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Influence of some pesticides on mortality and fecundity of the aphidophagous coccinellid *Adalia bipunctata* L. (Col., Coccinellidae)

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Abstract: The influence of 30 pesticides (insecticides, acaricides and fungicides) on different stages of *Adalia bipunctata* was evaluated under laboratory conditions by: (1) immersing individuals for 5 s in the pesticide solution; (2) placing the second and fourth instar larvae on leaves picked from trees treated with the pesticide; and (3) feeding adult coccinellids with aphids contaminated by a recommended concentration of the pesticide. Fenpropathrin, alphacypermethrin, esfenvalerate, acrinathrin, phosalone and propoxur + methoxychlor caused high mortality (up to 100%) not only by direct contact but also as fresh residues on leaves, or even 28 days after application. The mortality also varied with stage and mode of treatment. Feeding with aphids contaminated by fenpropathrin, clofentezine, hexythiazox, brompropylate and vinclozolin decreased the coccinellid fecundity.

1 Introduction

The effects of various pesticides on coccinellids are summarized by Croft and Brown (1975) and new data added by Kalushkov and Zeleny (1981), Olszak (1982), Zoebelein (1987), Zeleny et al. (1988), Thacker (1991), Olszak et al. (1994). Nevertheless new information is still required for the introduction of integrated fruit production (IFP) systems. This is particularly important in the case of such predators as coccinellids that commonly occur in orchards (Olszak and Niemczyk, 1986).

In the present study the toxicity of some pesticides that are frequently used in the orchards of Poland and other European countries were investigated.

All tests were conducted under laboratory conditions using different stages of *Adalia bipunctata* L (Col., Coccinellidae), although laboratory results sometimes do not reveal the effect in the orchard.

2 Material and methods

We used laboratory reared adults, larvae and eggs of *A. bipunctata* and different developmental stages of the aphid *Acyrthosiphon pisum* (Harris). The pesticides were used in the recommended concentrations. The tests were conducted at 21–24°C, approximately 70% relative humidity and a 16 h light : 8 h dark photoperiod. The apple trees were kept in a field insectary with a glass-covered roof. Three methods of testing pesticides were used:
(a) Immersing specimens for 5 s in a pesticide solution and subsequent rearing for 7 days in glass containers, with regular food supply.
(b) Placing the larvae in small cylindrical containers of 50 cm^3 with two leaves picked from a pesticide-treated tree. Leaves from a nontreated tree were used as a control. The containers were covered with cheese-cloth for free air exchange. Mortality was recorded daily for 7 days. The exposure started 2 h and 3, 7, 14, 21 and 28 days after the tree was treated.
(c) Adult coccinellids were fed with aphids immersed (and subsequently dried) in the recommended concentration of the pesticides.

Experiments (a) and (b) were carried out in six replicates with five individuals each and experiment (c) with 10 females for each tested insecticide.

The data obtained for both larvae and adults have been corrected according to Abbot's formula (Abbot, 1925) with regard to mortality in the control group of insects.

3 Results

3.1 Immersion in a pesticide solution

3.1.1 Immersion in insecticides and acaricides

Acaricides (clofentezine, amitraz, brompropylate, hexythiazox, propargite, fenbutatin-oxide) were less toxic or even harmless to all developmental stages, particularly to fourth instar larvae, pupae and adults. Only azocyclotin constituted an exception, causing great mortality of most developmental stages (table 1).

Other chemicals, particularly the synthetic pyrethroids were very harmful to larvae and some of them were harmful to pupae and adults as well. The fecundity decreased slightly, after a short immersion in acaricides whereas azocyclotin caused an increase (fig. 1). When the coccinellid eggs were immersed (table 2), all insecticides reduced hatching but the results varied with the age of the egg and the kind of chemical. The greatest mortality was caused by fenpropathrin and heptenophos.

3.1.2 Immersion in fungicides

Fungicides were generally less harmful. However, all stages were susceptible to pyrazophos (table 3). Manco-

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Table 1. *Mortality of different coccinellid stages after a short-time immersion in the insecticide/acaricide solution*

