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EFFECTS OF SOME INSECT GROWTH REGULATORS ON NATURAL ENEMIES OF SCALE INSECTS (*HOM. : COCCOIDEA*)

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We report and discuss effects of four insect growth regulators : buprofezin, fenoxycarb, pyriproxyfen and chlorfluazuron, at concentrations recommended for agricultural use on six species of natural enemies of homopteran pests.

Dipping in buprofezin had no appreciable effect on adult mortality, oviposition and development of *Comperiella bifasciata* (Howard) (Hymenoptera : Encyrtidae). When exposed to hosts treated with buprofezin, percentage mortality of adult *Encyrtus infelix* Embleton (Encyrtidae) was low ; buprofezin had some detrimental effect on immature stages of *E. infelix* when applied prior to parasitization, but not when introduced after parasitization. Buprofezin had a slight effect on the immature stages of *Cryptochaetum iceryae* Williston (Diptera : Cryptochaetidae), while fenoxycarb and pyriproxyfen had marked detrimental effects on parasitization and/or development of the parasitoid fly. None of the larvae of *Rodolia cardinalis* Mulsant (Coleoptera : Coccinellidae) developed into adults after application of buprofezin, fenoxycarb or pyriproxyfen. Buprofezin and chlorfluazuron completely prevented egg hatch of *Chilocorus bipustulatus* L. (Coleoptera : Coccinellidae). Buprofezin did not adversely affect egg hatch and larval development of *Elatophilus hebraicus* Pericart (Hemiptera : Anthocoridae) ; fenoxycarb or pyriproxyfen applied either before or after oviposition on pine needles caused total suppression of egg hatch.

KEY-WORDS : Insect growth regulator, natural enemies, side effect, scale insects, *Comperiella bifasciata, Encyrtus infelix, Cryptochaetum iceryae, Rodolia cardinalis, Chilocorus bipustulatus, Elatophilus hebraicus.*

Integrated pest management in Israeli subtropical fruit orchards relies basically on biological control, with minimum involvement of chemical control. However, inadequate and excessive use of nonselective insecticides led to frequent outbreaks of major scale insects (Homoptera : Coccoidea) which became resistant to the commonly used insecticides. Since the early 1980s different groups of Insect Growth Regulators (IGRs) have been replacing the nonselective organophosphates and carbamates regularly applied against the key scale insects and whitefly pests in Israeli agriculture (Bar-Zakay, 1992b ; Ishaaya *et al.*, 1988 ; Ishaaya & Horowitz, 1992). The fact that insect growth regulators have been considered safer than organophosphates and carbamates to natural enemies, harmless to humans, and in many situations the only practical solution to the problems faced by the growers, facilitated their introduction into the agricultural environment.

In recent years the role of insect growth regulators in integrated pest management of homopteran pests has been tested in many studies (e.g. Darvas & Varjas, 1990 ; Garrido *et* *al.*, 1984 ; Ishaaya *et al.*, 1989 ; Mendel & Rosenberg, 1988 ; Mendel *et al.*, 1991 ; Uchida *et al.*, 1987). Studies of the effects of these chemicals on beneficial insects began in the mid 1970s. However, information on the effects of insect growth regulators on natural enemies of homopteran pests is contradictory and conclusions are inconsistent. It has been suggested that the products are only slightly harmful to beneficial arthropods, although some moderately adverse effects were recorded when coccinellids were treated with the chemicals. For example, fenoxycarb and methoprene had no adverse effects on the development and activity of several hymenopteran parasitoids of Coccidae and Diaspididae in citrus groves (Peleg, 1983a ; Peleg & Gothilf, 1980) ; however, Abd El-Kareim *et al.* (1988) showed that *Aphytis mytilaspidis* (LeBaron) (Hymenoptera : Aphelinidae) was affected by hydroprene, methoprene and kinoprene ; and the juvenoid fenarimol strongly reduced to occurrence of *Encarsia berlesei* (Howard) (Aphelinidae) (Darvaś & Zseller, 1985). Adverse effects of insect growth regulators were recorded on immature stages of several Coccinellidae, i.e., *Chilocorus bipustulatus* L. (Peleg, 1983a), *Stethorus punctillum* (LeConte) (Hull *et al.*, 1991), *Cryptolaemus montrouzieri* Mulsant and *Rodolia cardinalis* Mulsant (Viggiani & Loia, 1991). In the case of Anthocoridae, damaging effects were recorded after application of fenoxycarb on larvae of *Anthocoris nemoralis* (F.) (Solomon & Fitzgerald, 1990), whereas chlorfluazuron had an inhibitory effect on the moulting of *Orius* sp. (Nagai, 1990).

