

Potential of Fenoxycarb on the Growth Duration and Longevity of Adults of Rice Moth, *Corcyra Cephalonica* Staint. (Lepidoptera: Pyralidae) Exposed as Second Instar Larvae

Tiwari Sk*

Department of Zoology, D.D.U. Gorakhpur University, India

***Corresponding author:** Shri Krishna Tiwari, Department of Zoology, D.D.U. Gorakhpur University, Gorakhpur- 273009, Uttar Pradesh, India, Tel: 07705985710; Email: sktzddu@rediffmail.com

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Abstract

The rice moth, *Corcyra cephalonica* Stainton is a notorious pest of stored cereals and cereal commodities in Asia, Africa, North America, Europe and other tropical and sub-tropical regions of the world. Attempts were made to control this lepidopterous pest with the application of an Insect Growth Regulator (IGR) Fenoxycarb, a juvenile hormone analogue which affects the growth and development of the insect, and thus, reducing the pest population in socio-economically and environmentally safe and suitable way. *Corcyra cephalonica* larvae, at second instar level, were exposed to 0.001, 0.005, 0.01, 0.05, 0.10, 0.50 and 1.00 ppm concentrations of Fenoxycarb. It was observed that increased concentrations of Fenoxycarb caused a significant ($P < 0.01$) enhancement in growth duration, due to its juvenoids action, and an insignificant reduction in adult longevity in both the sexes of this pest, causing adverse effect on adult emergence, so, reduces pest population without harming mammalian population including human being and environment as well as non-target organisms. Thus, it may be concluded that Insect Growth Regulators may be applied as an insecticide for the effective control of *Corcyra cephalonica*.

Keywords: *Corcyra Cephalonica*; Fenoxycarb; Growth Duration; Longevity

Introduction

Control of insect pests is a puzzling problem since many decades. *Corcyra cephalonica* Stainton, commonly known as rice moth, is a severe pest of stored cereals and cereal products in Asia, Africa, Europe, North America and other tropical and subtropical regions of the world. Its larval stages cause serious damage to rice, gram, sorghum, maize, groundnut, cotton seeds, peanuts,

linseeds, raisins, nutmeg, currants, chocolates, army biscuits and milled products [1-4].

Ordinarily, the control measures in stores are based on fumigation with chemicals like hydrogen phosphate. Residues and insect resistance are reasons for potentially limiting the use of fumigation with chemicals in the near future. In recent years, there has been great concern over the toxicity of pesticides on non-target organisms and the environment. Although, chemical pesticides are

invaluable in controlling insect populations both in the field and storage, their indiscriminate use has resulted in the destruction of beneficial insects and has caused environmental hazards [5-7]. Moreover, insecticide resistance has already developed in many insects which is now a great concern in post-harvest ecosystems throughout the world [8,9].

In such condition, there is a need for new alternatives to traditional insecticides used in stored product pest management [9-11]. In this regard, the insect growth regulators which mimic insect's hormone and regulate the insect population through the disruption of moulting and metamorphosis have captured the interest of stored product entomologists [12-14]. The first use of IGRs against stored product pests was tested on a small number of insect species [15]. The term IGR was designed and described as a class of bio-rational compounds [16]. Through selectivity of action, these compounds appear to fit the requirements for "Third Generation Pesticides" that disrupt the normal development of several species of insects [13,17]. These compounds are highly effective against various insects attacking stored products and other pests that have become resistant to organic insecticides. Meanwhile, all these compounds are less toxic to mammals and non-target organisms because of their non-toxic effect and their quick disintegrating abilities [14,16,18-22].

Recently, a new term "Insect Growth Disrupters" has been proposed instead of "Insect Growth Regulators" [23]. At present time, a famous statement, "Third Generation Pesticides" has been made in describing the use of JHs as environmentally safe control agents to which the insect will be unable to develop resistance [13]. The development of highly potent synthetic analogues of JH, which were several fold more active than the native hormone, gave credence to William's claim [13]. Role of JHAs on the growth duration of insects have also been reported in different insect species like *C. cephalonica* exposed to methoprene [24], resistant strains of *Tribolium castaneum* treated with methoprene [22], *Plodia interpunctella* following exposure of pyriproxyfen [25], *Eurygaster integriceps* treated with pyriproxyfen [26], cowpea weevil, *Callosobruchus maculatus* exposed to hydroprene [27]. Adult longevity has also been found to be influenced by the exposure of IGRs as observed in case of *Tenebrio molitor* treated with diflubezuron [28], *C. cephalonica*, *C. maculatus* and *T. castaneum* exposed to methoprene and hydroprene [29], *Rhizopertha dominica*, *Sitophilus oryzae* and *T. castaneum* following treatment with methoprene and pyriproxyfen [22], (*Plodia*

interpunctella treated with pyriproxyfen [25], *E. integriceps* exposed to pyriproxyfen [26], *T. castaneum* and *T. confusum* following treatment with methoprene [30].

