CONTACT TOXICITY OF DECAMETHRIN AND PERMETHRIN ON BLACK BEAN APHID AND TWO OF ITS COCCINELLID PREDATORS

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ABSTRACT

The contact toxicity of decamethrin and permethrin was evaluated on adult black bean aphids. (*Aphis craccivora* Koch) and third instar larvae and adults of its coccinellid predators. *Chilomenes sexmaculata* Fabr. and *Coleophora inaequalis* Fabr.

Based on LC_{50}, decamethrin is more toxic to the black bean aphid than permethrin particularly after 48 hours exposure. The third instar larvae of *C. inaequalis* exhibited higher LC_{50} than *C. sexmaculata* at 24 hours but not after 48 hours of exposure to decamethrin. However, the latter species was more tolerant to permethrin than the former as indicated by the lower LC_{50} obtained in *C. inaequalis*. The LC_{50} values of the two insecticides were consistently lower for adults of *C. sexmaculata* than *C. inaequalis* at both exposure periods.

The two insecticides used were more toxic to the aphids than to the coccinellid predators. Hence, they could be used to control aphids without adversely affecting the coccinellids which could also be utilized as biocontrol agents.

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KEY WORDS: Black bean aphid (*Aphis craccivora* Koch). Coccinellid predators. *Chilomenes sexmaculata* Fabr. *Coleophora inaequalis* Fabr. Decamethrin. Permethrin. LC_{50}

INTRODUCTION

The black bean aphid (*Aphis craccivora* Koch) is an economically important insect pest of legumes. This polyphagous pest sucks a great amount of sap from young shoots of leguminous plants, resulting in curling of leaves and stunting of growth. It also feeds on flowers and pods at later stages of plant growth. The aphid's feeding activity may facilitate transmission of certain virus diseases from infected to healthy plants. It has a very short life cycle and tremendous reproductive capacity.

For the chemical control of black bean aphids, CFOPR (1973) recommended 14 insecticides, namely: demeton (0,0-diethyl-0-2-ethylthioethyl phosphorothioate + 0,0-diethyl S-2-ethylthioethyl phosphorothioate), demeton S-methyl (S-2-ethylthioethyl 0,0-dimethyl phosphorothioate), dichlorvos (2,2-dichlorovinyl dimethyl phosphate), dicrotophos (dimethyl cis-2-dimethylcarbamoyl-1-methylvinyl phosphate), dimethoate [0,0-dimethyl S-(N-methyl carbamoyl methyl) phosphorodithioate], disulfoton (0,0-diethyl S-2-ethylthioethyl phosphorodithioate), endosulfan (6,7,8, 9,10,10 - hexachloro - 1,5,5a,6,9,9a - hexahydro - 6,9-methano-2,4,3 -beno [e] dioxathiepin 3-oxide), malathion [2 - di (ethoxy carbonyl) ethyl 0,0-dimethyl phosphorothioate], menazon [S - (4,6-diamino-1,3,5 - triazin-2-ylmethyl) 0,0-dimethyl phosphorodithioate], monocrotophos (dimethyl cis-1-methyl - 2 - methylcarbamoylovinyl phosphate), parathion (0,0-diethyl 0-4-nitrophenyl phosphorothioate), phorate [0,0-diethyl S - (ethylthiomethyl) phosphorodithioate], phosphamidon (2-chloro-2 diethylcarbamoyl-1-methylvinyl dimethyl phosphate), and thiometon (S-2-ethylthioethyl 0,0-dimethyl phosphorodithoate). Most of these insecticides, however, are broad spectrum poisons and may adversely affect the natural enemies and other non-target organisms. Moreover, majority of them have been in use for quite some time and *A. craccivora* may have gradually developed resistance to them.

Van den Bosch and Messenger (1974) predicted that continuous use of pesticides could result in ecological backlashes such as target pest resurgence, secondary pest outbreaks and development of pesticide-resistant pest populations. On the other hand; the use of predators and parasites, pest resistant crop varieties, and different cultural practices have not been consistently proven effective when used alone (Glass, 1977). A combination of these control measures with regulated pesticide application thus appears promising for bean aphid control.

Coccinellids are among the most efficient predators of aphids. Before they could be used in combination with chemical control, however, insecticides effective against aphids but relatively harmless to the coccinellids have to be identified.

Pyrethroids can control insects as effectively as and more safely than most currently used insecticides (Casida, 1973). Their fast action is extremely useful in fighting outbreaks of pests that multiply rapidly (Rose, 1963). The low persistence of pyrethroids, however, may be considered a disadvantage in that repeated applications are necessary for effective pest control. Pyrethroid-coccinellid combination may thus result in better aphid control than the use of pyrethroids or coccinellids alone. The toxicant could effect a rapid decrease in aphid population and if coccinellids are not adversely affected by the insecticide, this biocontrol agent may be able to check the population of survivor aphids.

This study aimed to evaluate the direct toxicity of pyrethroids, namely: decamethrin [S-α-cyano-3-phenoxybenzyl (1R, 3R)-3-(2,2-dibromovinyl)-2,2-dimethyl-cyclopane carboxylate] and permethrin [3-phenoxybenzyl (±)-cis, trans-3-(2,2 - dichlorovinyl) 2,2 - dimethyl cyclopropanecarboxylate] to the black bean aphid and two of its coccinellid predators.

MATERIALS AND METHODS

Mass Rearing of Test Insects

Black Bean Aphid (Aphis craccivora Koch*).* Potted healthy bush beans (*Vigna unguiculata* (L.) Walp. x *V. sesquipedalis* Fruw.) at the 3-leaf stage or older were artificially infested with field-collected adults and nymphs of the black bean aphid in the screenhouse. The aphids were allowed to reproduce to serve as prey for the mass rearing of the two species of coccinellid beetles. One- to 2-day old apterous adult aphids (Fig. 1) were used for the subsequent insecticide evaluation.

Coccinellid Predators (Chilomenes sexmaculata Fabr. *and Coleophora inaequalis* Fabr.*).* Field-collected adults of the two species of coccinellid beetles were mass-reared in the laboratory using rearing cages provided with bush bean plants heavily infested with aphids. The beetles were immediately transferred to other aphid-infested plants upon depletion of prey.

Figure 1. Apterous adult black bean aphid, *(Aphis craccivora* Koch*).*

Adult beetles were paired and allowed to mate. Gravid females were provided daily with aphid-infested plants to serve as oviposition substrate. The eggs were then incubated and allowed to hatch. Once the prey supply became limited, the larvae were immediately transferred to other infested bush bean plants. One- to 2-day old third instar larvae were used for subsequent insecticide evaluation.

Other sets of the predator larvae were continually reared. Pupae were collected, placed in rearing jars, then kept at room temperature until adult emergence. Adults emerging on the same day were collected and transferred to other rearing bottles provided with unlimited supply of prey. One- to 2-week old adults were used in the subsequent insecticide evaluation.

Determination of Contact Toxicity of Decamethrin and Permethrin

Black Bean Aphid. Bush beans planted singly in clay pots (15 cm dia.) were sprayed at the 3- to 4-leaf stage with graded concentrations (1^{-1} to 1^{-6} mg a.i./mL) of decamethrin and permethrin using a fine mist hand sprayer until run-off. Water was sprayed on control plants. Five potted plants were used for each concentration of insecticide and each plant served as a replicate.

To support fallen aphids, a 36 x 24 cm white cartolina was placed on top of the pot rim by sliding the stem of the plant through a slit cut up to the center of the paper (Fig. 2). The slit was then sealed with cellophane tape to cover any opening. The edges of the paper and the points of contact with the plant were coated with an adhesive to prevent possible escape of fallen aphids.

Sprayed plants were air-dried for 6 hours after which 20 apterous adult aphids were introduced onto each plant. Mortality counts were taken after 24 and 48 hours exposure to treated plants. Natural mortalities were corrected using Abbott's (1925) formula. The median lethal concentration (LC_{50}) and the dosage mortality regression line were determined using probit analysis (Finney, 1952).

Coccinellid Beetles. Graded concentrations (1^{-1} to 1^{-4} mg a.i./mL) were prepared. Using a pipet, one mL of each insecticide preparation

