A CONTROLLING EFFECT OF A JUVENILE HORMONE ANALOGUE ON *EPHESTIA CAUTELLA* (WLK.) BY NON-DIRECT APPLICATION

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INTRODUCTION: The effects and feasibility of juvenile hormones (JH) and of juvenile hormones analogues (JHA) as control agents for stored product insects has been extensively studied and reviewed (3, 4, 5, 6, 15; for more references, see 13). The insect specificity revealed by these control agents, the non-toxicity to warm-blooded animals (1), and their non-toxic degradation products (12), offer some advantages especially where toxic insecticide residues are of great significance, e.g. in stored food. Some of the main difficulties in using JHA for the control of stored product insects stems from two facts:

(a) The insects comprising the multi-species community that is usually associated with stored products differ in their susceptibility (13, 14, 16);
(b) The different species differ also in their behaviour and distribution within a grain bulk or a stack of bags--a fact that complicates even more the logic of JHA application.

One of the most common stored product pests, against which some JHA have been shown to be effective, is the almond moth, *Ephestia cautella* (Wlk.). The efficiency of controlling *E. cautella*, as well as other stored product moths with JHA, has been demonstrated mainly by mixing the JHA with the food substrate (3, 4, 5, 14). Another possible approach could be to take advantage of a fundamental biological difference between *E. cautella* and most other stored product insects, i.e., the fact that the fully grown larvae, as well as the deposited eggs of *E. cautella*, come in contact with the surface of the infested bulk.

The purpose of these experiments was, therefore, to evaluate the effectiveness of a JHA for the control of *E. cautella* experimental populations that either received direct sprays or were brought into contact with previously treated surfaces.

MATERIALS AND METHODS: The insects were reared on ground wheat (12% m.c.) mixed with glycerin (12% w/w). Rearing and experimental conditions, unless otherwise specified, were 26±1°C and 70±5% R.H.

The JHA used was Altosid SR10 (Zoecon, Palo Alto, California). It contained 10% of the active ingredient isopropyl 11-methoxy-3,7,11 - trimethyl-2,4 dedecadienoate. Dilutions to desired concentrations were made in distilled water.

(a) Effect on eggs. Filter paper discs (Whatman No. 1) were sprayed with doses of 0.6-73.7 mg/m^2. After the paper discs dried out, each disc was placed in a petri dish which contained 10 g of rearing medium. To avoid contact between the treated filter paper and rearing medium, 20 polyethylene tubes (2 mm in diameter and 10 mm in length) were placed on top of the rearing medium. These tubes served later as pupation sites. Twenty 0-24 h-old eggs were placed on each filter paper disc. The discs were removed after completion of egg hatch. Five replicates were used for each tested dose. Emerging adults were counted.

(b) Effect of direct spraying on last instar larvae. Plastic vials of 250 ml each were lined with tissue paper. Ten last instar larvae were introduced into each of four vials for each tested dose. The tissue paper, with the larvae on it, was sprayed with doses ranging from 0 to 6.6 mg/m^2 of vial surface. Emerging adults were counted until emergence stopped.

(c) Effect of contact with a sprayed jute surface. Six small jute sacks were filled with unshelled peanuts - 100-115 g in each - and placed into each of twenty-eight 20-l metal containers. The external surfaces only of the jute sacks were sprayed with the JHA at rates ranging between 0.22 to 221.7 mg/m^2. Four replicates were used for each dose. One hundred *E. cautella* eggs, 0-24 h-old, were dispersed in each of the containers. Adult emergence was recorded from its onset until cessation.

(d) Persistence of the JHA activity on a sprayed surface under two temperature conditions. Vials lined as described above were sprayed with 6.6 mg/m^2 and kept at 18° and 26°C for periods ranging between 3 and 120 days. After the desired periods, ten last instar larvae were introduced into each of four replicate vials at each of the two temperatures. The vials with the larvae were returned to 26°C and adult emergence was recorded.

RESULTS:

(a) Effect on eggs. The effect of contact of *E. cautella* eggs with a JHA sprayed surface on the subsequent development of adults, is demonstrated in Table 1. No meaningful reduction in number of adults that developed from eggs that were in contact with a sprayed surface could be detected up to a dose of 14.7 mg/m^2. The higher doses tested reduced the number of developing adults by about 60%.

