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Sublethal effects of penfluron on the feeding physiology of *Papilio demoleus* Linn (Lepidoptera: Papilionidae)†

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Abstract. Topical and oral application of penfluron to *Papilio demoleus* Linn indicated that 7·6 μg of penfluron was needed through topical method to produce 50% mortality. Penfluron treatment caused a marked reduction in growth to a significant level of 42% in oral administration at dose 1·96 μg and 35% in topical application at sublethal dose 1·52 μg over that of control larva. The efficiency of *Papilio demoleus* to grow on citrus plant was very much affected.

Keywords. Penfluron; *Papilio demoleus*; growth rate; growth efficiency; food utilization.

1. Introduction

Papilio demoleus Linn (Lepidoptera: Papilionidae) is a serious pest of citrus plant, *Citrus limonum*. Studies on the damage potential by this pest to the citrus plant indicated a heavy rate of defoliation of plant to the tune of 4837 mg/g body weight of larvae in a day (Somasundaram 1985). The present study evaluates the potential use of penfluron, an analogue of chitin inhibitor diflubenzuron, through its effect on the food utilization efficiency and growth of *P. demoleus*.

2. Materials and methods

The larvae of *P. demoleus* were collected from the field and reared in the laboratory on leaves of *C. limonum* under LD 12:12 and temperature 30 ± 1°C at 80 ± 10% rh. 4 h old final instar larvae were used in the experiment.

2.1 *Bioassays*

Penfluron, chemically known as 1-(2, 6-diflurobenzoyl)-3-(4-trifluromethyl phenyl) urea was obtained as a 25% (w/w) wettable powder formulation from Duphar B V, Netherlands and used. Solutions of different strengths of penfluron (active ingredient) were prepared by dissolving in water. LC_{50} and LD_{50} of penfluron for *P. demoleus* for a 48 h period were calculated by plotting the progress of mortality and time of exposure to penfluron on log probit paper. Based on these lethal concentrations, 3 sublethal doses of penfluron were prepared and used for topical and oral experiment.

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For oral administration experiment, larvae were allowed to feed on penfluron treated leaves for one day and then untreated leaves were offered for the remaining larval period. For topical application experiment, larvae were treated with penfluron and they were allowed to feed on untreated leaves till the completion of larval period. For control experiment, larvae were fed on leaves without treatment of penfluron. Each experiment was replicated 5 times. The impact of penfluron was assessed based on conversion and utilization efficiencies of feeding on the host plant, *C. limonum*.

2.2 *Calculation of feeding efficiencies*

The following food conversion and utilization efficiencies were calculated as described by Waldbauer (1968) and Petrusewicz and MacFadyen (1970).

Relative consumption rate (RCR) = mg biomass eaten/g larval biomass/day.

Relative growth rate (RGR) = mg biomass gained/g larval biomass/day.

$$\text{Approximate digestibility (AD)} = \frac{\text{Assimilation (mg dry wt)}}{\text{Consumption (mg dry wt)}} \times 100.$$

$$\text{Efficiency of conversion of digested food (ECD)} = \frac{\text{Growth (mg dry wt)}}{\text{Assimilation (mg dry wt)}} \times 100.$$

3. Results

3.1 *Toxicity*

The efficacy of penfluron was investigated by oral and topical administrations. LD_{50} and LC_{50} values of penfluron for fifth instar larvae of *P. demoleus* were 9·8 and 7·6 μg/larva/48 h respectively. Of the two modes of application topical application produced 50% mortality at a very minimum dose of 7·6 μg.

Table 1. Effect of sublethal doses of penfluron on the food utilization in the fifth instar of *P. demoleus*.

