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The influence of some insect growth regulators on mortality and fecundity of the aphidophagous coccinellids *Adalia bipunctata* L. and *Coccinella septempunctata* L. (Col., Coccinellidae)

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Abstract

Investigations were carried out to evaluate the influence of some insect growth regulators (IRGs) on different developmental stages of *Adalia bipunctata* and *Coccinella septempunctata*. The experiment was based on eggs, larvae and adults reared in laboratory conditions. These stages were treated with IGRs in 3 ways: 1. by immersing the specimens for 5 sec into a solution of the insecticide tested; 2. by placing the adults and larvae of different stages into a small container together with two leaves picked up from a tree just treated with the insecticide in question; 3. by feeding adult coccinellids with aphids contaminated by a recommended concentration of an IGR solution. The experiments have shown that the tested IGRs affected all developmental stages of both coccinellid species but the results varied according to stage, way of treating and kind of chemical used. Some of the insecticides elicited a drastical reduction of the fecundity, especially in ladybirds fed with contaminated aphids (e.g. with teflubenzuron, fenoxycarb and flufenoxuron). Moreover, chlorfluazuron was the most dangerous one for almost all larval stages. From the other hand IGRs exerted a relatively low influence on adult coccinellids.

1 Introduction

The effects of various pesticides on coccinellid predators have been summarized by Croft and Brown (1975). More recently, additional data have been presented, e.g. by Kalushkow and Zeleny (1981), Olszak (1982) and Zeleny et al. (1988).

There is less information on the new generation of insecticides based on juvenile hormones or inhibitors of chitin synthesis, collectively named Insect Growth Regulators (IGRs). Acting usually as stomach or contact poisons they are reported to be effective against insect species which feed on foliage and fruit, and therefore considered (mainly by producers) as safe and not affecting the beneficial fauna. As selectivity is the crucial property for integrated pest management, we decided to investigate the toxicity of these insecticides to two beneficial and most important coccinellid species occurring in apple orchards.

2 Material and methods

Laboratory reared adults, larvae and eggs of *Coccinella septempunctata* and *Adalia bipunctata* as well as aphids (*Aphis fabae*) were treated with the recommended concentrations of the IGR insecticides tested. All experiments were conducted under laboratory conditions (21–24 °C, about 70 % rh and 16 h photoperiod).

Three methods of applying the insecticides were used:

a. through immersing the specimens for 5 seconds in a solution of the insecticide at a recommended concentration;
b. by placing the larvae and adults in small containers (50 ccm) together with 2 leaves picked up from a pesticide treated tree. Leaves from an untreated tree were used in a control. The containers with individuals under observation were covered with cheesecloth for free air exchange. Mortality was recorded daily throughout a period of 7 days. In order to test the residual toxic effects of the IGRs to ladybird larvae and adults, experiments began 2 h and 7 days after treatment of the tree;

c. by feeding adult coccinellids with aphdis immersed (and subsequently dried up) into the recommended concentration of the IGR solution.

In exp. a and b 6 replications with 5 individuals each, and in exp. c 10 females for each tested insecticide were used.

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

3 Results

3.1 Immersion in IGRs

The response of *A. bipunctata* and *C. septempunctata* adults to contact with the insecticides was similar. The mortality was reasonably low and varied from 0% to 25%. *C. septempunctata* beetles treated with diflubenzuron (Dimilin) and fenoxycarb (Insegar) suffered a mortality of 24% and 25%, respectively, whereas other treatments usually gave a lower mortality (< 10%) (table 1).

The same preparations were tested on larvae of *C. septempunctata* and *A. bipunctata*. All insecticides used, increased the mortality rate of each larval stage, however the increase varied and was dependent on species, larval stage and kind of pesticide. In general, *A. bipunctata* larvae treated with triflumuron (Alsystin) and chlorfluazuron (Aim) suffered a

Table 1. **Mortality rise in coccinellid adults and larvae after a short-time immersion in an IGR solution**

Insecticide active ingredient (commercial name)	Concentration %	Percentage mortality			
		A. bipunctata		*C. septempunctata*	
		Adults	Larvae[1]	Adults	Larvae[1]
Cyromazyne (Trigard)	0.3	–	–	4	52.5
Triflumuron (Alsystin)	0.05	4	20.5	12	36.5
Chlorfluazuron (Aim)	0.05	8	37.7	4	77.5
Teflubenzuron (Nomolt)	0.05	0	56.7	16	38.7
Diflubenzuron (Dimilin)	0.08	12	50.5	24	56.7
Flufenoxuron (Cascade)	0.1	0	61.5	–	–
Fenoxycarb (Insegar)	0.04	4	60.7	25	71.2
S-71639	0.1	8	36.5	–	–

[1] average mortality calculated from mortality values of all larval stages.