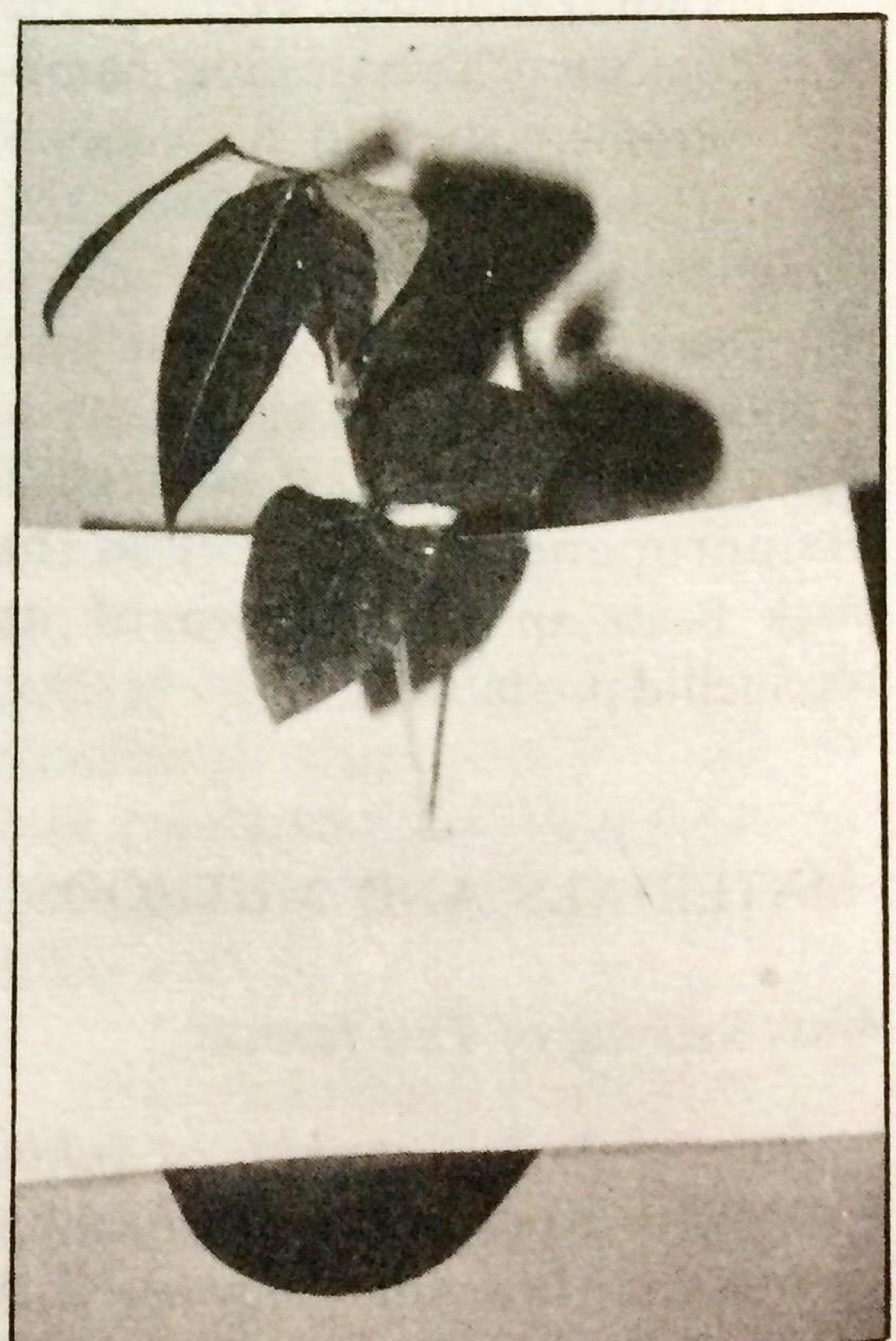

Figure 2. Potted bush bean plant with white cartolina for collecting fallen aphids.

was evenly distributed on a petri dish lined with a filter paper disc. Water was used for the control. Treated filter paper discs were air dried for 6 hours.

One- to 2-day old third instar larvae (Fig. 3) and 1- to 2-week old adults (Fig. 4) of the coccinellid predators were treated separately. Since mortality was high when the test insects were subjected to chill treatment for 5 minutes before exposure to insecticides, this control treatment was discontinued. Preliminary tests also showed that when 20 larvae were confined in each petri dish; the insects exhibited cannibalism, hence only five larvae were

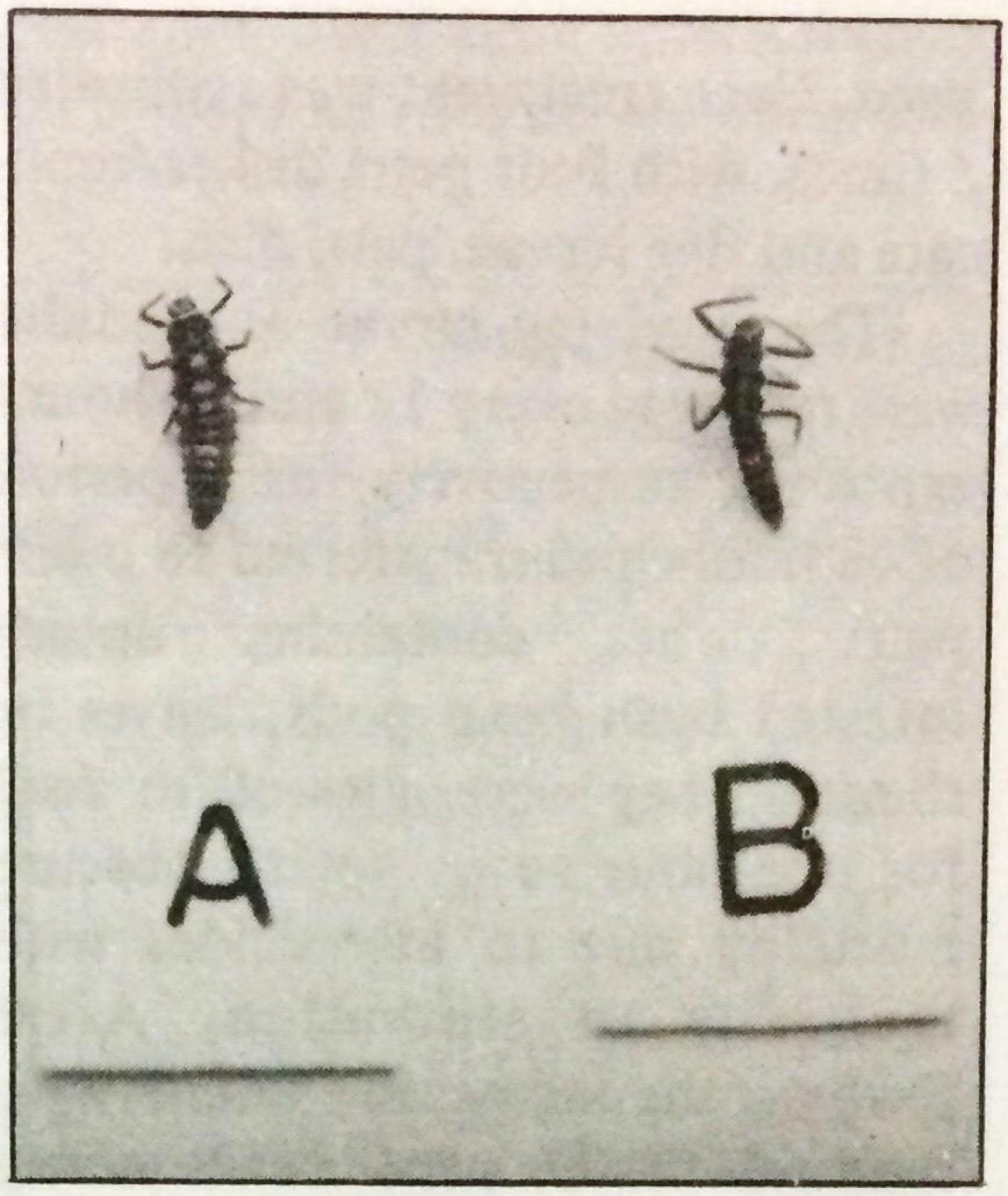

Figure 3. Third instar larvae of: A. *Chilomenes sexmaculata* Fabr. B. *Coleophora inaequalis* Fabr.