During the last decade, outbreaks of a few of the major scale insect pests in the Israeli citrus groves have been related to application of juvenoids. Outbreaks of *Icerya purchasi* Maskell (Margarodidae) were frequent between 1986 and 1989 after application of fenoxycarb against soft and armored scale insects. Recently, outbreaks of *Planococcus citri* Risso and *Pseudococcus cryptus* Hempel (Homoptera : Pseudococcidae) in citrus orchards and in surrounding cotton fields have been correlated with the intensive use of a novel juvenoid-pyriproxyfen (e.g. Bar-Zakay, 1992a ; Mendel & Blumberg, personal observations).

The objective of this paper is to report and discuss new information on the effect of some insect growth regulators commonly used in Israeli agriculture, on six common species of parasitoids and predators of homopteran pests : *Comperiella bifasciata* (Howard) (Hymenoptera : Encyrtidae), a parasitoid of *Aonidiella aurantii* (Maskell) (Diaspididae) ; *Encyrtus infelix* Embleton (Encyrtidae), a parasitoid of *Saissetia coffeae* (Walker) (Coccidae) (Blumberg & Goldenberg, 1992) ; *Cryptochaetum iceryae* Williston (Diptera : Cryptochaetidae), a parasitoid of *I. purchasi* (Mendel & Blumberg, 1991) ; *R. cardinalis*, a principal predator of *I. purchasi ; C. bipustulatus*, a major enemy of armored and soft scale insects ; and *Elatophilus hebraicus* Pericart (Hemiptera : Anthocoridae), the principal predator of *Matsucoccus josephi* Bodenheimer et Harpaz (Homoptera : Matsucoccidae). In addition, we tested two juvenoid compounds, fenoxycarb and pyriproxyfen, and the benzoylphenyl urea, chlorfluazuron, on few of the above listed natural enemies.

MATERIALS & METHODS

REARING PROCEDURE

Cucurbita moschata Duchesne infested with *A. aurantii* served as the rearing substrate for *C. bifasciata, C. bipustulatus,* and potato sprouts infested with *S. coffeae* were used to maintain the culture of *E. infelix. R. cardinalis* and *C. iceryae* were reared on saplings of *Pittosporum tobira* Ait. and *Citrus sinensis* Osbeck. *E. hebraicus* was reared on *M. josephi* infesting saplings of *Pinus halepensis* Mill. Stock cultures of scales and natural enemies and bioassays were kept under constant conditions of 24 ± 2 °C and 70 ± 10 % r.h.

Chemicals

The insect growth regulators examined in the study were buprofezin (Aplord), 25 % WP (Nihon Nohyaku, Tokyo, Japan) ; fenoxycarb (Insegar) 50 % WP (Dr. R. Maag, Dielsdorf, Switzerland) ; pyriproxyfen (Tiger) 10 % EC (Sumitomo Chem., Japan) ; and chlorfluazuron (Atabron), 5 % EC (Ciba-Geigy A. G., Switzerland). Concentrations of the aqueous suspensions are expressed in percent active ingredients (a.i.).

Bioassays

Effect of buprofezin on C. bifasciata

Squash infested with 3rd instar nymphs of *A. aurantii* were dipped for 10 seconds in 0.0025 or 0.0125 % buprofezin or water (control). The residues were allowed to dry and the fruits were then placed in ventilated plastic cages (11 × 11 × 14 cm) and exposed to 100, 1-2 day-old adult parasitoids per fruit, with three or four replicates. After 48 h the parasitoids were removed and the mortality among them was recorded. Number of offspring per parent was determined.