Table 2. **Effects of short-time immersing of *A. bipunctata* and *C. septempunctata* eggs into an IGR solution**

Insecticide active ingredient (commercial name)	Concentration %	Percentage of non hatched eggs					
		A. bipunctata			*C. septempunctata*		
		Age of eggs (in days)					
		1	2	3	1	2	3
Cyromazyne (Trigard)	0.3	–	–	–	0	78	2
Triflumuron (Alsystin)	0.05	13	58	29	6	11	53
Chlorfluazuron (Aim)	0.05	12	53	38	18	9	38
Teflubenzuron (Nomolt)	0.05	24	88	14	0	28	13
Diflubenzuron (Dimilin)	0.08	46	75	32	0	80	3
Flufenoxuron (Cascade)	0.1	36	10	17	–	–	–
Fenoxycarb (Insegar)	0.04	96	90	75	100	100	84
S-71639	0.1	94	40	26	–	–	–
check		0	4	8	0	0	0

lower mortality (from 20 % to 37 % on average), than treated with diflubenzuron (Dimilin), teflubenzuron (Nomolt), fenoxycarb (Insegar) and flufenoxuron (Cascade), which killed an average of 50 % to 62 % of the larvae (table 1).

The susceptibility of coccinellid eggs was variable and depending on their age and kind of insecticide. Except of fenoxycarb, all other insecticides were of moderate or low toxicity to eggs of both species. Nevertheless diflubenzuron, triflumuron, chlorfluazuron and teflubenzuron were more toxic to 2 day old eggs of *A. bipunctata* than to 1 or 3 day old eggs.

Diflubenzuron, teflubenzuron and fenoxycarb exerted a similar effect on eggs of *C. septempunctata* (table 2).

3.2 Exposure to leaves treated with an IGR

Through contact with IGR treated leaves, *C. septempunctata* and *A. bipunctata* larvae and adults were confronted with 6 insecticides. In most cases the mortality of all larval stages increased considerably. This was observed not only with a fresh residue (2 h after the tree was sprayed) but also with a 7 days old residue (table 3 and 4).

In the case of 1st instar larvae the contact with leaves picked up shortly after the treatment was less disadvantageous than 7 days later. Larvae of *A. bipunctata* exposed to leaves treated with chlorfluazuron constituted the only exception. From among the

Table 3. **Mortality (in %) of the developmental stages of *C. septempunctata* reared on leaves treated with IGRs**

Insecticide active ingredient (commercial name)	Instar of larvae: I		II		III		IV		Adults	
	Period after treatment[1]: 2 h	7 d	2 h	7 d	2 h	7 d	2 h	7 d	2 h	7 d
Cyromazyne (Trigard)	0	45	85	11	41	32	0	0	6	5
Triflumuron (Alsystin)	0	25	85	5	73	41	5	0	0	0
Chlorfluazuron (Aim)	0	35	71	74	91	23	60	5	6	0
Teflubenzuron (Nomolt)	0	40	57	50	91	36	0	10	0	0
Diflubenzuron (Dimilin)	0	25	43	5	82	36	25	5	0	0
Fenoxycarb (Insegar)	5	25	100	50	55	50	10	5	0	0

[1] h = hours, d = days.

Table 4. **Mortality (in %) of the developmental stages of *A. bipunctata* reared on leaves treated with IGRs**

Insecticide active ingredient (commercial name)	Instar of larvae: I		II		III		IV		Adults	
	Period after treatment[1]: 2 h	7 d	2 h	7 d	2 h	7 d	2 h	7 d	2 h	7 d
Triflumuron (Alsystin)	31	66	26	5	5	0	5	0	0	20
Chlorfluazuron (Aim)	74	73	89	70	39	26	20	38	0	10
Teflubenzuron (Nomolt)	16	33	16	10	16	20	35	5	5	0
Diflubenzuron (Dimilin)	5	73	31	15	9	53	20	5	5	0
Fenoxycarb (Insegar)	0	73	5	30	5	73	25	38	5	5
Flufenoxuron (Cascade)	26	73	31	45	22	33	–	–	–	–

[1] h = hours, d = days.

insecticides tested, chlorfluazuron exhibited the most harmful influence on larvae of both species.

