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AGRICULTURAL PESTICIDES AND
THEIR INFLUENCE ON FOOD PREFERENCE AND
CONSUMPTION BY RING-NECKED PHEASANTS

presented by

Richard Seigel Bennett, Jr.

has been accepted towards fulfillment
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Masters degree in Wildlife

Harold H. Prince
Major professor

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AGRICULTURAL PESTICIDES AND

THEIR INFLUENCE ON FOOD PREFERENCE AND

CONSUMPTION BY RING-NECKED PHEASANTS

By

Richard Seigel Bennett, Jr.

A THESIS

Submitted to
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# ABSTRACT

## AGRICULTURAL PESTICIDES AND THEIR INFLUENCE ON FOOD PREFERENCE AND CONSUMPTION BY RING-NECKED PHEASANTS

By

Richard Seigel Bennett, Jr.

The use of agricultural pesticides on corn was evaluated in three Michigan counties. A total of 270 landowners responded to a questionnaire concerning their land use and pesticide practices. Insecticides are used on 45 percent of all corn, while herbicides are applied to 90 percent. Herbicide practices are similar among counties, and insecticide use varies, suggesting that potential effects from pesticide use on wildlife populations may be variable and local.

The fungicide captan and three insecticides, Diazinon®, Furadan®, and Lorsban®, were used in various concentrations of foods to evaluate their influence on food consumption and preference by ring-necked pheasants. Free choice feeding trials were conducted using combinations of untreated and treated food. Untreated food is preferred whenever available. Food with lesser concentrations of pesticide are selected when only treated food was offered. Food preferences by pheasants shift when preferred food types are treated. Pheasants are able to detect the presence of pesticides, and will avoid treated foods if alternatives are available.

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I also wish to thank Martin Polluck of the Michigan Department of Natural Resources and Cal Flegal of the Poultry Science Department at Michigan State University for providing the birds. Robert Ruppel of the Entomology Extension Service provided the insecticides, and captan was furnished by the Michigan Foundation Seed Association.

TABLE OF CONTENTS

Page

APPENDICES

LIST OF TABLES

Table | Page

LIST OF FIGURES

USE SURVEY OF AGRICULTURAL PESTICIDES

## INTRODUCTION

Chlorinated hydrocarbons were the primary compounds used on corn to control corn rootworms and other soil insects in the early days of soil insecticide use. An estimated 271,000 acres of corn (12 percent of the total corn planted) were treated with insecticides, mostly for rootworm control, in a survey of Michigan farms in 1971 (Michigan Crop Reporting Service 1972). Aldrin was used on 166,000 acres (61 percent), while heptachlor, Diazinon,® and BUX® were used in smaller amounts. In the Great Lakes region of Illinois, Indiana, Michigan, Minnesota, and Wisconsin, aldrin was the most commonly used pre-emergent insecticide on corn (31 percent of the treated acres) in surveys conducted in the period of 1969 to 1971, with Furadan® (21 percent), Thimet® (16 percent), and BUX (12 percent) also used in large amounts (Michigan Crop Reporting Service 1972). In surveys conducted in Iowa and Illinois during 1972 and 1973, aldrin was again the most commonly used soil insecticide on corn, although the use of Furadan was increasing rapidly, because corn rootworms were becoming more resistant to the chlorinated hydrocarbons (Turim et al. 1974).

The western corn rootworm first entered Michigan in 1971 already resistant to chlorinated hydrocarbon insecticides (Ruppel and Kaiser 1973). The resident northern corn rootworm was also resistant to aldrin and chlordane in some parts of the state. Consequently, aldrin was removed from the recommended list of insecticides in Michigan to prevent future problems with persistent residues (Ruppel (1975).

Additionally, the registration of dieldrin as a seed treatment was withdrawn in 1975 (Ruppel, personal communication), and the use of chlordane has been recommended for non-dairy farms only (Ruppel 1975).

In light of these recent restrictions on many chlorinated hydrocarbon insecticides, this study investigated the current pesticide practices in Michigan in order to better understand their potential impact on wildlife populations. A landowner survey was conducted in the counties of Allegan, Gratiot, and Huron (Figure 1). These counties were chosen because they were among the ten leading Michigan counties for corn production in 1975 (Michigan Crop Reporting Service 1976), while varying considerably in their pheasant populations in 1976 (Michigan Department of Natural Resources, personal communication). The relative pheasant densities for the fall of 1976 were high to moderate in Allegan county, moderate to low in Gratiot county, and very low in Huron county, except for moderate densities near Saginaw bay in the western portion of the county.

## METHODS

A cover letter explaining the nature of the survey (Appendix A) and a two page questionnaire (Appendix B) were sent to each landowner in the survey. A postcard reminder (Appendix C) was sent to all persons receiving the survey three weeks after the initial mailing.

Names of persons owning 40 acres or more were chosen systematically from the card files at Agricultural Stabilization and Conservation Service (USDA) county offices. Forty acres was assumed to be the smallest acreage that would be farmed for cash crops by the landowner.

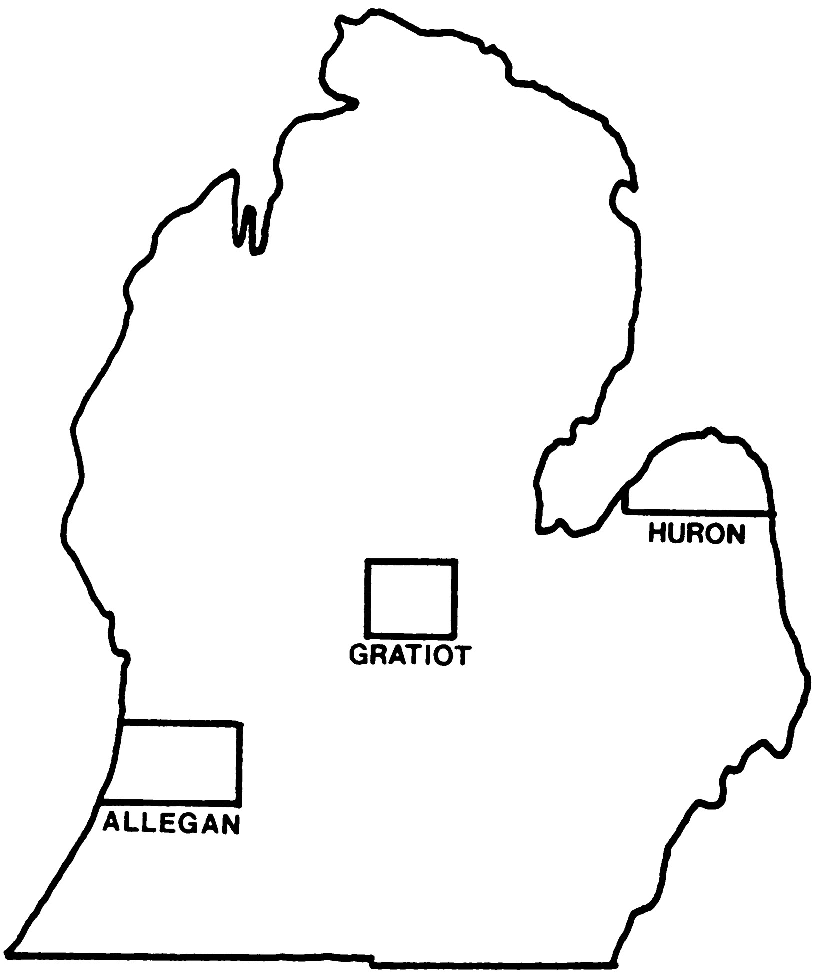



Figure 1.--Counties of Michigan in which the survey was conducted

A pilot survey was done prior to the three county survey to check the return rate and the quality of the responses. A total of 30 questionnaires were sent to landowners in Ingham county, in south central Michigan, in June of 1977. The questionnaire was then revised and a separate work sheet was included for respondents that needed more space to adequately complete all of the questions. A total of 900 questionnaires were mailed in July, 1977, with 300 each sent to residents of Allegan, Gratiot, and Huron counties.