Treatment (μg)	Consumption	Assimilation	Growth	Metabolization
Control	1825·26 ± 172·20	695·26 ± 59·00	169·87 ± 15·00	525·39 ± 51·14
Oral				
0·33	2658·25 ± 251·12	1079·25 ± 101·00	160·00 ± 14·70	919·25 ± 70·00
0·98	1941·85 ± 180·90	979·20 ± 89·00	136·04 ± 13·00	843·16 ± 81·40
1·96	1897·46 ± 169·70	779·85 ± 78·60	99·42 ± 8·40[b]	680·43 ± 62·70
Topical				
0·25	1965·14 ± 178·15[a]	895·28 ± 82·30	158·00 ± 14·90	737·28 ± 70·00
0·76	1860·20 ± 180·00	796·12 ± 772·60	130·60 ± 12·70	665·52 ± 58·60
1·52	1560·20 ± 145·20	705·12 ± 69·75	110·20 ± 10·00[b]	594·92 ± 55·45

All values are expressed in mg/individual. $\bar{X} \pm SD$.
[a]$P < 0{\cdot}1$; [b]$P < 0{\cdot}001$.

Table 2. Effect of sublethal doses of penfluron on the food utilization in fifth instar of *P. demoleus*.

Treatment (μg)	Relative consumption rate (RCR)	Relative growth rate (RGR)	Approximate digestibility (AD)	Growth efficiency (ECD)
Control	392·19 ± 32·15	36·49 ± 6·10	38·09 ± 5·00	24·43 ± 4·23
Oral				
0·33	695·88 ± 67·00	41·88 ± 3·50	40·60 ± 3·00	14·83 ± 2·00
0·98	585·28 ± 56·00	41·04 ± 4·00	50·43 ± 5·00[a]	13·89 ± 1·65
1·96	639·74 ± 61·00	33·52 ± 2·90	41·09 ± 6·00	12·75 ± 1·45[a]
Topical				
0·25	560·51 ± 53·00	45·07 ± 5·00	45·56 ± 3·00	17·65 ± 2·95
0·76	583·13 ± 58·10	40·94 ± 4·00	42·80 ± 5·40	16·40 ± 2·20
1·52	456·47 ± 46·14	32·24 ± 3·75	45·19 ± 4·80[b]	15·63 ± 1·25[a]

Rates are in mg/g/day and efficiencies in percentage. $\bar{X} \pm SD$.
[a]$P < 0{\cdot}001$; [b]$P < 0{\cdot}01$.

3.2 *Food utilization*

The results on feeding budget of *P. demoleus* indicate a greater quantity of food consumption in larvae subjected to both oral and topical administration of penfluron and also an enhanced consumption rate (RCR), growth rate (RGR) and assimilation efficiency (AD). However, growth efficiency (ECD) of larvae in both the treatments showed a significant decline compared to that of control (tables 1 and 2). Larvae of *P. demoleus* either treated with or feeding on maximum sublethal doses of penfluron gained significantly lesser weights, 110 and 99 mg, compared to control larva which gained 170 mg (table 1). These differences are statistically significant as shown in the following regression equation:

Topical application:

$$\text{Growth} = 163{\cdot}97 - 36{\cdot}80 \text{ penfluron}$$
$$r = -0{\cdot}9806;\ P < 0{\cdot}1.$$

Oral administration:

$$\text{Growth} = 172{\cdot}25 - 37{\cdot}09 \text{ penfluron}$$
$$r = -0{\cdot}9988;\ P < 0{\cdot}05.$$

4. Discussion

4.1 *Toxicity*

The LD_{50} and LC_{50} values of 9·8 and 7·6 μg/larva/48 h showed that those doses of penfluron compound required to cause 50% mortality to an oligophagous pest, *P. demoleus* are considered to be very minimum when compared to those values recorded for a polyphagous pest, *Pseudoplusia includens* (43·9 μg) (Reed and Bass 1980) and for a monophagous pest, *Ergolis merione* (27·76 μg) (Chockalingam and Krishnan 1984). Such a comparative account on the efficacy of chitin synthesis inhibitor compounds delineates the point that *P. demoleus* is more sensitive to penfluron than to its parental compound diflubenzuron (Somasundaram and Chockalingam 1988).

