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Influence of food plants on the food utilization and chemical composition of *Henosepilachna septima* (Coleoptera: coccinellidae)

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Abstract. Influence of three food plants, *viz Memordica charantia*, *Luffa acutangula*, and *Trichosanthus anguina* on the food utilization and chemical composition of *Henosepilachna septima* has been studied. The rate of conversion and conversion efficiencies were higher in *T. anguina* fed beetles. The rate of conversion was positively correlated with the protein content of the food plants. The organic constituents of *H. septima* specially protein and lipid increased when fed on the different food plants. Greater increase of all the organic constituents occurred when the insect was fed on the nutrient rich *T. anguina* than when fed on other food plants.

Keywords. Food plants; food utilization; chemical composition; *Henosepilachna septima*.

1. Introduction

Studies on the consumption, digestion and utilization of food plants by insect pests are important both from fundamental and applied points of view. They provide information on the quantitative loss brought about by the pests. Several workers have made such quantitative study of food consumption and assimilation by insects (SooHoo and Fraenkel 1966; Waldbauer 1968; Latheef and Harcourt 1972; Bailey and Mukerji 1976; Muthukrishnan and Rajeeya 1979; Ganga and Meenakshi Nagappan 1983). These studies reveal that the quantity of food consumed is very much influenced by the type of food. The different feeding activities of insects on different food plants are influenced by the chemical composition of the diets. Direct relationship between the protein, carbohydrate, lipid and water content of the food plants and the growth and conversion efficiencies have been noted in many herbivorous insects (Keller *et al* 1963; Dhandapani and Balasubramanian 1980; Manoharan *et al* 1982) and also the chemical composition of the insect tissues are modified according to the composition of the diet (Subbiah *et al* 1981). Such studies seem to be less in coleoptera and the present work is designed to relate the influence of food plants on the feeding budget and biochemical composition of a coleopteran, *Henosepilachna septima*.

2. Material and methods

The lady bird beetle, *Henosepilachna septima* were collected from the infected crops of bitter gourd from the local gardens of Madurai, and maintained on the leaves of bitter gourd *Memordica charantia* at 30 ± 1°C and 70 RH. Freshly emerged adults were used for feeding experiments. Since the individual beetles were small and consumed little food, a group of 10 insects (5 males + 5 females) was used for the feeding experiment (Ganga and Meenakshi Nagappan 1983). The experimental groups were reared in perforated plastic containers (10 × 8 × 6 cm). The food plants used in this feeding study were *M. charantia* (bitter gourd), *Luffa acutangula* (ridge gourd) and *Trichosanthus anguina* (bottle gourd). The experimental groups were fed *ad libitum* on weighed quantities of their respective food for 10 days, and triplicate groups for each food were maintained. Unfed leaves and faeces were collected daily and dried at 60°C to find out the percentage of water content. The scheme of feeding budget followed is the slightly modified IBP formula (Petrusewicz and Macfadyen 1970) represented as $C = P + R + (F + U)$, where C is the total food consumed, P the growth (conversion), R the energy spent on metabolism and $F + U$ the energy loss *via* faeces including nitrogenous excretory products; it has been described in detail elsewhere (Muthukrishnan *et al* 1978). The total protein, carbohydrate and lipid contents of the food plants, freshly emerged adults and adults after being fed on different food plants for 10 days were estimated following the methods of Lowry *et al* (1951), Seifter *et al* (1950) and Bragdon (1951) respectively.

3. Results and discussion

3·1 *Composition of the leaves*

Percentage composition of protein, carbohydrate, lipid and water content of leaves of the food plants are presented in table 1. The results of the biochemical analysis of the leaves of food plants reveal that organic constituents and water content are higher in *T. anguina* suggesting that the nutritive value of this plant is more than that of the other food plants used.

3·2 *Feeding budget of H. septima*

The feeding budget of *H. septima* on three food plants is given in table 2.

3.2a *Consumption*: The total amount of food consumed by a group of 10 beetles for 10 days on three food plants used showed significant variations. The total consumption amounted to 2210·33, 1043·33 and 674·00 mg when fed on *L. acutangula*, *T. anguina* and *M. charantia* respectively. The rate of food intake of *H. septima* significantly increased from 153·05 mg/g live wt/day on *M. charantia* to 286·51 mg/g live wt/day on *T. anguina* and 532·27 mg/g live wt/day on *L. acutangula*. Hence the potential damage that this insect can cause is maximum on *L. acutangula* and minimum on *M. charantia*.