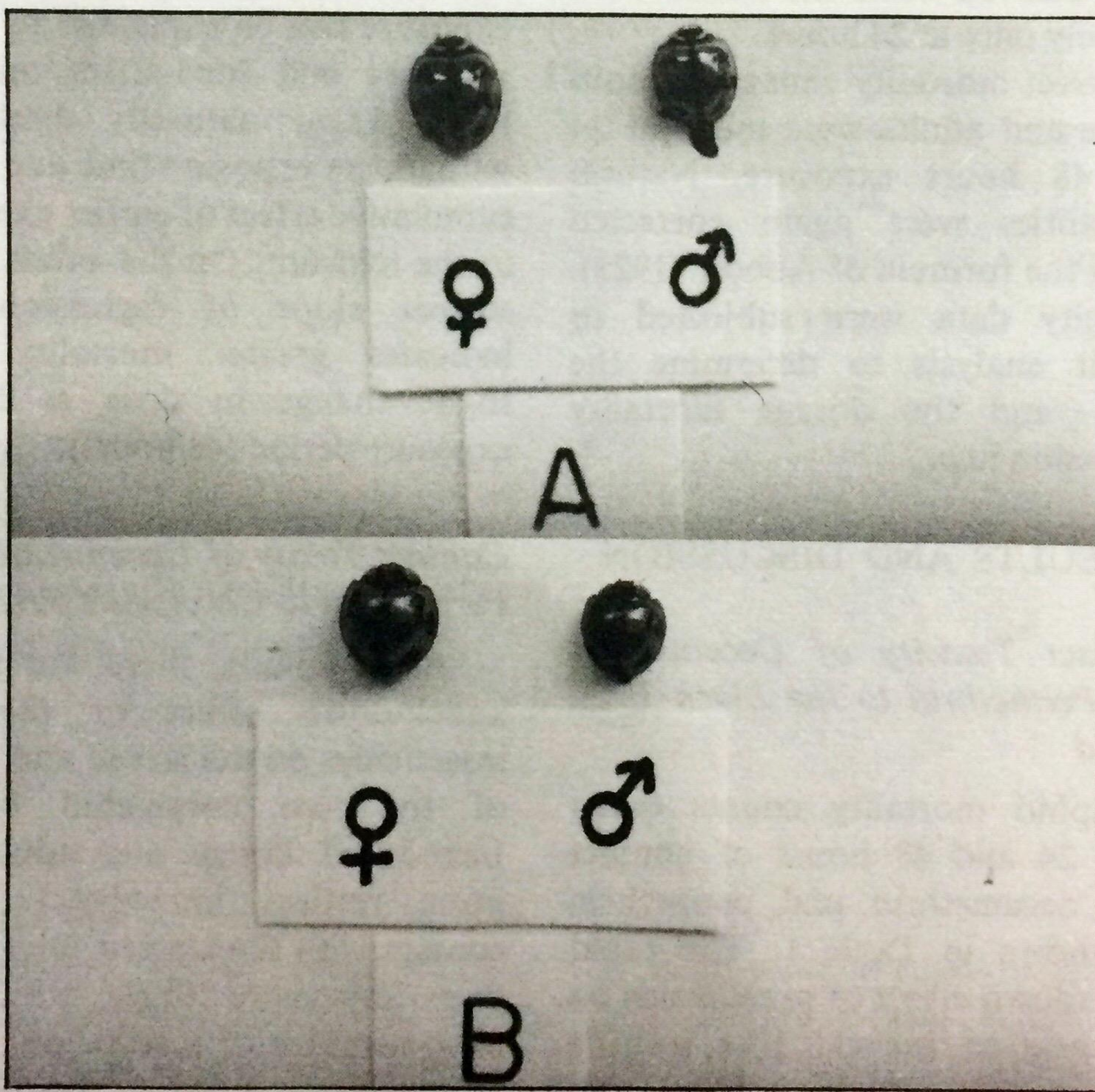

Figure 4. Adults of: A. *Chilomenes sexmaculata* Fabr. B. *Coleophora inaequalis* Fabr.

used. Each treatment was replicated 5 times, with four petri dishes/replicate and five larvae/petri dish.

The surviving larvae and adults were removed every 12 and 24 hours exposure, respectively for a period of 48 hours and transferred to other petri dishes containing aphid-infested bush bean pods, leaves or shoots. They were allowed to feed for one hour so as not to obscure mortality due to insecticides with that due to starvation. After feeding, the larvae and adults were returned to the petri dishes where they were taken. The larvae were fed twice, i.e. at 12 hours and 24 hours since they exhibited cannibalism when starved while the adults were fed only once at 24 hours.

Insect mortality counts for both larvae and adults were made at 24 and 48 hours exposure. Natural mortalities were again corrected using the formula of Abbott (1925). Toxicity data were subjected to probit analysis to determine the LC_{50} and the dosage mortality regression line.

RESULTS AND DISCUSSION

Contact Toxicity of Decamethrin and Permethrin to the Black Bean Aphid

Aphid mortality counts taken after 24 and 48 hours of contact with decamethrin and permethrin are shown in Table 1. The rapid knockdown effect of pyrethroids on soft-bodied insects like aphids (Rose, 1963; Casida, 1973) was confirmed in this study. Many of the adult aphids introduced to plants treated with decamethrin or permethrin at concentrations of 1^{-1} and 1^{-2} mg a.i./mL fell off a few minutes after contact with the treated surface but not those introduced to plants treated with lower concentrations.

The LC_{50} and 95% confidence limits of the two insecticides are presented in Table 2 and the regression lines in Figures 5 and 6. Decamethrin showed higher toxicity than permethrin as revealed by its lower LC_{50} and 95% confidence limits (Table 2) and steeper slope of regression line at 48 hours exposure (Fig. 6). The difference in LC_{50} values between 24 and 48 hours exposure can be explained by dose-response and time-effect relationships. LC_{50} naturally diminishes with longer exposure time due to the cumulative effect of earlier exposure to the toxicant. On the other hand, steeper slope of regression line indicates greater mortality with slight change in dose at longer exposure period (48 hours).

Contact Toxity of Decamethrin and Permethrin to Coccinellid Predators

As in aphids, there was also a knock-down effect of the two insecticides on the larvae and adults of the two coccinellid beetles. Introduced larvae and adults became restless immediately upon contact with the treated filter paper discs especially those with high concentration of insecticides. Since pyrethroids are nerve poisons, the restlessness exhibited by the insect

Table 1. Mortality counts of 1- to 2-day old adult black bean aphids *(Aphis craccivora)* after 24 and 48 hours of contact with decamethrin and permethrin.[1]

Insecticide/ Concentration (mg. a.i./mL)	Percent Mortality		Corrected Percent Mortality[2]	
	24 hours	48 hours	24 hours	48 hours
Decamethrin				
1.0^{-1}	100	100	100.00	100.00
1.0^{-2}	100	100	100.00	100.00
1.0^{-3}	84	95	83.33	94.38
1.0^{-4}	61	70	59.38	66.29
1.0^{-5}	36	46	33.33	39.33
1.0^{-6}	16	18	12.50	7.86
0.0	4	11	—	—
Permethrin				
1.0^{-1}	100	100	100.00	100.00
1.0^{-2}	89	98	88.78	97.80
1.0^{-3}	54	59	53.06	54.94
1.0^{-4}	32	37	30.61	30.77
1.0^{-5}	14	20	12.22	12.09
1.0^{-6}	2	5	—	—
0.0	2	9	—	—

[1] Data based on 100 aphids per concentration

[2] Based on Abbott's formula.

was the first symptom of poisoning. Matsumura (1976) described the typical sympton pattern of nerve poisoning in insects as follows: (1) excitation, (2) convulsion, (3) paralysis and (4) death.

High concentrations of the pesticidal solutions also induced the larvae and adults to exude a greenish black liquid from their mouth after

Table 2. Median lethal concentration (LC_{50}), and 95% confidence limit of decamethrin and permethrin on black bean aphid, (*Aphis craccivora*) at 24 and 48 hours contact with the sprayed plants.

Insecticide/ Duration of Contact (hours)	LC_{50} (mg a.i./mL)	95% Confidence Limit	
		Lower	Upper
Decamethrin			
24	0.00003427	0.00002124	0.00005556
48	0.00001485	0.00000965	0.00002231
Permethrin			
24	0.00041814	0.00027694	0.00649130
48	0.00020111	0.00004021	0.00033535

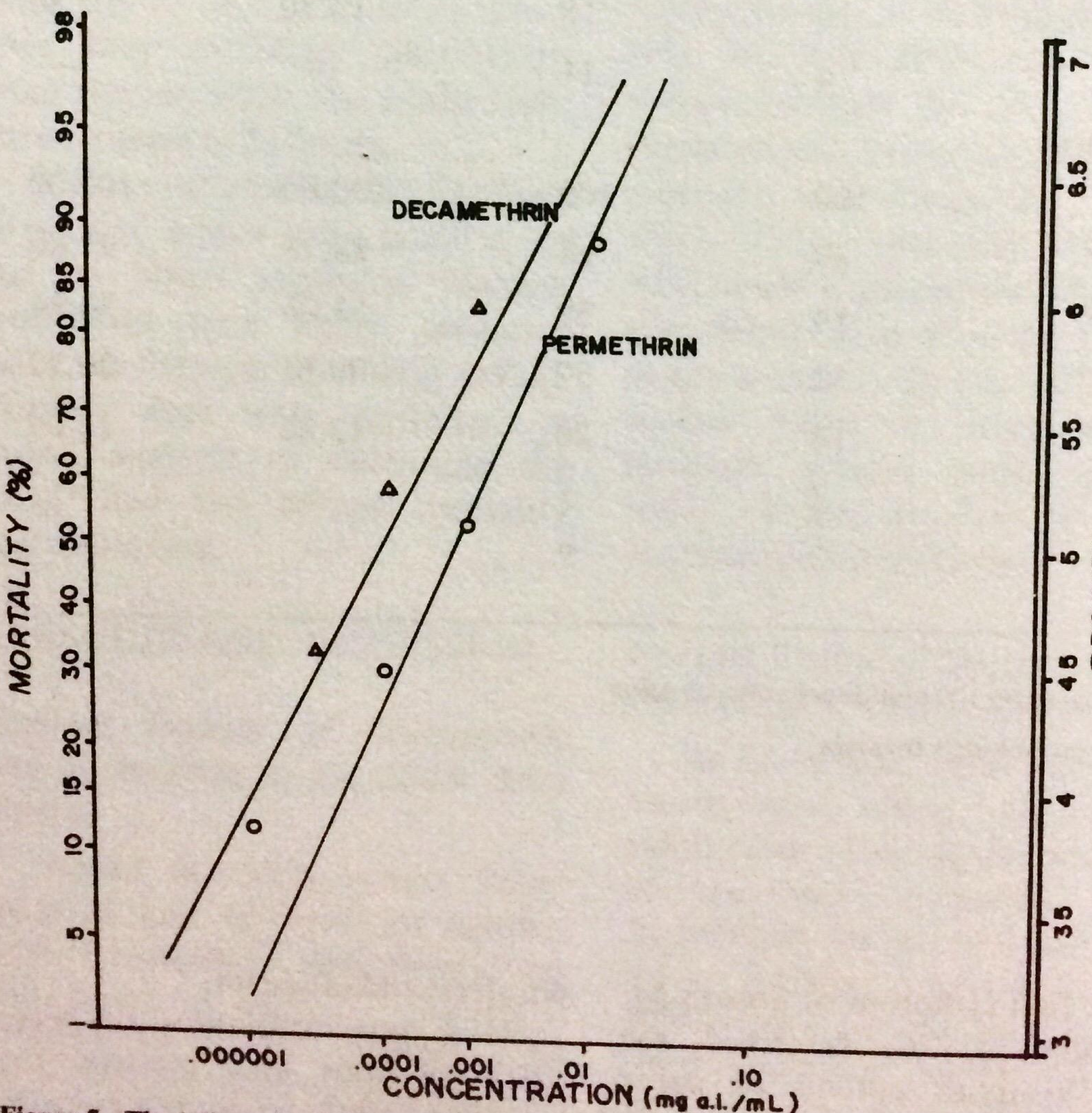

Figure 5. The LC-probit line of 1-to 2-day old adult black bean aphids (*Aphis craccivora*) after 24 hours of contact with decamethrin and permethrin.

