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Response of Labidura Riparia (Pallas) to Residues of Pesticides Used on Peanuts

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ABSTRACT

The effect of agricultural chemicals used in peanut production on the predaceous earwig *Labidura riparia* (Pallas) was demonstrated by exposure of adult males and females to residues on glass, on foliage, and in soil. In addition, food chain toxicity was evaluated by feeding predators on *Spodoptera frugiperda* (J. E. Smith) larvae treated with chemicals. Toxicity to chemicals decreased with less direct routes of exposure and with time after exposure and varied with product tested. Residues of carbaryl, methomyl, monocrotophos, toxaphene and dinoseb + alachlor resulted in 100% earwig mortality in 48 h when exposed on glass. In general herbicides were more toxic than the fungicides benomyl + maneb or chlorothanlonil, but were less toxic than insecticides. The mortality level was reduced by 50-90% when the pesticide residues were on foliage compared to glass. Phorate in soil resulted in more than 85% mortality, and the herbicide vernolate in soil caused more than 50% mortality. When fed chemically treated larvae, 30-100% of earwigs were killed. The most toxic pesticide when in the food chain was monocrotophos, the least toxic ones were toxaphene and methomyl.

Key Words: Labidura riparia (Pallas), Earwig, Herbicides, Insecticides, fungicides, Pesticides, Peanuts, Food chain Toxicity.

Labidura riparia (Pallas), the striped earwig, is an important predator in cultivated crops such as soybeans (5) and peanuts (7). It attacks and consumes larvae and eggs of many crop pests (loopers, armyworms, cutworms, velvet bean caterpillar, corn earworms, and others). The species, of cosmopolitan distribution, has been reported from Africa, Europe, South America, and North America. In the United States, it is common in the Southeast from North Carolina to Florida to Louisiana and also occurs in Arizona and California.

In peanuts, large earwig populations develop during the growing season in North and Central Florida. These earwigs are beneficial for the control of pest insects that feed on peanut plants. However, their population numbers are diminished by the use of toxic pesticides. Earwig populations in soybeans were many times greater in old fields than in newer fields, but numbers of earwigs were reduced when methyl-parathion and methomyl were applied late in the season (5). Numbers of earwigs in fields treated warly in the season were greater, indicating some recovery *L. riparia* adults in plots treated with monocrotophos were less abundant than in plots treated with methyl-parathion plus methomyl (5). The number of earwigs caught in traps in Florida peanut fields showed a stong correlation to numbers of small caterpillar prey present on the foliage (7). Parathion and monocrotophos had the greatest effect on reducing *L. riparia* populations, carbaryl was least harmful, and methomyl led to slightly more diminution in earwig numbers than did carbaryl.

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Workman (8) considered the earwig a household pest and tested pesticides in soil in glass jars for its mortality. His results show that *L. riparia* was tolerant of chlorinated hydrocarbon insecticides such as endrin, aldrin, dieldrin, and toxaphene, but it was highly susceptible, after 24 h, to the organophosphates parathion, diazinon, naled, dimethoate, and malathion. Also, Clements (2), regarded *L. riparia* as a pest in residential and commercial areas and concluded that the species was tolerant to chlordane but highly susceptible to diazinon and propoxur.

A single application to 40-day-old Florunner peanuts of carbaryl, methomyl, triphenyltin hydroxide, maneb, and carbofuran demonstrated that parathion resulted in significant mortality of young earwig nymphs at 1 and 2 days after treatment (7). Young earwigs continued to be affected for up to 7 days post-treatment by parathion and carbofuran.

Dinoseb was reported to be the most toxic herbicide used against insects and spiders in Louisiana cotton (6). Diuron and MSMA were relatively nontoxic to the insects tested. However, directed sprays of the three herbicides to the base of the cotton plants resulted in little mortality to insects or spiders. Benomyl was moderately ovicidal and more toxic to immature *Amblyseius fallacis* (Garman) predators by residual contact than by direct impingement (4).

The purpose of this research was to determine the relative toxicity of pesticides used in peanut production and the influence of method of exposure on toxicity to individual *Labidura riparia.*

Material and Methods

Labidura riparia used in the experiments were collected in peanut fields by using pitfall traps consisting of an 11.5 cm dia (480 ml) plastic cottage-cheese container embedded to the rim in soil between peanut plants in field rows. Each trap was covered with a 15 x 15 cm flat wooden roof elevated 5 cm on legs placed at the corners and baited with Gaines® Puppy Choice dog food. In the laboratory, earwigs were held in plastic boxes of moistened soil and fed dog food and lettuce until used, 24-48 h after trapping. Test units were held at 25 ± 1 C and 50-80% RH under a 14:10 light:dark regime.