In a second experiment squash infested with 50-100 3rd instar nymphs of *A. aurantii,* each containing a pupa of *C. bifasciata,* were dipped in buprofezin 0.0125 % or water as described above. Numbers of emergent parasitoids were recorded.

Effect of buprofezin on E. infelix

Potato sprouts each infested with 70 young adult females of *S. coffeae,* were exposed for 24 h to 10-20 adult parasitoids per sprout. In treatments A, B and C the sprouts were dipped in 0.0125 % buprofezin (as described above) ; in treatment A they were dipped 30 sec before exposure to the parasitoids, and in treatment B 30 min after removal of the parasitoids, and in treatment C 6 days after their removal. Treatment D involved sprouts dipped in water.

In a second experiment potato sprouts infested with young females of *S. coffeae* parasitized with *E. infelix* in the pupal stage were dipped in buprofezin 0.0125 % as described above, or in water (control). Percentages of non-emergent parasitoids were recorded.

The reproduction of emergent females from both treatments was determined by exposure for 48 h to untreated sprouts infested with 70-80 young females of *S. coffeae.* Each replicate included a single sprout with approximately ten parasitoids, with a total of 8-10 replicates. The offspring-to-female parasitoid ratio was calculated.

In a third experiment adult parasitoids, 1-2 days old, were exposed for 48 h to potato sprouts infested with young adult females of *S. coffeae* treated with buprofezin 0.0025 % (n = 127), or water (n = 80). The percentage mortality among the exposed parasitoids was recorded.

Effect of buprofezin, fenoxycarb and pyriproxyfen on R. cardinalis *and* C. iceryae

Citrus or *Pittosporum* saplings infested with young females of *I. purchasi* were sprayed until runoff with buprofezin 0.0125 %, fenoxycarb 0.0025 %, pyriproxyfen 0.0125 %, or water. In the first experiment, half of the saplings of each treatments were exposed to 2nd or early 3rd instar larvae of *R. cardinalis* (10-20 larvae per seedling, 5-10 replicates per treatment). Percentage of pupation and adult emergence were monitored. In the second experiment the other half of the saplings of each treatment were exposed in a greenhouse for 2 weeks to a wild population of *C. iceryae* ; the saplings were then transferred to rearing cages in controlled chambers (23 ± 2 °C ; 65 ± 10 % r.h.). The number of scales successfully parasitized by the fly were determined, and the number of emergent flies per treated scale was calculated.

Effect of buprofezin and chlorfluazuron on C. bipustulatus

Potato tubers infested with *A. aurantii* were dipped for 3 seconds in 0.0125 % buprofezin, 0,0125 % chlorfluazuron or water and placed 20 min later in rearing cages. To study the effect of the chemicals through adult feeding, 3-6 predators (per replicate, in three replicates) were exposed 2-3 days after emergence for 24 h to the treated tubers infested with adults females of *A. aurantii.* Pieces of flannel cloth (2 cm^2) placed in the cages served as the oviposition substrate. In another experiment, adult beetles kept in small plastic-net cages were dipped, as described above, in one of the three solutions. After drying for 20 min on blotting paper, the beetles were allowed to feed on untreated scales for 7-9 days. In both tests beetle mortality and egg hatch were recorded daily.

Effect of buprofezin, fenoxycarb and pyriproxyfen on E. hebraicus

Pinus halepensis saplings were sprayed until runoff with 0.0125 % buprofezin, 0.025 % fenoxycarb, 0.0125 % pyriproxyfen or water (control). Each chemical was applied at different times and compared with a separate control. Forty-eight hours after application, two or three mated females of *E. hebraicus* per replicate were introduced for 4 days into sealed organdy sleeves enclosing 10-cm-long twigs of pine. In a parallel test, the females were exposed to treated pine saplings for 2 days, and then transferred into sleeve cages on untreated saplings. Each test was conducted in three or four replicates. The female predator fed during the experiments on fresh ovisacs of *M. josephi* attached to the twigs. Eggs laid and hatching neonates were counted. The latter were placed in Petri dishes with a constant supply of ovisacs. Then numbers of larvae reaching the adult stage was recorded.