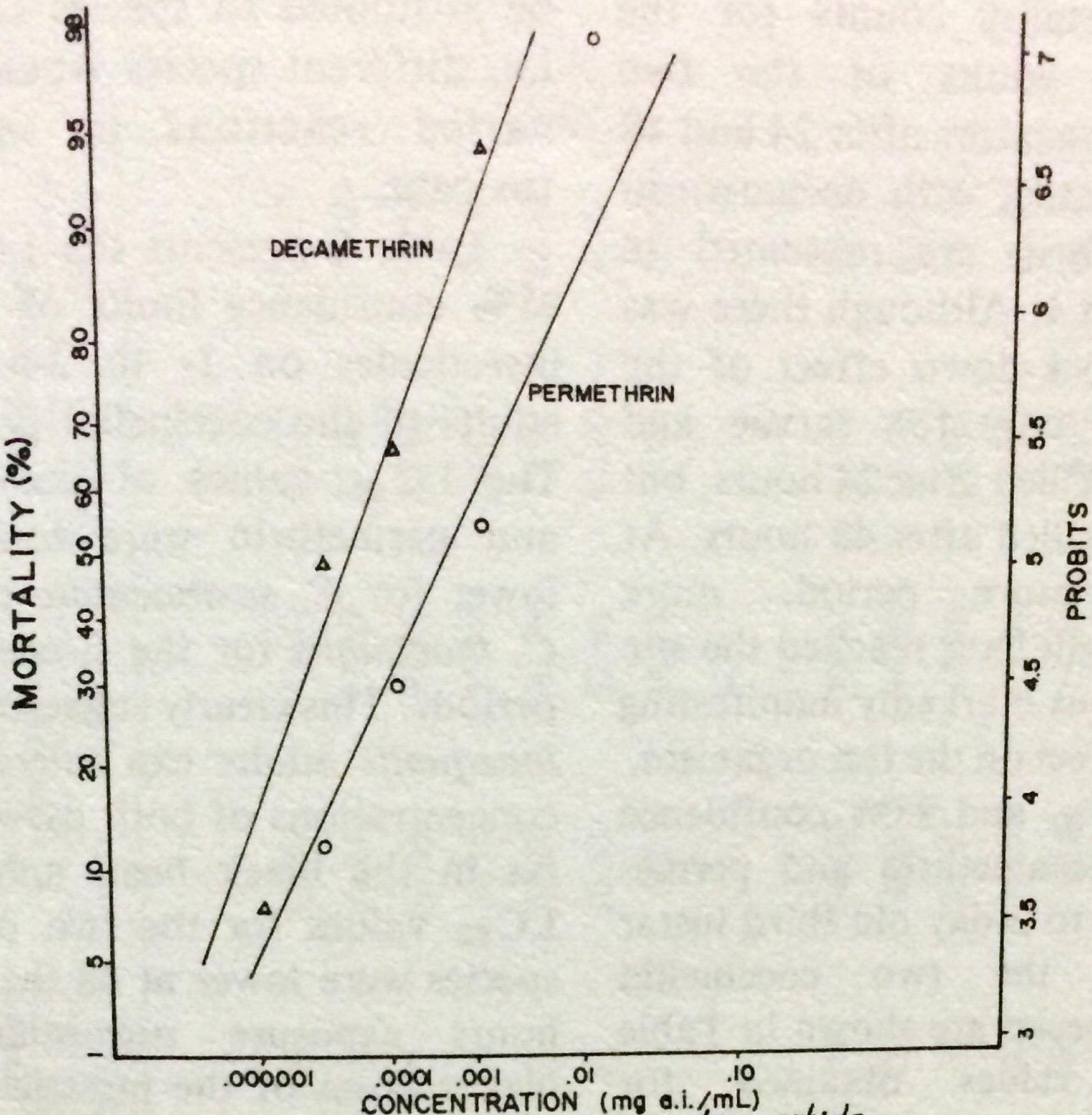

Figure 6. The LC-probit line of 1-to 2-day old adult black bean aphids (*Aphis craccivora*) after 48 hours of contact with decamethrin and permethrin.

a few minutes exposure to the treated surfaces. This again suggested poisoning. A few hours after introduction, the larvae and adults became weak and quiescent but some were able to recover and behave normally again after several hours. Some larvae got immobilized with their caudal tips glued to the filter paper discs.

At low concentrations, the effect of the insecticides was only temporary. Treated insects which exhibited the toxicity symptoms recovered later and behaved normally again like the control. Surviving adults exposed to a concentration of 1^{-3} mg a.i./mL or lower acted normally like those in the control. This was suggested by duration of copulation (lasting from a few minutes to 1 or 2 hours) which was similar to the untreated control.

According to Tattersfield (1932 as cited by Martin and Woodcock, 1983), recovery from sublethal doses of pyrethroids indicates that the biological interaction of pyrethroid poisoning is reversible, or that the insect is able to detoxify the insecticides. The major metabolic pathway for the enzymic detoxification of pyrethroids involves the oxidation of the trans-methyl group of the isobutenyl moeity to a hydroxymethyl derivative which when acted upon by other enzymes either forms conjugates or further oxidizes to aldehyde and acid (Yamamoto, 1970; Perry and Agosin, 1974).

The mortality counts for the larvae and adults of the two coccinellid predators after 24 and 48 hours of contact with decamethrin and permethrin are presented in Tables 3 and 4. Although there was a rapid knock-down effect of the insecticides, only few larvae and adults were killed after 24 hours, but many were killed after 48 hours. At longer exposure period, more toxicant might have reached the site of action thus markedly manifesting its lethal effect on the test organism.

The LC_{50} and 95% confidence limits of decamethrin and permethrin on 1- to 2-day old third instar larvae of the two coccinellid predator species are shown in Table 5. The values obtained for decamethrin were higher on *C. inaequalis* than on *C. sexmaculata* at 24 hours exposure. However after 48 hours, markedly higher LC_{50} was observed on *C. sexmaculata* than on *C. inaequalis*. This could probably be explained by the difference in the penetration rates of decamethrin into the two predator species. It appears that for *C. inaequalis,* penetration was slow initially and became faster with longer exposure. However, *C. sexmaculata* exhibited the reverse, i.e. fast followed by slow absorption rates. Since the absorption rate is directly related to mortality, it followed that the LC_{50} values were changed accordingly.

For permethrin, *C. sexmaculata* always showed markedly higher LC_{50} values than *C. inaequalis* at both exposure periods. This could be attributed to species selectivity, i.e. different species would exhibit varied reactions to the same toxicant.

Table 6 presents the LC_{50} and 95% confidence limits of the two insecticides on 1- to 2-week old adults of the coccinellid predators. The LC_{50} values of decamethrin and permethrin were consistently lower for *C. sexmaculata* than for *C. inaequalis* for the two exposure periods. This clearly suggests that *C. inaequalis* adults can tolerate high concentrations of both pyrethroids. As in the black bean aphid, the LC_{50} values for the two predator species were lower at 48 than at 24 hours exposure suggesting that higher doses of the insecticides are needed to kill the predators immediately.

The regression lines for the third instar larvae, and adults of *C. inaequalis* and *C. sexmaculata* are presented in Figures 7-10 and 11-14, respectively. Steeper slopes were always noted at 48 hours of contact than at 24 hours. This implies that high mortality rates could be attained with slight change in toxicant's concentration at longer exposure period.

Contact toxicity of an insecticide is not only species specific but also stage specific. Theoretically, larvae are more susceptible than adults because they have bigger surface area. The sclerotized integument and hard elytra of adults serve as barriers to rapid penetration of the toxicant into the insect's body. However in the study conducted,

Table 3. Mortality counts of 1- to 2-day old third instar larvae of *Chilomenes sexmaculata* and *Coleophora inaequalis* after 24 and 48 hours of contact with decamethrin and permethrin.[1]

Insecticide/	Percent Mortality				Corrected Percent Mortality[2]			
Concentration	*C. sexmaculata*		*C. inaequalis*		*C. sexmaculata*		*C. inaequalis*	
(mg a.i./mL)	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.	24 hrs.	48 hrs.
Decamethrin								
0.0	5	5	0	0	—	—	—	—
1.0^{-1}	56	100	44	100	53.68	100.00	44.00	100.00
5.0^{-2}	45	98	37	98	42.11	97.89	37.00	98.00
1.0^{-2}	44	91	27	97	41.05	90.53	27.00	97.00
5.0^{-3}	30	77	20	81	26.32	75.79	20.00	81.00
1.0^{-3}	28	46	15	62	24.21	46.16	15.00	62.00
5.0^{-4}	15	37	11	41	10.53	37.68	11.00	41.00
1.0^{-4}	9	21	7	17	4.21	16.84	7.00	17.00
Permethrin								
0.0	0	0	0	0	—	—	—	—
1.0^{-1}	58	93	69	96	58.00	93.00	69.00	96.00
5.0^{-2}	40	84	67	86	40.00	84.00	67.00	86.00
1.0^{-2}	25	57	61	78	25.00	57.00	61.00	78.00
5.0^{-3}	16	35	55	63	16.00	35.00	55.00	63.00
1.0^{-3}	6	15	26	41	6.00	15.00	26.00	41.00
5.0^{-4}	3	11	4	10	3.00	11.00	4.00	10.00
1.0^{-4}	1	5	0	4	1.00	5.00	0.00	4.00

[1]Data based on 100 individuals per concentration.

