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Experiments with Insect Growth Regulators (IGRs) on Lepidopterous Pests[1] and some of their parasitoids

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Derivatives of aryl-pentenoic acid and aryloxy-butenoic acid were tested as insect growth regulators (IGRs) against a number of injurious lepidoptera (diamondback moth, large cabbage white, gypsy moth) and some of their main parasitoids under greenhouse and field conditions. Even though damage to plants could not be prevented, the fact that these compounds did not adversely affect a number of parasitoids suggests that they might be used in integrated control programs, to achieve long term reductions in pest-populations, e.g. in forestry.

Introduction

After the identification of natural juvenile hormones (JUDY et al., 1973; MEYER et al., 1968; RÖLLER et al., 1967) several hundreds of bio-analogues have been synthesized at universities, research institutes and industry. Results from bio-assays with some of our IGRs were recently given by KARRER et al. (in press). In the laboratory, these compounds acted by contact and by ingestion on insect species of various orders, e.g. coleoptera, lepidoptera, hemiptera, diptera. To get an idea of their potential for practical use, experiments were conducted under controlled field conditions with some selected products against lepidopterous pests. In addition, an examination was made of the selectivity of these compounds in regard to beneficial insects.

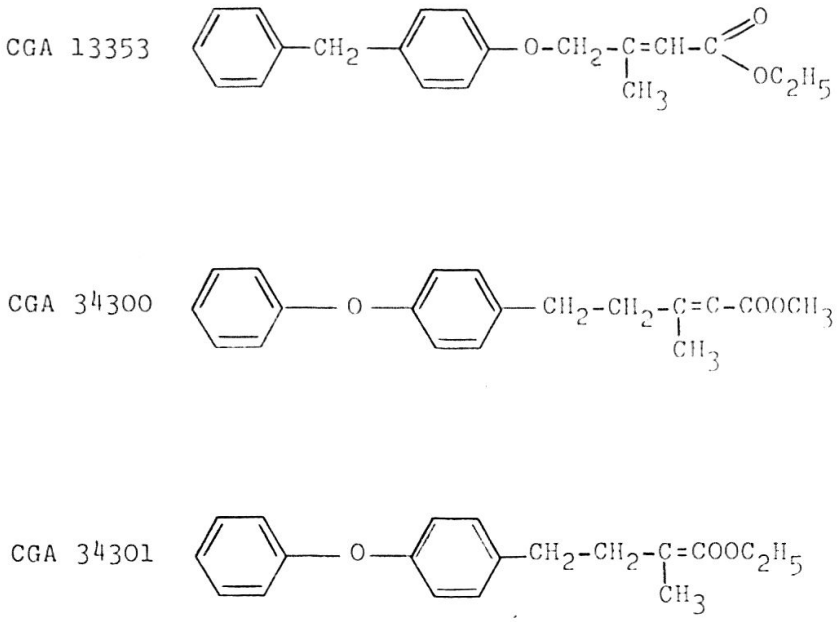
Material and Methods

The IGRs CGA 13353, CGA 34301 and CGA 34302 were synthesized in our laboratories and formulated as emulsifiable concentrates containing 40% a.i. (Fig. 1).

The test insects (large cabbage white, diamondback moth, gypsy moth) were collected in the field and placed on plants. The infested plants were sprayed to run off with an ordinary knapsacksprayer; treatments were replicated at least twice. After the applications, the plants or branches were enclosed in a nylon screen. Assessments were made several times and the effects on single insects were recorded. The parasites *Apanteles glomeratus* (L.) *(Braconidae),* Apanteles fulvipes (H.) *(Braconidae), Nythobia fenestralis (Hlmg.) (Ichneumonidae), Pteromalus puparum* (L.) *(Pteromalidae),* or infested host insects were collected in the field, but tests on them were made in a greenhouse or in a laboratory.

[1] *Plutella xylostella (Yponomeutidae), Pieris brassica (Pieridae), Porthetria dispar (Lymantriidae)*

Fig. 1



Results

Table I shows the effects on the development of the diamondback moth. As a consequence of a single treatment on third and fourth larval instars, a high percentage moulted into abnormal pupae (larvae-pupae intermediates), which were blocked in their development and either did not become adult or developed into deformed adults which were not able to fly. In addition, it seems that the treatment with CGA 13353 and CGA 34302 not only had a morphogenetic effect, but also an influence on fertility. Thus, the number of descendants was reduced when normal adults, which developed from treated larvae, were set together for copulation.

Table I: Effects of IRGs on the development of the diamondback moth *(Plutella xylostella)* after a treatment on last larval instars.

