

Laboratory evaluation of 2-[1-methyl-2-(4-phenoxyphenoxy)-ethoxy]pyridine against larvae of mosquitoes and housefly

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Abstract: A newly synthesized juvenile hormone active compound, S-31183 (2-[1-methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine) was evaluated for its inhibition of emergence of adult *Culex pipiens pallens*, *Anopheles stephensi*, *Aedes aegypti* and *Musca domestica* in the laboratory. It was more active than methoprene, diflubenzuron, or temephos against last instar larvae of *Cx. p. pallens*, *An. stephensi* and *Ae. aegypti*. S-31183 was more active than methoprene and diflubenzuron against 4-day-old larvae of *M. domestica* in the artificial medium, and more active than methoprene against eggs and 4-day-old larvae of *M. domestica* in the chicken manure medium.

INTRODUCTION

Synthetic juvenile hormone (JH) compounds have been used as insect growth regulators (IGR). We have synthesized oxime ether compounds act as IGR against larvae of mosquitoes and houseflies (Hatakoshi *et al.*, 1985, 1986). A new JH active compound, S-31183 (2-[1-methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine) was synthesized in our laboratory; it acts as an IGR against tea scale (Cooper and Oetting, 1985) and mosquitoes (Estrada and Mulla, 1986). In this paper, we report the larvicidal activity of S-31183 against mosquitoes and houseflies studied under laboratory conditions.

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MATERIALS AND METHODS

1. *Test compounds.* S-31183 (2-[1-methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine; (purity, 97.2%) was synthesized in our laboratory. Methoprene (purity, 88.2%), diflubenzuron (25% wettable powder) and temephos (5% wettable powder) were used as standards.

2. *Test insects.* *Culex pipiens pallens*, *Anopheles stephensi*, *Aedes aegypti*, and WHO and CSMA strains of *Musca domestica* were reared for successive generations on artificial feed in the laboratory at 26°C with a 16L-8D photoperiod. The age of the housefly larvae was defined as day 0 at the time of oviposition.

3. *Bioassays.* All experiments were done at 26°C.

1) *Mosquitoes:* Since the 4th (last) instar larvae are more sensitive to the inhibition of emergence into adults by the juvenile

hormone active oxime ether compound S-21149 (propionaldehyde oxime *O*-2-(4-phenoxyphenoxy)ethyl ether) than 3rd instar larvae or pupae of *Cx. p. pallens* (Hatakoshi *et al.*, 1986), the activities against 4th instar larvae of *Cx. p. pallens*, *An. stephensi* and *Ae. aegypti* were evaluated by the immersion method. An emulsifiable concentrate or the wetttable powder of each test compound was diluted with deionized water to the concentration desired. Thirty 4th instar larvae were released into 150 ml of each solution in an aluminum cup. Mortality was assessed after 24 hr; then feed was added into the cup, which was covered with net and left until adults emerged. The data observed were corrected for the percentage of control adult emergence by Abbott's formula, and probit analyses (Finney, 1952) were done. The activity was expressed as the IC_{50} value, the concentration required for 50% inhibition of emergence into adults.

2) Housefly: The effects of the compounds on eggs or 4-day-old larvae of *M. domestica* were evaluated by the artificial and chicken manure medium methods. The artificial medium was composed of 14 g of bran and 2 g of powdered animal food, which were mixed, and suspended in 28 ml of a test solution. An equal volume of water was added to the control. Chicken manure was collected from a poultry house and 5 ml of emulsion or water was added to 100 g of the manure. Eggs deposited within 3 hr or larvae were released into the medium and reared until pupation. Pupae were transferred to new containers, and the adults emerged normally were counted. The activities expressed as IC_{50} or IC_{90} (90% inhibition) were calculated as stated above, but the units are given by the amount of active ingredient in the medium.

RESULTS AND DISCUSSION

Activity against mosquitoes

The IC_{50} of S-31183 against the larvae of *Cx. p. pallens*, *An. stephensi*, and *Ae. aegypti* were 0.0046, 0.043, and 0.023 ppb, respectively (Table 1). S-31183 was less active than S-21149, the IC_{50} of which against *Cx. p. pallens* and *Ae. aegypti* is 0.000036 and 0.00017 ppb, respectively (Ha-

Table 1 Inhibition of emergence of mosquitoes by test compounds treated for 4th instar larvae.

Compound	IC_{50} (ppb)		
	<i>Cx. p. pallens</i>	<i>An. stephensi</i>	<i>Ae. aegypti</i>
S-31183	0.0046	0.043	0.023
Methoprene	0.013	0.54	0.77
Diffubenzuron	0.37	0.84	0.6-0.8
Temephos	1.7	2.7	4.5

takoshi *et al.*, 1986). Against *Cx. p. pallens*, S-31183 was 3, 80, and 370 times as active as methoprene, diflubenzuron, and temephos, respectively. Against *An. stephensi*, S-31183 was 13, 20, and 63 times as active, and against *Ae. aegypti*, 33, 30, and 196 times as active as methoprene, diflubenzuron, and temephos, respectively. Compared with their sensitivity to S-31183, *An. stephensi* and *Ae. aegypti* were about 1-10th as sensitive as was *Cx. p. pallens*. The same tendency was observed with methoprene and temephos.