In September, 1977 a telephone survey was conducted with 26 randomly chosen non-respondents. Several questions from the questionnaire were asked to check for bias in the returns. The telephone survey questions are marked with an asterisk in Appendix B.

## RESULTS

A total of 10 usable questionnaires (33 percent) were returned from the pilot survey. With the revised form, 270 usable questionnaires (30 percent) were returned from the three county survey. The return rate was the same ($X^2$=.153, df=1) for the pilot and the three county surveys. Forty five returns were classified as unusable because the questionnaires were left blank with only written comments, or the owner currently owned less than 40 acres.

The usable questionnaires were classified into one of four land ownership size classes: 40 to 79 acres, 80 to 159 acres, 160 to 319 acres, and 320 or more acres. There was no significant difference ($X^2$=1.26, df=3) between the number of questionnaires sent and returned by size class (Table 1), although the largest size class had the highest rate of return. The returns by county were as follows: Allegan, 109 (36 percent); Gratiot, 89 (30 percent); and Huron, 72

(24 percent). There was a significant difference in the rate of return by county ($X^2$=10.88, df=2).

TABLE 1.--Number of questionnaires sent and returned by size class of acreage owned.

| Acreage Owned | Number of Questionnaires | | Percent Returned |
|---|---|---|---|
| | Sent | Returned | |
| 40 to 79 | 247 | 73 | 29.6 |
| 80 to 159 | 375 | 111 | 29.6 |
| 160 to 319 | 222 | 64 | 28.8 |
| 320 or more | 56 | 22 | 39.3 |

## General Characteristics of Respondents

Of all the respondents, 90 percent resided on their own property. There were 180 of the respondents (67 percent) that farmed their land alone or with the help of relatives. Sixty one respondents (23 percent) rented their land, and 29 (11 percent) used the land primarily for purposes other than farming. The average acreage owned for the three counties was 149 acres (Table 2). This compares with a state average of 157 acres per farm in 1977 (Michigan Crop Reporting Service 1978). For the 209 respondents that did not rent their land the average acreage farmed, both owned and rented, was 237 acres. A total of 164 respondents (78 percent of respondents that farmed) reported growing corn in 1977. There was no significant difference in the proportion of farmers growing corn by county ($X^2$=4.24, df=2). For the three counties combined there was an average of 108 acres of corn planted in 4.6 fields for an average field size of 22 acres.

TABLE 2.--Means (±SE) for several parameters of farm size and corn acreage in the three counties surveyed.[a]

| Parameter | Allegan | Gratiot | Huron | Total |
|---|---|---|---|---|
| Acreage Owned | $116 \pm 8^{b}$ | $178 \pm 21^{c}$ | $162 \pm 25^{b,c}$ | $149 \pm 10$ |
| Acreage farmed (including rented) | $158 \pm 20^{b}$ | $324 \pm 37^{c}$ | $258 \pm 35^{b,c}$ | $237 \pm 18$ |
| Acres of corn | $83 \pm 17^{b}$ | $149 \pm 27^{c}$ | $98 \pm 20^{b,c}$ | $106 \pm 13$ |
| Number of fields | $4.8 \pm 0.8^{b}$ | $4.8 \pm 0.6^{b}$ | $4.2 \pm 0.5^{b}$ | $4.6 \pm 0.4$ |
| Size of fields | $18.0 \pm 2.0^{b}$ | $29.2 \pm 3.6^{c}$ | $21.0 \pm 2.3^{b,c}$ | $22.4 \pm 1.6$ |

[a] Any two county means in a row having the same superscript ($^{b,c}$) are not significantly different using Tukey's test (P=.05).

Comparisons with Non-respondents

The average acreage owned by the 26 non-respondents in the telephone survey was 136 acres, which was not significantly different from those that did respond. Also, the distribution of acreage owned by size classes was the same as the respondents group ($X^2$=0.48, df=3). There was a significant difference between the two groups in the proportion of landowners renting their land ($X^2$=7.12, df=1). The proportion of non-respondents (46 percent) renting their land was twice that of the respondents group (23 percent). Consequently, the true number of renters in the population may be under represented on the returns of the three county survey.

Among persons that farmed their own land there were no significant differences between respondents and non-respondents in acreage farmed, acreage rented, acres of corn, or acreage treated with pesticides.

Insecticide Practices on Corn

A total of 49,522 acres were reported by 209 respondents that farmed their own land. Corn was planted on 17,765 acres (36 percent) by respondents. Insecticides were applied to 8033 acres (45 percent) by 47 of the growers (29 percent). Six insecticides were used: two carbamates, carbofuran (Furadan) and bufencarb (BUX); and four organic phosphates, fonofos (Dyfonate®), Diazinon, ethoprop (Mocap®), and phorate (Thimet)(Table 3). Furadan accounted for 46 percent of all the insecticides used, and was applied to 21 percent of all corn planted. Dyfonate was the only other insecticide reported from all three counties.

TABLE 3.--Insecticide usage by 164 corn growers in the three county survey.

| Insecticide | Number of Farms | Acres Treated | | | | Percent of Total Corn |
|---|---|---|---|---|---|---|
| | | Allegan | Gratiot | Huron | Total | |
| None | 129 | 1527 | 5056 | 2128 | 8711 | 49.0 |
| Furadan (carbofuran) | 26 | 1910 | 455 | 1370 | 3735 | 21.0 |
| Dyfonate (fonofos) | 17 | 1187 | 766 | 676 | 2629 | 14.8 |
| Diazinon (dimpylate) | 2 | 0 | 498 | 280 | 778 | 4.4 |
| Mocap (ethoprop) | 2 | 240 | 0 | 0 | 240 | 1.4 |
| Thimet (phorate) | 2 | 40 | 0 | 0 | 40 | 0.2 |
| BUX (bufencarb) | 1 | 0 | 0 | 25 | 25 | 0.1 |
| No name given | 3 | 300 | 286 | 0 | 586 | 3.3 |
| No response | 10 | 95 | 717 | 209 | 1021 | 5.7 |
| Total corn acreage | | 5299 | 7778 | 4688 | 17765 | 100.0 |

Granular formulations of insecticides were used on 96 percent of all the treated acres. A seed treatment formulation of diazinon was used on 280 acres (4 percent). No other formulations were reported. Also, all insecticide application occurred at planting.

The proportion of insecticide treated acres to total corn acreage varied considerably between counties: Allegan, 69 percent; Gratiot, 26 percent; and Huron, 50 percent. Likewise, the proportion of growers using insecticides was significantly different between counties ($X^2$=10.7, df=2). The number of growers using insecticides was as follows: Allegan, 26 (42 percent); Gratiot, 8 (16 percent); and Huron, 13 (27 percent).

The number of corn acres per farm was classified into four categories as follows: less than 49 acres, 50 to 124 acres, 125 to 249 acres, and 250 or more acres. The total number of growers using insecticides was significantly different between categories ($X^2$=36.3, df=3). Compared to 29 percent of all corn growers, only 11 percent of the growers from the first category used insecticides, while 50 percent and 79 percent used insecticides on all or part of their corn in the third and fourth categories, respectively (Table 4).

TABLE 4.--Percent of farms (n) using insecticides on all or part of their corn by county.

| Acres of Corn | Allegan | Gratiot | Huron | Total |
|---|---|---|---|---|
| Less than 49 | 21 (34) | 0 (16) | 4 (26) | 11 (76) |
| 50 to 124 | 47 (17) | 8 (13) | 33 (9) | 31 (39) |
| 125 to 249 | 100 (7) | 20 (15) | 60 (10) | 50 (32) |
| 250 or more | 100 (4) | 57 (7) | 100 (3) | 79 (14) |
| Total | 42 (62) | 16 (51) | 27 (48) | 29 (161) |

Herbicide Practices on Corn

Of the 17,765 acres of corn reported, 16,067 acres (90 percent) were treated with herbicides by 147 of the growers (92 percent). Although 12 herbicides were used, five (Dual®, Eradicane®, Ramrod®, Paraquat®, and Prowl®) amounted to only one percent of the total use Table 5). Aatrex®, used alone or in combination, was used on 73 percent of the treated acreage and 66 percent of all corn planted. Five other herbicides (Lasso®, Bladex®, Sutan®, Banvel®, and 2,4-D) were used in all three counties.