Insecticide active ingredient (commercial name)	Concentration (%)	Percent mortality L_1[1]	L_2	L_3	L_4	P[2]	I[3]
Amitraz (Mitac® 200 EC)	0.2	21	5	5	0	0	0
Clofentezine (Apollo® 500 SC)	0.027	11	13	0	5	15	11
Hexythiazox (Nissorun® 10 EC)	0.05	11	27	12	20	25	5
Fenbutatin-oxide (Torque® 50 WP)	0.06	74	75	5	0	0	0
Propargite (Omite® 30 WP)	0.1	95	85	16	10	5	0
Azocyklotin (Peropal® 25 WP)	0.1	89	90	42	50	5	75
Brompropylate (Neoron® 500 EC)	0.075	100	80	100	0	15	58
Etiofencarb (Croneton® 500 EC)	0.1	100	100	100	95	10	95
Propoxur + Methoxychlor (Propotox® M.pł.)	0.2	100	100	100	100	5	100
Endosulfan (Thiodan® 350 EC)	0.1	100	100	100	100	63	95
Heptenophos (Hostaquick® 500 EC)	0.01	100	100	100	100	100	100
Phasolone (Zolone® 35 EC)	0.12	100	100	100	100	100	100
Fenpropathrin (Danitol® 10 EC)	0.05	100	100	100	100	100	100
Alphacypermethrin (Fastac® 10 EC)	0.05	100	100	100	100	100	100
Acrinathrin (Rufast® 10 EC)	0.03	100	100	100	100	100	100
Esfenvalerate (Sumi Alpha® 050 EC)	0.03	100	100	100	100	100	100

[1] L_1–L_4, larval stages. [2] Pupae. [3] Adults.

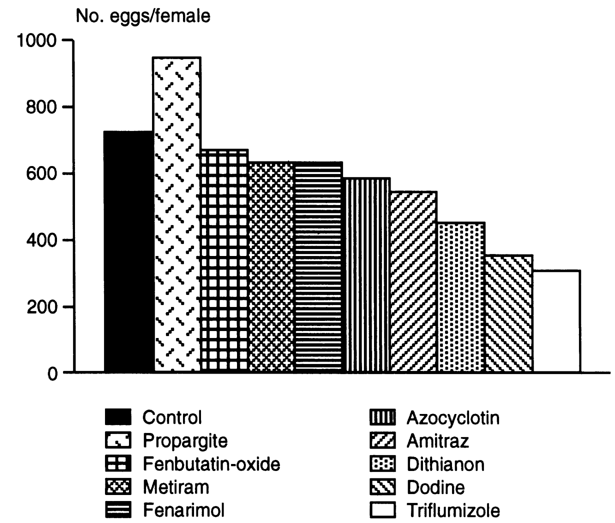

Fig. 1. *Fecundity of* A. bipunctata *females after a short-time immersion in different pesticides*

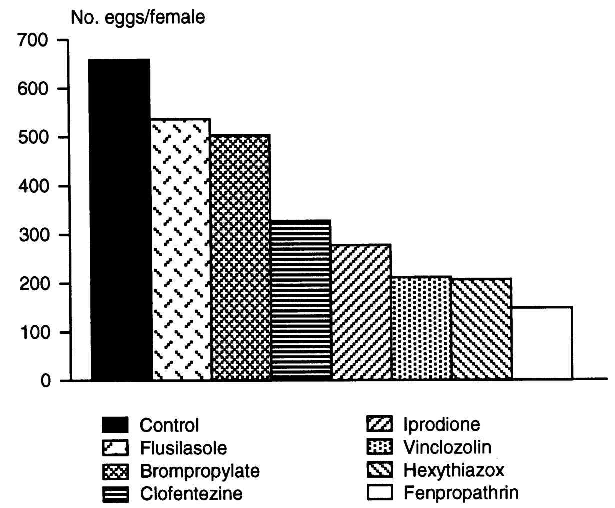

Fig. 2. *Fecundity of* A. bipunctata *female feeding on aphids treated with different pesticides*

zeb, dichlofluamid, flusilazole, vinclozolin, iprodione and difenoconazole were harmful to first and second instar larvae. Some fungicides (particularly triflumizole also decreased fecundity when females were immersed for a short time. With the exception of parazophos, the fungicides showed moderate or low toxicity to eggs (table 2).

3.2 Exposure to leaves treated with pesticides

Second and fourth instar larvae were exposed to residues of 16 insecticides and three fungicides on apple leaves taken from sprayed trees. The mortality increased considerably (tables 4 and 5) not only with fresh residue (2 h after tree treatment) but also with residue 3, 7, 14, 21 and 28 days after spraying. Fenpropathrin, alphacypermethrin, propoxur + metoxychlor, acrinathrin, esfenvalerate, endosulfan and phosalone had the most harmful influence and were able to cause 100% mortality of fourth instar larvae even after 28 days. Only the acaricides clofentezine, amitraz, hexythiazox propargite and fenbutatin-oxide and fungicides caused a low mortality or had no harmful effect (tables 4 and 5).

3.3 Feeding on aphids contaminated with pesticides

Contaminated aphids were provided to females after 7, 23 and 39 days from the beginning of the experiment. Untreated aphids were supplied daily in between periods and the eggs laid by *A. bipunctata* females were counted. The experiment was continued until the death of the last beetles (over 3.5 months).