The activities of methoprene shown in Table 1 against three species of mosquitoes were about 10 times as high as those reported previously (Hatakoshi *et al.*, 1986). S-31183 against *Ae. aegypti* in the present test was 10 times as active as that of Estrada and Mulla (1986). The reason is not clear, because the test methods were slightly different.

Activity against housefly

Oxime ether S-21150 (propionaldehyde oxime *O*-2-(4-phenoxyphenoxy)propyl ether) is more effective in the inhibition of adult emergence from 4-day-old larvae than from eggs or 2-day-old larvae of WHO houseflies (Hatakoshi *et al.*, 1985). In the present experiment, the activities of S-31183 against 4-day-old WHO and CSMA larvae were examined. Against WHO larvae, the IC_{50} of S-31183 was 0.0091 $\mu\text{g/g}$ medium; the compound was 50 and 220 times as active as methoprene and diflubenzuron, respectively (Table 2). Against CSMA larvae, the IC_{50} of S-31183 was 0.0031 $\mu\text{g/g}$ medium; the compound was 260 and 2,800 times as active as methoprene and diflubenzuron, respectively. S-31183 was less effective against the WHO housefly than the CSMA

Table 2 Inhibition of emergence of houseflies after treatment of test compounds to 4-day-old larvae by the artificial medium method.

Compound	IC ₅₀ ($\mu\text{g/g}$ medium)	
	WHO	CSMA
S-31183	0.0091	0.0031
Methoprene	0.45	0.80
Diflubenzuron	2.0	8.7

Table 3 Inhibition of emergence of houseflies after treatment of test compounds to eggs and 4-day-old larvae of WHO strain by the artificial and chicken manure medium methods.

Compound	IC ₅₀ ($\mu\text{g/g}$ medium)			
	Artificial medium		Chicken manure medium	
	Eggs	Larvae	Eggs	Larvae
S-31183	0.027	0.0091	0.012	0.0030
Methoprene	2.0	0.45	>4.8	0.21

housefly. On the contrary, methoprene and diflubenzuron were less effective against the CSMA housefly than the WHO housefly.

By the chicken manure medium method using 4-day-old larvae of the WHO housefly, the IC₅₀ of S-31183 was 0.0030 $\mu\text{g/g}$ medium; the compound had the highest activity against 4-day-old larvae of the four compounds tested (Table 3).

The activity against eggs of the housefly was also evaluated with the WHO strain (Table 3). In both the artificial and chicken manure media, S-31183 was more active than methoprene. The effect of JH depends on the target insect stage; eggs just after oviposition and fully developed larvae are the most sensitive (see review by Retnakaran *et al.*, 1985). In our experiment, at the IC₉₀ level of S-31183 or methoprene, eggs hatched and grew normally until pupation in the artificial or chicken manure medium, but they failed to emerge. This means that these JH active compounds had no direct effect on eggs at this concentration, and the results given in Table 3 are the activities cumulative through the stages from the egg to the pupa. When houseflies were exposed to these com-

pounds in the media from the egg stage, stability of the compounds is essential for the inhibition of adult emergence. In the artificial medium method, the activity of S-31183 against eggs decreased to one-third compared with that against 4-day-old larvae. The activity of methoprene against eggs also decreased to 1-4th compared with that against 4-day-old larvae. This means that S-31183 was slightly more stable than methoprene in the artificial medium. In the chicken manure medium method, the activity of S-31183 against eggs decreased to 1-4th of that against 4-day-old larvae. The activity of methoprene decreased to 1/23. This means that S-31183 was more stable than methoprene in the chicken manure medium, and these compounds were less stable in the chicken manure than in the artificial medium. The chicken manure medium seems to reduce the activity of S-31183 and methoprene more quickly than the artificial medium, as time elapses after treatment, by pH, degradation by microorganisms, and so on.

When larvae of mosquitoes or houseflies were treated with S-31183, they were killed at the pupal stage or they failed to emerge into adults in the same way as S-21149, S-21150, and other JH active compounds (Spielman and Williams, 1966; Morgan and LaBreque, 1971; Morgan *et al.*, 1975; Steelman *et al.*, 1975; Hatakoshi *et al.*, 1986).

In summary, S-31183 is a strong IGR against larvae of mosquitoes and houseflies, and should be of practical use for control of these insects.

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摘 要

2-[1-methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine のメソプロレンおよびハエ幼虫に対する室内評価

新規幼若ホルモン活性化合物 2-[1-methyl-2-(4-phenoxyphenoxy)ethoxy]pyridine の *Culex pipiens pallens*, *Anopheles stephensi*, *Aedes aegypti*, *Musca domestica* に対する羽化阻害活性を室内で評価した。その結果、S-31183 は *Cx. p. pallens*, *An. stephensi*, *Ae. aegypti* 終齢幼虫に対し、メソプロレン、ジフルベンズロン、テメフォス以上の活性を示した。また、S-31183 は *M. domestica* 4日齢幼虫に対し、人工培地でメソプロレン、ジフルベンズロン以上の、卵および4日齢幼虫に対し、鶏糞培地でメソプロレン以上の活性を示した。