

THE EFFECTS OF ORGANOPHOSPHATE PESTICIDES
ON WILDLIFE IN SOUTHEASTERN IDAHO

- Arco
Hawne

A Joint Proposal

to

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INTRODUCTION

Use of pesticides that act as acetylcholinesterase (ChE) inhibitors (organophosphate [OP] and carbamate compounds) has increased greatly as the use of chlorinated hydrocarbons has decreased. Use of the less persistent OP compounds has led to special problems because many are extremely toxic to wildlife. Large die-offs of waterfowl and other birds have occurred in areas treated with OP compounds (Mendelssohn and Paz 1977, Hill and Fleming 1982, White et al. 1982a, White et al. 1982b). Use of OP compounds for treating seed (Stanley and Bunyan 1979) and spraying golf courses (Stone 1979) has also led to die-offs of birds. Application of famphur (an OP) to backs of cattle for warble control resulted in mortality of black-billed magpies (Pica pica) and red-tailed hawks (Buteo jamaicensis). This use of famphur is correlated with a recent decline in magpie populations in the western United States (Henny et al. 1985). The secondary poisoning of red-tailed hawks in the field by famphur resulted from experimental work with barn owls (Tyto alba) by Hill and Mendenhall (1980). Adverse effects of OPs on reproduction was demonstrated in wild birds (White et al. 1982b) and in experimental birds (Stromborg 1981). Recent review papers summarized the effects of OPs on wildlife in general (Grue et al. 1983) and on forest birds in particular (Peakall and Bart 1983).

Die-offs of sage grouse (Centrocercus urophasianus) were noted in agricultural areas in southeastern Idaho over the past 5 years (Fig. 1). Relatively large die-offs reportedly occurred in August 1981 and 1982 near Arco, Idaho. ChE activity in brains of five grouse collected alive in the area during 1981 indicated

exposure to an anticholinesterase (antiChE) compound (Table 1). The grouse were maintained in captivity several days before they were killed, and the gastrointestinal (GI) tract contained no OP residues.

In August 1983, we contacted landowners and spray pilots around Arco and Mud Lake, Idaho. These individuals were helpful and cooperative. We collected birds in and around fields sprayed with parathion, methamidophos (Monitor®) or dimethoate (Cygon®) as well as control birds from non-agricultural areas. Vesper sparrows (Poocetes gramineus) showed the greatest brain ChE inhibition, ranging from 19 to 72 percent for the 14 birds (Table 2). Sage grouse brain ChE activity ranged from 7 to 65 percent less than controls. Inhibition of brain ChE activity ≥ 20 percent also occurred in horned larks (Eremophila alpestris), and a western meadowlark (Sturnella neglecta). Low residues of methamidophos (0.02 to 0.06 ug/g) and dimethoate (0.19 ug/g) were found in the upper GI tracts of sage grouse. During 3 weeks of field work in August 1983, we observed no avian mortality in the vicinity of Mud Lake and Arco. One farmer near Mud Lake reported a large flock of sage grouse that appeared "intoxicated". Judging from past die-offs and severe brain ChE inhibition noted in grouse and other birds, aerial spraying of alfalfa and potato fields with certain OPs represents a hazard to some forms of wildlife. The magnitude of the impact from the hazard remains to be determined.

A number of OP compounds are used in agricultural areas of southeastern Idaho, including methyl parathion, parathion, methamidophos, and others (Table 3). Many of these compounds

have a high acute toxicity (Tucker and Crabtree 1970), but there is little information on the effects of these OP compounds on wildlife populations.

OBJECTIVES

The recurring wildlife/pesticide problems in southeastern Idaho present an ideal opportunity to quantify the effects of several OP pesticides on wildlife in a field situation. The objectives of the proposed study are to:

1. Verify the continuing occurrence and extent of die-offs of sage grouse and other species in southeastern Idaho.
2. Identify the pesticide(s) inducing the die-offs and related sublethal effects.
3. Quantify the effects of the pesticide(s) on wildlife populations.