[2]Based on Abbott's formula.

Table 4. Mortality counts of 1- to 2-week-old adults of *Chilomenes sexmaculata* and *Coleophora inaequalis* after 24 and 48 hours of contact with decamethrin and permethrin.[1]

Insecticide/ Concentration (mg a.i./mL)	**Percent Mortality**				**Corrected Percent Mortality**[2]			
	C. sexmaculata		*C. inaequalis*		*C. sexmaculata*		*C. inaequalis*	
	24 hrs.	**48 hrs.**	**24 hrs.**	**48 hrs.**	**24 hrs.**	**48 hrs.**	**24 hrs.**	**48 hrs.**
Decamethrin								
0.0	2	3	0	0	—	—	—	—
1.0^{-1}	58	90	40	95	57.14	89.69	40.00	95.00
5.0^{-2}	51	77	36	85	50.00	76.29	36.00	85.00
1.0^{-2}	37	69	35	69	35.71	68.04	35.00	69.00
5.0^{-3}	26	55	30	52	24.49	53.61	30.00	52.00
1.0^{-3}	19	42	15	38	17.35	40.21	15.00	38.00
5.0^{-4}	14	31	5	11	12.24	28.87	5.00	11.00
1.0^{-4}	4	13	0	5	2.04	10.21	0.00	5.00
Permethrin								
0.0	3	4	0	0	—	—	—	—
1.0^{-1}	78	89	66	88	77.32	88.54	66.00	88.00
5.0^{-2}	62	81	67	80	60.82	79.38	67.00	80.00
1.0^{-2}	45	57	45	63	43.30	55.21	45.00	63.00
5.0^{-3}	33	44	30	37	30.93	41.24	30.00	37.00
1.0^{-3}	27	38	13	16	27.74	35.42	13.00	16.00
5.0^{-4}	21	28	1	6	18.56	25.00	1.00	6.00
1.0^{-4}	8	12	0	4	5.15	8.33	0.00	4.00

[1] Data based on 100 individuals per concentration.

[2] Based on Abbott's formula.

Table 5. Median lethal concentration (LC_{50}) and 95% confidence limits of decamethrin and permethrin on 1- to 2-day-old third instar larvae of *Chilomenes sexmaculata* and *Coleophora inaequalis* at 24 and 48 hours exposure.

Insecticide/ Insect/Duration of Contact (hours)	LC_{50} (mg a.i./mL)	95% Confidence Limit	
		Lower	Upper
Decamethrin			
C. sexmaculata			
24	0.04903981	0.02650962	0.11521412
48	0.00086951	0.00066093	0.00112247
C. inaequalis			
24	0.26033173	0.10689896	1.04845752
48	0.00056652	0.00000048	0.00000000
Permethrin			
C. sexmaculata			
24	0.07241383	0.04868986	0.12013240
48	0.00705089	0.00556434	0.00899672
C. inaequalis			
24	0.01030995	0.00339595	0.04327672
48	0.00288497	0.00154593	0.00519613

higher tolerance of the third instar larvae than of adults of *C. inaequalis* to decamethrin and *C. sexmaculata* to permethrin was observed (Tables 5 and 6). These results are similar to the findings of Bartlett (1958) and Patil et al. (1979) that larvae of pyrethrum-treated coccinellid predator *Hippodamia* sp. of alfalfa aphid, and those of

Table 6. Median lethal concentration (LC_{50}), and 95% confidence limits of decamethrin and permethrin on 1- to 2-week old adults of *Chilomenes sexmaculata* and *Coleophora inaequalis* at 24 and 48 hours exposure.

Insecticide/ Duration of of Contact (hours)	LC_{50} (mg a.i./mL)	95% Confidence Limit	
		Lower	Upper
Decamethrin			
C. sexmaculata			
24	0.04355331	0.02693940	0.08091585
48	0.00264834	0.00188765	0.00366621
C. inaequalis			
24	0.13189904	0.03401448	5.53101920
48	0.00365360	0.00166251	0.00793528
Permethrin			
C.sexmaculata			
24	0.01265678	0.00875117	0.019233357
48	0.00390878	0.00283391	0.005393050
C. inaequalis			
24	0.02106678	0.01187968	0.04348640
48	0.00782110	0.00615728	0.01000349

parathion- and carbaryl-treated houseflies were more tolerant than adults.

Busvine (1971) reported that insects which underwent complete metamorphosis showed radical changes in insecticide susceptibility. He stated that the different levels of susceptibility in later developmental stages could be possibly caused by differences either in liability to penetration, in sensitivity associated with variations in rate of metabolism and number of sense organs, or in tolerance ascribed to fat reserves.

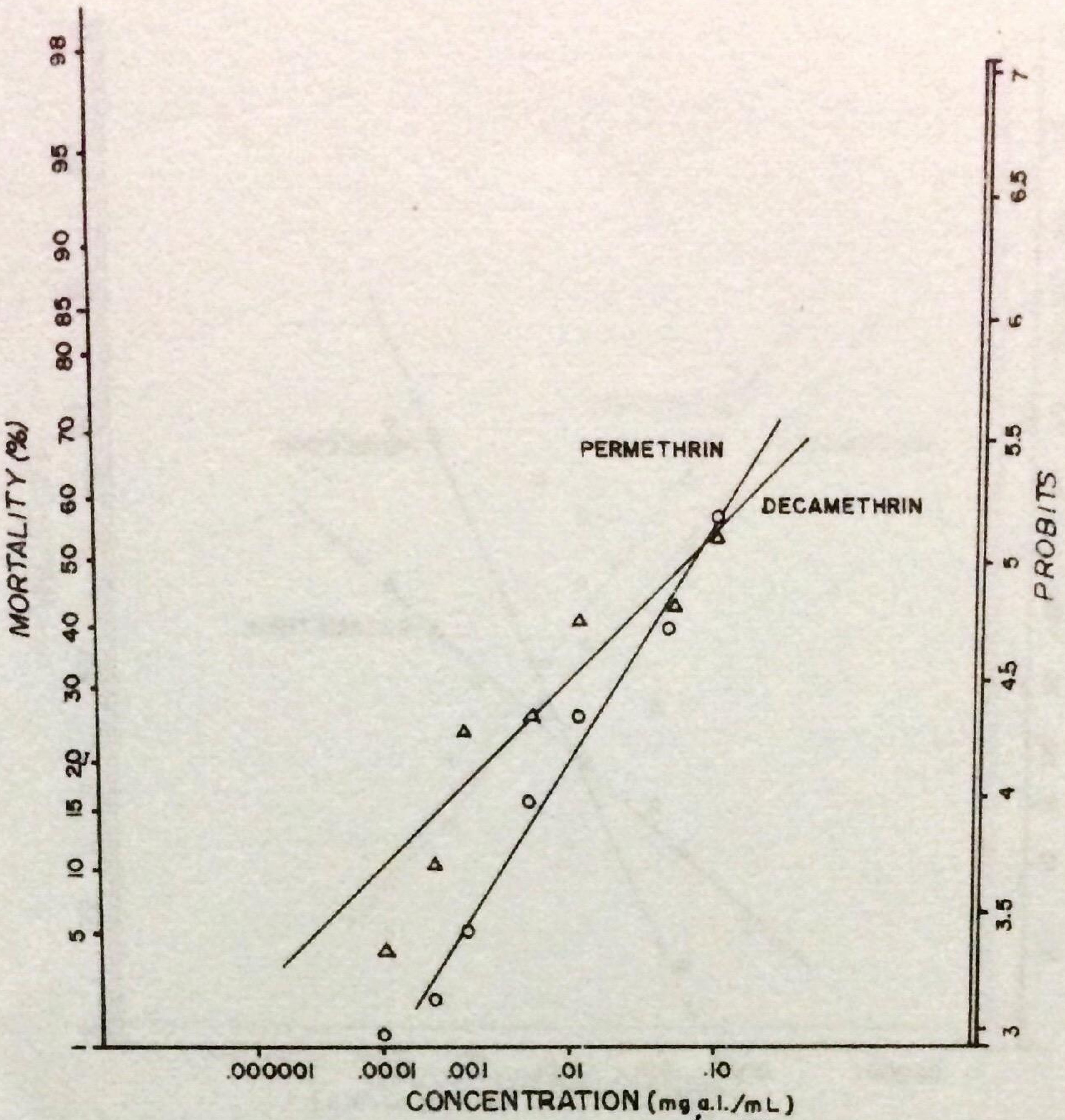

Figure 7. The LC-probit line of 1-to 2-day old third instar larvae of *Chilomenes sexmaculata* after 24 hours of contact with decamethrin and permethrin.

