FOOD CONSUMPTION OF THE TROPICAL GRASSHOPPER, *POECILOCERUS BMTONIUS* ON THE TOXIC PLANT *CALOTROPIS PROCERA*.

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INTRODUCTION

The tropical grasshopper, *Poecilocerus bmtonius* from the wild life of Saudi Arabia Kingdom (K.S.A.), attacks alternative host plants like, *Calotropis procera* shrub, *Aizoon canarense, Zygophylum simplex* herbs and *Pulicaria crispa* shrub. But *C. procera was* the prefered plant for accepting its defensive fluid (Cardenolides), which is used as chemical defense against natural enemies. The tropical grasshopper in nature releases the white liquid (Cardenolides) of *C. procera* from the first abdominal segment. Cardenolides are almost universally described as bitter tasting (Heftmann, 1970), and this feature, combined with their potential toxicity, that has implicated cardenolides in assessment of their defensive use by plants against their natural enemies, including herbivorous, parasites and pathogens (Harborne, 1988).The grasshopper, *P. pictus* ejects this defensive fluid as an escape measure against the attack of predators (Sreenivasulu *et al*., 1996). *Poecilocerus pictus* in three villages in Madhya Pradesh, India caused high damage in vegetables. *P. pictus* appeared on *Calotropis procera* in May and migrated to vegetables in June (Singh, 1997).

The ecological triangle of insect, host plant and allelochemical constitutes a relationship with profound evolutionary implications. Individuals of the same insect species may show different host plant preference in different areas of its distribution and even individuals belonging to the same population may be much more restricted in their choices than the population as a whole (Howard *et al.*, 1994). Some oligophagous or even polyphagous insects should more appropriately be considered as monophagous when their host-plant selection is based upon a specific type of plant chemical (Klausnitzer, 1983). Polyphagous insect species may feed on a great diversity of plant species but certainly do not indiscriminately accept all green plants. *Schistocerca gregaria,* which feeds on a wide range of plants belonging to many different families, exhibits pronounced preferences for particular plants, eating some species in small amounts and others in large amount (Chapman, 1990). Specialist herbivorous are frequently limited to plants that constitute "forbidden fruits" for other phytophages because these plants contain natural products that are unpalatable and/or toxic for most other animals (Fraenkel, 1959).

Following Waldbaure's (1968) detailed review, nutritional indices became the standard tool for assessing insect food utilization; to determine how nutritional indices for insect fed leaves are affected by the experimental condition and the physiology of plant material (Bowers *et al.*, 1991). Quantitative nutritional analyses are commonly employed to evaluate larval performance on different host plants (Scrib.r and Slansky, 1981).

The purpose of this study is to evaluate the effectiveness of *Calotropis procera* plant on the consumption and development of *Poecilocerus bmtonius.*

MATERIAL AND METHODS

The first instar nymphs of *Poecilocerus bmtonius* were collected from the field and reared on the milk weed, *Calotropis procera* (Delvi, 1983). Egg masses were incubated in a closed one litter jar at 30-33 ^{0}C until hatching. Nymphs were maintained in rearing cages measuring 120x50x54 cm at 30 ^{0}C, 50-70/o RH, and a 12:12 (L:D) cycle (ELsayed, 1998).

For quantitative nutritional determination, standard gravimetric techniques were followed (Waldbaure, 1968). Ten individual nymph females were selected randomly and reared on dried leaves of *Calotropis procera* or wheat seedlings. On the day of moulting, each third or fourth instar nymph received food weighing one third of its body. The food was replenished each day to maintain the initial quantity all the time. Each nymph was kept in a separate one litter glass jar covered with wire gauze for ventilation, and contained wet cotton wool to provide water A Petri dish for the dry food and a bamboo stick as a moulting support were provided in each jar. Fecal pellets were collected from the jar every day and kept in a deep freezer. At the end of the experiment all remains (fecal pellets and uneaten food) were dried and weighed after arrival to a constant weight to calculate nutritional indices. To estimate the dry weight of nymphs, five newly moulted third or fourth instar nymphs were weighed then dried, and re-weighed to calculate their water content. The same method for estimation of the dry weight was used for the experimental nymphs. At the end of the experiment newly emerged nymphs were dried to determine their dry weight.