CHARACTERISTICS OF OP COMPOUNDS

Leop and parathion (also referred to as diethyl parathion) were the first OP compounds used as insecticides; they were both introduced in 1945. Scores of OP compounds are in current use. They are mainly of the molecular forms known as phosphorothioates, phosphorodithioates, and phosphates (Brown 1978). At least 18 OP pesticides are used in southeastern Idaho (Idaho Agricultural Coordinating Committee 1984). Some information is available on the effects of 13 of these pesticides (Table 3); the LD₅₀ for birds is < 50 ug/g for 9 of the OPs (Tucker and Crabtree 1970). In insects, as well as birds and mammals, OP compounds act by inhibiting ChE--the enzyme that

normally breaks down the neurotransmitter acetylcholine at the synapse immediately after its action is completed. Thus, they are ganglionic rather than axonic poisons, causing first the facilitation and then the blocking of the reflex arc, so that the initial hyperactivity and subsequent convulsions are followed by tetanic paralysis. Organophosphate compounds inhibit ChE by combining with and phosphorylating the active site of the enzyme. The inhibition depends on the OP being interrupted by its two alkyl substituents (usually ethyl or propyl) and the much larger substituent (phenyl, heterocyclic, or aliphatic). The sequence of events following exposure to OP compounds that leads to adverse effects including death is: (1) inhibition of cholinesterase, (2) acetylcholine accumulation, (3) disruption of nerve function, either centrally or peripherally, (4) respiratory failure, and (5) death by asphyxia (O'Brien 1960).

Organophosphate pesticides are generally susceptible to rapid inactivation by chemical and biological processes and are therefore considered less hazardous in the environment than more persistent compounds (Stoker and Seager 1977). Organophosphate compounds may be taken into the body through ingestion of food, inhalation, and dermal absorption (Matsumura 1975). Secondary poisoning has been established in animals consuming prey that are contaminated with OP residues (Mandelstam and Paz 1977, Hill and Mendenhall 1990, Henny et al. 1985).

Currently parathion and the dimethyl analogue (methyl parathion) constitute the principal OPs used in the United States. Use of the dimethyl analogue is increasing because the acute toxicity is somewhat lower to certain test animals than

carathion (Schrader 1963). Both of these compounds are used in southeastern Idaho. Parathion is a very toxic OP that resulted in extensive die-offs of waterfowl when used on winter wheat in Texas; brain ChE levels were depressed and residues of both parathion and methyl parathion were detected in contents of the digestive tract (White et al. 1982a, White et al. 1982b). Parathion also caused mortality and lowered reproductive success of longwing quills (*Larus argentatus*) feeding in treated cotton fields (White et al. 1983). No known instances of wildlife mortality have been reported from use of methyl parathion. Methamidophos is a very toxic OP that was associated with wildlife die-offs in cabbage fields in Wisconsin; ChE levels in brains of passerine birds found dead ranged from 39 to 76 percent of control values and residues in the gastrointestinal tract ranged up to 3.8 ug/g (Carl A. Bartha, pers. commun.) The few records of methamidophos-induced die-offs is probably indicative of a lower rate of use than some of the other more common OPs.

Apparently no reports of wildlife die-offs related to diazinon have been verified. Judging from ChE inhibition of 20 percent in brains of birds collected in or near diazinon-treated fields in 1983 in Idaho, this OP poses some hazard. Also, a large number of other avian die-offs from parathion and other OP insecticides have been documented (Gross et al. 1980), but no wild mammal die-offs were verified from these compounds (Brown 1978).

APPROACH

This section is divided into two subsections. The first

discusses the overall strategy and procedures that will be used to study the effects of OP pesticides on wildlife. The second section provides information on planned research activities for each fiscal year, FY1985-FY1987.

Procedures

Selection of Study Areas. The study will be conducted in agricultural areas bordering sagebrush (*Artemisia* spp.) and riparian habitats on the upper Snake River plain of southeastern Idaho (Harriss and West 1973). The climate in this area is characterized by hot summers and cold winters with annual precipitation averaging 20.6 cm. Major agricultural crops include potatoes and alfalfa, in addition to some grain crops and peas. Most farmland is bordered by fence rows that supports a variety of forbs and grasses. Adjacent sagebrush habitats are dominated by big sagebrush (*A. tridentata*), rabbitbrush (*Chrysothamnus* spp.), and several species of bunchgrass (Harriss and West 1973). The study areas will include farmland where OP pesticides are used. Other selection factors are that the study areas occur in the general vicinity of previous sage grouse sightings or in areas where we found serious inhibition of CHE in chains of birds collected in 1983.

