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The use of insect growth regulators in integrated pest control*

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The use in integrated pest control of certain insect growth regulators (IGR) with juvenile hormone activity is reviewed. The main emphasis is placed on Epofenonane (proposed common name), which has no adverse effect on the natural enemies of the insect pests controlled.

Many of the requirements in integrated pest control (FAO 1966, STEINER 1974, METCALF & LUCKMANN, 1975) can be met by the use of certain insect growth regulators (IGR). It is the aim of this article to justify the foregoing assertion with the help of results found in the literature or obtained from our own experiments. In this context the main emphasis is placed on Epofenonane (proposed common name), an active compound tested by Dr. R. Maag Ltd., 8157 Dielsdorf, Switzerland. Unlike the majority of known IGRs this compound persists long enough in the field to justify extensive investigations under practical conditions. Its mammalian toxicity is extremely low (acute oral LD_{50}, rat, more than 32000 mg/kg). The main fields of application are discussed, paying special attention to beneficial insects.

Lepidoptera

Good results were obtained in laboratory and/or outdoor experiments of the following species:

orchard pests	*Adoxophyes reticulana* HUEBN.
	Lobesia botrana SCHIFF.
forest pests	*Zeiraphera diniana* GUEN.
	Choristoneura fumiferana CLEM.
	Porthetria dispar L.
stored product pests	*Ephestia kuehniella* ZELL.
	Plodia interpunctella HUEBN.

Field trials with the test compound in the southern part of Switzerland (Valais) showed that the natural population of *A. reticulana* could be kept below the economic injury level while in a small scale field trial in the Netherlands the compound showed no effects on two parasites of *A. reticulana,* namely *Colpoclypeus floreus* WALK. (Eulophidae) and *Meteorus ictericus* NEES (Braconidae). Such tolerance of IGRs by lepidopteran parasites is not a common occurrence. Although a compound synthesized by BOWERS showed no effect against *Apanteles rubecula* MARSHALL (Braconidae) parasitizing IGR

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treated larvae of *Pieris rapae* L. (WILKINSON *et al.* 1973), synthetic JH-1 (mixture of isomers of C_{18} JH) proved to be harmful to *Glypta fumiferana* VIERECK (Ichneumonidae), *Meteorus trachynotus* VIERECK (Braconidae) and *Phryxe pecosensis* TOWNSEND (Tachinidae), all parasites of *C. fumiferana* (OUTRAM 1974). IGR R 20458 produced not only a retarded development but also a reduction of the hatching rate of two parasites of *Heliothis virescens* F., namely *Cardiochiles nigriceps* (VIERECK) (Braconidae) and *Campoletis sonorensis* CAMERON (Ichneumonidae) (VINSON 1974). NEAL *et al.* (1971) were able to show that a mixture of isomers of JH-III (C_{16} JH) applied to larval stages of *Hypera postica* GYLLENHAL reduced the hatching rate of *Microctonus aethiops* NEES and *M. colesi* DREA (Braconidae).

In our experiments we studied the activity of the test compound against *Habrobracon juglandis* ASHMEAD (Braconidae), an ectoparasite of *E. kuehniella* larvae. *Ephestia* larvae are not able to pupate in treated flour and, before they die, they remain for a long time in a stage comparable to a diapausing last larval instar (HOPPE & SUCHY 1975). *Ephestia* larvae from flour treated with 10, 30 and 100 ppm were put at the parasites' disposal. No reduction of the hatching rate could be observed in comparison to the control. In a further experiment, where free choice between treated and untreated larvae was provided, the former had no repellent effect on the parasites. For the order Hymenoptera BOHM (1972) and BARTH *et al.* (1975) were able to demonstrate a stimulated ovarian function after IGR treatment in *Polistes annularis* L. and *P. metricus* SAY. BRACKEN & NAIR (1967) showed that, as a consequence of feeding and topical application of farnesylmethylether, increased egg production occurs in the parasite *Exeristes comstocki* CRESSON (Ichneumonidae). On the other hand, WISSINGER & GROSCH (1975) demonstrated that a decrease in the number of eggs laid daily, in the hatchability of those eggs and degeneration of the ovaries occurred after topical treatment of virgin *Habrobracon* females with an acetone solution of some other IGRs. As our experiments were performed under practical conditions, whereas WISSINGER & GROSCH conducted laboratory experiments, it may be that their negative results are of no practical significance. In experiments with the honeybee comparable results were obtained with other compounds. In the laboratory nearly all IGRs tested showed negative effects, whereas in field trials absolutely no negative effects could be observed (see below).

