1980).
†Four replications per treatment.
‡Arcsine square root transformation performed on the data before analysis. Untransformed means are reported.
<table>
<thead>
<tr>
<th>Treatment†</th>
<th>mg ai/m²</th>
<th>24 % Mortality†</th>
<th>72 % Mortality†</th>
<th>168 % Mortality†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sevin XLR (carbaryl)</td>
<td>4886.6</td>
<td>15.0 a</td>
<td>60.0 a</td>
<td>97.5 a</td>
</tr>
<tr>
<td>Sevimol 4 (carbaryl)</td>
<td>4886.6</td>
<td>10.0 a</td>
<td>45.0 ab</td>
<td>62.5 c</td>
</tr>
<tr>
<td>Cythion (malathion)</td>
<td>692.6</td>
<td>5.0 a</td>
<td>25.0 b</td>
<td>55.0 c</td>
</tr>
<tr>
<td>Cythion (malathion)</td>
<td>376.7</td>
<td>7.5 a</td>
<td>50.0 ab</td>
<td>82.5 b</td>
</tr>
<tr>
<td>Atroban 25 WP (permethrin)</td>
<td>266.8</td>
<td>0.0 a</td>
<td>32.5 ab</td>
<td>85.0 ab</td>
</tr>
<tr>
<td>Control</td>
<td>–</td>
<td>0.0 a</td>
<td>2.5 c</td>
<td>2.5 d</td>
</tr>
</tbody>
</table>

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†Four replications per treatment.
‡Arctgine square root transformation performed on the data before analysis. Untransformed means are reported.
Table 3. Laboratory evaluation of three insecticide formulations for the control of hide beetle, *Dermestes maculatus* late instar larvae and adults.*

<table>
<thead>
<tr>
<th>Treatment†</th>
<th>mg ai/m²</th>
<th>% Mortality‡</th>
<th></th>
<th>% Mortality‡</th>
<th></th>
<th>% Mortality‡</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
<td>Adults</td>
</tr>
<tr>
<td>Rabon 50 WP (tetrachlorvinphos)</td>
<td>3911.2</td>
<td>6.7 a</td>
<td>100.0 a</td>
<td>51.7 ab</td>
<td>100.0 a</td>
<td>95.0 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>Sevin XLR (carbaryl)</td>
<td>4886.6</td>
<td>5.0 a</td>
<td>53.3 c</td>
<td>46.7 ab</td>
<td>93.3 b</td>
<td>96.7 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>Knox-Out 2FM (diazinon)</td>
<td>241.9</td>
<td>5.0 a</td>
<td>76.7 bc</td>
<td>45.0 ab</td>
<td>100.0 a</td>
<td>95.0 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>0.0 a</td>
<td>18.3 d</td>
<td>0.0 c</td>
<td>58.3 c</td>
<td>0.0 b</td>
<td>91.7 b</td>
</tr>
</tbody>
</table>

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Table 4. Laboratory evaluation of four insecticide formulations for the control of hide beetle, *Dermestes maculatus* late instar larvae.*

<table>
<thead>
<tr>
<th>Treatment†</th>
<th>mg ai/m²</th>
<th>24</th>
<th>72</th>
<th>168</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demon 40 WP (cypermethrin)</td>
<td>108.6</td>
<td>1.7 a</td>
<td>16.7 b</td>
<td>36.7 c</td>
</tr>
<tr>
<td></td>
<td>217.3</td>
<td>1.7 a</td>
<td>16.7 b</td>
<td>55.0 bc</td>
</tr>
<tr>
<td>Bendiocarb 20 WP</td>
<td>133.6</td>
<td>1.7 a</td>
<td>51.7 a</td>
<td>80.0 a</td>
</tr>
<tr>
<td>Bendiocarb 50 SC</td>
<td>135.8</td>
<td>6.7 a</td>
<td>53.3 a</td>
<td>78.3 a</td>
</tr>
<tr>
<td>Sevimol 4 (carbaryl)</td>
<td>4886.6</td>
<td>5.0 a</td>
<td>30.0 b</td>
<td>75.0 ab</td>
</tr>
<tr>
<td>Control</td>
<td>-</td>
<td>0.0 a</td>
<td>1.7 c</td>
<td>6.7 d</td>
</tr>
</tbody>
</table>