The area around Mud Lake, Idaho will be the primary study area (Fig. 1). We selected this area over the Arco, Idaho area for several reasons. The fields tend to be larger and center-pivot irrigation circles are more common, application rates of OPs tend to be heavier (e.g., 2 pints of methamidophos are used per acre of potatoes versus 1.5 pints in the Arco area), a greater percentage of the alfalfa acreage is sprayed with OPs

compared to the Arco area, and we detected inhibition of ChE in brains of grouse and other birds from this area. Other areas including the Arco area will be used as secondary study sites. Control samples for ChE analysis will be collected in control treatment units or, if necessary, in non-agricultural areas at least 15 km from treated farmland.

Selection of species for study. The selection of the primary species for this study is based on the following criteria: (1) relative abundance, (2) vulnerability to pesticide contamination, and (3) ease of sampling. Based on these guidelines, sage grouse, vesper sparrows, horned larks, western meadowlarks, Brewer's sparrows (Spizella breweri), American kestrels (Falco sparverius), and smaller cavity nesters such as European starlings (Sturnus vulgaris) will be the primary species. The vesper sparrow is the only species that meets all three criteria. Although field work will key on the species listed above, data pertaining to other species will be recorded.

Sage grouse are of special concern because of low reproductive success and apparent population declines in recent years. Counts of male sage grouse at leks near the die-off sites have generally decreased over the past 4 years. At the same time, productivity decreased from about 3.0 juveniles per adult female observed on agricultural and sagebrush areas from 1977 to 1979 to about 0.7 in the same areas in 1980. Routes in agricultural areas indicated 0.3 juveniles per adult female in 1980, 1.0 in 1981, and 0.7 in 1982. The area covered and accuracy of surveys dropped considerably in 1983 and 1984: reproductive success apparently improved slightly in 1983 and

1984 (J. W. Connelly, pers. commun.). A number of factors can cause decreases in reproductive success of sage grouse including adverse spring weather that occurred during several of these years. The declines also coincided with aerial spraying of potato fields with methamidophos (0.25 to 1.13 kg/ha) to control green peach aphids (Myzus persicae): this practice apparently became widespread about 5 years ago. The green peach aphid is an important vector of viruses in sugar beets and potatoes. Its resistance to OPs was first confirmed in England 26 years ago (Perrins 1983). This pest is of great concern to seed potato growers in Idaho because it causes a disease that can significantly lower the value of their crop. The virus disease also concerns growers of potatoes raised for human consumption because it shortens storage life.

The study sites in southeastern Idaho are used by a number of other vertebrates. Gray partridge (Perdix perdix) and ring-necked pheasants (Phasianus colchicus) are fairly common. American kestrels, red-tailed hawks, ferruginous hawks (Buteo borealis), Swainson's hawks (Buteo swainsoni) and a number of passerine species are common summer residents of the proposed study areas. Townsend's ground squirrels (Spermophilus townsendii), black-tailed jack rabbits (Lepus californicus) and cottontail rabbits (Sylvilagus nuttallii) also frequently occur in these habitats.

Following the selection of study areas and species of concern, the evaluation procedures may be grouped into three general categories or methodologies: (1) telemetry studies with sage grouse; (2) study of reproductive success of birds using

nest boxes placed on the perimeter of treated and control alfalfa fields; and (3) collection of birds for ChE and residue analysis.

Telemetry Studies. Sage grouse trapping will commence in the vicinity of Mud Lake as soon as the birds begin moving into agricultural land from sagebrush habitats where essentially all reproductive activities take place. The grouse, primarily, hens with broods, begin moving into alfalfa fields in mid to late June. Grouse using alfalfa fields are often easily trapped with night-lighting or other techniques (Wallestad 1971, Connelly 1982, Connelly and Markham 1983). Trapped grouse will be weighed, banded, sexed, and aged. Forty grouse will be fitted with radio transmitters that change signal when the bird dies. The data derived from the radio telemetry studies will be used in several ways. First, movements of birds will be monitored one or more times a day to determine their movements and utilization of agricultural fields. The dates, applications rates, and types of spray used on each field will be determined, and the exposure of each bird will be based on a system of scoring related to the numbers of days that individual is tracked to treated fields. A score of "0" will be assigned each day that a bird is not exposed to treated fields. Negative scores for birds exposed to treated fields will be related to toxicity of the OP, persistence of residues on vegetation, and persistence of ChE inhibition various times after spray. This system will be fully developed as data are obtained during the study. The scores will pertain to the entire summer for each bird. Mortality of radioed birds will be determined, and cause of mortality determined by necropsy, ChE

analysis, and residue analysis. The continuum of exposure scores will then be related to mortality by Chi-square analysis.