Thirty-two percent of the corn acreage for which the herbicides used were known were treated with one herbicide, while 64 percent were treated with two herbicides and 5 percent with three herbicides. Sixteen double and 8 triple combinations were reported (Table 6), although only seven of the double and none of the triple combinations accounted for more than two percent of total use. The most widely used combination was Aatrex and Lasso on 3873 acres (22 percent of all corn) by 28 growers. Aatrex was also represented in 12 other combinations.

In response to a question concerning the mixing of pesticides before application, respondents reported that this was done on 2611 acres (26 percent of the corn treated with two or more herbicides). However, a large number of the respondents did not complete this question or did not name the pesticides mixed, so that the actual acreage treated with pesticide mixtures may be much greater. Whether mixed or not, 94 percent of the acreage treated with a combination of herbicides were sprayed at or near the same time.

TABLE 5.--Relative use of herbicides, applied singly or in combination, on 17,765 acres of corn reported by 164 corn growers in the three county survey.

| Herbicide | Number of Farms | Acres Treated | | | | Percent of Total Corn |
|---|---|---|---|---|---|---|
| | | Allegan | Gratiot | Huron | Total | |
| None | 18 | 151 | 376 | 135 | 662 | 3.7 |
| Aatrex (atrazine) | 105 | 4408 | 4916 | 2403 | 11727 | 66.0 |
| Lasso (alachlor) | 47 | 1601 | 2575 | 854 | 5030 | 28.3 |
| Bladex (cyanazine) | 41 | 1186 | 1115 | 1033 | 3334 | 18.8 |
| 2,4-D | 23 | 112 | 1416 | 384 | 1912 | 10.8 |
| Sutan (butylate) | 11 | 70 | 410 | 974 | 1454 | 8.2 |
| Banvel (dicamba) | 8 | 40 | 573 | 98 | 711 | 4.0 |
| Princep (simazine) | 9 | 502 | 0 | 196 | 698 | 3.9 |
| Others [a] | 7 | 150 | 0 | 20 | 170 | 1.0 |
| No name given | 16 | 82 | 734 | 728 | 1544 | 8.7 |
| No response | 11 | 95 | 717 | 224 | 1036 | 5.8 |
| Total corn acreage | | 5299 | 7778 | 4688 | 17765 | 100.0 |

[a]Other minor herbicides reported were: Dual, Eradicane (EPTC), Ramrod (propachlor), Paraquat, and Prowl (penoxalin).

TABLE 6.--Corn acreage from the three county survey on which two or more herbicides were applied.

| Herbicides | Number of Farms | Total Acres Treated | Percent of Total Corn |
|---|---|---|---|
| Aatrex and Lasso | 28 | 3873 | 21.8 |
| Aatrex and Bladex | 11 | 1117 | 6.3 |
| Aatrex and 2,4-D | 8 | 931 | 5.2 |
| Lasso and Bladex | 14 | 906 | 5.1 |
| Aatrex and Sutan | 4 | 855 | 4.8 |
| Aatrex and Princep | 6 | 561 | 3.2 |
| Bladex and Sutan | 5 | 404 | 2.3 |
| Other double combinations [a] | 12 | 582 | 3.2 |
| All double combinations | | 9229 | 51.9 |
| All triple combinations [b] | | 697 | 3.9 |

[a] Nine other double combinations were reported, but all were used on less than 1.5% of the total corn acreage.

[b] Eight triple combinations were reported, but all were used on less than 1.5% of the total corn acreage.

The proportion of corn treated with herbicides by county was as follows: Allegan, 95 percent; Gratiot, 86 percent; and Huron, 92 percent. The proportion of growers using herbicides was not significantly different between counties ($X^2$=1.38, df=2). Nor was there a significant difference ($X^2$=6.94, df=3) in herbicide use between the four categories of corn acreage (Table 7). There were 13 growers that did not use herbicides on any of their corn. All of these planted less than 125 acres of corn.

TABLE 7.--Percent of growers (n) using herbicides on all or part of their corn by county.

| Acres of Corn | Allegan | Gratiot | Huron | Total |
|---|---|---|---|---|
| Less than 49 | 79 (34) | 94 (16) | 92 (25) | 87 (75) |
| 50 to 124 | 100 (17) | 85 (13) | 89 (9) | 92 (39) |
| 125 to 249 | 100 (7) | 100 (15) | 100 (10) | 100 (32) |
| 250 or more | 100 (4) | 100 (7) | 100 (3) | 100 (14) |
| Total | 89 (62) | 94 (51) | 94 (47) | 92 (160) |

All the reported herbicides were applied as sprays. The time of application of herbicides varied considerably among counties. The mean for the three counties was as follows: pre-planting, 20 percent; at planting, 19 percent; pre-emergent, 28 percent; and post-emergent, 34 percent. However, in Allegan county 69 percent of the herbicide applications were made at planting or in the pre-emergent period. Fifty-five percent of the treated acreage in Gratiot county were sprayed in the post-emergent period, while in Huron county 33 percent was sprayed in the pre-planting period.

## Fungicide Usage on Corn

When corn growers were asked if they used corn seed pretreated with the fungicide captan, 65 respondents (40 percent) replied yes, 32 (20 percent) replied no, and 66 (40 percent) did not know. The responses were not significantly different between counties ($X^2$=1.38, df=4), nor were they different between the size classes of corn acreage ($X^2$=1.72, df=6). No other fungicides were listed as being used, although four growers reported that they used Furadan, Dyfonate, or Isotox (a seed treatment bird repelling insecticide) as fungicides. All of these growers had 80 acres or less of corn. Many growers that did not know if a fungicide was used made written comments about the brand of seed corn they planted.

## Plowing Practices on Corn

The season in which a corn field was plowed was examined to see how this influenced pesticide use (Table 8). Plowing practices were reported on 15,221 acres of corn, although the soil was not plowed on 5 percent of the acreage. Fall plowing accounted for 50 percent of the acreage, and spring plowing occurred on 45 percent. The season of plowing varied greatly between counties. Eighty-eight percent of the corn acreage in Allegan county was plowed in the spring, while 68 and 66 percent were plowed in the fall in Gratiot and Huron counties, respectively.

Insecticides were used on 41 percent of the fall plowed land, 49 percent of the spring plowed land, and 87 percent of the unplowed land. However, due to the high degree of variability of plowing practices and insecticide use, meaningful comparisons are hard to identify. The higher insecticide use on spring plowed land was due to the higher insecticide use in Allegan county, which accounted for 60 percent of the Spring plowed land.

TABLE 8.--Acreage plowed (percent of county total) for corn by season in the three counties surveyed.

| Season Plowed | Allegan | Gratiot | Huron | Total |
|---|---|---|---|---|
| Fall | 564 (12) | 4254 (68) | 2787 (66) | 7601 (50) |
| Spring | 4147 (88) | 1962 (31) | 749 (18) | 6858 (45) |
| Not plowed | 0 | 85 (1) | 677 (16) | 762 (5) |
| Total acreage | 4711 | 6301 | 4209 | 15221 |

## Pesticide Practices with Respect to the Previous Crop

Insecticide use was highly related to the previous crop. When corn or pasture land was the previous crop, insecticides were used on 62 and 61 percent of the acreage, respectively (Table 9). Insecticide use following other crops was: small grains, 32 percent; soybeans, 16 percent; all other beans, 11 percent; hay, 9 percent; and all other crops, 6 percent. The high use of insecticides on corn-after-corn was primarily due to problems with corn rootworms in many parts of the state. In Allegan and Huron counties 75 and 76 percent, respectively, of the corn-after-corn was treated with insecticides, while only 41 percent was treated in Gratiot county. Part of this disparity between counties can be explained by the crop rotation practices within the counties, since rotation is the most effective way to control corn rootworms. Forty percent of the corn acreage in Gratiot and Huron counties were preceeded by crops other than corn, while only 16 percent of the corn in Allegan county was not previously corn.