Analysis

Statistical analysis was carried out by one way ANOVA ; significant differences among treatments were determined by Duncan's multiple range test. Means are given with LSD values.

RESULTS

Effect of buprofezin on *C. bifasciata*

Dipping in buprofezin 0.0125 % and 0.0025 % had no effect on adult mortality or oviposition of *C. bifasciata.* Furthermore, the offspring parent ratios were apparently the same in all treatments (table 1). When scales containing parasitoid pupae were treated with buprofezin (n = 993) or water (n = 452), only 12.6 ± 6.5 % and 3.9 ± 4.7 % parasitoids failed to emerge in buprofezin and water treatments, respectively. Differences between treatments were not significant ($P = 0.05$, $F_{(2,12)} = 2.51$).

Effects of buprofezin on *E. infelix*

A significant reduction of the offspring parent ratio of *E. infelix* (from 1.0 to 0.4) was observed when *S. coffeae* was treated with buprofezin before parasitization (table 2, treat-

TABLE 1

Mortality and progeny/parent of adults of Comperiella bifasciata *after 48 h exposure to* Aonidiella aurantii *treated with buprofezin (Aplord)**

Treatment (% a.i.)	Parasitoids		
	Number exposed to treated scales	% Mortality (Mean ± S.D.)	Progeny/parent parasitoid ratio
0.0025	400	77.3 ± 12.8	2.47
0.0125	400	81.0 ± 16.0	2.22
water (control)	300	70.7 ± 23.6	2.26

* Differences between treatments are not significant (P = 0.05).

TABLE 2

Effect of buprofezin 0.0125 % (Aplord) applied to Saissetia coffeae *before and after parasitization, on survival of immature stages of* Encyrtus infelix

Treatment (time of application)	Number of scales exposed to parasitization	Number of emergent parasitoids	Ratio of progeny-parasitoid/ scale exposed to parasitization (mean ± S.D.)	Progeny parent ratio (mean ± S.D.)
A 30 min. before exposure to the parasitoids	370	149	0.4 ± 0.2b	1.7 ± 1.2b
B 30 min. after exposure	214	181	0.8 ± 0.2a	2.6 ± 0.3b
C 6 days after exposure	331	331	1.0 ± 0.0a	4.8 ± 1.0a
D Control (water), 30 min. after exposure	756	756	1.0 ± 0.0a	6.3 ± 1.2a

Within columns, figures followed by the same letter do not differ significantly.

ment A), as compared with 0.8 when the chemical was applied 30 min after removal of the parent parasitoids (B) and to 1.0 when the scales were treated 6 days after parasitization with buprofezin (C), or with water immediately after the parasitization (D) (table 2).

Offspring production per parent *E. infelix* was the lowest (1.7) when buprofezin was applied before parasitization (treatment A), and increased to 2.6 when the chemical was applied 30 min after the termination of 48 h parasitization (treatment B). When the scales were treated with buprofezin 6 days after the parasitization (C) or with water immediately after parasitization (D), the number of offspring per female parasitoid was 4.8 and 6.3, respectively (not significant, table 2).

When buprofezin 0.0125 % or water, was applied to *S. coffeae* parasitized with *E. infelix* pupae, neither percent mortality of pupae (24.2 ± 18.3 and 22.8 ± 15.4, for buprofezin and water, respectively) nor offspring parasitoid per parent female emerging from the treated scales (7.4 ± 2.5 and 6.3 ± 2.8, for buprofezin and water respectively) differed significantly between the chemical and the water treatment.

When adults of *E. infelix* were exposed to *S. coffeae* treated with buprofezin 0.0025 % or water, percentage of mortality after 48 h exposure was low : 1.6 and 3.5, respectively.

Effect of buprofezin, fenoxycarb and pyriproxyfen on *R. cardinalis* and *C. iceryae*

Pyriproxyfen almost totally prevented pupation of the beetles, while fenoxycarb and buprofezin only partially prevented pupation. However, all treated individuals died during pupation, as compared with 35 % in the control (table 3).