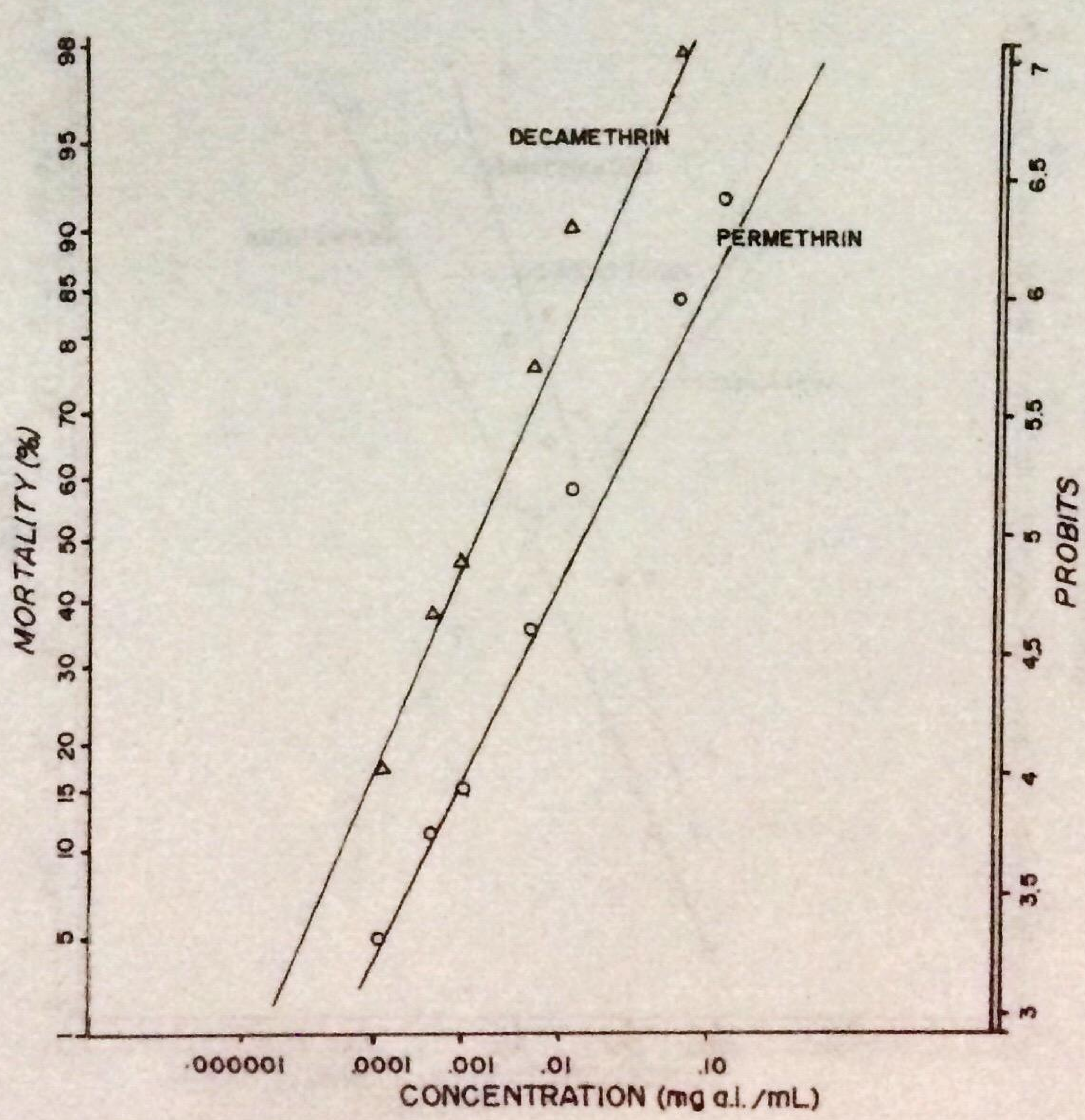

Figure 8. The LC-probit line of 1-to 2-day old third instar larvae of *Chilomenes sexmaculata* after 48 hours of contact with decamethrin and permethrin.

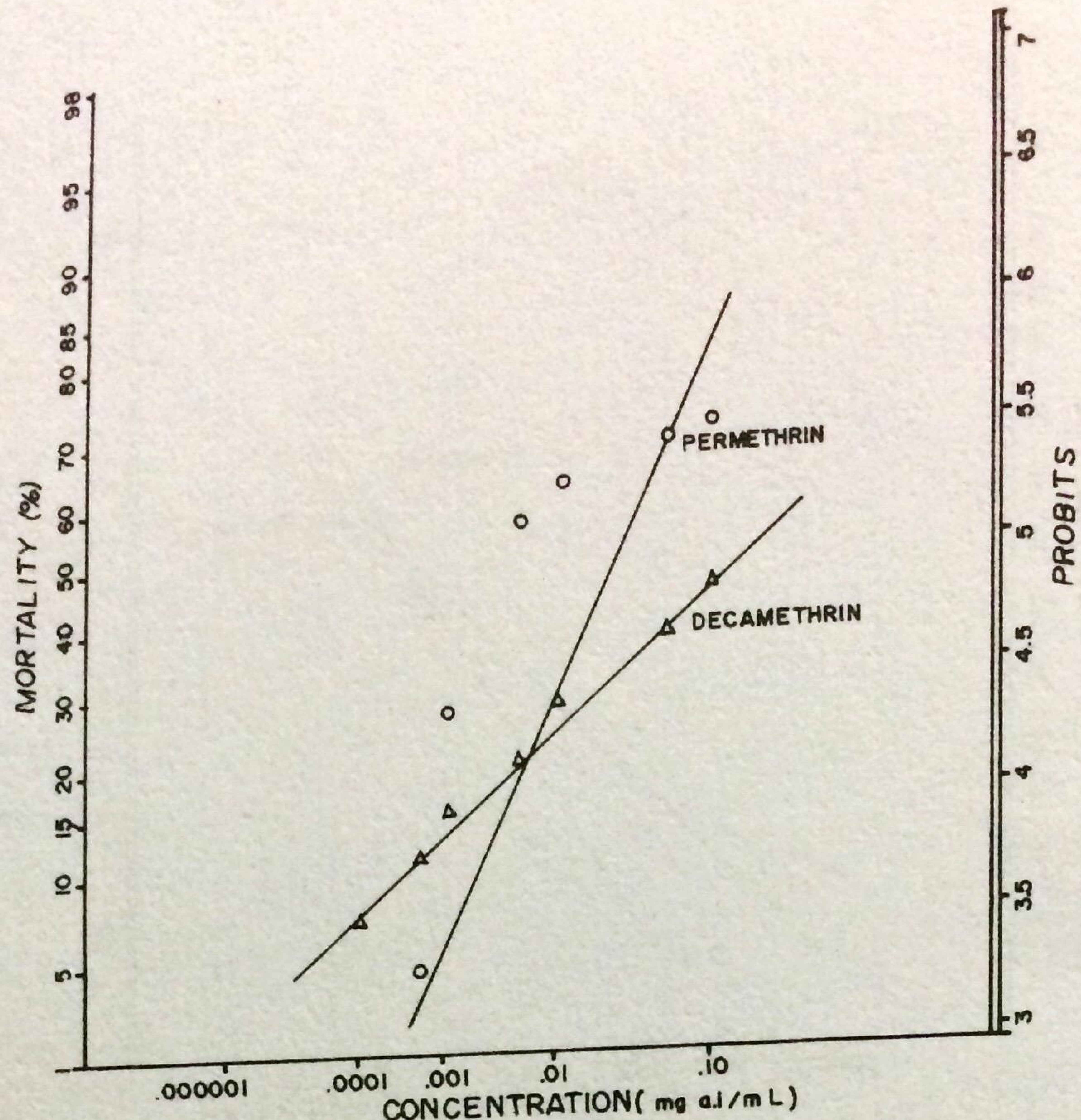

Figure 9. The LC-probit line of 1-to 2-day old larvae of *Coleophora inaequalis* after 24 hours of contact with decamethrin and permethrin.