Scale insects

Good results were obtained in laboratory and/or outdoor experiments on the following species: *Quadraspidiotus perniciosus* COMST., *Aonidiella aurantii* MASK., *Aspidiotus nerii* BOUCHÉ (= *hederae* VALL.), *Planococcus citri* RISSO, *Unaspis citri* COMST., *Pseudococcus maritimus* EHRH., *Saissetia coffeae* WALK., *Coccus hesperidum* L., *Saissetia oleae* BERN.

Under outdoor conditions more than one application is necessary against Coccidae, since this family is more difficult to control than Diaspididae and Pseudococcidae, where one application may be sufficient. The effects of IGRs are early larval mortality, sterility and hatching disturbances in females, as well as marked morphogenetic effects in males.

In laboratory experiments with the test compound we observed that treatment of «mixed» (i.e. all developmental stages represented) scale populations of *Q. perniciosus* with a high degree of parasitization by *Prospaltella perniciosi* Tow. had no influence on the chalcid and managed to control the scale population efficiently. SCHEURER & RUZETTE (1974) obtained similar results with two different IGRs against the same host-parasite system. Furthermore, in two additional host-parasite systems *C. hesperidum* (Lecaniidae) with *Coccophagus semicircularis* FOERSTER, *C. lycimnia* WALKER, *C. insidiator* DALMAN (Aphelinidae) and *S. coffeae* (Lecaniidae) with *Encyrtus infelix* EMBLETON (Encyrtidae) Epofenonane gave good control of the pests without adverse effects on the parasites.

These and other observations suggest that the relatively low sensitivity of hymenopteran endoparasites to IGRs may be a consequence of a specific adaptation to their special environment which has a varying juvenile hormon titre. Our hypothesis is supported by the fact that non-parasitic, non-social pest hymenoptera such as *Athalia rosae* L., *Diprion pini* L. and *Neodiprion sertifer* GEOFF. are very sensitive to IGRs. Detailed investigations on the effects of IGR on Hymenoptera are currently in progress in our laboratories.

Aphids

Various IGRs showed moderate to good activity against aphids (HANGARTNER *et al.* 1971, NASSAR *et al.* 1973). MEIER *et al.* (1975) reported promising results from field trials on *Acyrthosyphon pisum* HARR. on beans and *Phorodon humuli* SCHR. on hops. The majority of papers published on the action of IGRs on aphids agree that the main effect is the abnormal production of supralarvae, which parthenogenetically develop a great number of embryos, but cannot give birth because of malformed genital tracts. We also found a large number of lethal disturbances of ecdysis, which must play an important role in the control of aphids in the field. MEIER (pers. comm.) studied the influence of several IGRs on the parasitic wasp *Aphidius ervi* HALIDAY and its host *A. pisum*. *Aphidius* is very efficient in controlling aphids in the greenhouse (MCLEOD 1936, SCOPES 1970, TREMBLAY 1974). Young third larval instars of *A. pisum* were treated with the test compound and offered to *A. ervi* for parasitization. The majority of *A. ervi* in the treated plots emerged from supralarval instars of *A. pisum*.