The fourth larval stage was the least susceptible one in contact with treated leaves. The mortality was reasonable (on average 0 %–18 %) and most larvae pupated without any apparent difficulty. Some individuals however, were not able to cast off the pupal skin and some other carried teratogenic defects (abnormal abdomen, deformed elytrae). The adults were more resistant to the contact with IGR treated leaves. With two exceptions their mortality did not exceed 5 % (table 3 and 4).

3.3 Feeding on aphids contaminated with IGRs

Aphids (*Acyrthosiphon pisum*) treated with an IGR at the recommended concentration, were supplied to *A. bipunctata* and *C. septempunctata* beetles. In the case of *C. septempunctata* the aphids were supplied every other day. The experiment was continued until the death of last beetles (almost four months). An apparent reduction in fecundity was noticed in all treatments (fig. 1). Three treatments had a more marked effect than other (reduction

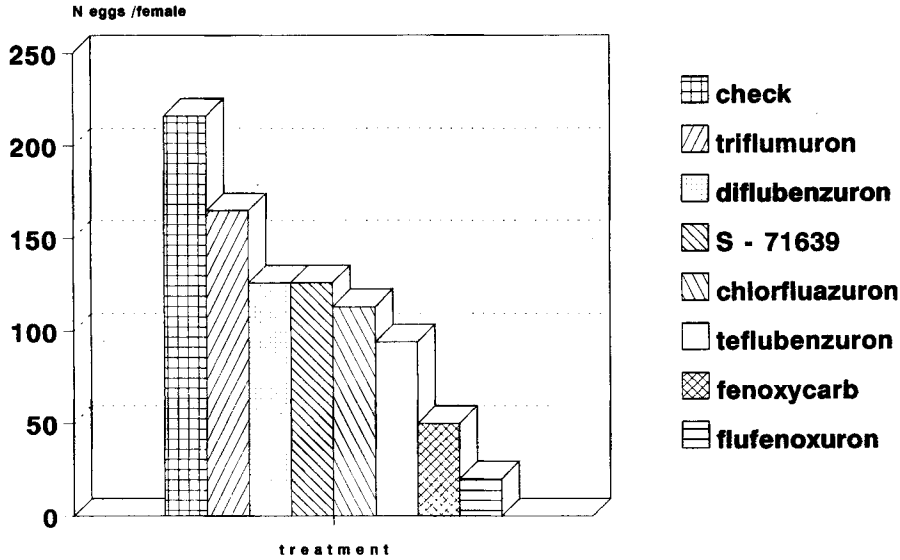

Fig. 1. Fecundity of *C. septempunctata* females feeding on aphids treated with IGRs

of 67 % to 91 %), i.e. with teflubenzuron, fenoxycarb and flufenoxuron. Moreover, the fertility of eggs laid by beetles treated with fenoxycarb, diflubenzuron, flufenoxuron and teflubenzuron was drastically reduced (99 %–100 %), and adults longevity decreased by one fourth.

A similar investigation was carried on with *A. bipunctata* adults. In this case however, contaminated food was supplied to beetles only on three occasions during the experimental period (over 6 months).

The results (fig. 2) indicate that the chemicals can be divided into two groups. Triflumuron, S-71639 and teflubenzuron, slightly stimulating the female fecundity constitute the first group. A distinct reduction of the fecundity was induced by insecticides belonging to the second group, i.e. by flufenoxuron, chlorfluazuron, fenoxycarb and diflubenzuron.