The radio telemetry work with sage grouse will enable us to locate flocks of birds that will either be trapped, bled and released or collected by shooting. We plan to obtain blood samples when the birds are initially trapped and then periodically take blood samples throughout the remainder of the study. Samples of brain or blood plasma will be analyzed for ChE. Birds will be shot only if trapping procedures prove ineffective; however, at the end of the study all surviving birds will be either shot or trapped to retrieve their transmitters. Of the instrumented sage grouse surviving to the end of the study, 10 birds with diverse exposure to treated fields will be killed and analyzed for OP residues and ChE activity. Remaining birds will be released.

Nest Box Studies. This phase of the study will be directed toward alfalfa fields. Potato fields are generally sprayed late in the season after nesting is completed. In April 1985, approximately 400 wooden nest boxes will be placed on the perimeter of alfalfa fields in the vicinity of Mud Lake, Idaho. The boxes will be placed just outside the range of the irrigation sprinkler systems. Size of entrance holes will vary so that one-half of the boxes will accommodate birds up to the size of European starlings; the other one-half will not be available to birds larger than bluebirds (*Sialia* spp.). Boxes with different-sized entrance holes will be alternated; they will be placed on fence posts or metal posts about 90 m apart. All nest boxes will be serially numbered.

Alfalfa fields will be treated with parathion or dimethoate at recommended rates. Some fields will remain untreated and serve as controls. Landowners and spray pilots will be contacted to select suitable fields; spraying costs will be supplemented with funds from the Ecological Effects Branch of EPA. For the nest box study, each treatment will consist of 3.2 square km (1.3 square miles) divided into three treatment units of 1.1 square km (0.5 square miles). Treatment fields will be selected on the basis of strategic location and cooperation by landowners and pilots. Those fields partially abutting non-agricultural lands such as sagebrush or riparian habitat will provide the best opportunity of preventing unanticipated spraying of treated fields and associated nest boxes. Large blocks of alfalfa sprayed at the same time will enable us to select a 1.3 square km unit from the block for the nest box study; however, birds will be collected from the entire block or any other fields where the exact spray history is known. When feasible, treatment units selected will be similar for each of the three treatments.

Nest boxes will be monitored twice a week to determine basic reproductive data including laying dates, laying rates, hatching dates, and fledging rates. A nest will be considered successful if at least one young fledges. The Mayfield Exposure Day Method (Mayfield 1975, Hensler and Nichols 1981) will be used to evaluate the exposure in nest-days and to calculate mortality and survival rates in these units at each stage of the nesting cycle starting with the day that spraying commences. With this technique, we can evaluate nesting success based on stage of nest development at onset of spraying. Data obtained from each

treatment unit will be used in statistically analyzing the results for each species. Fields will be sprayed as soon as possible after 1 June. To some extent, species such as European starlings can be forced to recycle by destroying eggs or nestlings in early nests that would probably fledge young before spraying. Approximately 25 larger nest boxes for American kestrels will be located around alfalfa fields. Procedures for analysing the nesting data will be the same as for the other species using nest boxes, but with fewer nest boxes, significant differences will be expected only if treatment effects are severe. The nest boxes will be placed on the edges of the same fields where the smaller boxes are placed, but because only one will be placed around each square km, most boxes will be placed around fields where we will have essentially no control of the spraying regime.

Growth data will be collected from a sample of broods in small nest boxes that hatch within a few days of spraying. Young will be marked individually by painting their toenails and later by attaching standard aluminum bands. Adults captured in nest boxes also will be banded. Approximately 20 broods in the small boxes will be monitored for each treatment. Young will be weighed first at 4 days of age, then weighed every 2-3 days thereafter until fledging. The growth data will be compared for each treatment group by multivariate-analysis model for fitting polynomials (Powell and Gray 1980, Powell 1984).

Food habits analysis of individually marked young in 20 broods will be periodically sampled by using pipe stem cleaners as a ligature. The ligatures will be placed around the neck of

young (≥ 1 week of age) passerines such that they cannot swallow food brought to them by the parents. Ligatures will be in place for a maximum of 1 hour before the food is collected and the ligature removed. Such sampling will only be conducted a maximum of three times for individuals in a brood. Food samples will be weighed and food items identified when possible; some of the samples will be analyzed for residues of OPs.