A reduction in fecundity following the application of pesticide-treated aphids was observed in all cases (fig. 2). However, for some pesticides (fenpropathrin, clofentezine, hexythiazox, brompropylate, vinclozolin) such an effect was stronger than for others (flusilazole, iprodione). The highest reduction of fecundity (78%) was caused by fenpropathrin and for this compound the hatching of eggs also decreased drastically.

Table 2. *Effect of short-time immersion of* A. bipunctata *eggs in the pesticide solution*

Insecticide active ingredient (commercial name)	Percent of hatched larvae after egg treatment Age of eggs at treatment (days) 1	2	3
Insecticides/Acaricides			
Clofentezine (Apollo 500 SC)	76.9	70.0	45.0
Fenpropathrin (Danitol 10 EC)	0.0	0.0	0.0
Heptenophos (Hostaquick 500 EC)	33.6*	39.8*	0.0
Brompropylate (Neoron 500 EC)	49.0	53.6	66.0
Hexythiazox (Nissorun 10 EC)	65.0	58.5	39.6
Propargite (Omite 30 WP)	63.1	63.7	46.0
Azocyklotin (Peropal 25 WP)	35.9	40.7	32.3
Fenbutatin-oxide (Torque 50 WP)	51.4	69.5	63.3
Fungicides			
Pyrazophos (Afugan® 30 EC)	26.6*	35.8*	0.0
Vinclozolin (Ronilan® 50 WP)	76.0	56.0	60.0
Iprodione (Rovral® 50 WP)	82.3	62.0	60.8
Fluzilazole (Punch® 400 EC)	37.2	53.7	54.5
Control	85.2	76.7	82.0

* All larvae died during hatching.

Table 3. *Mortality of different coccinellid stages after a short-time immersion in the fungicide solution*

Fungicide active ingredient (commercial name)	Concentration %	Percent mortality L_1[1]	L_2	L_3	L_4	P[2]	I[3]
Triforine (Saprol®)	0.125	18	21	10	0	15	5
Fenarimol (Rubigan® 12 EC)	0.03	32	0	16	10	83	5
Vinclozolin (Ronilan 50 WP)	0.1	100	93	35	0	15	5
Dithianon (Delan® SC 750)	0.08	16	37	16	5	94	5
Mancozeb (Dithane® M-45)	0.2	100	31	25	11	0	16
Flusilazole (Punch 400 EC)	0.2	47	12	42	0	95	0
Triflumizole (Trifmine® 30 WP)	0.05	63	6	37	20	94	5
Metiram (Polyram combi®)	0.01	100	100	65	0	25	42
Difenoconazole (Score® 250 EC)	0.01	94	95	30	16	0	32
Dichlofluamid (Euparen® 50 WP)	0.15	100	89	20	22	0	52
Pyrifenox (Dorado® 200 EC)	0.03	94	89	45	5	5	52
Iprodione (Rovral 50 WP)	0.1	100	73	88	10	20	5
Dodine (Sylli® 65 WP)	0.1	47	12	84	0	83	0
Pyrazophos (Afugan 30 EC)	0.1	100	100	100	100	95	100

[1] L_1–L_4, larval stages. [2] Pupae. [3] Adults.

4 Discussion and conclusions

Integrated pest management requires knowledge of the effects of pesticides on beneficial organisms. There are numerous data concerning the side-effects of different pesticides on predatory and parasitoid insects, however, many of them are limited to the direct influence of one pesticide on a single developmental stage of a particular species. However, in the open field, pesticides affect predators in different ways. Only experiments simulating pesticides action within a particular agrocenosis may give us some idea about their influence on beneficial species. The techniques of our experiment simulated the effect of pesticides under different conditions: direct contact with a chemical; contact with chemical residue; and feeding on prey contaminated with the chemical.

According to the IOBC/WPRS working group (Hassan, 1985) 'pesticides found to be harmless to a particular beneficial in the laboratory test are most likely to be harmless to the same organism in the field and no further testing in the semi-field experiments is therefore recommended'. The pesticides tested in the laboratory are classified into four categories depending on the degree of mortality they cause to the beneficials: 1 = harmless (< 30% mortality); 2 = slightly harmful (30–79% mortality); 3 = moderately harmful (80–99% mortality); 4 = harmful (> 99% mortality) (Hassan, 1994).