TABLE 9.--Pesticide usage on corn in relationship to the previous crop.

| Previous Crop | Insecticides | | | Herbicides | | |
|---|---|---|---|---|---|---|
| | Acres not treated | Acres treated | Percent of crop treated | Acres not treated | Acres treated | Percent of crop treated |
| Corn | 3844 | 6396 | 62 | 177 | 10063 | 98 |
| Small grains | 951 | 440 | 32 | 154 | 1237 | 89 |
| Soybeans | 178 | 35 | 16 | 0 | 213 | 100 |
| Other beans | 1718 | 220 | 11 | 3 | 1935 | 100 |
| Hay | 339 | 35 | 9 | 16 | 358 | 96 |
| Pasture | 92 | 146 | 61 | 120 | 118 | 50 |
| Other crops [a] | 737 | 48 | 6 | 0 | 785 | 100 |
| Total | 7859 | 7320 | 48 | 470 | 14709 | 97 |

[a] Other crops include sugar beets, cucumbers, and summer plowed land.

Herbicide use on corn was 89 percent or greater following all crops, except on pasture land (50 percent). The sample sizes (number of acres) for most of the crops were quite small, therefore the percentages presented here represent only rough estimates of the actual population.

## Sprout Pulling Damage to Corn

The occurence of sprout pulling (uprooting of emerged corn seedlings) was reported by 59 (36 percent) of the corn growers. Sixty-six growers (40 percent) indicated that they had no problem, and 29 growers (18 percent) did not know if sprout pulling occurred on their land. Ten growers did not respond to this question.

Various methods of preventing sprout pulling were reported by 9 growers. Seven were from Allegan county, and there was one each from Gratiot and Huron counties. Seven of the growers used a chemical repellent on a total of 627 acres. The repellent used on 4 of the farms was Isotox, a seed treatment animal repellent. One grower reported that he used a shotgun to control the problem, and one grower did not elaborate on how he prevented damage.

There were several species of animals responsible for the sprout pulling. Growers experiencing sprout pulling listed the following animals as being responsible: blackbird species (39 of the growers), pheasants (28), crows (23), deer (6), rodents (5), and cattle (1). When asked which of these animals caused the most damage, the growers responded as follows: blackbird species (31), crows (15), pheasants (11), rodents (4), deer (2), cattle (1), or do not know (1). The incidents with deer and cattle were apparently in terms of animals grazing on the green plant rather than pulling the plant from the ground. Also, due to the relatively secretive nature of several of these species, their importance in crop damage may be underestimated.

# DISCUSSION

This survey was designed to compare the pesticide practices on corn of three Michigan counties chosen for their high corn production and varied pheasant populations. It was not statistically designed to estimate pesticide practices for the entire state, although the combined totals of pesticides used for the three counties do represent a rough estimate of statewide practices.

## Trends of Pesticide Use

Comparisons between a statewide pesticide survey conducted in 1971 and this survey indicated a significant increase in the percentage of corn acreage treated with insecticides, as well as a major shift in the types of insecticides used. Although less than half of the corn acreage in 1977 was treated with insecticides, there has been approximately a fourfold increase in the percentage of insecticide treated acres since 1971. Also, the use of chlorinated hydrocarbons has virtually been replaced by carbamate and organic phosphate insecticides. There were no chlorinated hydrocarbons reported in this survey, even though chlordane remains on the recommended list. Furadan, a carbamate, and Dyfonate, an organic phosphate, have largely replaced aldrin for control of the corn rootworm and other soil insects. These two insecticides combined accounted for 85 percent of the known insecticides used.

On the other hand, there were no differences in the percentage of corn treated with herbicides (90 percent) between 1971 and 1977, nor was there a significant change in the herbicides used. Aatrex, alone or in combination, was the primary herbicide used in both surveys, with Lasso and 2,4-D also widely used.

The replies for the question concerning fungicide usage indicate that a large percentage of corn growers do not know that their seed has been pretreated, or they do not know what it was treated with. This is probably because for several years most of the certified seed sold was pretreated, and growers have come to expect that any necessary treatment has been done (Cooperative Extension Service 1976).

## Pesticide Practices Among Counties

Insecticide practices within the three counties varied considerably in the percentage of corn treated. This may reflect the severity of the insect problems, as well as the effectiveness of crop rotation as a control of rootworm damage in each county. However, the reason for insecticide application, whether for insurance against damage or because of an actual damage threat, was not investigated in this study.

Herbicide usage was extensive and relatively the same in all three counties. Due to the low toxicity of most herbicides, their major influence on wildlife populations is the habitat structural changes resulting from the elimination of weed species. However, this influence should be comparable for these three counties.

Other farming practices, such as plowing and crop rotation, were found to be as variable as insecticide use between counties. For this reason studies of the impact of farming or pesticide practices on wildlife populations should consider local practices as well as overall trends, because pesticides may present different problems in different areas.

INFLUENCE OF PESTICIDES ON FOOD PREFERENCE
AND CONSUMPTION IN PHEASANTS

## INTRODUCTION

Agricultural crops provide an important food source to ring-necked pheasants throughout their range. In several areas corn is the most consumed food item during all or part of the year (Dalke 1937, Fried 1940, Trautman 1952, Korshgen 1964, Kopischke and Harris 1969). Although most corn consumed is waste grain or unharvested, Dambach and Leedy (1948) observed both male and female pheasants pulling corn sprouts from the ground in the spring, and Fried (1940) found that sprouted corn accounted for 5.8 percent of the diet in June. Recently, pheasants have been rated as the most important species in sprout pulling damage in the midwestern United States (Stone and Mott 1973).

Due to the increased use of agricultural pesticides in recent years, sprout pulling and consumption of treated waste seed in newly planted field provide a potential source for pesticide contamination. The ingestion of seed treated with mercury compounds has been reported by Tejning (1967), Borg et al. (1969), and Fimreite (1971). Stromborg (1979) found small quantities of three currently used pesticides on corn in the crop contents of 45 percent of the 22 pheasants collected in the spring near recently planted corn fields.

In spite of evidence that documents the consumption of pesticide treated food by pheasants, studies with several other avian species have shown that there is an ability to identify and avoid chemically treated food. Hill (1972) found that house sparrows were aware of the presence of toxic chemicals, and reduced their food consumption, unless an untreated choice was available. Treated foods were eventually accepted by sparrows as an alternative to starvation. Grackles readily discriminate between untreated food and food treated with various dyes or toxicants (Ridsdale and Granett 1969). Rogers (1978) concluded that red-winged blackbirds formed a conditioned aversion to methiocarb, a bird repellent, after two days of exposure to treated food. When an aversion formed birds preferred untreated food to treated, and avoided other food types treated with methiocarb.

Stromborg (1977) found that ring-necked pheasants reduced consumption of foods treated with high levels of pesticides. Because of this apparent avoidance, this study was initiated to evaluate the ability of pheasants to identify pesticide treated food, and to avoid it if alternatives exist. Also, this study evaluated the food avoidance behavior as it affects food preferences. Three experiments were conducted to assess the avoidance behavior of pheasants to four pesticides registered in Michigan. These are the fungicide captan (3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-1H-isoindole-1,3(2H)-dione) and three insecticides, Diazinon (phosphorothioic acid 0,0-diethyl 0-[6-methyl-2-(1-methylethyl)-4-pyrimidinyl]ester), carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate), commercially known as Furadan, and chlorpyrifos (phosphorothioic acid 0,0-diethyl 0-(3,5,6-trichloro-2-pyridinyl)ester), commercially known as Lorsban. Diazinon is recommended as both a seed treatment and a broadcast insecticide for soil insects, while Furadan and Lorsban are currently recommended as soil band insecticides (Ruppel et al. 1978), although registration for Lorsban as a seed treatment is being sought (R. Ruppel, personal communication).