Natural nests found on the study area will be routinely monitored, but the sample size will probably not be sufficient for statistical comparisons.

ChE and Residue Analyses. To determine the extent and persistence of ChE inhibition after spraying, three birds of several species will be collected from each of the nine treatment units at 2, 7, and 14 days post-spray. The species to be collected for routine analysis of ChE activity in brains are horned larks, western meadowlarks, vesper sparrows, and Brewer's sparrows. The smaller birds, especially the sparrows, are common and relatively easy to collect. The use of radio telemetry on sage grouse will facilitate collections, but collecting will still be primarily opportunistic. In addition to collection of dead instrumented grouse, we will collect other birds found dead in nest boxes and birds or mammals found dead during routine field work.

Birds collected by shooting or trapping and those found dead will be placed on dry ice and processed as soon as possible. One-half of the brain of each bird collected or found dead will be analyzed for ChE activity using standard procedures described by Ellman et al. (1961) and modified by Dieter and Ludke (1975)

and Hill and Fleming (1982). Project personnel are experienced in ChE analysis procedures (Henny et al. 1985). A spectrophotometer (Bausch and Lomb Spectronic 88[®]) fitted with a water-jacketed micro flow-through cell will be set up in the EC&G Laboratory in Idaho Falls. Brains of birds will be analyzed for ChE activity within 48 hr of collection. The timeliness of the analyses will enable us to determine the seriousness of the ChE inhibition immediately as well as determining when collections should cease (point where ChE activity levels are within 20% of control values).

Depression of brain ChE activity by 20 percent or a decrease of 2 standard deviations from control values (whichever is less) will be used as a conservative criterion to indicate absorption of OPs. Depression of brain ChE activity by ≥ 50 percent from controls in birds that died was the criterion used to diagnose lethality in experimental birds exposed to antiChE compounds (Ludke et al. 1975). Organophosphate residues found in the ingesta and ≥ 50 percent depression of brain ChE will be employed for diagnosing cause of death by a specific antiChE compound in wild birds. Depression of ≥ 70 percent in brain ChE is found in most experimental (Burvan et al. 1968, Shellenberger et al. 1970) and wild animals (Zinkl et al. 1977, Henny et al. 1985) that die from antiChE compounds.

Cholinesterase assays for sage grouse will be directed toward plasma (primarily butyrylcholinesterase) rather than brain (primarily acetylcholinesterase). Plasma ChE is also a sensitive indicator of exposure to most antiChE compounds; however, the interpretation of hazard from these values is not well known

(Hill and Fleming 1982). Since the primary objective of this phase of the study is to determine exposure of grouse to OPs and their subsequent survival, some tradeoffs will be necessary. Grouse will be shot only if trapping proves nonproductive or at the end of the study when transmitters are collected.

When grouse are trapped at the initiation of the study, a sterilized hypodermic needle and heparinized syringe will be used to obtain a 1-ml sample of blood from the brachial vein after the site is disinfected with alcohol. The blood will be stored on wet ice until it is processed and ChE analysis completed as described by Hill and Fleming (1982). Processing of samples will be carried out the day of sampling. ChE assays will be run the same day or 1 day later. Grouse will be trapped and bled opportunistically (once a week if possible) during the remainder of the study. Particular effort will be made to trap and bleed grouse soon after exposure to OPs. Depression of plasma ChE activity by ≥ 50 percent or 2 SD of control values (whichever value is less) will be used to indicate exposure to an antiChE compound.

Project personnel will examine euthanized birds and record data regarding sex, age, body condition and other factors. The upper GI tract (primarily the gizzard and its contents) and livers of each bird will be removed, weighed, placed in chemically-cleaned jars, and stored in a freezer. The GI tracts of birds having the highest ChE inhibition will be analyzed for residues of OPs at the Patuxent Wildlife Research Center (PWRC) in Laurel, Maryland; a gas chromatograph equipped with a flame photometric detector will be used (White et al. 1982b; E. J.

Kolbe, pers. commun.)

Birds found dead and in suitable condition will be sent to the National Wildlife Health Laboratory in Madison, Wisconsin where necropsies will be performed. The upper GI tracts and livers of certain birds will be removed and shipped to RWHC for residues analyzed for OPs. When OPs are not implicated in deaths of birds or mammals found dead, the other half of the brain of each such animal will be analyzed for residues of OCs (Kaiser et al. 1980).