Four types of experiments were done to determine the mortaility of adult earwigs exposed to chemical pesticides using a randomized block design with pesticides as main variables. Table 1 lists the pesticides, their formulation and rates used in all tests and the exposure method tested for each. Four replicates of earwigs selected at random by sex were done for each test using five female, five small male and five large male earwigs, since two male morphotypes are common in *L. riparia.* When earwigs were held past 24 h, dog food and lettuce were provided to prevent starvation and cannibalism. No comparisons were made based on sex or any variables other than the pesticides themselves.

Deposit on Glass (DOG). Residues of chemicals were deposited on glass by diluting the measured product in 50 ml of water, then pouring

Table 1. Chemical pesticides used in peanuts tested for mortality to *Labidura riparia* (Pallas)

Material	Formu-lation	Rate ai kg/ha	METHOD OF EXPOSURE[1/] DOG	ROF	RS	RF
Insecticides						
carbaryl	80WP	1.0	+	+	-	+
toxaphene	8EC	1.92	+	+	-	+
monocrotophos	5L	0.6	+	+	-	+
methomyl	1.8L	0.32	+	+	-	+
phorate	15G	10.0	-	-	+	-
disulfoton	15G	7.5	-	-	+	-
parathion	10G	10.0	-	-	+	-
carbofuran	10G	10.0	-	-	+	-
Fungicides						
benomyl +	50WP	0.25	+	+	-	-
+ maneb	80WP	1.25				
chlorothalonil	6F	0.72	+	+	-	+
Herbicides						
benefin	1.5L	1.1	+	-	+	-
vernolate	7E	3.8	+	-	+	-
dinoseb +	3E	1.4	+	-	+	-
+ alachlor	4E	1.9				
bentazon	4S	1.9	+	-	+	+

[1/] DOG = Deposit on Glass; ROF = Residue Sprayed on Foliage; RS = Residue in Soil; RF = Residue on Food; - indicates no test

the finished material into 9-cm dia glass petri dishes. After 10 min the material was removed, the dish air dried, and earwigs added. Water served as a check. Mortality was recorded at 1, 24, 48, 72, and 96 post-treatment. Materials tested were carbaryl, toxaphene, monocrotophos, methomyl, dinoseb + alachlor, vernolate, benefin, bentazon, benomyl + maneb and chlorothalonil. Formulations and rates of application are provided on Table 1.

Residue on Foliage (ROF). To determine if pesticide residues on foliage are lethal to earwigs, a single application of carbaryl, toxaphene, monocrotophos, methomyl, benomyl + maneb and chlorothalonil, at the rates listed in Table 1, was made with a hand sprayer to 45-day old 'Florunner' peanuts grown in 15.3-cm dia plastic pots. After treatment, 6 leaves were removed from the treated plants and placed on a layer of moist soil in plastic cottage-cheese containers. Earwigs of each category, female, small male and large male, were added to individual containers bearing the treated peanut foliage. Untreated foliage served as a check. This procedure was followed by 1, 4 and 8 days after application. Earwig mortality was recorded at 1, 24, and 48 h after exposure to the foliage.

Residues in soil (RS). Toxicity of pesticides in soil was determined by exposing the earwigs by sex and morphotype to phorate, disulfoton, parathion, carbofuran, benefin, vernolate, dinoseb + alachlor and bentazon at the rates listed in Table 1. Each chemical was mixed with 50 cc of moist soil in plastic cottage-cheese containers. Untreated moist soil served as a check. Mortality was recorded at 1, 24 and 48 h post-exposure.

Residues on food (RF). To determine if "prey" contaminated by pesticides, a common source of food for earwigs under field conditions (Poe, personal observation), would be lethal when consumed, the predators were offered 7-day-old fall armyworms, *Spodoptera frugiperda* (J. E. Smith), that had been sprayed separately with each toxicant. One h after treatment, five dead or moribund larvae were placed in the plastic cottage-cheese containers as 'food' for earwigs. Mortaility was recorded at 1, 24 and 48 h after the larvae were offered. Untreated but dead larvae were fed to one group of earwigs as a check for the experiment. Materials used at the rate given in Table 1 were carbaryl, toxaphene, monocrotophos, methomyl, chlorothanlonil and bentazon.

Data from all experiments were adjusted to account for natural mortality observed in the control (1) and expressed in percentages for analysis of variance. Relationships among mean values were determined by using Duncan's Multiple Range Test.