# METHODS

## Experiment 1

This experiment was designed to test the hypothesis that pheasants can readily identify pesticide treated food, and that the presence of pesticides will lower food consumption unless an untreated choice is available. To test this hypothesis hen pheasants were used in several feeding trials to evaluate food consumption. Individual birds were placed in 3.6 x 1.8 x 1.8m (12 x 6 x 6 ft) outdoor pens with a sod base two weeks prior to testing. Birds were maintained on an ad libitum diet of whole corn and commercial game bird breeder pellets. All food was presented in 23 cm aluminum pie plates fastened to a sheltered 61 x 61 cm wooden platform with a .3 cm wire mesh barrier to prevent spilling of food to the ground. Water, calcium grit, and a next box were provided.

Feeding trials were divided into two periods: pretreatment and treatment. The pretreatment period consisted of the first 8 days, during which birds were given 150 g/day of untreated corn and pellets in equal proportion by weight. Consumption was recorded daily to the nearest gram. Mean daily consumption was converted to grams of food per kg body weight due to the highly significant correlation ($r=0.62$, $P<.01$) between food consumption and pretreatment body weight of the hen pheasants used in this experiment.

The next 8 days constituted the treatment period. Five birds were randomly assigned to one of 15 treatment groups consisting of combinations of untreated and/or treated food.

The pesticide formulations used were Captan 80SP (80% active ingredient, seed treatment formulation), Furadan 4F (0.48 kg active ingredient/liter, spray formulation), Lorsban 25SL (25% active ingredient, seed treatment formulation), and Diazinon 4EC (0.48 kg active ingredient/liter, spray formulation). The active ingredient doses used for each pesticide were as follows: captan, 60 mg/100g food; Furadan, 5 mg/100g food; and Diazinon and Lorsban, 220 mg/100g food. Captan and diazinon were used at the recommended field dosage in Michigan. Although no recommended dosage yet exists for Lorsban as a seed treatment, it was used at the same seed treatment dosage as Diazinon. Since Furadan is used primarily as a granule, and is not in direct contact with the seed at planting, the dosage was calculated to be a sublethal level possible in the field environment. Also, the formulation of captan used contains a red dye, which is required with all commercially pretreated seed. Consequently, all captan treated food had a light red appearance.

Seven groups were given 150 g/day of treated food to evaluate how each pesticide influenced consumption. These treatment groups were: control (untreated), captan, Furadan, captan with Furadan, Lorsban, Diazinon, and the carrier (in all cases distilled water). Eight groups of birds were given two choices of food. These groups were: untreated vs vaptan, Furadan, captan with Furadan, Lorsban, or Diazinon; captan vs Furadan; and captan or Furadan vs the combination captan with Furadan. Two plates with 150 g of food each were placed on a platform divided by a 5.5 cm wire mesh fence to prevent mixing. The position of the plates was changed daily to minimize the position effect. Food consumption was measured daily.

Males were randomly assigned to inseminate a group of four hens on a 4 day rotation. To avoid male effects on consumption data, only the six days when no male was present were used to calculate the mean daily consumption. When males were present the pair received 200g of untreated corn and pellets.

## Experiment 2

This experiment was designed to test the degree to which different concentrations of the same pesticides can be detected by pheasants. The experiment was similar to the first experiment, except that during the treatment period four choices of food were offered. Five birds were randomly assigned to each of three treatment groups: captan, Furadan, and captan with Furadan. The four choices of food were untreated, 100 percent of the dosage used in experiment 1, 20 percent dosage, and 4 percent dosage. The feeding platform was divided into four 30 cm square sections by 15 cm wooden barriers to prevent mixing of different choices. The high barriers posed no apparent problems with feeding. The position of the choices was changed daily. All other procedures were the same as in experiment 1.

## Experiment 3

This experiment was designed to test the hypothesis that pheasants will switch to less preferred food types if their preferred types are treated with pesticides. Individual hens were kept in 1.8 x 1.2 x 1.2 m (6 x 6 x 4 ft) outdoor pens with a sod base. Prior to testing the birds were given an ad libitum diet choice of whole corn, commercial game bird breeder pellets, oats, and wheat. All foods were separately presented in small aluminum bread load pans on a sheltered 61 x 61 cm wooden platform divided as in experiment 2. Water, calcium grit, and a nest box were provided.

This experiment was repeated twice using captan with Furadan to treat the food preference, and then with captan and Lorsban. In May ten randomly chosen hens in reproductive condition were used in the captan with Furadan group. Eight randomly chosen nonproductive hens were used in June for the captan with Lorsban group. During the feeding trials birds were given 100 g of each of the four foods per day. Grams of consumption were transformed to kcal of metabolizable energy due to the different caloric values of each food. The conversions used were: pellets, 2.90 kcal/g; corn, 3.43 kcal/g; oats, 2.62 kcal/g; and wheat, 3.25 kcal/g (Scott et al. 1969). The amounts consumed were then converted to kcal/kg body weight due to the significant correlation ($r=0.65$, $P<.05$) between body weight and pretreatment consumption in the captan with Furadan group, although the same correlation for the captan with Lorsban group ($r=0.57$) was not significant ($P<.05$).

The feeding trials were divided into four, 8-day periods. During pretreatment (days 1 to 8) all foods were untreated. In the first treatment period (days 9 to 16) each bird's first preference was treated, and all other preferences were untreated. In the second treatment period (days 17 to 24) each bird's first and second preferences were treated, and the other preferences were untreated. Finally, in the post-treatment period (days 25 to 32) all foods were untreated.

For each bird the four foods were ranked according to preference. Each preference was defined as follows: preference 1 was the food type most consumed in kcals during the pretreatment period. Preferences 2 and 3 were the untreated food types most consumed during the first and second treatment periods, respectively. And preference 4 was the remaining food type.

In the captan with Furadan group, males were randomly assigned to inseminate a group of four hens on a 4 day rotation. To avoid male effects on consumption data, only the six days when no male was present were used in the calculations. In the captan with Lorsban group no males were used because egg production had terminated prior to the feeding trials. All eight days were used to calculate mean daily consumptions.

## Data Analysis

Comparisons of mean total daily food consumption between pre-treatment and treatment periods in experiments 1 and 2 were made with paired t-tests at $P=.05$. For treatment groups in experiment 1 receiving two food choices during the treatment period, comparisons of mean daily consumption between the two choices were also made using paired t-tests at $P=.05$. In experiment 2 a one way analysis of variance design was used to test for differences in food consumption between the four choices. Comparisons of consumption means were made with Bonferroni t statistics at $P=.05$ (Miller 1966). A three way factorial repeated measure design was employed in experiment 3. Comparisons of a mean total daily food consumption and mean daily consumption of each preference between periods were made using a Bonferroni t statistic at $P=.05$. In all experiments significant differences are reported at $P<.05$.

RESULTS

## Experiment 1

Food consumption of hen pheasants was monitored daily during the pretreatment and treatment periods when pesticide treated food was offered in the treatment period. Hens consumed an average of 51 g/kg of food per day during the pretreatment period (Table 10). There was no significant difference in the mean daily food consumption between periods in the control, carrier, or captan groups. Food consumption was significantly reduced during the treatment period for birds given Furadan, captan with Furadan, Lorsban, or Diazinon treated food. The birds exposed to foods treated with Lorsban or Diazinon reduced their intake by more than 90 percent, and three birds died in the first day of treatment after consuming 4, 4, and 9 grams of food treated with Diazinon.

All treatment groups given two choices of food which had untreated or captan as one of the choices did not show a significant difference in total consumption between the pretreatment and treatment periods, except for untreated vs Diazinon, when the birds stopped eating for up to 2 days after Diazinon treated food was first introduced (Table 11). Untreated food was more preferred when it was present. Although there was no significant preference between foods treated with captan and foods treated with Furadan or captan with Furadan, Furadan treated food was eaten in greater amounts than food treated with captan and Furadan. Every bird at least ate small quantities of both choices presented, though in treatment groups involving Lorsban or Diazinon consumption of treated food stopped after one or two days.