In our experiments with hoverflies, treatment of the eggs of *Syrphus corollae* FABR. did not result in an ovicidal effect. Even when all larval stages were fed exclusively with IGR treated *Myzus persicae* SULZ., neither larvicidal nor morphogenetic effects were observed, though the larvae were throughout their development in direct contact with treated pea seedlings. There was no adverse effect on the reproductive rate of adult hoverflies emerging from treated larvae.

In outdoor trials against *Aphis pomi* DEG. and *Dysaphis plantaginea* PASS., where the treated branches were enclosed in cheesecloth bags, an impressive number of adult *Epistrophe balteata* DEG. and larval stages of several other hoverflies, Chrysopids and Coccinellids were found. The larvae were reared in the laboratory. Except for a few diapausing larvae of *Syrphus ribesii* L. all larvae

pupated and normal adults emerged. This very low activity against hoverflies is not surprising, if we take into consideration that most of the IGRs known show very poor activity against Diptera such as *Musca domestica* L. and *Ceratitis capitata* WIED. Furthermore, our results are in accordance with those obtained by RUZICKA *et al.* (1974), who tested 30 different IGRs by applying them topically to *S. corollae* larvae. On the other hand, few IGRs demonstrate excellent activity against Diptera. Thus, WRIGHT & SPATES (1972) were able to show that IGRs control *Stomoxys calcitrans* L., but do not affect its parasite *Muscidifurax raptor* GIR. and SAND. (Pteromalidae).

Spider mites and predatory mites

The test compound, like the majority of IGRs, has a poor activity against spider mites. For that reason, special attention was paid to the question whether beneficial predatory mites such as *Phytoseiulus persimilis* ATHIAS-HENRIOT are harmed by IGRs. In several greenhouse trials with this species, which is extensively used for biological control, we were able to show that treated prey-predator populations caused much less foliar damage. Besides a slight reduction in the number of treated spider mites (ca. 30%) we observed a decreased locomotory activity of the prey but no effect on the predator. For that reason we suggest that a shift of the biological balance occurred in favor of the predator, based on a higher catching rate which at least enables the predator to build up a very high population in a shorter time than usual.

Bees

One of the most urgent questions to answer was whether the new compound is harmful to bees. Dutch researchers (WIRTZ *et al.* 1972, WIRTZ 1973) showed that the development of queenlike adultoids may be observed if three days old worker larvae are treated topically with cecropia hormone (JH-1). ZDAREK *et al.* (1974) received comparable results with similar methods in testing 31 different IGRs. In a small outdoor trial BEETSMA & TEN HOUTEN (1974) tested the effect of six IGRs on the population dynamics and ontogenesis of honeybees. The compounds tested varied from those «harmless to bees» to those «very harmful to bees». Four of the compounds caused the formation of queenlike adults from worker cells. The two most dangerous led to the death of brood and queen. Compound number 1 tested by BEETSMA & TEN HOUTEN was Epofenonane. It led to a quantitative improvement of the brood and must be classified as «harmless to bees».

In co-operation with the Swiss Federal Dairy Research Station, Bee Section, in Liebefeld/Berne we were able to confirm the Dutch results in larger field trials (GERIG 1975). In spite of treating whole rape fields in full bloom several times, no effects on the development of brood and/or population dynamics were observed. On the other hand, in feeding experiments in the laboratory it was shown that our IGR reduces the protein titre in the haemolymph, leads to a partial degeneration of the food sap glands (RUTZ *et al.* 1974) and increases the number of pycnotic leucocytes, which are of importance in

determining the general physiological state of bees (WILLE *et al.* 1966, 1974; WILLE 1973). However, once again the trials made under field conditions show that results from the laboratory are often of little practical relevance.

Conclusions

Having reviewed the literature and our own as yet unpublished results we can state that some IGRs, as Epofenonane, are able to meet important requirements of integrated pest control. However, it should be pointed out that IGRs show two main disadvantages: their slow mode of action is a serious handicap where a rapid control of pests is demanded, and their selectivity, which is observed in some cases, may not be desirable. On the other hand, sustained control of a remarkable number of insect pests was obtained and beneficial species were either not or only slightly disturbed. In special cases their control efficiency was even improved. If the extremely low toxicity of these compounds and their rapid degradability is taken into account, it may be concluded that a step forward has been made to improve integrated pest control programs.