Experimental cages (120 X 50 X 54 cm) were maintained at 34 ^{0}C during the day; humidity was not controlled. The following nutritional indices were calculated according to Waldbaure (1968):

$$\text{Approximate digestibility (AD)} = \frac{\text{weight (wt) of food ingested} - \text{wt of faeces}}{\text{Wt of food ingested}} \text{ X } 100 \quad (1)$$

$$\text{Efficiency of conversion of ingested food (ECI)} = \frac{\text{Biomass gained}}{\text{Wt of food ingested}} \text{ X } 100 \quad (2)$$

$$\text{Efficiency of conversion of digested food (ECD)} = \frac{\text{Biomass gained}}{\text{Wt of food ingested - wt of faces}} \text{ X100} \quad (3)$$

$$\text{Growth rate (GR)} = \frac{\text{Biomass gained}}{\text{No. Of days}} \quad (4)$$

$$\text{Relative growth rate (RGR)} = \frac{\text{Biomass gained}}{\text{Mean nymph weight XNo. of days}} \quad (5)$$

$$\text{Consumption rate (CR))} = \frac{\text{Wt of food ingested}}{\text{No. of days}} \quad (6)$$

$$\text{Relative consumption rate (RCR)} = \frac{\text{Wt of food ingested}}{\text{Mean nymph weight x No. of days food}} \quad (7)$$

Consumption initial food = Uneaten food

Assimilation = Consumption - Feces

Nutritional indices in the fourth instar nymphs were measured only on *C. procera* for comparing the consumption and assimilation in the third instar nymph with the late instar nymph (fourth instar).Data of nutritional indices were analyzed using T test at $P< 0.05$.

RESULTS AND DISCUSSION

The results of the nutritional experiment on third instar nymphs are presented in Table (1). Grasshoppers fed on *C. procera* consumed much more food than that fed on wheat seedlings. Nymphs consumed and assimilated significantly more *C. procera* than wheat seedlings. Similarly, the weight gain by grasshoppers fed on *C. procera* was much more than those fed on wheat seedlings, but the duration time of the nymphs on the two plants was similar.

The approximate digestibility (AD) was significantly higher in nymphs fed on *C. procera* leaves than those fed on wheat seedlings. The approximate digestibility of third instar was l 8.6 on *C. procera* 'but it was 7.5 on wheat seedlings (Figure 1). The higher consumption and assimilation of grasshoppers on *C. procera* were reflected in their significantly higher efficiency of conversion of ingested food and efficiency of conversion of digested food (ECD) compared with wheat seedlings.

Growth rate (OR) and relative growth rate (RI3R) were significantly higher in grasshopper nymphs fed on *C. procera* than those fed on wheat seedlings. Also consumption rate (CR) and relative consumption rate (RCR) were significantly higher in those fed on C. *procera* than those fed on wheat seedlings (Table 2).

P. bmtonius grasshopper grew slowly in the laboratory, the duration of development from egg deposition till appearance of the immature adult was five months on *C. procera.* The percentage of mortality after feeding on wheat seedlings was 600/0. No mortality was recorded on *C. rocera.* Table (3) indicates that, the high weight gain of fourth instar nymphs fed on *C. procera* was correlated with higher consumption and assimilation. The duration of development was 28 days. Efficiency of conversion of ingested and digested foods (Eel & ECD) were 4.6 and 29.9 %, respectively. Higher growth rate can be attained by either increasing food intake rate (CR). The means of RGR and RCR were 0.03 ± 0.00 and 0.58 ± 0.02 respectively.