TABLE 10.--Mean (±SE) daily food consumption (g/kg body wt.) by hen (n=5) during an 8 day pretreatment period and an 8 day treatment period for treatment groups when individuals were given a single food choice.[a]

| Treatment Group | Pretreatment Period | Treatment Period |
|---|---|---|
| Control (Untreated) | 53.3 ± 5.8[b] | 52.7 ± 1.0[b] |
| Carrier (Distilled water) | 52.8 ± 3.8[b] | 51.4 ± 4.5[b] |
| Captan | 54.4 ± 1.6[b] | 52.7 ± 2.8[b] |
| Furadan | 48.1 ± 0.8[b] | 38.0 ± 3.6[c] |
| Captan with Furadan | 58.5 ± 5.5[b] | 35.6 ± 1.1[c] |
| Lorsban | 50.0 ± 3.6[b] | 5.2 ± 1.5[c] |
| Diazinon[d] | 47.1 ± 3.2[b] | 1.4[c] |

[a] Any two means in a row having the same superscript ([b,c]) are not significantly different ($P>.05$).

[d] Treatment period mean based on two birds.

TABLE 11.--Mean (±SE) daily food consumption (g/kg body wt.) by hen (n=5) during an 8 day pretreatment period and an 8 day treatment period for treatment groups when individuals were given two food choices.[a]

| Treatment Group | Pretreatment Period | Treatment Period | | |
|---|---|---|---|---|
| | Total | Total | Choice 1 | Choice 2 |
| Untreated vs Captan | 43.5 ± 5.9$^{b}$ | 45.3 ± 4.3$^{b}$ | 38.6 ± 5.2$^{d}$ | 6.7 ± 2.3$^{e}$ |
| Untreated vs Furadan | 52.5 ± 3.4$^{b}$ | 46.7 ± 6.9$^{b}$ | 35.6 ± 7.3$^{d}$ | 11.1 ± 2.7$^{e}$ |
| Untreated vs Captan with Furadan | 50.8 ± 5.2$^{b}$ | 54.1 ± 5.8$^{b}$ | 51.6 ± 6.5$^{d}$ | 2.5 ± 0.9$^{e}$ |
| Untreated vs Lorsban | 53.0 ± 1.5$^{b}$ | 45.8 ± 3.8$^{b}$ | 45.2 ± 3.4$^{d}$ | 0.6 ± 0.5$^{e}$ |
| Untreated vs Diazinon | 57.0 ± 2.6$^{b}$ | 40.5 ± 3.2$^{c}$ | 39.8 ± 3.0$^{d}$ | 0.6 ± 0.3$^{e}$ |
| Captan vs Furadan | 51.7 ± 2.9$^{b}$ | 45.1 ± 8.5$^{b}$ | 20.3 ± 8.4$^{d}$ | 24.8 ± 6.2$^{d}$ |
| Captan vs Captan with Furadan | 47.5 ± 6.3$^{b}$ | 46.6 ± 1.5$^{b}$ | 25.8 ± 1.9$^{d}$ | 20.8 ± 1.5$^{d}$ |
| Furadan vs Captan with Furadan | 48.7 ± 3.9$^{b}$ | 33.0 ± 6.1$^{c}$ | 31.7 ± 5.7$^{d}$ | 1.4 ± 1.2$^{e}$ |

[a] Any two total means ($^{b,c}$) or choice means ($^{d,c}$) in a row having the same superscript are not significantly different ($P>.05$).

## Experiment 2

Food consumption was monitored during the pretreatment and treatment periods when the birds were offered four food choices with different concentrations of pesticides in the treatment period. The mean total daily food consumption was not significantly different between the periods for any of the treatment groups (Table 12). The consumption of untreated food was significantly greater than any of the treated food choices in all groups, however, the consumption of the three treated choices combined was not different than the untreated choice. Although there were no significant differences among the treated food choices, the bird consistently consumed more of the food treated at the 4 and 20 percent concentrations than at the 100 percent concentration.

## Experiment 3

The influence of pesticides on the food preference of pheasants was measured using two combinations of pesticides. Seventeen of the 18 birds from both treatment groups selected commercial pellets as their first or second preference, while none of the birds chose oats as their first or second preference. The first food preferences were: commercial pellets (13), corn (3), and Wheat (2). The second preferences were: corn (11), pellets (4), and wheat (3).

TABLE 12.--Mean (±SE) daily food consumption (g/kg body wt.) by hen (n=5) during an 8 day pretreatment period and an 8 day treatment period for treatment groups when individuals were given four food choices.[a]

| Treatment Group | Pretreatment Period | Treatment Period | | | | |
|---|---|---|---|---|---|---|
| | Total | Total | Untreated | 4 Percent | 20 Percent | 100 Percent |
| Captan | $58.1 \pm 1.7^{b}$ | $49.8 \pm 4.2^{b}$ | $33.0 \pm 7.8^{c}$ | $8.5 \pm 3.0^{d}$ | $6.5 \pm 2.8^{d}$ | $1.5 \pm 0.6^{d}$ |
| Furadan | $47.8 \pm 7.4^{b}$ | $44.6 \pm 4.4^{b}$ | $22.9 \pm 4.2^{c}$ | $9.4 \pm 2.5^{d}$ | $6.6 \pm 1.0^{d}$ | $5.7 \pm 1.6^{d}$ |
| Captan with Furadan | $53.3 \pm 4.1^{b}$ | $48.2 \pm 5.9^{b}$ | $28.4 \pm 7.3^{c}$ | $6.0 \pm 3.6^{d}$ | $10.6 \pm 4.0^{d}$ | $3.1 \pm 1.7^{d}$ |

[a] Any two total means ($^{b}$) or choice means ($^{c,d}$) in a row having the same superscript are not significantly di-ferent ($P>.05$).

Total daily food consumption was significantly reduced when treated with captan and Furadan during both treatment periods when pesticides were present (Table 13). There was a nonsignificant decrease in total food consumption when treated with captan and Lorsban during the first treatment period. However, the consumption was significantly reduced during the second treatment period. Total food consumption was the same during the post-treatment period as it was in the pretreatment period for both treatment groups.

The presence of pesticides on the preferred food resulted in major shifts in the patterns of consumption (Figure 2). In both experimental groups the consumption of the most preferred food was significantly lower in the two periods when it was treated with pesticides. Consumption of the second food preference increased during the first treatment period when it was not treated, and decreased during the second treatment period when pesticides were applied to both the first and second preferences. Consumption of the third and fourth food preferences remained low during all periods, except when a significant increase in the consumption of the third preference occurred after the first and second food preferences were treated. There were no significant differences in daily consumption in any of the food preferences between the pretreatment and post-treatment periods.

In the captan with Furadan treatment group the first preference remained as the most consumed food during all four treatment periods, even though the mean daily consumption was significantly decreased when treated. The degree of shift in food preference was much greater for birds exposed to food treated with captan and Lorsban. In this group birds switched to a different food preference during the second