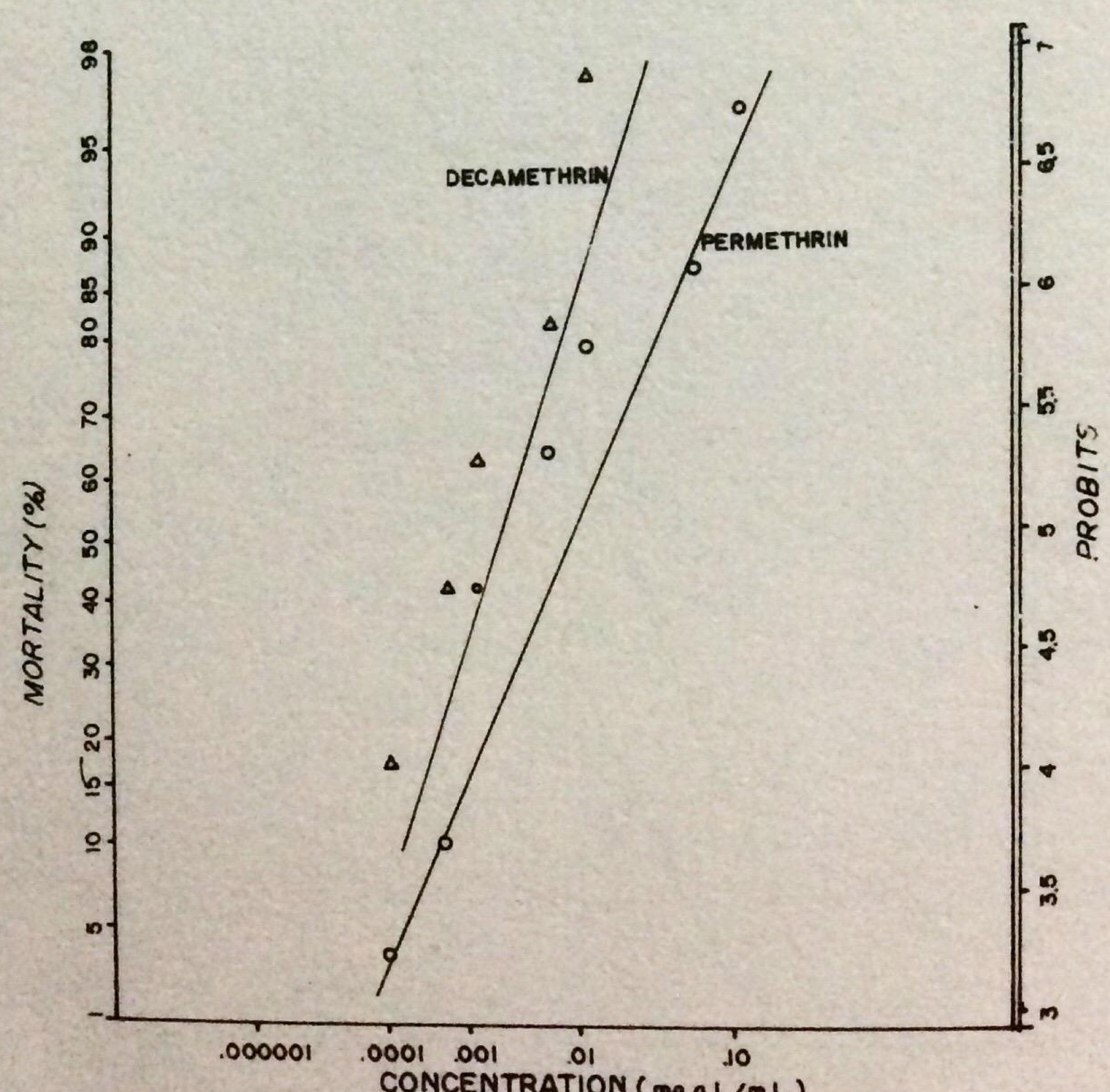

Figure 10. The LC-probit line of 1-to 2-day old larvae of *Coleophora inaequalis* after 48 hours of contact with decamethrin and permethrin.

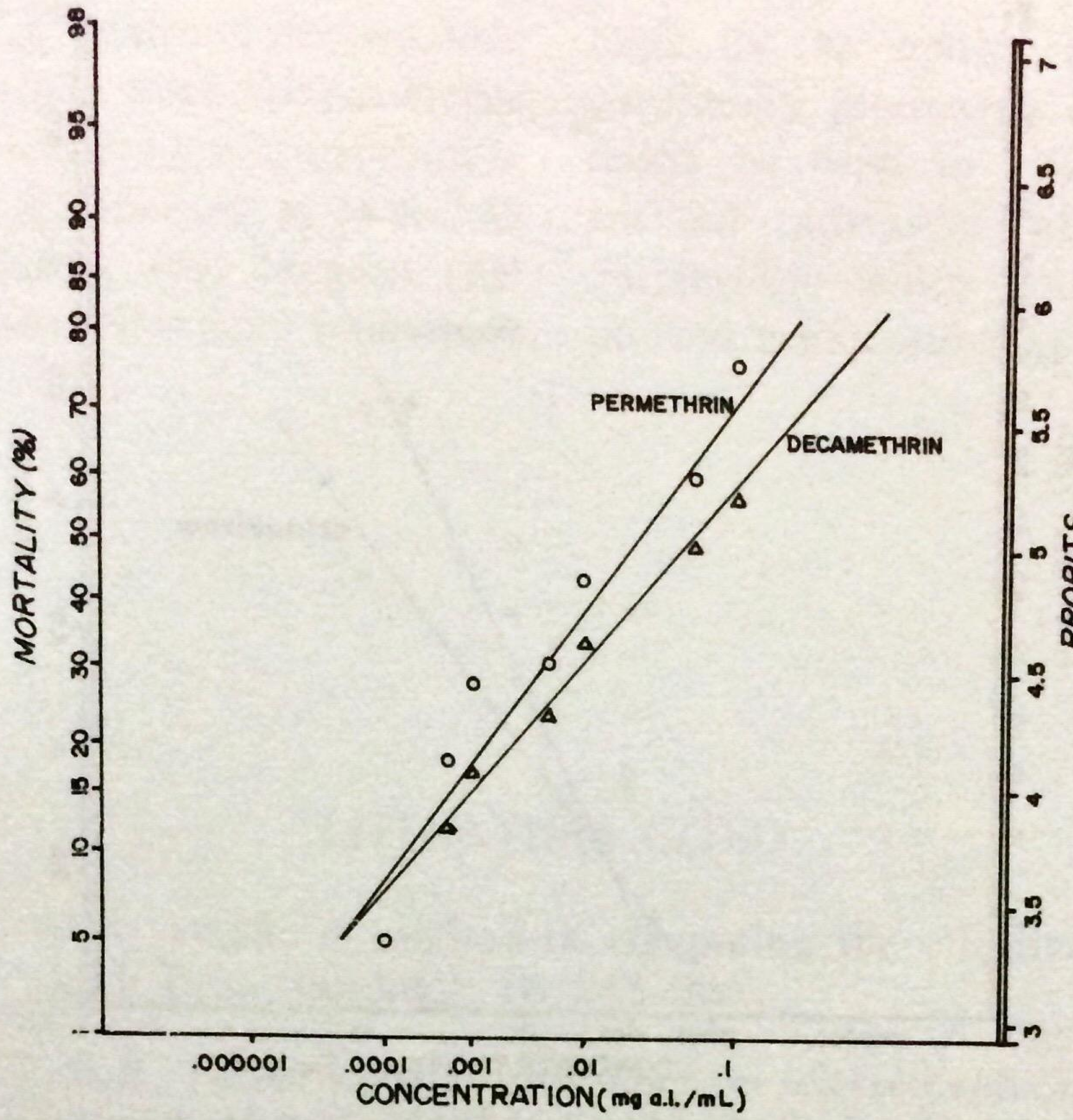

Figure 11. The LC-probit line of 1-to 2-week old adults of *Chilomenes sexmaculata* after 24 hours of contact with decamethrin and permethrin.

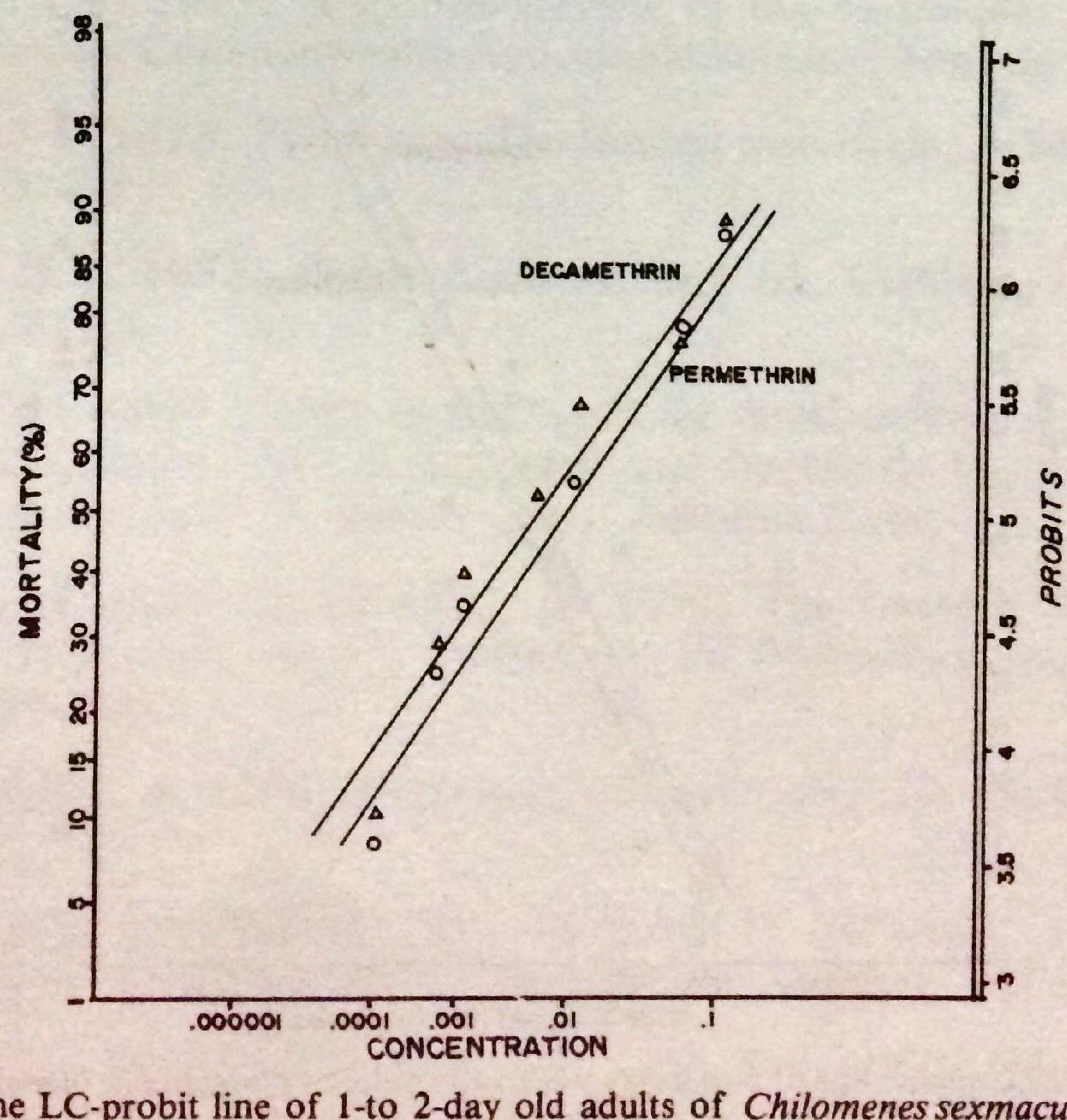

Figure 12. The LC-probit line of 1-to 2-day old adults of *Chilomenes sexmaculata* after 48 hours contact with decamethrin and permethrin.