(b) Effect of direct spraying on last instar larvae. As shown in Figure 1, complete mortality at larval or pupal stages was induced by a dose of 6.6 mg/m^2. The treatment also caused a delay of up to 3 months in the pupation process, especially at the

Table I. *E. cautella* adult development (% of control±S.E.) from eggs in contact with a JHA-sprayed surface

Adult development	JHA dose (mg/m^2)						
	0.6	1.2	1.8	6.6	14.7	44.2	73.7
	97.9 ±1.5	97.1 ±0.4	98.9 ±1.1	89.7 ±6.3	84.1 ±3.3	44.3 ±10.0	40.9 ±7.0

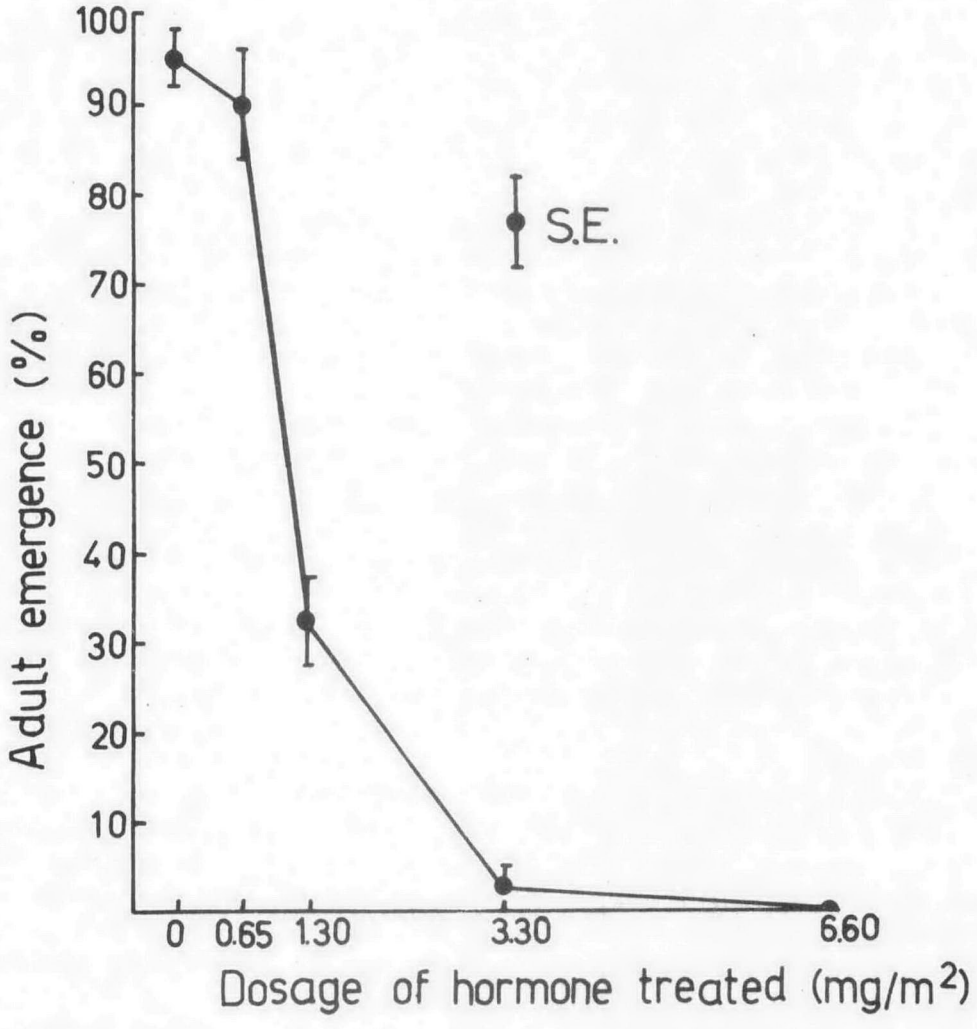

Figure 1. Emergence of *E. cautella* (%) from last instar larvae treated with juvenile hormone analogue.

three higher doses tested (Table II). The mortality of larvae treated with 1.3-6.6 mg/m^2 rose gradually over this extended period, starting 1-2 days after treatment (Table II).

Table II. Mortality of *E. cautella* last instar larvae treated with a JHA, and adult emergence (%)

JHA dose (mg/m^2)	Mortality of larvae after		Mortality of pupae and intermediate forms (%)	Adult emergence (%)
	1-2 days (%)	2-3 months		
0	0	0	5.0	95.0
0.65	0	0	10.0	90.0
1.30	7.5	32.5	27.5	32.5
3.30	22.5	55.0	20.0	2.5
6.60	22.5	50.0	27.5	0

(c) Effect of contact with a sprayed jute surface. As the outer surface only of the jute sacks had been treated, the chances of the larvae coming into contact with it were limited. The effect of this limited contact on the proportion of insects reaching the adult stage, is recorded in Table III.

Table III. The effect of JHA spraying of the exterior of small jute sacks containing peanuts, on completion of the life cycle of *E. cautella* (% of control±S.E.)

	Dose of JHA (mg/m^2)						
	0.22	0.66	1.47	14.75	44.20	73.75	221.75
Insects completing life cycle	93.0 ±0	58.5 ±17.3	26.1 ±4.4	18.3 ±2.3	1.7 ±1.0	2.0 ±2.0	0

A dose of 44.2-73.7 mg/m^2 was required to achieve 96-98% control. The higher dose tested - 221.7 mg/m^2 - resulted in complete suppression of development to the adult stage. However, it is presumed that this result could be achieved with a lower dose.

d. Persistence of the JHA activity at two temperatures. The difference in the rate of loss of bioactivity at the two temperatures tested, is presented in Figure 2. The JHA retained its activity for a longer period at 18° than at 26°C. The selected dose - 6.6 mg/m^2 - retained its full activity for 3 and 5 days only at 26° and 18°C, respectively. At 18°C it retained 90% of its activity for 45 days, and at the end of 120 days it prevented 76% of adult development. At 26°C, the activity was reduced to 80% after three days only, and thereafter the reduction in activity was rapid and declined to 35% after 120 days.