Compounds	% a.i.	% abnormal pupae	% deformed adults	% normal adults
CGA 13353	0.05	64.6	9.6	25.8
	0.075	70.4	14.8	14.8
CGA 34301	0.05	42.4	0.0	57.6
	0.075	43.8	0.0	56.2
CGA 34302	0.05	57.7	7.7	34.6
	0.075	34.6	3.4	62.0
Untreated	-	0.0	0.0	100.0

The development of the ichneumonid *N. fenestralis,* a major parasite of *P. xylostella* was not affected when the host and its food plant were sprayed with 0,05% a.i. The same percentage hatch of *N. fenestralis* was recorded in treated and untreated fourth instar larvae of the diamondback moth (Table II).

Table II: Effect of IGRs on *N. fenestralis,* a parasitoid of the diamondback moth, following treatments of parasitized diamondback moth larvae.

Compounds	% a.i.	No. of parasitized diamondback moth larvae	% hatch of N. fenestralis
CGA 13353	0.05	21	95.2
CGA 34301	0.05	25	92.0
CGA 34302	0.05	25	96.0
Untreated	-	23	95.6

The effect of an application with IGRs on last young larval instars of the large cabbage white is shown in table III. Due to handling and disease, a relatively high mortality occurred. Individuals referred to as abnormal fifth instar larvae which mainly appeared following treatment with CGA 13353, were larvae which were unable to accomplish a moult into a supernumerary instar (L_6) and as a consequence died as L_5. Extralarvae and deformed pupae were only observed following IGR treatments. Such individuals did not undergo any further moult.

Table III: Effect of IGRs on the large cabbage white

Compounds	% a.i.	% L_5 dead	% abnormal L_5 (dead)	% extra larvae	% deformed pupae (dead)	% normal pupae
CGA 13353	0.025	23.1	22.4	33.3	9.1	12.1
	0.05	22.5	36.9	6.2	15.6	18.8
CGA 34301	0.025	40.0	20.0	6.6	0.0	33.4
	0.05	29.5	2.9	8.8	32.3	26.5
CGA 34302	0.025	34.3	0.0	0.0	9.5	56.2
	0.05	32.2	3.3	9.7	12.9	41.9
Untreated	-	21.1	0.0	0.0	0.0	78.9

Parasitized third and fifth instar larvae of the large cabbage white were collected in the field and sprayed with the IGRs at 0,05% a.i. The results are given in table IV. A two-way analysis of variance and the Tukey-test did not show any significant differences in the number of *Apanteles* pupae per *P. brassicae* larvae and in the percentage of parasitoid hatch in treated and untreated insects.

Table IV: Effect of IGRs on the development of the parasitoid *A. glomeratus* following the spraying of 0,05% a.i. IGR on parasitized third and fifth larval instars of the large cabbage white.

Compounds	Stage of the host treated	No. of parasitized L.	No. of Apanteles pupae	% hatch of A. glomeratus	No. of hyperparasites emerged a)
CGA 13353	L 5	28	563	86.3	35
	L 3	7	265	72.0	-
CGA 34301	L 5	25	449	83.0	12
	L 3	10	375	72.8	-
CGA 34302	L 5	28	472	79.6	35
	L 3	6	196	85.2	-
Untreated	L 5	35	946	77.1	26
	L 3	7	204	92.2	-

a) different species of chalcids

Table V shows the results of a laboratory experiment with the pupal parasitoid *Pteromalus puparum*. Young adult wasps of both sex were exposed to the compounds in treated glass jars for 3 h. They were then allowed to parasitize young untreated pupae of *P. brassicae*. The compounds had no significant effect on the fertility of the parasites when applied at 0,025% a.i. However, at a rate of 0,05% a.i., the number of emerged *P. puparum* is reduced in the treatments with CGA 13353 and CGA 34302.

Table V: The effect of a treatment with IGRs on the adult parasite of the large cabbage white *Pteromalus puparum*.

Compounds	% a.i.	No. of parasitized P. brassicae	No. of emerged P. puparum per P. brassicae
CGA 13353	0.025	7	72.3
	0.05	8	46.3
CGA 34301	0.025	9	63.3
	0.05	8	53.6
CGA 34302	0.025	11	68.3
	0.05	10	34.3
Untreated	-	6	80.6

Last larval instars of the gypsy moth are very susceptible to a treatment with IGRs. CGA 13353 at a rate of 0,025% a.i. gives a complete inhibition of the development (Table VI). This compound causes a high percentage of the larvae to undergo a supernumerary larval moult. CGA 34302 is less active than CGA 13353 but still produces extralarvae, deformed pupae and abnormal adults. In addition, this compound has an effect on the fertility at 0,05% a.i. Eggs of normal adults, which developed from treated larvae, do not hatch. A treatment with

CGA 34301 does not stimulate the production of extralarvae, but it affects the formation of the pupae and adults. No effect was observed on the fertility of the normal adults. CGA 34301 and CGA 34302 have an insecticidal activity on last instar larvae.