Scientific contribution in relation to juvenile hormone analogues (JHAs) influencing developmental stages of *C. cephalonica* has been explored but their potential on growth duration and adult longevity is completely wanting [31]. The acquisition of such knowledge in this area becomes essential for a comprehensive appreciation of the physiological and ecological relationship that exists between this pest and its host material (stored cereals and cereal commodities). This knowledge in turn, is likely to generate new insights into devising ways and means for controlling *C. cephalonica*, by disrupting its metabolic frame work so that evolution of a new generation of this pest for the eventual establishment on stored cereals and cereal products can be considerably restricted. Hence, as an objective of such programme the present work for the first time, has been designed and conducted to examine into the impact of a juvenile hormone analogue (JHA) i.e. Fenoxycarb on the growth duration and adult longevity of rice moth, *C. cephalonica*.

Materials and Methods

Corcyra cephalonica Stainton adults were obtained from already existing laboratory stock culture maintained on normal dietary medium composed of coarsely ground jowar (*Sorghum vulgare*) mixed with 5% (w/w) powdered yeast inside large glass containers (150 mm diameter, 200 mm height) at temperature $26 \pm 10^{\circ}\text{C}$, relative humidity (R.H.) $93 \pm 5\%$ and a light regime of 12 h light and 12 h darkness. Such a standard culture was maintained throughout the year.

From the above culture whenever needed, newly emerged males and females were transferred to oviposition glass chambers (35 mm diameter, 200 mm height). Since *C. cephalonica* individuals do not feed during their adult stage, no food was provided to them during their confinement in these vessels. Eggs laid by the females were collected and then placed in glass chambers (consisting of 250 ml beakers) with the help of zero number camel hair brush for hatching.

Fenoxycarb ethyl[2-(4-phenoxy-phenoxy)-ethyl]carbamate, molecular formula- $\text{C}_{17}\text{H}_{19}\text{NO}_4$, a non terpenoid juvenile hormone analogue, P-686N, Lot-20071 used throughout the experiment, was obtained from AccuStandard, New Haven, CT 06513, USA Figure 1.

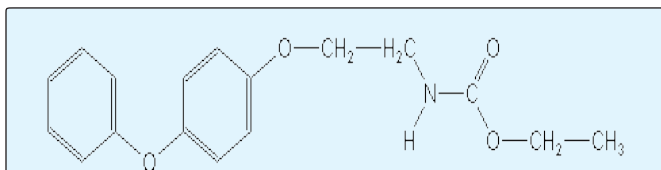


Figure 1: Fenoxycarb; Ethyl [2-(4-phenoxy-phenoxy)-ethyl] carbamate.

Experimental Design

Different concentrations of Fenoxycarb, in dietary media, were prepared. For this purpose, a stock solution of known concentration of this JHA was prepared by dissolving it in acetone and then adjusted via serial dilutions to achieve its required concentrations. Now, required volume of different concentrations of Fenoxycarb was thoroughly mixed with the required quantity of normal food (roughly ground jowar mixed with 5% w/w yeast powder) to get different desired concentrations i.e. 0.001, 0.005, 0.01, 0.05, 0.10, 0.50 and 1.00 ppm of Fenoxycarb in dietary media. This treated food was then air dried at room temperature to eliminate completely the acetone. For control purposes, the normal food was thoroughly mixed with a required volume of acetone similar to that of treated food and then air dried in the same way.

For evaluation of growth duration, at each concentration of Fenoxycarb, freshly hatched larvae of *C. cephalonica* were allowed to feed on a normal dietary medium for exactly nine days and on the 10th day, 25 second instar larvae were transferred to each rearing chamber containing 50 g of dietary medium mixed and treated separately with different known concentrations of Fenoxycarb. On completion of life-cycle, when adults emerged, their growth duration of both sexes was

recorded (Table 1). The longevity of adults emerged from these treated food were also recorded from day of emergence to day of death of males and females (Table 1).

Experiments were replicated six times and the values have been expressed as mean \pm SEM in days. Straight line regression equation was applied manually between different concentrations of Fenoxycarb and their corresponding growth duration of males and females and longevity of adults to observe the significant correlation [32].

Results

In the present study, the growth duration of control male moth was found to be 37.83 ± 0.70 days while that of female moth was recorded 40.83 ± 0.87 days which significantly increased with increase in concentrations of Fenoxycarb. At 0.001 ppm concentration the growth duration of male and female was 41.33 ± 0.67 and 43.83 ± 1.01 days respectively which increased to 85.17 ± 1.81 and 86.50 ± 1.98 days for males and females respectively at 0.10 ppm concentration of Fenoxycarb (Table 1).