4.2 *Food utilization*

An enhanced level of food consumption observed at sublethal quantity of penfluron administered to *P. demoleus* either through topical or oral method may be to ensure intake of more food energy for its utilization at a later time to meet the impending energy demands that are likely to be warranted by toxic stress. Reports on the efficacy of diflubenzuron on the feeding physiology of monophagous pest, *E. merione* and an oligophagous pest, *P. demoleus* seem to be in conformity with the present findings of enhanced food consumption (Chockalingam and Krishnan 1984; Somasundaram and Chockalingam 1988). Similar report of higher consumption of food has also been recorded in cabbage webworm, *Crocidalmia binotalis* fed on a growth regulator compound, azadirachtin (Fagoonee 1983). The efficiency of *P. demoleus* to assimilate the food substances increased as the dosage of penfluron applied on the insect or fed along with food became higher. Such an increase in assimilation efficiency (AD) has already been reported in *Achaea junta* feeding on insecticide treated leaves (Ramdev and Rao 1980). Working on the effect of diflubenzuron on the feeding physiology of *P. demoleus* a similar kind of finding of an increase in AD with increasing dosage of diflubenzuron compound was drawn (Somasundaram and Chockalingam 1988). And this sort of increase in assimilation efficiency might be due to retention of food material in the gut for longer time (Mattson 1980). This might be due to a feeble peristaltic mobility of the gut caused by the action of insecticide accumulation in the alimentary tract of insects (Price 1975). However, growth and growth efficiency are lesser in all treatments compared with control experiment. Hence, it is concluded that higher consumption generally leads to poor growth and growth efficiency (ECD). This means that efficacy of digestive and metabolic process suffers when a lot of food is ingested. At 1·96 and 1·52 μg penfluron administered through oral and topical methods, detoxification mechanisms reach a maximum and food utilization is hindered; this is reflected in poor growth and growth efficiency (ECD). Much metabolic energy is wasted in detoxification process; nearly about 85–87% of assimilated food was utilized on metabolic activity of *P. demoleus* indicating that *P. demoleus* could divert a large part of the assimilated energy to confront with toxic stress. Lepidopterans such as *E. merione* (Chockalingam and Krishnan 1984) and *Pericallia ricini* (Krishnan 1984) expended more energy to detoxify the toxicity when exposed to various doses of diflubenzuron.

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References

Chockalingam S and Krishnan M 1984 Effects of sublethal doses of difluorobenzuron on the food utilization and growth in *Ergolis merione* (Lepidoptera: Noctuidae); *Entomon* **9** 121–126

Fagoonee I 1983 Effect of azadirachtin and of a neem extract on food utilization in *Crocidolomia binotalis*; in *Proc. 2nd Int Neem Conf.*, Rauischholzhausen, pp 211–224

Krishnan M 1984 Studies on the bioenergetics of a chosen insect pest *Pericallia ricini* (Fabricius), Ph.D. dissertation, Madurai Kamaraj University, Madurai

Mattson W J Jr 1980 Herbivory in relation to plant nitrogen content; *Annu. Rev. Ecol. Syst.* **11** 119–161

Petrusewicz K and MacFadyen A 1970 *Productivity of terrestrial animals* IBP Hand book No. 13 (Oxford: Blackwell)

Price P W 1975 *Insect ecology* (New York: Wiley)

Ramdev Y P and Rao P J 1980 Effect of sublethal dose of insecticides on consumption and utilization of dry matter and dietary constituents of castor, *Ricinus communis* Linn by the castor semilooper *Achaea junta*; *Indian J. Entomol.* **42** 567–575

Reed T and Bass M H 1980 Larval and post larval effects of diflubenzuron on the soybean looper; *J. Econ. Entomol.* **73** 332–338

Somasundaram P 1985 *Ecophysiological studies on some insects*, Ph.D dissertation, Madurai Kamaraj University, Madurai

Somasundaram P and Chockalingam S 1988 Impact of chitin synthesis inhibitor diflubenzuron on the feeding physiology of *Papilio demoleus* (Lepidoptera: Papilionidae); *Insect Sci. Appl.* (in press)

Waldbauer G P 1968 The consumption and utilization of food by insects; *Adv. Insect Physiol.* **5** 229–288