The percent parasitism by *C. iceryae* and numbers of emergent flies per scale, were significantly reduced after treatment with the above three insect growth regulators ; buprofezin displayed a minor adverse effect (table 3).

TABLE 3

Effect of buprofezin (Aplord) 0.0125 %, fenoxycarb (Insegar) 0.0025 %, and pyriproxyfen (Tiger) 0.0125 % on development of larvae and pupae of Rodolia cardinalis, *and on parasitism by* Cryptochaetum iceryae. *The chemicals were applied prior to the introduction of the natural enemies*

Compound	*Rodolia cardinalis*			*Cryptochaetum iceryae*		
	Number of larvae tested	% Pupation	% Emergent adults	Number of treated scales	% Parasitized scales	Number of emergent flies per scale
Buprofezin	52	45a	0a	123	38.2b	1.09a
Fenoxycarb	64	70a	0a	15	13.3*	0.20*
Pyriproxyfen	45	8b	0a	121	0.8c	0.09b
Water (control)	115	85a	65b	125	64.8a	1.52a

Within columns, figures followed by the same letter do not differ significantly (P = 0.05).
* Insufficient data for statistical analysis.

Effect of buprofezin and chlorfluazuron on *C. bipustulatus*

Dipping adult beetles in buprofezin 0.0125 %, chlorfluazuron 0.0125 % or water resulted after 7-9 days in mortality of 93.0 %, 67 % and 0 %, respectively. When the beetles were fed with *A. aurantii* treated with the above chemicals, the mortality after 7-9 days was 0 % and 13.0 % for buprofezin and chlorfluazuron, respectively (table 4).

Both chemicals applied by feeding or dipping almost completely prevented egg hatch, as compared with 81.7 % prevention when the beetles were dipped in water and fed on untreated scales (table 4).

TABLE 4

Effect of buprofezin (Aplord) and chlorfluazuron (Atabron) on adult (13-17 females per treatment) mortality and egg hatch of Chilocorus bipustulatus

Compound	Application method	Adult mortality after 7-9 days (%)	Egg hatch (% of total)
Buprofezin 0.0125 %	adult feeding	0	0.9
	dipping of adults	93.0	0.0
Chlorfluazuron 0.0125 %	adult feeding	13.0	0.0
	dipping of adults	67.0	0.0
Water (control)	dipping of adults	0	81.7

EFFECTS OF BUPROFEZIN, FENOXYCARB AND PYRIPROXYFEN ON OVIPOSITION, EGG HATCH AND LARVAL DEVELOPMENT OF *E. HEBRAICUS*

Oviposition of *E. hebraicus* on pine needles after application of buprofezin, and that on needles treated with the chemical 2 days prior to oviposition, did not affect the number of eggs oviposited (2.6-3.4 eggs/female/day) or egg hatch (*ca* 63-75 %) or larval development (63-72 %). The effect of buprofezin on all three parameters did not differ significantly from the respective values obtained on untreated saplings. Development of neonates into adults was not prevented in the above-mentioned cases (table 5). Similar applications of fenoxycarb or pyriproxyfen before or after oviposition, resulted in total suppression of egg hatch, as compared with 52.3 % and 54.7 % in the parallel control treatments (table 5).

DISCUSSION

Our findings indicate that insect growth regulators differ in their toxicity to natural enemies of different groups and species. The moulting inhibitor buprofezin had no appreciable effect on adults and progeny formation of *C. bifasciata,* either upon exposure of adults to treated scales or upon treatment of scales infested with *C. bifasciata* pupae. Buprofezin may have a detrimental effect when applied prior to parasitization, but does not affect the development of immature stages when hosts are exposed to the chemical after parasitization. The compound had a slight effect on progeny formation when *E. infelix* females were exposed to treated scales. This may have resulted from transovarial activity which occurred upon exposure of females prior to oviposition (Ishaaya *et al.,* 1988). On the other hand, the compound did not affect developmental stages of *E. infelix* when the treatment was carried out after parasitization. These findings concur with previous results (Ishaaya *et al.,* 1992) showing that field application of buprofezin did not affect the populations of *C. bifasciata* or *Aphytis* spp. in the citrus grove. Fenoxycarb had no adverse effect on three species of *Aphytis* under laboratory conditions (Peleg, 1983b). It seems that in most cases, buprofezin and the juvenoid insect growth regulators have no appreciable effect on hymenopterous parasites attacking scale insects.