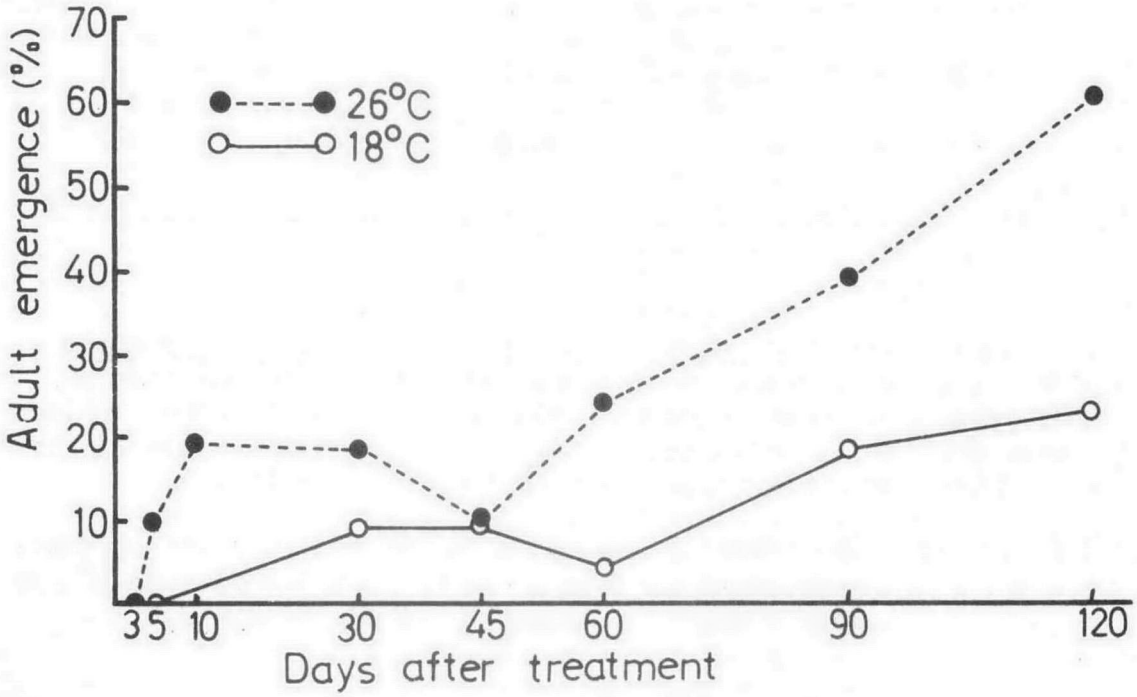

Figure 2: Biological activity persistence of an insect juvenile hormone which was sprayed on a paper surface and kept at two temperatures (at 6.6 mg/m^2)

DISCUSSION: A dose of 6.6 mg/m^2 was sufficient to prevent adult development not only in the case of direct application to last instar larvae (Figure 1), but also when contact between untreated larvae and a treated surface was formed within 3-5 days after application, depending on the temperature (Figure 2). Similar positive results were obtained by other workers (2, 15), who treated pupation sites only. This high sensitivity of the larvae

could not be reproduced in the small jute sacks experiment, in which the contact between the maturing larvae of the treated surfaces was formed 3-4 weeks after application of the JHA. A number of factors could contribute to the difference between these two sets of results. In the first experiment, the larvae were in constant contact with the treated surface and could not avoid it. In the jute sack experiment, the contact was probably not a constant one, as the larvae could move freely from treated surfaces--the jute sacks--to untreated places--the peanuts inside the sacks as well as the container's walls. The importance of such factors such as constant contact and the extent of contact with treated materials, in interfering with the normal course of development, has been demonstrated for *Plodia interpunctella* larvae (11). In addition, the reduction in bioactivity of the JHA contributed to the lower effectiveness of the treatment and to the need of much higher doses--73-221 mg/m^2--for achieving complete arrest of adult development. The rapid reduction in bioactivity is supported by similar published results on the compound's degradation when applied to wheat grains (9), although the main factors known to cause breakdown of such compounds (3) were not present.

The sensitivity of eggs was less than that of larvae and less than what could be expected on the basis of published results on insect egg sensitivity (7, 8, 10). However, the differences in the experimental conditions--mainly younger eggs and the direct application used by the above mentioned authors--as well as differences in species sensitivity, might account for these differences.

The results obtained in these experiments demonstrated that the concept of treating surfaces with which susceptible life stages of the insect come into contact, could be feasible. However, further experiments, probably with special formulations with a slower degradation rate, under warehouse conditions, are necessary.

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