* Means within columns followed by the same letter are not significantly different by Waller-Duncan's k-ratio t-test with k-ratio = 100 (Steel and Torrie 1980).
† Six replications per treatment.
‡ Arcsine square root transformation performed on the data before analysis. Untransformed means are reported.
Table 5. Laboratory evaluation of four livestock dust formulations for the control of hide beetle, *Dermestes maculatus* late instar larvae and adults.*

<table>
<thead>
<tr>
<th>Treatment†</th>
<th>mg ai/m²</th>
<th>24 Hours posttreatment</th>
<th>72 Hours posttreatment</th>
<th>168 Hours posttreatment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>% Mortality†</td>
<td>% Mortality†</td>
<td>% Mortality†</td>
</tr>
<tr>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
<td>Adults</td>
</tr>
<tr>
<td>Ectiban 0.25% Dust (permethrin)</td>
<td>50.2</td>
<td>20.0 a</td>
<td>86.7 ab</td>
<td>96.7 a</td>
</tr>
<tr>
<td>Co-Ral 1.0% Dust (coumaphos)</td>
<td>200.9</td>
<td>3.3 c</td>
<td>83.3 ab</td>
<td>46.7 b</td>
</tr>
<tr>
<td>bendiocarb 1.0% Dust</td>
<td>200.9</td>
<td>21.7 a</td>
<td>80.0 b</td>
<td>86.7 a</td>
</tr>
<tr>
<td>Rabon 3.0% Dust (tetrachlorvinphos)</td>
<td>1466.0</td>
<td>15.0 ab</td>
<td>93.3 a</td>
<td>58.3 b</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>6.7 bc</td>
<td>3.3 c</td>
<td>11.7 c</td>
</tr>
</tbody>
</table>

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† Six replications per treatment.
‡ Arcsine square root transformation performed on the data before analysis. Untransformed means are reported.
Table 6. Evaluation of Ectiban 25 WP and Dursban 4E for the control of hide beetle, *Dermestes maculatus*, late instar larvae in the laboratory.

<table>
<thead>
<tr>
<th>Treatment†</th>
<th>% Mortality‡</th>
<th>Hours posttreatment</th>
<th>% Mortality‡</th>
<th>% Mortality‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Larvae</td>
<td>Adults</td>
<td>Larvae</td>
<td>Adults</td>
</tr>
<tr>
<td>Ectiban 25 WP</td>
<td>533.6 mg ai/m²</td>
<td>1.7 a</td>
<td>48.3 c</td>
<td>23.3 a</td>
</tr>
<tr>
<td></td>
<td>1067.3 mg ai/m²</td>
<td>1.7 a</td>
<td>56.7 bc</td>
<td>13.3 ab</td>
</tr>
<tr>
<td>Dursban 4E (chlorpyrifos)</td>
<td>203.3 mg ai/m²</td>
<td>5.0 a</td>
<td>80.0 ab</td>
<td>13.3 ab</td>
</tr>
<tr>
<td></td>
<td>406.6 mg ai/m²</td>
<td>6.7 a</td>
<td>86.7 a</td>
<td>15.0 ab</td>
</tr>
<tr>
<td>Control</td>
<td>–</td>
<td>0.0 a</td>
<td>0.0 d</td>
<td>5.0 b</td>
</tr>
</tbody>
</table>

*Means within columns followed by the same letter are not significantly different by Waller-Duncan's k-ratio t-test with k-ratio = 100 (Steel and Torrie 1980).
† Six replications per treatment.
‡ Arcsine square root transformation performed on the data before analysis. Untransformed means are reported.
Table 7. Evaluation of four insecticide formulations for the control of hide beetle, *Dermestes maculatus*, late instar larvae and adults in the laboratory.*