The dipterous endoparasite *C. iceryae* was not appreciably affected by buprofezin, as judged by the rate of parasitism and emerging flies per scale. On the other hand, the juvenoid compounds fenoxycarb and pyriproxyfen strongly suppressed growth and development of the parasite. Application of fenoxycarb on parasitized larvae of *Ostrinia nubilalis*

TABLE 5

Effect on oviposition, egg hatch and larval development of Elatophilus hebraicus *of treatment with buprofezin (Aplord), fenoxycarb (Insegar) or pyriproxyfen (Tiger) applied to saplings of* Pinus halepensis

Treatment	Number of eggs/female/ day	% egg hatch	% Larvae that became adults
Buprofezin (0.0125 %)			
Oviposition over 4 days in treated saplings	2.6a	63.1a	63.1a
Oviposition over 2 days in untreated saplings after exposure for 2 days to treated saplings	3.4a	75.1a	72.1a
Oviposition over 4 days in untreated saplings	2.8a	64.7a	60.6a
Fenoxycarb (0.025 %)			
Oviposition over 4 days in treated saplings	4.2a	0.0b	0.0b
Oviposition over 2 days in untreated saplings after exposure for 2 days to treated saplings	4.1a	0.0b	0.0b
Oviposition over 4 days in untreated saplings	2.9a	52.3a	50.1a
Pyriproxyfen (0.0125 %)			
Oviposition for 4 days in treated saplings	3.5a	0.0b	0.0b
Oviposition over 2 days in untreated saplings after exposure for 2 days to treated saplings	2.8a	0.0b	0.0b
Oviposition over 4 days in untreated saplings	2.3a	54.7a	48.6a

Within columns, figures followed by the same letter do not differ significantly ($P = 0.05$).

(Hbn.) (Lepidoptera: Pyralidae) arrested growth of the fly parasitoid *Pseudoperichaeta nigrolineata* Walker (Diptera: Tachinidae) (Grenier & Plantevin, 1990). Juvenoid compounds suppressed egg hatch or inhibited pupal and adult formation upon exposure of females or larvae to the test compound (Ishaaya & Horowitz, 1992).

Coccinellidae are apparently more sensitive to insect growth regulators than hymenopteran parasitoids. Peleg (1983a) showed that larvae of *C. bipustulatus* fed on scales treated with fenoxycarb, methoprene or diflubenzuron did not reach the adult stage. Similar results were obtained in the present study when *R. cardinalis* fed on *I. purchasi* was treated with fenoxycarb, buprofezin or pyriproxyfen. Although the effect on rate of pupation of *R. cardinalis* differed among the three tested growth regulators, none of the treated larvae completed its development. Although some individuals managed to pupate, pupation was markedly reduced by pyriproxyfen. Loia & Viggiani (1991) showed that eggs of *R. cardinalis* treated with buprofezin hatched normally, but the larvae rarely developed into adults. All these findings may well explain the outbreaks of *I. purchasi* following application of fenoxycarb against armored or soft scale insects in Israeli citrus groves.