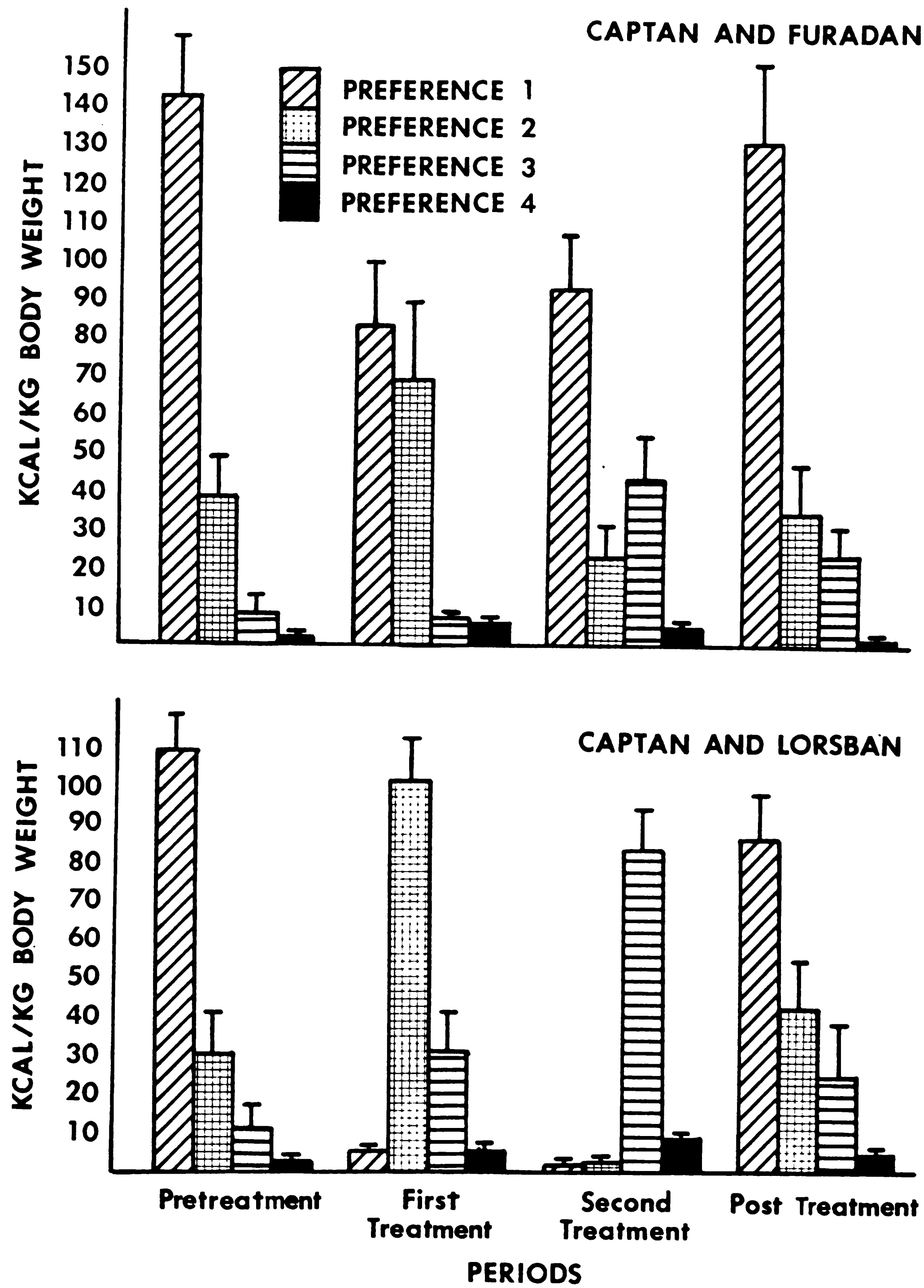
TABLE 13.--Mean (±SE) total daily food consumption (kcal/kg body wt.) by hen of commercial pellets, corn, wheat, and oats during four 8 day periods when the most preferred food was treated with pesticides during the first treatment period and the first and second preferences were treated during the second treatment period.[a]

| Period | Days | Treatment Group: Captan with Furadan (n=10) | Treatment Group: Captan with Lorsban (n=8) |
|---|---|---|---|
| Pretreatment | 1-8 | $191.9 \pm 5.0^{b}$ | $151.7 \pm 9.5^{b}$ |
| First Treatment | 9-16 | $165.0 \pm 8.4^{c}$ | $141.3 \pm 6.1^{b}$ |
| Second Treatment | 17-24 | $163.2 \pm 7.7^{c}$ | $94.1 \pm 8.4^{c}$ |
| Post-treatment | 25-32 | $189.0 \pm 9.6^{b}$ | $155.6 \pm 12.5^{b}$ |

[a] Any two means in a column having the same superscript ($^{b,c}$) are not significantly different (P>.05).

and third treatment periods. No bird consumed more than 11 kcal/day of any treated food. After pesticide treated food was removed, 14 of the 18 birds returned to, or stayed with, their first preference. Three birds switched the bulk of their consumption to their second preference during the post-treatment period, and one bird switched almost entirely to it's third preference.

Figure 2.--Mean daily consumption (kcal/kg body wt.) of commercial pellets, corn, wheat, and oats by individual preferences of hen pheasants during four, 8-day periods when captan and Furadan (n=10) or captan and Lorsban (n=8) were applied to preference 1 during the first treatment period and preferences 1 and 2 during the second treatment period. Variation is expressed as the standard error.


CAPTAN AND FURADAN
PREFERENCE 1
PREFERENCE 2
PREFERENCE 3
PREFERENCE 4
KCAL/KG BODY WEIGHT
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
CAPTAN AND LORSBAN
KCAL/KG BODY WEIGHT
110
100
90
80
70
60
50
40
30
20
10
Pretreatment
First Treatment
Second Treatment
Post Treatment
PERIODS

## DISCUSSION

Ring-necked pheasants will avoid eating a food treated with pesticides if given a choice. This ability to identify pesticide treated food, and to avoid it if suitable alternatives exist, are similar to the behaviors shown in house sparrows (Hill 1972) and grackles (Ridsdale and Granett 1969). With house sparrows it was found that if a choice existed, low and moderately toxic chemical treatments presented little threat to the birds. However, highly toxic food could be lethal even if an untreated food choice existed, because a lethal dose may be ingested before a conditioned aversion to the treated choice was formed. Although no mortality occurred, the influence of highly toxic insecticide on total consumption was seen in the untreated vs Diazinon group. When only Diazinon treated food was offered three birds died on the first day of the treatment period after ingesting small amounts of treated food. The approximate active ingredient doses ingested were 8, 11, and 18 mg/kg compared to an $LD_{50}$ of 4.3 mg/kg (Tucker and Crabtree 1970). Consequently, even if pheasants can form a strong conditioned aversion for pesticides, highly toxic seed treatment pesticides may still pose a direct fatal threat during early exposures.

On the other hand, even though captan, a seed treatment with low toxicity, was avoided when presented with an untreated choice, the total food consumption was not reduced when presented alone. The high consumption of captan did not produce any adverse effects in any of the birds in this study. Also, Stromborg (1977) did not find any significant difference in the reproductive parameters measured between control and captan treated groups.

The behavioral cue used to identify captan treated food was apparently the red dye associated with the formulation of captan used. It has been shown in studies with avian species that color can greatly influence the preference between food choices (Ridsdale and Granett 1969, Pank 1976). Also, Wilcoxon et al. (1971) found that Japanese quail formed poison aversions more readily to visual stimuli than taste. However, due to the low toxicity of captan, pheasants apparently overcame this color aversion when no choice existed in the captan treatment group of experiment 1. Therefore, under field conditions, the presence of captan alone may not deter the consumption of seed corn by pheasants.

The use of insecticides in combination with captan may disrupt the diet selection and daily consumption of pheasants due to the association of the red dye with a more toxic insecticide. In experiment 3 the two combinations tested produced both a shift in food preference and a decrease in total food consumption. The degree of preference shifting between the two groups is probably attributable to the different insecticide dosages, rather than the insecticides themselves or some synergistic reaction of captan with either insecticide. The use of Lorsban as a seed treatment with captan would virtually eliminate newly planted corn seed as a food source, unless no other alternatives existed. The same is probably true for diazinon because of the very high toxicity at field levels. This would force birds to utilize less preferred food sources, which are probably not found in equal abundance and availability as the choices were in experiment 3. Consequently, besides posing a direct fatal threat, seed treatment insecticides may also create an indirect threat by eliminating potential food sources, and thereby making it more difficult for hen pheasants to meet their daily energetic requirements during egg production. Reduced food consumption by pheasants during pesticide treatment was found to be a major factor in reduced egg production (Stromborg 1977). However, the degree of energetic stress under field conditions would depend on local conditions.

The use of granular formulations provides less risk for poisoning because the active ingredients are not in direct contact with the seed at planting. Shellenberger (1971) found that a Furadan granular formulation did not cause any adverse effects in bobwhite quail, even when used at several times the recommended field level. However, in this study the presence of Furadan, alone or with captan, reduced total daily consumption when fed at a sublethal dose. In experiment 3 the captan with Furadan group experienced significantly lower total consumption in both periods when food was treated. The potential for Furadan treatments to influence the energetic requirements of pheasants still exists, but to a lesser degree than seed treatment insecticides. Even though pheasants do possess the ability to identify and avoid pesticides under various conditions, local conditions, in terms of available food, cover, and pesticide practices, are the ultimate determinant in the seriousness of this problem.