In case of control males, the adult longevity was found to be 13.67 ± 0.33 days, which significantly reduced to 11.50 ± 0.43 days at 0.001 ppm and 5.50 ± 1.48 days at 0.10 ppm concentrations of Fenoxycarb respectively. The longevity of control females was recorded as 8.67 ± 0.33 days, which also reduced with increasing concentrations of Fenoxycarb. At 0.001 ppm concentration of Fenoxycarb the longevity of female was 8.00 ± 0.52 days which reduced to 4.17 ± 1.05 days at 0.10 ppm concentration of Fenoxycarb. In addition at 0.05 and 0.10 ppm concentrations of Fenoxycarb many of emerged adults were died within 24 h of their emergence (Tables 1 & 2).

Fenoxycarb concentration (ppm)	Growth duration [#] of males (Days)	Growth duration [#] of females (Days)	Adult longevity [#] of males (Days)	Adult longevity [#] of females (Days)
Control	37.83 ± 0.70	40.83 ± 0.87	13.67 ± 0.33	8.67 ± 0.33
0.001	41.17 ± 0.87^c	42.83 ± 0.60	11.50 ± 0.43^b	8.00 ± 0.52
0.005	43.50 ± 1.52^b	46.83 ± 1.60^b	11.33 ± 0.49^b	7.33 ± 0.49^c
0.01	51.83 ± 1.58^a	53.83 ± 1.14^a	10.33 ± 0.49^a	6.67 ± 0.56^c
0.05	78.17 ± 1.36^a	80.17 ± 0.98^a	6.00 ± 1.67^b	4.50 ± 1.15^b
0.1	85.17 ± 1.81^a	86.50 ± 1.98^a	5.50 ± 1.48^a	4.17 ± 1.05^b
0.5	$90.17 \pm 2.41^{a*}$	$90.17 \pm 2.41^{a*}$	-	-
1	$103.67 \pm 2.95^{a*}$	$103.67 \pm 2.95^{a*}$	-	-

#Values are expressed as mean \pm SEM of six replicates.

Table1: Effect of Fenoxycarb on growth duration and longevity of adults of rice moth, *C. cephalonica* exposed as second instar larvae.

a, b, c and d significantly different $p < 0.001$, $p < 0.01$ and $p < 0.05$ respectively compared control when t- test was applied.

Straight line regression equation was applied between different concentrations of Fenoxycarb and their corresponding growth duration of males and females and longevity of adults to observe the significant correlation:

Growth duration of males	$y = 42.98 + 480.53x$;	$r = 0.95$	$p < 0.01$
Growth duration of females	$y = 45.54 + 468.43x$;	$r = 0.95$	$p < 0.01$
Longevity of male adults	$y = 11.76 - 73.74x$;	$r = - 0.90$	$p < 0.05$
Longevity of female adults	$y = 7.71 - 41.71x$;	$r = - 0.90$	$p < 0.05$

*Larval tenure since adults did not emerge, so these concentrations have not been accounted in correlation.

Table 2: Concentrations of Fenoxycarb and their corresponding growth duration of males and females.

It is notable that at 0.50 and 1.00 ppm concentrations of Fenoxycarb larval period was much prolonged which lead to production of giant larvae, supernumerary larvae and their average life-span was recorded to be 90.17 ± 2.41 and 103.67 ± 2.95 days respectively. These larvae did not emerge as adults so whether these were male or female could not be determined.

Discussion

Juvenile Hormone Analogue (JHA) as a whole disrupts insect metamorphosis, hence, the developmental time for pupation and adult exclusion are considerably increased. Due to prolongation of larval period there was delayed pupation or adult emergence. Hence, overall duration of growth period was found to be increased with increase in the concentration of Fenoxycarb (Table 1). A short exposure to IGRs at definite instars of insect larvae would not affect the developmental time but a long exposure usually showed profound effects [33]. In the previous investigation, application of Fenoxycarb to the first instar larval stage of *C. cephalonica* caused significant influence on its growth duration i.e. the time elapsing between egg laying to adult emergence [31,34]. Similarly, methoprene at a dose level of 10 and 100 μg also influenced the time required for emergence of *C. cephalonica* when treated at 0-24 h old larval stage [24], but methoprene at a concentration of 0.5 ppm was found to be poorly effective in case of resistant strains of *T. castaneum* while its 0.1