Egg hatch of *C. bipustulatus* was actually prevented when buprofezin or chlorfluazuron was applied by feeding or dipping. According to Peleg (1983a), feeding of *C. bipustulatus* on scales treated with fenoxycarb, methoprene or diflubenzuron did not affect egg production; however, only when the beetles were transferred to untreated scale populations was there egg hatch similar to the control treatment. In our case, the effect of buprofezin and chlorfluazuron continued up to 7-9 days after the transfer of the beetles from treated to untreated scales. Peleg (1983a) ranked fenoxycarb, methoprene and diflubenzuron as slightly to moderately harmful (see Franz *et al.*, 1980). However, from the analysis of our results, and Peleg's findings, it is suggested that insect growth regulators affect coccinellids throughout their life cycle. Since some of these products are highly residual (e.g. De Cock *et al.*, 1990) eggs and larvae of coccinellids exposed to a treated plant surface could be strongly affected. Hence, the toxicity of some of the insect growth regulators on lady beetles may last for longer periods than that of the conventional organophosphates or carbamates used now in Israeli agriculture. It is assumed that outbreaks of the mealybug *P. citri* in pyriproxyfen-treated orchards may be related to the adverse effects of the chemical on the coccinellid predators, which play an important role in the scale population dynamics in citrus groves (Klein, Mendel & Blumberg, unpublished data).

Results of applications of buprofezin, fenoxycarb or pyriproxyfen on Aleppo pine twigs serving as an oviposition substrate for the predatory bug *E. hebraicus,* did not differ significantly from the controls. Total suppression of egg hatch was recorded with the two latter chemicals when applied either before or after oviposition.

Integrated pest management utilizes combinations of various methods of control in the assumption that each method will contribute in its own way to the overall mortality of the pest and should be more efficient than any single method applied alone. Although an integrated pest management programs aims to reduce the use of nonselective insecticides, in practice, most of these programs involve the use of one or more such compounds. However, only long-term field studies regarding their effects on natural enemies of scale insects can indicate their overall effect on the population dynamics of the pest complex in a given ecosystem. Some insect growth regulators are selective towards natural enemies, while others may exhibit strong detrimental effects. Buprofezin and other groups of IGRs seem to be quite safe for hymenopterous parasites such as *Comperiella, Aphytis* and *Encyrtus* species. Buprofezin has no appreciable effect on the dipterous endoparasite *C. iceryae* and on the predator *E. hebraicus,* while the juvenoid compounds fenoxycarb and pyriproxyfen are very harmful for both. Inclusion of an insect growth regulator in an IPM program should take into account its usefulness for controlling the pest along with its selectivity towards the natural enemies present in the field.

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RÉSUMÉ

Effets de quelques régulateurs de croissance d'insectes sur les ennemis naturels de cochenilles (Hom. : Coccoidea)

Les effets de quatre régulateurs de croissance d'insectes (buprofézine, fénoxycarbe, pyriproxyfène et chlorfluazuron) sur six ennemis naturels de cochenilles font l'objet de cette étude, aux concentrations recommandées pour usage agricole.

L'immersion dans la buprofézine n'a pas d'effet appréciable sur la mortalité, l'oviposition et le développement de *Comperiella bifasciata* (Howard) (Hym. : Encyrtidae). La mortalité des adultes d'*Encyrtus infelix* Embleton (Encyrtidae) exposés à des hôtes traités avec de la buprofézine est faible ; la buprofézine produit un certain effet négatif sur les stades immatures d'*E. infelix* quand ce produit est appliqué avant le parasitisme mais n'a pas d'effet lorsque le produit est appliqué après. Ce régulateur de croissance n'a qu'un faible effet sur les stades immatures de *Cryptochaetum iceryae* Williston (Dipt. : Cryptochaetidae), alors que le fénoxycarbe et le pyriproxyfène ont un effet négatif sur le parasitisme et/ou le développement de la mouche parasitoïde. Aucune larve de *Rodolia cardinalis* Mulsant (Col. : Coccinellidae) n'atteint le stade adulte après application de buprofézine, fénoxycarbe ou pyriproxyfène. La buprofézine et le chlorfluazuron empêchent totalement l'éclosion des œufs de *Chilocorus bipustulatus* L. (Col. : Coccinellidae). La buprofézine n'a pas d'effet négatif sur l'éclosion des œufs et le développement larvaire d'*Elatophilus hebraicus* Péricart (Hem. : Anthocoridae) ; par contre le fénoxycarbe et le pyriproxyfène appliqués sur les aiguilles de pin avant ou après l'oviposition empêchent totalement l'éclosion des œufs chez cette espèce.

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