Results and Discussion

No obvious differences were observed between the large male and the small male response to the chemicals used in the various tests. Consequently, data for small males were omitted from Tables 2-5. In addition, no mortality was observed after the first hour, so Tables 3-5 show only 24 and 48 h observations.

Effects of chemicals (DOG). Mortaility of earwigs exposed to residues of chemicals depositied on glass is shown in Table 2. Within 1 h after exposure, carbaryl and

Table 2. Mortality of *Labidura riparia* (Pallas after exposure to chemical residues deposited on glass. [1]

Material	Percent mortality post-exposure 1-h F[2/]	M	24-h F	M	48-h F	M
Carbaryl	100a[3/]	100a	-	-	-	-
Toxaphene	5c	5c	75b	100b	100a	-
Monocrotophos	10c	5c	100a	100a	-	-
Methomyl	100a	100a	-	-	-	-
Dinoseb + alachlor	85b	33b	100a	100a	-	-
Vernolate	0c	0c	15c	10bc	20b	50a
Benefin	0c	0c	15c	5bc	30b	15bc
Bentazon	0c	0c	5c	20bc	5c	35bc
Benomyl + maneb	0c	0c	20c	25b	20b	40b
Chlorothalonil	0c	0c	20c	5c	30b	10c

[1/] Data adjusted by Abbotts formula. (1)

[2/] F = female; M = male; values are for large males, but are representative for small males also.

[3/] Values in each column followed by a common letter do not differ significantly (P ⩾ 0.05).

methomyl produced in 100% mortaility of both males and females. The herbicides dinoseb and alachlor were toxic to 85% of females and 33% of males wich 1 h. This apparent difference was not observed after 24 h when all the test insects were dead. Within 48 h all the insecticides and the herbicide combination had resulted in 100% mortaility to both earwig sexes (Table 2). Increased duration of exposure resulted in significant increases in mortality for the remaining herbicides.

Residue on foliage (ROF). Results from exposure of *L. riparia* to either 1, 4, or 8-day-old pesticide residues on peanut foliage are given in Table 3. Comparisons among

Table 3. Mortality of *Labidura riparia* (Pallas) after exposure to chemical residues on peanut foliage[1].

Pesticide	Residue Age (Days)	Percent mortality post-exposure 24-h F[2/]	24-h M	48-h F	48-h M
Carbaryl	1	15ab[3/]	0b	15b	10a
	4	0b	10ab	5b	25ab
	8	0b	15a	0b	15ab
Toxaphene	1	5b	10b	5b	25a
	4	25a	25a	45a	45a
	8	0b	5ab	15a	25a
Monocrotophos	1	0b	5b	0b	15a
	4	10ab	0b	10b	10b
	8	0b	0b	0b	0b
Methomyl	1	30a	25a	35a	30a
	4	0b	5b	5b	25ab
	8	10a	0b	25a	20ab
Benomyl + Maneb	1	10ab	10b	13b	15a
	4	10ab	10ab	15b	10b
	8	0b	0b	0b	0b
Chlorothalonil	1	0b	10b	5b	10a
	4	0b	10ab	0b	20ab
	8	0b	0b	0b	0b

1/ Data adjusted by Abbotts formula. (1)

2/ F = Female; M = Male; values are for large males but are representative for small males also.

3/ Values for each respective category followed by a common letter do not differ significantly (P > 0.05).

the ages of residue were not made. No mortality was observed in earwigs exposed to peanut leaves sprayed 24 h earlier and evaluated after 1 h. However, after 24 h exposure time to 1-day-old residues, methomyl and carbaryl had resulted in 30 and 15% mortality of females. Males were more severely affected by methomyl (25%) than by carbaryl (0%). After 48 h, the mortality due to all the materials had increased, the highest level being 35% of females killed by methomyl (Table 3). In no case was mortaility as extreme as when the earwigs were in direct contact with residues on glass (Table 2). In this test, earwigs may avoid long contact with the treated foliage, and the chemicals themselves were undoubtedly absorbed by foliage to reduce levels on the surface. It is of interest that exposure to chemicals after 4 and 8 days resulted in substantial mortality from most chemicals and, in the case of toxaphene, a higher level than for one day (45% at 4 days compared to 25% and 5% for males and females respectively at 1 day). This suggests that toxicity of field applied chemicals may persist for seveal days, and because of the earwig's habit of nocturnal feeding, mortality might also be expected to extend for several days. Of the fungicides, benomyl + maneb and chlorothalonil resulted in low mortality (10-20%) within 48 h.

Clearly the most toxic residues were from sprays of methomyl, toxaphene, carbaryl, and monocrotophos. The latter insecticide, while initially toxic, was less so after 4 and 8 days.

