Activity of Ro13-5223 and Ro13-7744 Against Stored-Product Insects[1]

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ABSTRACT

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Two carbamate-type compounds that exhibit juvenile hormone activity were effective as progeny suppressants of stored-product insects. Ro13-5223 {ethyl [2-(p-phenoxyphenoxy)ethyl] carbamate} prevented development of F_1 progeny of nine coleopteran and three lepidopteran species at <0.1 to 10 ppm levels in wheat media. Ro13-7744 {S-ethyl [2-(p-phenoxyphenoxy)ethyl] thiocarbamate} was slightly less active against three of the species. A malathion-resistant strain of the Indian meal moth was not cross-resistant to Ro13-5223.

Two nonneurotoxic carbamate insecticides (Fig. 1) which exhibit insect juvenile hormone activity are Ro13-5223 {ethyl [2-(p-phenoxyphenoxy)ethyl] carbamate} and Ro13-7744, its thiocarbamate analog {S-ethyl[2-(p-phenoxyphenoxy)ethyl] thiocarbamate}. Because they are active against adults and larvae of numerous species representing various insect orders and have relatively low mammalian toxicity (S. Dorn, M. L. Frischknecht, V. Martinez, R. Zurfluk and U. Fischer, unpublished data), these carbamate derivatives might be useful as protectants of stored products. Therefore, we applied them to wheat and evaluated their activity. Ro13-5223 was tested against the following coleopterans: the rice weevil, *Sitophilus oryzae* (L.), granary weevil, *S. granarius* (L.), maize weevil, *S. zeamais* Motschulsky, confused flour beetle, *Tribolium confusum* Jacquelin duVal, red flour beetle, *T. castaneum* (Herbst), sawtoothed grain beetle, *Oryzaephilus surinamensis* (L.), lesser grain borer, *Rhyzopertha dominica* (F.), flat grain beetle, *Cryptolestes pusillus* (Schönherr), and a warehouse beetle, *Trogoderma variabile* Ballum. It was also tested against the following lepidopterans: Indian meal moth, *Plodia interpunctella* (Hübner), Angoumois grain moth, *Sitotroga cerealella* (Olivier), and almond moth, *Ephestia cautella* (Walker). Ro13-7744 was tested against the rice weevil, confused flour beetle, and Indian meal moth.

Materials and Methods

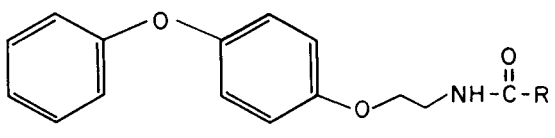
Ro13-5223 and Ro13-7744 were obtained from Maag Agrochemicals (Vero Beach, Fla.) as 98 and 97% pure powders, respectively, and were stored at −10°C. All insects were obtained from cultures maintained at the U.S. Grain Marketing Research Laboratory. The Sechreist malathion-resistant strain of the Indian meal moth also was tested. Lancato wheat was used in all tests and was obtained from a commercial source. Kernels were cleaned and tempered to a moisture of 12.5% as determined by a Motomco® moisture meter (Motomco, Inc., Clark, N.J.).

Fifty coleopteran adults or 50 lepidopteran eggs were added to 100 g of whole wheat or ground wheat moth medium, respectively, (Kinsinger 1975) that had been treated with 0.1 to 100 ppm of the test compound (McGregor and Kramer 1975, Kramer and McGregor 1979) by pipetting 5 ml of acetone or methanol solution onto the diet and mixing thoroughly until the solvent evaporated. The treated diet was allowed to equilibrate for at least 24 h before testing.

All experiments were conducted at 27 ± 2°C and 60 ± 5% RH. Four replications were used for each dose. Toxicity to the coleopterans was determined after 21 days of exposure; for lepidopterans, percent mortality was calculated from the differences between the number of eggs added and the number of adults that emerged after 6 weeks. For coleopterans, the number of original parent insects were removed after 3 weeks, and the total dead and live progeny was determined after 9 weeks. When the progeny was reduced >20%, the samples were reexamined after 9 more weeks. Values were corrected for mortality in untreated samples and the corrected mortality values were then used to estimate the ppm in the diet required to suppress 95% of the control population (Finney 1952).