ppm concentration was not effective [22]. Pyriproxyfen, a Fenoxycarb derivative juvenile hormone analogue, with increased concentrations also increased growth duration effectively in case of the *P. interpunctella* even at poor concentrations [25], but the same compound was found to be poorly effective in case of *E. integriceps* [26]. Prolongation in the developmental period of *C. maculatus* has also been reported following exposure of hydroprene [27]. From these reportings, it is evident that toxicity of IGRs to developmental stages of insects is species specific. Since, in the present investigation, the duration of Fenoxycarb exposure to the second instar larvae was less in comparison to that of first instar treated larvae [34], hence, the growth duration was found to be maximum in case of first instar treated larvae. Thus, even at the same concentration of Fenoxycarb the growth duration of the insect increases with the decrease in the age related duration of exposure. Fenoxycarb when exposed to second and third instar larvae of European corn borer, *Ostrinia nubilalis* had no significant effects on the duration of these instars while the duration of the first instar treated larvae increased significantly [12].

It is noteworthy that in the present investigation growth duration of female was slightly longer than male in control as well as in treated groups. In all the instars maximum larval duration was achieved at 1.00 ppm concentration of Fenoxycarb which was 105.67 ± 3.51 days in case of first instar and 103.67 ± 2.95 days in second instar treated larvae [34] (Table 1). The intensity of increase in larval duration was decreased with older instar larval treatments as at 1.00 ppm concentration of Fenoxycarb larval duration was 102 ± 2.66 and 97.17 ± 2.96 days for third and fourth instars respectively [31]. These larvae remained as larvae and after variable periods they stopped feeding and movement, turned black and eventually died.

In the present work, the longevity of *C. cephalonica* adults emerged from Fenoxycarb treated larvae was significantly reduced (Table 1). Earlier findings suggest that in the control, adult longevity was 13.50 ± 0.42 days for males and 8.50 ± 0.43 days for females whereas the longevity of adults emerged from first instar larvae treated with 0.10 ppm Fenoxycarb was 5.00 ± 0.86 days for males and 4.00 ± 0.97 days for females [31,34]. Similar findings were reported following the exposure of 0.3 ppm pyriproxyfen to *P. interpunctella* and *E. integriceps*. When 6-day-old *T. molitor* pupae were treated with 0.1 μg JHA, adult life span was reduced to 4-6 days against the normal i.e. 14-16 days [11,12,26]. Methoprene and hydroprene also at the concentrations of 0.25, 0.5, 1 and 2 ppm

reduced longevity in case of *C. cephalonica*, *C. maculatus* and *T. castaneum* [29]. However, methoprene and pyriproxyfen act in a different way i.e. they have no effect on the life-span of *R. dominica* and *S. oryzae*, but have a profound effect on *T. castaneum* [22].

IGRs are not toxic to the adults themselves but long exposure to the early larval stages cause disruptions in the organ systems or interrupts adult ecdysiast and reduces the adult life-span [35]. Fenoxycarb reduced adult life-span in other species than did malathion in stored rice [36]. *T. castaneum* and *T. confusum* develop successfully when treated at late instar larval stage with methoprene (30). It was further reported that for *T. castaneum*, survival time for individuals exposed to methoprene was shorter than those exposed to control individuals, but the difference was significant for *T. confusum*.

Adult longevity also depends on healthy immature stages. Digestive disorders such as starvation, disturbance in metabolism, degeneration of peritrophic membrane and accumulation of faecal materials at the hind gut may be the cause of untimely adult mortality as observed in *T. molitor* exposed to BPU and *T. castaneum* treated with triflumuron [5,28]. Mean longevity of mated adults treated with 10 ppm IGR (juvenoids and BPUs) was decreased compared to untreated and unmated adults in *P. interpunctella* whereas the tested IGRs lengthened life-span of the mated adults of *C. cephalonica* [37]. The toxic effect of Fenoxycarb might be responsible for the reduction in the longevity of adults from treated culture. The longevity of adults has also been found to be increased with the increase in the age related duration of treatment. Adults emerged from first instar larvae treated with Fenoxycarb survived for shortest time in comparison to those adults emerged from second, third and fourth instars treated larvae [31,34].

Conclusion

On the basis of the present investigation it is obvious that as the concentration of this IGR i.e. Fenoxycarb increases a significant enhancement in growth duration and an insignificant reduction in adult longevity in both the sexes of this pest occurs. Correlating with earlier work [37], it may be suggested that Fenoxycarb should be applied to early stage of the larvae (I instar), so that the tenure of exposure of this insecticide may be maximum to cause severe effect on the growth and development of this insect, reducing its population in severe way Thus, Fenoxycarb may be applied for the effective control of rice

moth *C. cephalonica* in particular and lepidopterist pests in general.

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