## APPENDIX A

## QUESTIONNAIRE COVER LETTER

Dear Landowner:

As you very well know, pesticides are increasingly important in todays agriculture. It is important that you, the chemical manufacturers and the regulatory agencies know the facts about use of pesticides in agriculture. Decisions about pesticides can only be made if accurate information is available. In many cases, the grower is the best source of information. You will be providing information that only you, the grower, can offer by responding to this questionnaire. This information about individual farm practices will be helpful in assisting you in attaining the best protection against pests.

The enclosed questionnaire concerns your use of pesticides this spring. However, I need your report even if pesticides were not used--the information about acreages is very important. I am asking for assistance of only a small group out of thousands of landowners in this area, so your answers are essential to insure that the results are accurate. The enclosed envelope does not require any postage.

Your individual report will be kept strictly confidential. If you would like a copy of the results of the survey, please complete your mailing address on the back of the form. The address will be used only to mail the results. If you have any other comments about your use of pesticides, please feel free to write them down. I am looking forward to your help.

Thank you very much.

Sincerely yours,

Richard Bennett
Graduate Research Assistant
Michigan State University

APPENDIX B

SURVEY OF PESTICIDE USE ON CORN

1. How much land do you own?_____acres. Do you reside on this land?___yes;___no

2. How do you use your land?
   a.____ Farming by yourself.
   b.____ Farming by yourself and your relatives owning land nearby
   c.____ Rent or lease it to others for farming
   d.____ Other use (timber, personal pleasure, etc.)
   Please describe briefly________________________________

3. Besides the land you own, do you farm land which you rent or lease from others?___yes; ___no. If yes, how many acres?______acres.

4. On the land that you own and rent, how many acres are involved in each of the following: (Check the appropriate box.)

| | 0 acres | 1-10 acres | 11-40 acres | 41-80 acres | 81-150 acres | 151-300 acres | 300 or more acres |
|---|---|---|---|---|---|---|---|
| Corn | | | | | | | |
| Soybeans | | | | | | | |
| All other beans | | | | | | | |
| Wheat | | | | | | | |
| Oats | | | | | | | |
| All other cultivated crops | | | | | | | |
| Hayfields | | | | | | | |
| Pastures | | | | | | | |
| Unused fields | | | | | | | |
| Woodlots | | | | | | | |
| Wetlands | | | | | | | |
| Other uses | | | | | | | |

The following questions deal specifically with corn. If you did not plant any corn this year, you need not fill out the rest of the survey, but please return it to me.

5. How many acres of corn did you plant this year? ______acres.

6. How many distinct corn fields are there?______fields.

7. Did you use seed pretreated with the fungicide Captan?___yes;___no;___don't know
   If no, do you use any other fungicides?____no
   ____yes (please name)______________

*8. In the table below, please fill in the information about the pesticides used on each of your corn fields.

| corn field | estimated acres | When was this field plowed? (Check) Fall | Spring | What was the previous crop? | In the space below please write in the names of the pesticides (if any) that you used on each field: | How was this applied? (Check) Seed treatment | Granule | Spray | When was this applied? (Check) Pre-planting | At planting | Pre-emergent | Post-emergent |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | Insecticide: | | | | | | | |
| | | | | | Herbicide: | | | | | | | |
| 2 | | | | | Insecticide: | | | | | | | |
| | | | | | Herbicide: | | | | | | | |
| 3 | | | | | Insecticide: | | | | | | | |
| | | | | | Herbicide: | | | | | | | |
| 4 | | | | | Insecticide: | | | | | | | |
| | | | | | Herbicide: | | | | | | | |
| 5 | | | | | Insecticide: | | | | | | | |
| | | | | | Herbicide: | | | | | | | |

Commonly used insecticides:

Furadan (carbofuran)
Sevin (Carbaryl)
Mocap (prophos)
Di-Syston
Dyfonate
Counter
Diazinon

Commonly used herbicides:

Aatrex (atrazine)
Lasso (alachlor)
Bladex (cyanazine)
Sutan + (butylate)
Prowl (penoxalin)
Princep (simazine)
2, 4-D

9. Of the pesticides you listed, which (if any) did you mix together for application? (Please name) ____________________

When did you apply these? a.___ pre-planting b.___ at planting c.___ pre-emergent d.___ post-emergent

10. Do any animals pull up your corn seedlings? ___ yes; ___ no; ___ don't know

If yes, what animals are responsible? a.___ crows b.___ pheasants c.___ rodents d.___ blackbirds e.___ others ____________________ f.___ don't know

Which of these does the most damage? ____________________

11. Do you use any method to prevent this damage? ___ yes; ___ no

Do you use any chemical repellents? ___ yes; ___ no; If yes, how much of your corn do you treat with repellents? ______ acres.

APPENDIX C

REMINDER POSTCARD FOR QUESTIONNAIRE

Dear Landowner:

Several weeks ago, you received a questionnaire from Michigan State University concerning pesticide usage on your land. If you already sent back the survey, your help is greatly appreciated. If you have not yet responded, would you take a few moments to fill out as much of the questionnaire as you see fit, and return it as soon as you can. Your response is needed in order to make accurate conclusions. Thank you.

Sincerely,

Richard Bennett
Graduate Research Assistant

APPENDIX D

LIST OF COMMON AND CHEMICAL NAMES REFERRED TO IN THE TEXT[1]

INSECTICIDES

Aldrin - 1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4:5,8-dimethanonaphthalene

Carbofuran (Furadan) - 2,3-dihydro-2,2-dimethyl-7-benzofuranol methylcarbamate

Chlordane - 1,2,4,5,6,7,8,8-octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene

Bufencarb (BUX) - 3-(1-methylbutyl)phenyl methylcarbamate and 3-1(1-ethylpropyl)phenon methylcarbamate

Chlorpyrifos (Lorsban) - phosphorothioic acid 0,0-diethyl 0-(3,5,6-trichloro-2-pyridinyl)ester

Dieldrin - 3,4,5,6,9,9-hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7:3,6-dimethanonaphth[2,3-b]oxirene

Dimpylate (Diazinon) - phosphorothioic acid 0,0-diethyl 0-[6-methyl-2-1(1-methylethyl)-4-pyrimidinyl]ester

Ethoprop (Mocap, Prophos) - phosphorodithioic acid 0-ethyl SS-dipropyl ester

Fonofos (Dyfonate) - ethylphosphorodithioic acid 0-ethyl S-phenyl ester

Heptachlor - 1,4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-4,7-methanoindene

Phorate (Thimet) - phosphorodithioic acid 0,0-diethyl S-[(ethylthio) methyl]ester

HERBICIDES

Alachlor (Lasso) - 2-chloro-2,6-diethyl-N-(methoxymethyl)acetanilide

Atrazine (Aatrex) - 6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine

Butylate (Sutan) - S-ethyl diisobutylthiocarbamate

Cyanazine (Bladex) - 2-[[4-chloro-6-(ethylamino)-s-triazin-2-yl]amino]-2-methylpropionitrile [2-chloro-4-(1-cyano-1-methylethylamino)-6-ethylamino-s-triazine]

Dicamba (Banvel) - 3,6-dichloro-o-anisic acid

2,4-D - (2,4-dichlorophenoxy)acetic acid

EPTC (Eradicane) - S-ethyl dipropylthiocarbamate

Paraquat - 1,1'-dimethyl-4,4'-bipyridinium ion

Propachlor (Ramrod) -2-chloro-N-(1-methylethyl)-N-phenylacetamide

Simazine (Princep) - 6-chloro-N,N'-diethyl-1,3,5-triazine-2,4-diamine

FUNGICIDES

Captan - 3a,4,7,7a-tetrahydro-2-[(trichloromethyl)thio]-1H-isoindole-1,3(2H)-dione

[1] From the Merck Index (1976) and the Herbicide Handbook of the Weed Science Society of America (1974).

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