With regard to the IOBC categories it appears that: (a) The response of different *A. bipunctata* stages to direct contact (short-time immersion) with tested pesticides widely varies in the degree of mortality. The most harmful effects (IOBC category 4) were caused by synthetic pyrethroids, organophosphorus insecticides and carbamates. The least harmful were acaricides: amitraz, clofentezine, hexythiazox. Among fungicides, pyrazophos was harmful to all developmental stages of

Table 4. *Mortality (in %) of* A. bipunctata *L_2 reared on leaves treated with pesticides*

Insecticide active ingredient (commercial name)	Concentration (%)	Period after treatment 2 h	3 days	7 days	14 days	21 days	28 days
Insecticide/Acaricide							
Hexythiazox (Nissorun 10 EC)	0.05	21	0	12	0	0	–
Amitraz (Mitac 200 EC)	0.2	25	5	31	22	11	0
Brompropylate (Neoron 500 EC)	0.075	74	12	12	0	12	–
Clofentezine (Apollo 500 SC)	0.027	47	18	47	0	24	–
Etiofencarb (Croneton)	0.1	44	79	89	42	47	0
Propargite (Omite 30 WP)	0.1	65	72	68	22	55	21
Heptenophos (Hostaquick 500 EC)	0.05	85	72	80	33	66	0
Azocyklotin (Peropal 25 WP)	0.1	100	100	89	33	72	68
Fenbutatin-oxide (Torque 50 WP)	0.06	100	88	94	84	84	79
Endosulfan (Thiodan 350 EC)	0.1	100	100	89	74	82	–
Phosalone (Zolone 35 EC)	0.12	100	100	100	100	100	100
Propoxur + Methoxychlor (Propotox M.pł.)	0.2	100	100	100	100	100	100
Fenpropathrin (Danitol 10 EC)	0.05	100	100	100	100	100	–
Alphacypermethrin (Fastac 10 EC)	0.01	100	100	100	100	100	100
Acrinathrin (Rufast 10 EC)	0.03	100	100	100	100	100	–
Esfenvalerate (Sumi Alpha 050 EC)	0.03	100	100	100	100	100	100
Fungicide							
Vinclozolin (Ronilan 50 WP)	0.1	20	0	68	0	0	–
Flusilazole (Punch 400 EC)	0.01	20	0	16	0	0	–
Iprodione (Rovral 50 WP)	0.1	5	23	5	5	0	–

Table 5. *Mortality (in %) of* A. bipunctata L_4 *reared on leves treated with pesticides*

Insecticide active ingredient (commercial name)	Concentration (%)	Period after treatment 2 h	3 days	7 days	14 days	21 days	28 days
Insecticide/Acaricide							
Hexythiazox (Nissorun 10 EC)	0.05	5	0	47	20	5	–
Amitraz (Mitac 200 EC)	0.2	0	15	10	0	0	0
Brompropylate (Neoron 500 EC)	0.075	20	0	5	0	0	–
Clofentezine (Apollo 500 SC)	0.027	0	0	37	15	0	–
Etiofencarb (Croneton)	0.1	65	94	78	71	58	0
Propargite (Omite 30 WP)	0.1	0	10	15	0	0	–
Heptenophos (Hostaquick 500 EC)	0.05	38	35	80	0	5	0
Azocyklotin (Peropal 25 WP)	0.1	61	45	20	27	10	0
Fenbutatin-oxide (Torque 50 WP)	0.06	38	30	40	27	25	0
Endosulfan (Thiodan 350 EC)	0.1	95	100	57	33	42	0
Phosalone (Zolone 35 EC)	0.12	100	100	100	100	100	100
Propoxur + Methoxychlor (Propotox M.pł.)	0.2	100	85	85	77	80	79
Fenpropathrin (Danitol 10 EC)	0.05	100	100	100	100	100	100
Alphacypermethrin (Fastac 10 EC)	0.01	100	100	100	100	100	100
Acrinathrin (Rufast 10 EC)	0.03	100	100	100	100	95	100
Esfenvalerate (Sumi Alpha 050 EC)	0.03	100	100	100	100	100	100
Fungicide							
Vinclozolin (Ronilan 50 WP)	0.1	20	0	68	0	0	–
Flusilazole (Punch 400 EC)	0.01	20	0	16	0	0	–
Iprodione (Royral 50 WP)	0.1	5	23	5	5	0	–

A. bipunctata, whereas mancozeb, dichlofluamid, flusilazole, vinclozolin and iprodione were only harmful to first and second instar larvae. (b) The susceptibility of coccinellid eggs (immersion test) varied depending on their age and kind of insecticide but fenpropathrin showed the most harmful effect, followed by heptenophos and pyrazophos. (c) Exposure to pesticide residues (treated apple leaves) sometimes caused harmful effects not only shortly after spraying but also after a period of up to 28 days. It mainly concerned the synthetic pyrethroids (fenpropathrin, alphacypermethrin, acrinathrin, esfenvalerate), some organophosphorus insecticides (heptenophos, phosalone) and carbamates (endosulfan, propoxur + metoxychlor). This contradicts the common opinion that synthetic pyrethroids are nonpersistent agents. (d) Some insecticides and fungicides could reduce the fecundity of *A. bipunctata* with direct contact (short time immersion) or when the females feed on contaminated prey.

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