Feeding of the tropical grasshopper, *Poedilocerus bmtonius on C. procera,* which contains toxic compounds (cardenoildes), resulted in higher consumption, good assimilation and higher weight gain. But feeding on wheat seedlings resulted in lower consumption, poor assimilation, and lower weight gain. In contrast, Elsayed (1994) mentioned that better consumption and assimilation by the desert locust were showed with wheat seedlings compared with *Shouwia purpurea.* These results may indicate that, this grasshopper was adapted for feed:ng on *C. procera* because

TABLE (I)

Nutritional indices of *Poecilocerus bmtonius* third instar nymphs reared on *Calotropis procera* or wheat seedlings. Values in mg dry weight (means ± S.E., and P≤ 0.05).

Food plants	Nutritional indices								
	Initial food	Uneaten food	Consumed	Assimilation	Weight gain	Duration of insrar (days)	AD%	ECI%	ECD%
C. procera	677.5 ± 48.8	43 ± 4.9	634.5 ± 47.2	109.5 ± 7.5	46.5 ± 2.8	21 ± 1	18.6 ± 1.96	8.5 ± 2.6	45.2 ± 11.1
WheatSeedlings	187 ± 25	39.2 ± 9.5	147.8 ± 23.7	10.8 ± 1.3	4.2 ± 0.6	20 ± 1.6	7.5 ± 1.42	2.9 ± 0.6	38.6 ± 3.2

TABLE (II)

Comparison of meam and variance of relative growth rates (RGR) and relative consumption rate (RCR) of third instar nymphs *Poecilocerus bmtonius on Calotropis procera* and wheat seedlings (means ± S.E., and P≤ 0.05).

Food plants	GR	RGR	CR	RCR
C. procera	2.27 ± 0.478	0.05 ± 0.010	27.8 ± 4.38	0.62 ± 0.09
WheatSeedlings	0.21 ± 0.037	0.004 ± 0. 001	7.4 ± 11.98	0.16 ± 0.04

TABLE (III)

Waldbauer's indices of *Poecilocerus bmtonius* fourth instar nymphs on *Calotropis procera* values in mg dry weight (means ± S.E.).

Food plants	Waldbauer indices											
	Initial food	Consumed	Assimilation	Weight gain	Duration of insrar (days)	AD%	ECI%	ECD%	GR	RGR	CR	RCR
C. procera	2690±18.40	2555.0±5.7	395.2±11.8	118.2±1.20	28.0±0.50	15.5±0.90	4.6±0.90	29.9±1.6	4.2±0.08	0.03±0.0	91.3±1.16	0.58±0.02

this plant is a dominant fresh plant in the wild life of this grasshopper. Tropical grasshoppers that are adapted to cardenolides-rich food are unaffected and may even benefit from the presence of cardenolides in their food by stimulation of ingestion, among other factors. This phenomenon appeared clearly in male assimilation when this was fed on wheat seedlings in the laboratory, which are devoid of cardenolides. *P. pictus* preferred *C. procera* as food plant, followed by the bottle gourds, *Agenaria siceraria* cucumbers and the ridge gourds *Luffa acutangula* (Singh, 1997).

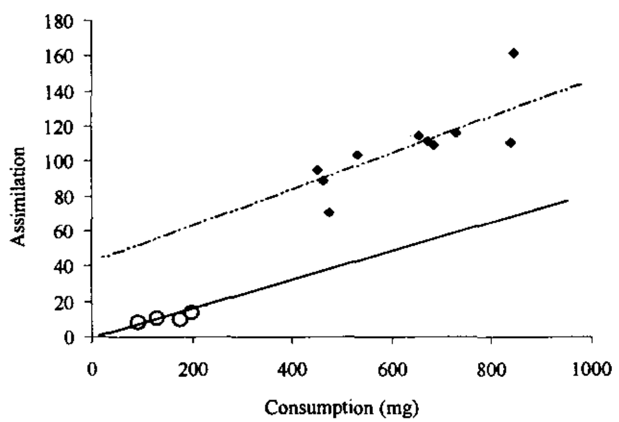

Figure (1): Regression of assimilation on consumption (mg) of *Poecilocerus bmtonius* third instar nymphs reared on *Calotropis procera* and wheat seedlings.