Samples of vegetation from sprayed and control alfalfa fields will be collected at the same time birds are collected (2, 7, 14 days and possibly longer post-spray). Samples from each collection date will be taken from four sites in each of the nine treatment units; samples will then be segregated into three pools on the basis of treatment (i.e., parathion, dimethoate, and control). Vegetation will be weighed when fresh and then dried. Samples of vegetation and food collected from young will be analyzed for OPs as outlined for GI tracts and livers of birds.

PLANNED ACTIVITIES (FY1985-FY1987)

FY1985. Comprehensive field investigations will be undertaken. Research efforts will include the following:

1. Beginning in March 1985 or earlier if feasible, alfalfa fields around Mud Lake, Idaho will be inspected and a number of potential study fields selected. Landowners will be contacted, and those agreeable to have certain fields serve as controls (not sprayed) and to have others sprayed at certain times will be included in the study.

2. Nest boxes will be established on nine 1.3-km treatment units in April 1985; distance between boxes will be 90 m. About 400 small boxes and 25 large boxes will be used.
3. Nest boxes will be monitored at least twice a week on all plots. The day of spraying will be considered Day 0 in the nesting study. Reproductive success in the various treatment units will be determined by the exposure-day method. Growth of nestlings in 20 broods will be determined by periodic weighing; a pipe stem ligature will be used to collect food from young in some broods.
4. Forty sage grouse will be trapped in June and fitted with radio transmitters. Blood samples will be taken for determination of plasma ChE activity; trapping and bleeding will continue opportunistically during the remainder of the study. The grouse will be tracked through August. A system of scoring based on exposure of sage grouse to treated fields will be developed. The transmitters will change signal when the birds die. All grouse found dead plus other birds and mammals found dead will be necropsied, their brains analyzed for ChE levels, and their tissues or upper GI tracts analyzed for residues of OPs or OCs.
5. Birds other than sage grouse will be collected systematically from treated and control fields during the study. Their brains will be analyzed for ChE activity within 1 or 2 days of collection to determine impact of the OPs and to determine when sampling should be discontinued. Upper GI tracts or livers will be analyzed for OP residues.

6. Vegetation in treated and control fields will be collected at the same time that birds are collected. Vegetation and food collected from young will be analyzed for residues of OPs.

FY1986. Pending continuing financing of the study by EPA, comprehensive field investigations will continue in the same manner outlined for FY1985 using the same fields, the same nest boxes, the same collection procedures, and the same statistical and analytical procedures when applicable.

1. Previous cooperating landowners will again be contacted in March to determine whether they are interested in cooperating in the study. New fields will be selected if necessary.
2. Spray regimes will be the same as the previous year.
3. Collection of nesting data will continue as in FY1985. Nest boxes will be cleaned or repaired and moved to new locations if necessary.
4. Radio telemetry work with sage grouse will continue as in FY1985.
5. Collections of birds for ChE and residue analysis will be modified according to sensitivity of certain species.
6. Collection of vegetation and food from young for residue analysis will continue if results from FY1985 are meaningful.

FY1987. No field work will be conducted. EG&S will take the lead role in analyzing the data and preparing the results of the portion of the study dealing with potato fields, while the U.S. Fish and Wildlife Service personnel will take the lead role in

analyzing the data and writing up the results of that portion of the study dealing with alfalfa fields. Results will be published in refereed journals. In addition, annual progress reports will be written and submitted to the EPA at the end of each fiscal year. A final project report will be written after the work is completed.

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Table 1. Brain cholinesterase activity in sage grouse collected near seed potato fields sprayed with methamidophos compared with controls. August 1981.

		ChE	
		u Moles/min/g (wet wt.)	% Inhibition
n	Treatment	mean and range	mean and range
5	Methamidophos	8.9 4.0 to 13.9	13.8 -51 to +35
9	Control	10.3 8.7 to 11.2	--

Table 2. Cholinesterase (ChE) levels in brains of birds found dead, collected in or near treated fields, and collected in untreated areas (controls).