Table VI: Effect of IGRs on the development of the gypsy moth

Compounds	% a.i.	No. of parasitized larvae	Av. No. of Apanteles cocoons/ larva	% hatch of a fulvipes	No. of hyper-parasites emerged (chalcids)
CGA 13353	0.05	5	19.6	18.3	105
CGA 34301	0.05	12	4.0	22.9	232
CGA 34302	0.05	5	15.4	0.0	35
Untreated	-	7	12.7	50.6	0

a) Larvae - pupae intermediates

A crude information on the effect of the IGR treatments on the parasite *A. fulvipes* is given in table VII. Since the parasitized gypsy moth larvae were collected from a field experiment, the material is not uniform and, therefore, does not allow a statistic analysis. But it appears that in all treatments the hatch of *A. fulvipes* is reduced. This reduction, however, has to be correlated with the activity of the hyperparasites (chalcids).

Table VII: Effects of IGRs on the development of the parasitoid *A. fulvipes;* Treatment of last larval instars of the gypsy moth.

Compounds	% a.i.	% L_6 dead	% extra larvae	% deformed pupae a)	% deformed adults	% normal adults
CGA 13353	0.025	8.1	70.2	21.7	0.0	0.0
	0.05	6.2	68.7	18.8	6.3	0.0
CGA 34301	0.025	11.1	0.0	14.8	18.6	55.5
	0.05	30.5	0.0	11.2	8.3	50.0
CGA 34302	0.025	19.3	22.6	16.1	19.4	22.6
	0.05	21.9	12.5	40.6	18.8	6.2
Untreated	-	5.7	0.0	2.8	0.0	91.5

Discussion

It is known that lepidoptera are most susceptible to a treatment with IGRs at the end of their larval period (SCHNEIDERMAN, 1972). Therefore, in our field experiments, we made the application on penultimate or last larval instars. Under these conditions, all compounds had an influence on the development of members of three different families. Typical effects were the formation of extra larval instars, deformed pupae (larvae-pupae intermediates), deformed adults

and pupae which failed to hatch. Similar morphogenetic effects were reported from field experiments with *Euproctis chrysorrhoea, Yponomeuta malinella, Tortrix viridana* (NOVAK, V. and SEHNAL, F., 1973, NOVAK, K. and SEHNAL, F., 1973), *Hyphantria cunea* (VARJAS, L. and SEHNAL, F., 1973).

Our data on the effect of the IGRs on the fertility of *Plutella xylostella* and *Porthetria dispar* are not very conclusive and need further investigations. But it appears that at least a partial sterility is caused by the treatment of larvae. During recent years, it has become evident that the selectivity of IGRs toward single groups of insects is not by any means as definite as was postulated at the beginning of research on IGRs as pesticides. We know that the compounds mentioned here have an effect on species of at least eight insects orders. However, as our data show, these compounds seem not to have too much of an influence on the development of hymenopterous parasitoids, although under practical conditions timing may be all important in determining selectivity.

In regard to a practical use of IGRs in plant protection, it is very unfavorable that such compounds exert their lethal activity in lepidoptera only at the end of the larval period. In addition, the feeding period is usually longer in treated insects than in untreated and is more injurious when extra larval instars occur. This fact reduces the potential of IGRs as direct pest control agents in plant protection to a great extent, but still leaves some interesting possibilities. In most of the annual cultures such as cotton and vegetables, we foresee the use of IGRs only in combination with other control methods. Early season treatments, to prevent the build up of insects which run through several generations during one season, are only likely to be successful if the whole of the first generation can be treated and thus may necessitate applications on a very large scale. In addition, for polyphagous insects, the treatment of one culture alone may not be sufficient because of the possibility of the development on and dispersal of the pest from other host plants.

A field of pesticide application where we see a reasonable chance for the use of IGRs is forestry. Contrary to agricultural crops, the damage of one pest generation can be tolerated in a forest (LEONARD, 1974). Beside the good results with our compounds on the gypsy moth, we have encouraging data from aerial trials in Canada against the spruce budworm *(Choristoneura fumiferana),* which will be reported somewhere else. We are of the opinion that the good activity of some of our compounds against injurious forest lepidoptera, their selectivity towards beneficial insects and their favorable mammalian, bird and fish toxicity are positive enough facts to justify our continuing the investigations with IGRs for future insect control programs in forestry.

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