Zusammenfassung

Die Eignung von Insektenwuchsregulatoren im integrierten Pflanzenschutz - In einem Überblick wird versucht, die Eignung gewisser Insektenwuchsregulatoren (IGR) für den integrierten Pflanzenschutz abzuklären. Schwergewicht wird auf Epofenonane (vorgeschlagener Name) gelegt, welches auf jene Nützlinge, die in den praktischen Anwendungsgebieten von Bedeutung sind, keinen ungünstigen Einfluss ausübte.

REFERENCES

BARTH, R.H., LESTER, L.J., SROKA, P., KESSLER, T. & HEARN, R. 1975. *Juvenile hormone promotes dominance behaviour and ovarian development in social wasps (Polistes annularis).* Experientia *31:* 691-692.

BEETSMA, J. & TEN HOUTEN, A. 1974. *Effect of juvenile hormone analogues in the food of honeybee colonies (Apis mellifera* L.). Z. ang. Ent. *77:* 292-300.

BOHM, M.K. 1972. *Effects of environment and juvenile hormone on ovaries of the wasp, Polistes metricus Say.* Proc. North Central Branch E.S.A. 27.

BRACKEN, G.K. & NAIR, K.K. 1967. *Stimulation of volk deposition in an ichneumonid parasitoid by feeding synthetic juvenile hormone.* Nature *216:* 483-484.

FAO 1966. *Proceedings of the FAO Symposium on Integreated Pest Control (Rome 1965).* FAO, Rome, 3 vol.

GERIG, L. 1975. *Wirkung von Juvenilhormon-Analoga auf Sommerbienen (Apis mellifera L.) im Freiland und Labor.* Schweiz. Landw. Forsch. *14:* 355-370.

HANGARTNER, W., PEYER, B. & MEIER, W. 1971. *Effects of a juvenile hormone analogue on the apterous form of the bean aphid, Aphis fabae Scop.* Meded. Fakulteit Landbouw. Gent *36:* 866-873.

HOPPE, T. & SUCHY, M. 1975. *Present status on Insect Growth Regulators for the protection of stored grain.* EPPO Bull. *5:* 193-196.

MCLEOD, I.H. 1936. *Some factors in the control of the common greenhouse aphid, Myzus persicae Sulzer, by the parasite Aphidius phorodontis Ash.* Rep. ent. Soc. Ont. *67:* 63-64.

MEIER, W., FELS, P. & KOLAR, O. 1975. *Über die Wirkung von Juvenilhormonanalogen als Wachstumsregulatoren bei Blattläusen.* Mitt. Schw. Ent. Ges. *48:* 1-2, 13-21.

MEIER, W., KOLAR, O. & RAMSER, E. 1975. *Erfahrungen mit Juvenilhormonanalogen zur Blattlausbekämpfung in Feldversuchen, 1972-1974.* Mitt. Schw. Landw. *23:* 1-16.

METCALF, R.L. & LUCKMANN, W. (ed.) 1975. *Introduction to Insect Pest Management.* John Wiley & Sons, 587 p.

NASSAR, S.G., STAAL, G.B. & ARMANIOUS, N.I. 1973. *Effects and Control Potential of Insect Growth Regulators with juvenile hormone activity on the greenbug.* J. econ. Ent. *66:* 847-850.

NEAL, J.W., HOLLAWAY, W.T. & BICKLEY, W.E. 1971. *Response of Microctonus aethiops and M. colesi, parasites of the alfalfa weevil, to a mixture of cistrans and trans-trans 10,11-epoxy-farnesenic-acid methyl ester.* J. econ. Ent. *64:* 338-339.