<table>
<thead>
<tr>
<th>Treatment‡</th>
<th>mg ai/m²</th>
<th>24</th>
<th>% Mortality‡</th>
<th>72</th>
<th>% Mortality‡</th>
<th>168</th>
<th>% Mortality‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>spectrace 2G (diazinon)</td>
<td>224.4</td>
<td>10.0 ab</td>
<td>90.0 a</td>
<td>31.7 a</td>
<td>100.0 a</td>
<td>85.0 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>ravap 28.7 EC (tetrachlorvinphos + dichlorvos)</td>
<td>935.4</td>
<td>1.7 bc</td>
<td>100.0 a</td>
<td>31.7 a</td>
<td>100.0 a</td>
<td>76.7 ab</td>
<td>100.0 a</td>
</tr>
<tr>
<td>dzn ag 500 (diazinon)</td>
<td>271.0</td>
<td>3.3 bc</td>
<td>36.7 c</td>
<td>40.0 a</td>
<td>100.0 a</td>
<td>88.3 a</td>
<td>100.0 a</td>
</tr>
<tr>
<td>cga 112913</td>
<td>1081.6</td>
<td>1.7 bc</td>
<td>–</td>
<td>1.7 b</td>
<td>–</td>
<td>3.3 c</td>
<td>–</td>
</tr>
<tr>
<td>control</td>
<td>–</td>
<td>0.0 c</td>
<td>11.7 d</td>
<td>0.0 b</td>
<td>21.7 b</td>
<td>1.7 c</td>
<td>100.0 a</td>
</tr>
</tbody>
</table>

* Means within columns followed by the same letter are not significantly different by Waller-Duncan’s k-ratio t-test with k-ratio = 100 (Steel and Torrie 1980).

‡ Six replications per treatment.

§ Arcsine square root transformation performed on the data before analysis. Untransformed means are reported.
Tetrachlorvinphos (Rabon 50 WP) and carbaryl (Sevin XLR), the pesticides currently used for litter beetle control in poultry houses, provided excellent control of hide beetle larvae and adults in the laboratory. In addition, both permethrin 0.25% (Ectiban) and bendiocarb 1.0% dusts were very effective. Of these two, only permethrin dust is currently labelled for use against other poultry pests. Microencapsulated diazinon (Knox-Out 2FM) also provided excellent control, but label restrictions currently prohibit the use of diazinon in poultry houses. The highest rate of permethrin (Ectiban 25 WP) tested (Table 6) produced high mortality but this concentration would not currently be cost effective.

Efficacy rates were highly variable in relation to different formulations containing the same active ingredient. In general, dusts were more effective than spray applications and wettable powders were more potent than emulsifiable concentrates or flowable formulations. Granular formulations may be valuable for application to the manure surface. Only one granular insecticide (Spectracide 2G) was included in these tests; however, dry conditions in the petri plates may have influenced the results. CGA 112913 was also not properly tested since insect growth regulators need to be ingested.

During these evaluations, the beetles were continuously exposed to the insecticide under controlled conditions for 7 d. Despite this high exposure pressure, few formulations and rates provided greater than 90% larval control. Residual spray applications of these insecticides to poultry house pit walls would probably not be effective due to rapid adult and larval migration across these surfaces. Further work is needed to identify highly efficacious compounds which are fast-acting and have long residual activity. These studies suggest that pyrethroid insecticides (permethrin, fenvalerate, and cypermethrin) are not effective for hide beetle control; both carbamate and organophosphate compounds have greater potential.

Vaughan and Turner (1984) found that the residual and topical toxicity of various insecticides to the lesser mealworm which is a similar problem in poultry houses, to be highly variable in relation to formulation, surface type and life stage of the insect. Tetrachlorvinphos 50% WP (Rabon) gave excellent control in both residual and topical applications which is in agreement with our results. Both carbaryl and permethrin were inferior to tetrachlorvinphos in residual tests, but permethrin was highly toxic to both adults and late instar larvae in topical applications.

Cross-sectional sampling of manure cones in poultry houses indicated that hide beetles do not inhabit the interior of the manure cone (unpublished data). Further sampling of aisles, cone edges, and other areas of the manure pit where food sources (Cloud 1984) are found should be performed to identify areas with high beetle populations. By targeting insecticide applications toward these high density locations, poultrymen may be able to achieve better control while reducing the total amount of pesticide used.

REFERENCES CITED