Results and Discussion

Although neither of the two carbamate compounds tested for insect growth regulating activity was acutely toxic at 100 ppm to 12 species of stored-product beetles or moths, both suppressed development of progeny when applied to the diet at very



I. R = $-OCH_2CH_3$

II. R = $-SCH_2CH_3$

FIG. 1.—Structures of juvenile hormone-active insect growth regulators Ro13-5223 (I) and Ro13-7744 (II).

[1] Mention of a pesticide or a proprietary product does not constitute a recommendation or an endorsement by the USDA. Received for publication 30 January 1981.

low levels of ≤20 ppm (Table 1). The oxy derivative Ro13-5223 (compound I) was ca. 10-fold more effective than the thiol compound Ro13-7744 (compound II) as a progeny suppressant of the rice weevil. Both were similar in activity against the confused flour beetle and Indian meal moth. The most susceptible species were the confused flour beetle, red flour beetle, Angoumois grain moth, and Indian meal moth ($ED_{95,I} \leq 0.1$ ppm). The rice weevil and granary weevil were ca. 10-fold more tolerant ($ED_{95} \approx 1$ ppm) of compound I, whereas the maize weevil, sawtoothed grain beetle, lesser grain borer, flat grain beetle, *T. variabile* and almond moth were 100-fold more tolerant ($ED_{95,I} \approx 10$ ppm) than the most susceptible species. For compound II, the tolerance factor was 160 times greater for the rice weevil than for confused flour beetle or Indian meal moth. Other carbamate-type juvenoids were synthesized recently but they exhibited poor insect growth regulating activity against several species not tested by us (Mumby et al. 1979).

Malathion-specific resistance in stored-product insects may be widespread (Attia et al. 1979). Although cross-resistance to insect growth regulators has been demonstrated in several malathion-resistant strains (Dyte 1972, Zettler et al. 1973, Cerf and Georghiou 1974, Silhacek et al. 1976), some other strains were not cross-resistant (Amos et al. 1974). A strain of Indian meal moth (R, Table 1) which was >200-fold resistant to malathion showed no cross-resistance to Ro13-5223. Candidate protectants such as Ro13-5223 which are extremely active against lepidopterans may represent desirable alternative chemical control agents for stored products.

Table 1.—Activity of Ro13–5223 (I) and Ro13–7744 (II) against development of insects exposed from eggs in wheat or in coarsely ground wheat medium

Species	Compound no.	Avg no. of F_1 insects in untreated sample[a]	ED_{95} (ppm)[b]
Rice weevil	I	967	1.2 (0.8–2.3)
	II	612	16.1 (12.5–21.4)
Granary weevil	I	392	1
Maize weevil	I	933	10
Confused flour beetle	I	228	<0.1
	II	295	<0.1
Red flour beetle	I	339	<0.1
Sawtoothed grain beetle	I	310	10
Lesser grain borer	I	122	10
Flat grain beetle	I	461	10
T. variabile	I	98	10
Indian meal moth S[c]	I	43	~0.1
	II	40	~0.1
Indian meal moth R[c]	I	46	~0.1
Almond moth	I	39	9.8 (5.4–22.9)
Angoumois grain moth	I	38	<0.1

[a] Whole kernel wheat diet used for all species except Indian meal moth and almond moth, for which ground wheat medium was used.
[b] 95% confidence limits given in parentheses.
[c] S, Malathion-susceptible strain; R, malathion-resistant strain.

We previously evaluated the stored-product insect growth regulating activity of several juvenile hormone analogs (McGregor and Kramer 1975, Kramer et al. 1979) and found, as have others (Strong and Diekman 1973, Staal 1975), that certain beetles are relatively insensitive to insect growth regulators of the JH type. The oxycarbamate JH-active compound Ro13-5223 exhibited an impressive broad spectrum of activity against both external and internal kernel-feeding coleopterans and lepidopterans, including species of curculionids. In all tests with this compound, 95% or more of the adult progeny were suppressed at 10 ppm in wheat. Inspection of infested grain by X-ray analysis revealed that some progeny development had occurred but that larvae had died before or during metamorphosis. Perhaps Ro13-5223 is more stable on grain or penetrates more into the endosperm than other JH-type growth regulators. Bioassay of grain 1 year after treatment with Ro-13-5223 demonstrated excellent activity against the confused flour beetle and Indian meal moth. Other species were not tested.

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