OUTRAM, I. 1974. *Influence of juvenile hormone on the development of some spruce budworm (Choristoneura fumifera: Lep. Olethreutidae) parasitoids.* Environmental Entomol. *3:* 361-363.

RUTZ, W., GERIG, L., WILLE, H. & LUESCHER, M. 1974. *A bioassay for juvenile hormone (JH) effects of insect growth regulators (IRG) on adult worker honeybees.* Mitt. Schw. Ent. Ges. *47:* 307-313.

RUZICKA, Z., SEHNAL, F. & CAIRO, V.G. 1974. *The effects of juvenoids on the hover fly Syrphus corollae Fabr. (Dipt., Syrphidae).* Z. ang. Ent. *76:* 430-438.

SCHEURER, R. & RUZETTE, M.A. 1974. *Effects of insect growth regulators on the oleander scale (Aspidiotus nerii) and the European fruit lecanium (Parthenolecanium corni).* Z. ang. Ent. *77:* 2, 218-222.

SCOPES, N.E.A. 1970. *Control of Myzus persicae on year-round chrysanthemums by introducing aphids parasitized by Aphidius matricariae into boxes of rooted cuttings.* Ann. appl. Biol. *66:* 323-327.

STEINER, H. 1974. *Richtlinien für den integrierten Pflanzenschutz.* Landesanstalt für Pflanzenschutz, Stuttgart.

TREMBLAY, E. 1974. *Possibilities for utilization of Aphidius matricariae Hal. (Hymenoptera, Ichneumonidae) against Myzus persicae Sulz. (Homoptera, Aphidoidea) in small glasshouses.* Z. Pfl.krankh. und Pfl.schutz *81:* 612-619.

VINSON, S.B. 1974. *Effect of an insect growth regulator on two parasitoids developing from treated tobacco budworm larvae.* J. econ. Ent. *67:* 335-336.

WILKINSON, J.D. & IGNOFFO, C.M. 1973. *Activity of a juvenile hormone analogue on a parasitoid, Apanteles rubecula, via its host, Pieris rapae.* J. econ. Ent. *66:* 643-645.

WILLE, H. 1973. *Beziehungen zwischen der Überlebensdauer, Krankheitsbefunden und dem Blutbild erwachsener Bienen (Apis mellifica L.).* Schw. Landw. Forsch. *12:* 4, 269-289.

WILLE, H. & VECCHI, M.A. 1966. *Etudes sur l'hémolymphe de l'abeille (Apis mellifica) 1ère partie: les frottis de sang de l'abeille adulte d'été.* Mitt. Schw. Ent. Ges. *39:* 1-2, 69-97.

WILLE H. & VECCHI, M.A. 1974. *Untersuchungen über die Hämolymphe der Honigbiene (Apis mellifica L.) 5. Teil: Beziehungen zwischen der Morphologie der Leukozyten und vier Krankheitselementen.* Mitt. Schw. Ent. Ges. *47:* 3-4, 133-149.

WIRTZ, P. 1973. *Differentiation in the honeybee larva. A histological, electronmicroscopical and physiological study of caste induction in Apis mellifera mellifera L.* Meded. Landbouw. Wageningen, 73-75.

WIRTZ, P. & BEETSMA, J. 1972. *Induction of caste differentiation in the honeybee (Apis mellifera) by juvenile hormone.* Ent. exp. et appl. *15:* 517-520.

WISSINGER, W.L. & GROSCH, D.S. 1975. *Influence of juvenile hormone analogues on reproductive performance in the wasp, Habrobracon juglandis.* J. Ins. Physiol. *21:* 1559-1564.

WRIGHT, J.E. & SPATES, G.E. 1972. *A new approach in integrated control: insect juvenile hormone plus a hymenopteran parasite against the stable fly.* Science *178:* 1292-1294.

ZDAREK, J. & HARAGSIM, O. 1974. *Action of juvenoids on metamorphosis of the honeybee, Apis mellifera.* J. Ins. Physiol. *20:* 209-221.