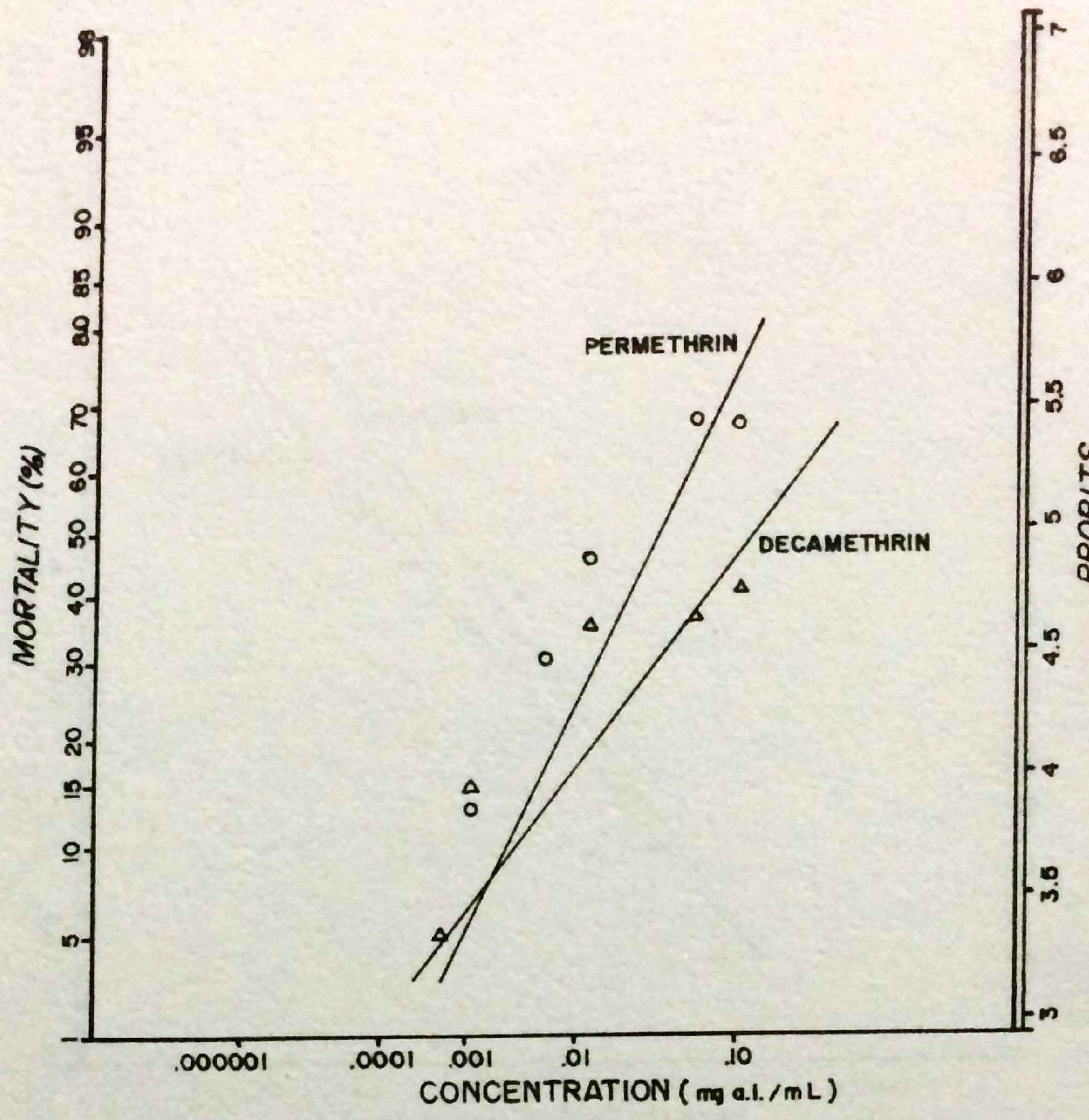

Figure 13. The LC-probit line of 1-to 2-week old adults of *Coleophora inaequalis* after 24 hours of contact with decamethrin and permethrin.

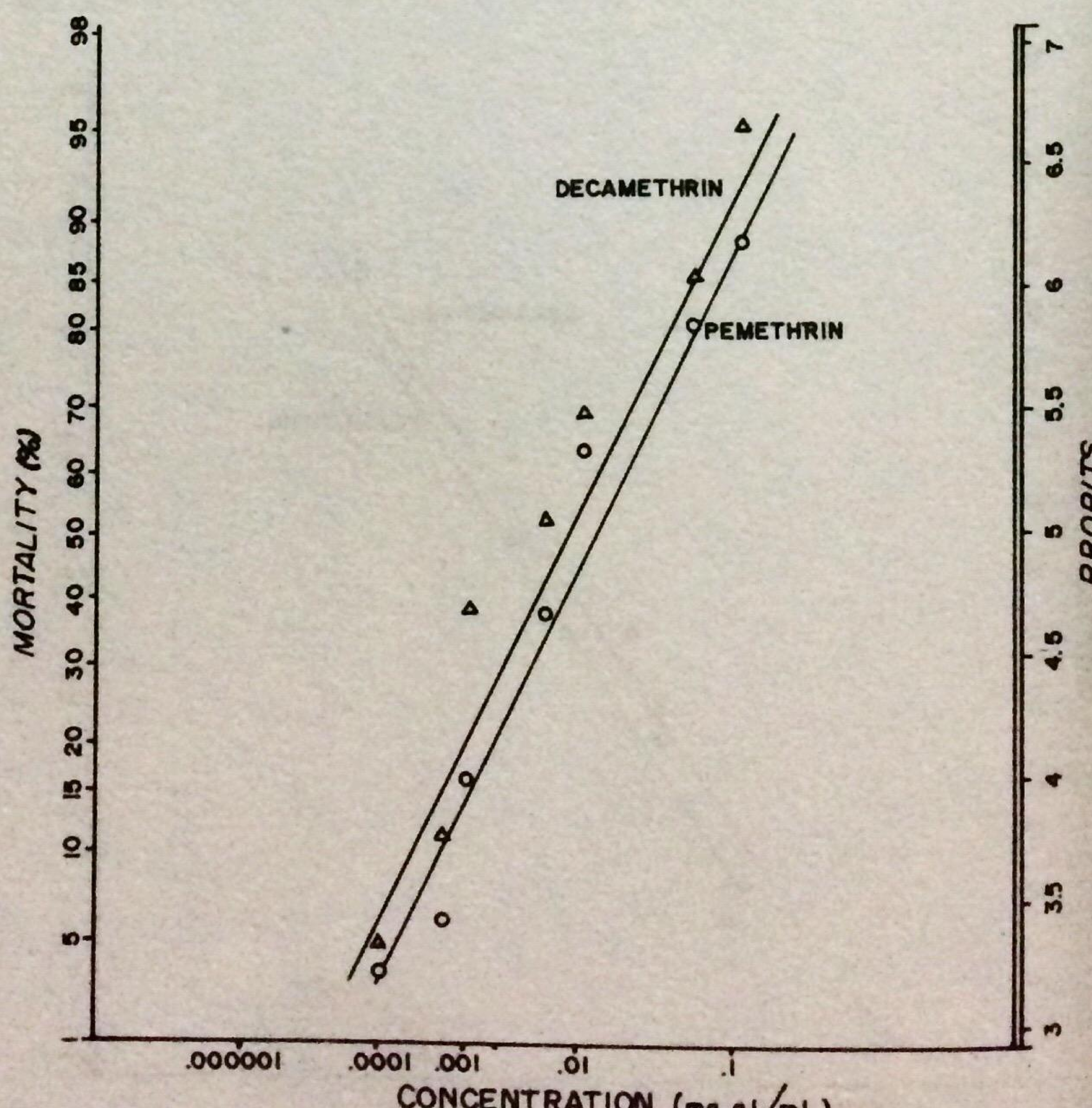

Figure 14. The LC-probit line of 1-to 2- week old adults of *Coleophora inaequalis* after 48 hours of contact with decamethrin and permethrin.

The LC_{50} values of decamethrin and permethrin were always higher in both coccinellid predators than in black bean aphids both at 24 and 48 hours exposure. This suggests that the two insecticides used were more toxic to the aphids than to the coccinellid predators. Hence, they could be used to control aphids without adversely affecting the coccinellids which could also be utilized as biocontrol agents.

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