Pesticide residues in soil. Mortality to *L. riparia* induced by insecticides in soil is shown in Table 4. The products selected for use included those that are incorporated into the soil in peanut fields. There appeared to be slight differences in susceptibility between males and females depending on the chemical used (Table 4), however, no statistical test was made. Carbofuran appeared less toxic to females than to males, as was vernolate. The remaining insecticides (phorate, disulfoton, and parathion) appeared equally toxic to the sexes and resulted in mortality ranging from 25% to more than 85%. All herbicides caused mortality after 48 h; vernolate (56%) and bentazon (40%) were most toxic.

Table 4. Mortality of *Labidura riparia* (Pallas) after exposure to chemical residues in soil.[1]

Material	Percent mortality post-exposure 24-h F[2/]	24-h M	48-h F	48-h M
Dinoseb + Alachlor	10ab[3/]	10ab	20b	30b
Vernolate	5b	10ab	19b	56ab
Benefin	20ab	15ab	35b	25b
Bentazon	20ab	20ab	20b	40b
Carbofuran	0b	15ab	0b	19b
Parathion	15ab	15ab	31b	25b
Disulfoton	15ab	6b	30b	31b
Phorate	30a	31a	85a	88a

1/ Data adjusted by Abbotts formula. (1)

2/ F = female; M = male; Values are for large males but are representative for small males also.

3/ Values in each column followed by a common letter do not differ significantly (P≥ 0.05).

Residues on food. Possible food chain toxicity to earwigs was demonstrated when larval fall armyworms treated with chemicals were fed to earwigs (Table 5). After 24 h, earwigs fed on carbaryl and monocrotophos-treated larvae showed as much as 55-75% mortality. Chlorothalonil-treated larvae induced earwig mortality in excess of 25%. Mortality was greater at 48 h; 100% of males fed on monocrotophos-treated larvae had succumbed. Although earwigs readily feed on dead or dying insects after field application of insecticides, these data suggest that food chain toxicity might be responsible for substantial predator mortality. Of the materials tested, methomyl and toxaphene caused less food toxicity than other insecticides.

Exposure of earwigs to residues of chemicals used in the production of peanuts in these experiments suggests that direct contact, such as that incurred by spraying, would result in high levels of mortality from insecticides, herbicides, and fungicides. Toxicity was observed most

Table 5. Mortality of *Labidura riparia* (Pallas) after consuming chemically treated *Spodoptera frugiperda* larvae.[1]

	Percent mortality hours after feeding			
	24-h		48-h	
Material	F[2/]	M	F	M
Carbaryl	75a[3/]	70a	75a	75bc
Toxaphene	5c	0c	25bc	30d
Monocrotophos	40b	55a	88a	100a
Methomyl	10c	0c	30bc	30d
Bentazon	0c	5c	0c	80ab
Chlorotholonil	25bc	30b	40b	55c

1/ Data adjusted by Abbotts formula. (1)

2/ F = Female, M = Male; values are for large males but are representative for small males also.

3/ Values for each respective category followed by a common letter do not differ significantly ($P \geq 0.05$).

rapidly with carbaryl and methomyl and least rapidly with the herbicides benefin and bentazon. Residues on foliage induced less mortality after 4 days of age and showed far less lethality than DOG. The predators not only could avoid contact with foliage, but the plants themselves probably absorbed a portion of the chemicals thus reducing toxicity. Soil applications of herbicides and insecticides resulted in greater mortality than foliage sprayed chemicals, suggesting that predator survival when these products are used might be low. Fortunately, in peanuts granular insecticides and herbicides are used at planting or very early in the season when predator populations are minimal or absent from the fields. The addition of products at pegging time for nematode control can, however, be expected to result in substantial mortality of earwigs. Consumption of dead or dying larvae from chemical sprays was demonstrated to be a predator hazard. The products that appeared to kill fewest earwigs (toxaphene and methomyl), however, were highly toxic in the DOG test.

Although slight variation in response of male and female earwigs to the chemicals used in these tests occurred, similar effects were almost always observed for a given chemical.

Selection of chemical pesticides for use in a crop management program should be made only after carefully considering the potential harmful effects to the population of beneficial arthropods in field crops such as peanuts. Demonstration of mortality to populations after field treatment with chemicals will provide further information on what might be less harmful to beneficial insects and therefore desirable for use in management systems where natural mortality is a major component of pest management. That there also may be pesticide related interactions among populations of predators has been demonstrated (3). Use of heptachlor and mirex resulted in increased numbers of striped earwigs, a response attributed to elimination of the fire ant as a natural enemy of earwigs.

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