			ChE	
			u moles/min/g (wet wt.)	% change from controls
Treatment	n	Days post-spray	mean and range	mean and range
MOURNING DOVE				
Dimethoate	4	1-2	18.38 16.73-20.11	-4.9 -15 to +9
Methamidophos	2	4-5	17.81 16.34-19.28	-7.7 -15 to 0
Control	9	-	19.30 16.51-24.57	-
VESPER SPARROW				
Dimethoate	4	1-2	17.54 11.66-19.28	-36.9 -59 to -51
Methamidophos	5	3	13.12 7.75-20.41	-52.8 -51 to -37
	5	4-5	18.19 15.12-22.55	-14.5 -45 to -19
Control	4	-	27.79 18.0 -38.00	-
SAGE GROUSE				
Dimethoate	3	1	12.75 12.65-12.96	-8.5 -9 to -7
	2	16	10.98 10.79-11.07	-21.6 -22 to -21

Table 2 (continued).

			ChE	
Treatment	n	Days post-spray	u moles/min/g (wet wt.)	% change from controls
			mean and range	mean and range
Methamidophos	3	4	6.52	-55.2
			4.83-8.36	-55 to -40
Control	4	-	13.95	-
			12.09-16.08	
WESTERN MEADOWLARK				
Methamidophos	1	4	17.90	-38.3
Control	2	-	29.08	-
			19.62-34.45	
CORNEO LARK				
Dimethoate	1	3	9.19	-29.6
Methamidophos	3	1	9.00	-31.0
			7.54-10.75	-42 to -12
Parathion	1	4	9.58	-34.3
Control	2	-	13.05	-
			11.57-14.52	
BREWER'S SPARROW				
Dimethoate	3	1-2	15.63	-
			14.43-16.77	
Methamidophos	5	4-5	15.08	-
			13.61-17.55	
Control	1	-	16.94	-

Table 2 (concluded)

ChE				
			u moles/min/g (wet wt.)	% change from controls
Treatment	n	Days post-spray	mean and range	mean and range
BLACK-BILLED MAGPIE				
Dibutylate	4	1-2	22.15	+11.7
			17.55-26.74	-19 to +10
Monitor	1	1	20.54	+5.1
Control	1	1	21.76	-
			17.81-25.13	
FERRUGINOUS HAWK				
Unknown	1 adult	-	19.45	+11.7
found dead				
Control	3 adults	-	17.43	-
			15.78-20.31	
Unknown	1 nestling	-	17.25	-14.4
found dead				
Control	4 nestlings	-	20.15	-
			16.84-24.38	
RED-TAILED HAWK				
Unknown	1 adult	-	19.05	+1.2
found dead				
Control	6 adults	-	18.83	-
			16.25-21.32	

Table 3. Organophosphate pesticides used in southeastern Idaho and their effect on avian species.^a

Pesticide	Common name	Use	Acute oral LD ₅₀ , mg/kg (95% confidence intervals)			
			Pheasants	Ducks	Passerines ^b	Chukars
Azinphosmethyl	Buthion	Field crops	74.9(59.5-94.3)	126(97.8-188)		84.2(53.0-134)
Diazinon		Soil, field crops	4.33(3.02-6.22)	3.54(2.17-5.27)		
Dimethoate	Cygon	Alfalfa, wheat	41.7(30.1-57.8)			
Fensulfethion	Dasanit	Soil		0.75(0.59-0.94)		
Fonofos	Dyfonate	Soil				
Malathion		Field crops	1485(1020-2150)			
Methamidophos	Monitor	Potatoes			8.0	
Methidathion	Supracide	Alfalfa				
Methylparathion		Alfalfa, peas	8.21(5.69-11.9)	10.0(6.12-16.3)		
Mevinphos	Phosdrin	Potatoes	1.37(0.95-1.98)	4.63(3.57-6.0)		
Naled	Dibrom	Alfalfa		51.2(37.8-72.3)		
Oxydemeton Methyl	Beta Systox R	Potatoes	42.4(30.6-58.8)	53.9(38.9-74.8)		113(81.7-157)
Oxydisulfoton	Disyston	Alfalfa, potatoes				
Parathion		Potatoes, grain	12.4(--)	2.13(1.54-2.96)		24.0(16.8-34.2)
Phorate	Thimet 156	Alfalfa, potatoes, sugar beets	7.12(4.94-10.3)	0.61(0.367-1.03)		12.8(3.20-51.2)
Phosmet	Imidan	Alfalfa, potatoes		1830(1270-2630)		
Terbufos	Counter	Soil				
Trichlorfon	Dylox	Alfalfa, sugar beets				

^aData from Tucker and Crabtree 1970, unless otherwise indicated.

^bFrom Zinkl et al. 1981.

Figure 1. Sage grouse summer range and location of die-offs in southeastern Idaho.