A higher efficiency of food utilization on *C. procera* was related with a higher relative growth rate and relative consumption rate of this grasshopper. Allelochemicals in the food is supposedly more important energy-requiring processes in the metabolic load hypothesis (Neal, 1987). In contrast, the food utilization efficiencies and weight gain by tropical grasshopper were not affected by the cardenolides in *C. procera* compared with wheat seedlings which haven't the cardenolides. Adaptation to high levels of toxic compounds in one host plant is often associated with a concomitant reduction in tolerance to compounds in other host plants (Gould, 1991).

The capability of consumption and assimilation by the tropical grasshopper fed on *C. procera* diet for long- term may be probably due to the fact that this grasshopper can destroy cardenolides contained in their food through an active enzyme system and sequester them into their haemolymph, then into the exterior body as white liquid, as defensive mechanism against their natural enemies. This capability of detoxification prevented these compounds from showing any effect on the assimilation of carbohydrates and nitrogen of the food plant *C. procera* in insect gut. Many insect herbivorous on cardenolide- bearing plants are anosmatic and sequester cardenolides as a defense against their natural enemies (Usher and fenny, 1983).

Male assimilation and high mortality were recorded with *P. bmtonius* fed on wheat seedlings as compared with those fed on *C. procera* may be because this insect is not attracted to wheat seedlings which haven't the chemical food cues (cardenolides) used by insect for feeding stimulation, while it was capable of destroying the cardenolides of *C. procera* produced from the plant steroids. ECI and RGR values were not affected when locust ingested plants containing sinigrin (Bernays, 1990).

In this study, the values of nutritional indices of *C. procera* food are higher for third instar compared to late-instar nymphs (fourth instar), this may be probably related to that the quantity of food intake by the third instar was lower, levels of detoxifying enzymes are much lower and the energy used for destroying the toxic cardenolides was also much lower. Losses of insect energy in destroying the compounds having high molecular weight in fourth Instar was related to the higher consumption, lower assimilation and decrease in weight gain. Larvae of *Spodoptera littoralis* for instance grow much faster on cotton leaves of low gossypol content than on high gossypol strains (Bernays, 1991). In contrast, to the situation mentioned above, the first instar larvae of *Helicoverpa virescens* show a reduction in weight gain due to the presence of condensed tannins in their food at a concentration about ten times lower than that required to reduce growth of fifth instar larvae (Navon *et al.*, 1993).

Allelochemicals can negatively affect herbivorous insects in three ways. First they can reduce food intake by an inhibitory effect on feeding behavior. Second, they can reduce the efficiency of food utilization or, third, they can poison the insect by interference with other physiological processes. Frequently, allelochemicals act through a combination of all three mechanisms. But in the present study *P. bmtonius* did not-exhibit any of the three mentioned ways when fed on *C. procerct.* Specialized insects are often able to cope with higher concentrations of those allelochemicals that typically occur in their food plant (Berenbaum, 1986).

It can be concluded that, the tropical grasshopper was capable of growing and developing normally on the milkweed *C. procera* because the insect can tolerate host plant toxic compounds and must possess intrinsic mechanisms to prevent poisoning.

SUMMARY

This study compared the nutritional indices in third instar female nymphs of the tropical grasshopper, *Poecilocerus bmtomus* after feeding on *Calotropis procera* or wheat seedlings. Analysis of the main and interactive effects of feeding on *C. procera* indicated that nymph performance was not affected by cardenolides present in *C. procera.* The rate of consumption and assimilation on *C. procera* was higher as compared with that on wheat seedlings and weight gain of the nymphs on *C. procera* was correlated to higher assimilation. Relative consumption rate (RCR) and Relative growth rate (RGR) were significantly higher in nymphs fed on *C. procera* than those fed on wheat seedlings. Feeding on wheat seedlings significantly reduced approximate digestibility (AD); efficiency of conversion of ingested food (ECI) and efficiency of conversion of digested food (ECD). Feeding on wheat seedlings resulted in 60 % mortality of nymphs before moulting to the fourth instar stage. The nutritional indices also were estimated after feeding fourth instar nymphs on *C. procera* only.

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