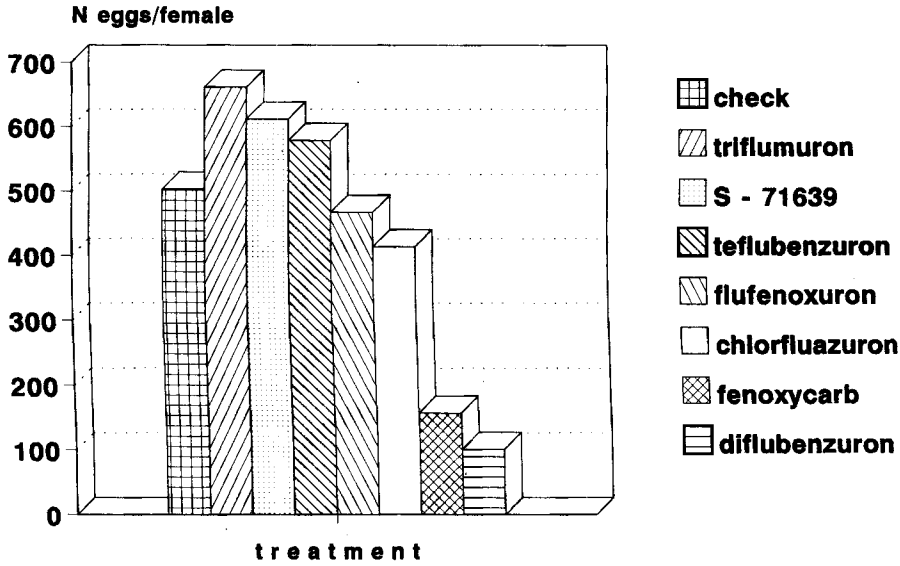

Fig. 2. Fecundity of *A. bipunctata* females feeding on aphids treated with IGRs

The worst effect was here observed again with diflubenzuron and fenoxycarb (fig. 2). Also the hatchability of eggs in these two treatments was reduced by 80 % and 75 %, respectively.

4 Conclusions

The insecticides tested (IGR's) can affect the developmental stages of *A. bipunctata* and *C. septempunctata* in 3 ways: a) by direct contact with the chemical, b) by contact with the treated plants and c) by feeding on contaminated prey. The IGRs affect the adult mortality relatively low. Some of the insecticides, however, can drastically reduce the fecundity, especially when the ladybirds are fed with contaminated prey.

The direct contact of coccinellid eggs with these chemicals results in a moderate or low mortality, and reveals, that 2 day old eggs are more susceptible than 1 or 3 day old ones. For egg development and eclosion the transovarian effect is more dangerous and occurs when females feed on prey contaminated with an IGR.

The response of larval stages to contact with the insecticides varies widely. A direct contact (by immersing) distinctly increases the mortality of *A. bipunctata* and *C. septempunctata* larvae. A contact with insecticide residues (on treated leaves) can be disadvantageous for larvae, both shortly after the treatment and also 7 days later. From among the larval stages the fourth seems to be the most resistant, but harmful effects can often appear later during the pupal stage and adult emergence.

Of all the IGRs tested, chlorfluazuron (Aim) is the most dangerous for almost all larval stages. In conclusion, insecticides advertised as selective may cause considerable harm to the preimaginal stages of predatory coccinellids, but without doubt they are less dangerous than many other, e.g. some carbamates and pyrethroids.

Zusammenfassung

Zum Einfluß einiger Insekten-Wachstumsregulatoren auf die Mortalität und Fekundität zweier aphidovorer Marienkäferarten

Es wurden Untersuchungen durchgeführt, um die Wirkung einiger moderner Insektizide, sog. Insektenwachstumsregulatoren (IWR), auf verschiedene Entwicklungsstufen von *Adalia bipunctata* und *Coccinella septempunctata* kennenzulernen. Der Versuch basierte auf Eiern, Larven und erwachsenen Käfern, die aus einer Laborzucht stammten. Diese Entwicklungsstufen wurden mit IWR auf dreierlei Weisen behandelt: 1. durch Tauchen der Individuen für 5 sec in einer Lösung des Insektizids; 2. durch Haltung der Käfer und Larven in einem kleinen Behälter (50 ccm) zusammen mit zwei Blättern, die einem gerade mit dem Insektizid behandelten Baum entnommen wurden; 3. durch Füttern der Marienkäfer mit Blattläusen, die in eine bestimmte IWR-Lösung getaucht (und getrocknet) worden waren. Die Versuche zeigten, daß die untersuchten Wirkstoffe alle Entwicklungsstufen beider Marienkäferarten beeinflußten, die Ergebnisse aber je nach Stadium, Behandlungsweise und Präparat verschieden waren. Manche Insektizide schränkten die Fekundität drastisch ein, besonders wenn die Marienkäfer mit kontaminierten Blattläusen gefüttert wurden (mit Teflubenzuron, Fenoxycarb und Flufenoxuron). Außerdem erwies sich Chlorfluazuron als ein Wirkstoff, der die Larven fast aller Entwicklungsstadien am stärksten beeinflußte. Andererseits aber übten die IWR einen nur geringen Einfluß auf die adulten Marienkäfer aus.

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