Table 1. Composition of the food plants (in % of dry weight except water) ($\bar{X}$ + SD).

Food plants	Protein	Sugar	Lipid	Water
L. acutangula	15·76 ± 0·38	0·70 ± 0·00	7·73 ± 0·05	75·2 ± 0·37
T. anguina	17·75 ± 0·36	1·11 ± 0·02	10·98 ± 0·11	81·1 ± 0·42
M. charantia	2·90 ± 0·00	0·82 ± 0·01	7·56 ± 0·00	78·4 ± 0·26

Table 2. Feeding budget of *H. septima* when fed on three different food plants. ($\bar{X}$ + SD).

Food plants	Consumption (mg)	Assimilation (mg)	Production (mg)	Metabolism (mg)	Consumption rate*	Assimilation rate*	Production rate*	Metabolic rate*	Assimilation efficiency (%)	Gross conversion efficiency (%)	Net conversion efficiency (%)
L. acutangula	2210·33 ± 139·34	2180·33 ± 143·71	69·06 ± 5·08	2111·27 ± 148·78	532·27 ± 40·26	525·08 ± 41·50	16·60 ± 1·03	509·11 ± 42·89	98·78 ± 0·29	3·15 ± 0·43	3·20 ± 0·45
T. anguina	1043·33 ± 45·11	1007·00 ± 42·71	61·73 ± 5·77	945·27 ± 37·22	286·51 ± 15·07	276·56 ± 15·00	16·88 ± 0·25	259·69 ± 14·99	96·52 ± 0·32	5·90 ± 0·32	6·10 ± 0·34
M. charantia	674·00 ± 15·56	607·67 ± 9·02	37·00 ± 2·45	570·67 ± 10·06	153·05 ± 8·19	138·06 ± 8·24	8·40 ± 0·64	129·67 ± 7·97	90·18 ± 0·78	5·50 ± 0·41	6·09 ± 0·44

* mg/g live wt/day.

Differences in food consumption may result from a variety of factors. Feeding is governed by passiveness of food, water content and other physico-chemical properties of food material (Bhat and Bhattacharya 1978). Continuation of a feeding response in a feeding behaviour scheme which inevitably, would lead to a greater amount of food intake by an insect is governed by certain chemical feeding stimulants in its diet (Beck 1965). This possibility of such chemical feeding stimulant in *L. acutangula* is ruled out by studies on food orientation behaviour by *H. septima* (Mary Saroja 1982). The higher feeding rate on *L. acutangula* may be due to some nutritional deficiency due to which, *H. septima* have to consume more food to fulfil the nutritional requirements or that the food may be nutritionally unbalanced which increased the feeding rate (Babu *et al* 1979).

3·2b *Assimilation*: The total amount of food assimilation was also higher in *L. acutangula* (2180·33 mg) than that of *T. anguina* (1007 mg) and *M. charantia* (607·67 mg) in ten days. Of these three plants, *L. acutangula* has a lower water content (75·2 %). Maximum assimilation of food having low water content was also reported by Waldbauer (1968). Total food assimilation was directly related to the total amount of the food consumed. In *Periplaneta americana* and *Pieris brassicae* also assimilation is found to be proportional to the amount of food consumed (Muthukrishnan and Rajeeya 1979; Yadava *et al* 1979). The relationship between the approximate digestibility and the palatability of food reported by Mathavan and Baskaran (1975) probably accounts for this direct relationship between consumption and assimilation. The rate of assimilation of *H. septima* feeding on *L. acutangula*, *T. anguina* and *M. charantia* were 525·08, 276·56 and 138·06 mg/g live wt/day respectively. Any two mean values obtained for total assimilation or for assimilation rate of *H. septima* on the three different food plants were significantly different from each other at 1 % probability level. Assimilation efficiency represents the ability of an insect to digest the food. The insect fed on *L. acutangula* has a high assimilation efficiency (98·78 %) than that fed on *T. anguina* (96·52 %) or on *M. charantia* (90·18 %). The lowest assimilation efficiency of *H. septima* when fed on *M. charantia* appears to be related to the lesser nutrient content present in this food, as nutrient imbalance has been implied to be a factor inversely affecting digestive efficiency (Waldbauer 1964). However, statistical analysis has revealed that no significant correlation exists between the amount of any of the organic constituents of the food and assimilation by *H. septima*.

3·2c *Conversion*: The conversion by *H. septima* fed on different food plants are in the following decreasing order. *L. acutangula* (69·06 mg) > *T. anguina* (61·73 mg) > *M. charantia* (37 mg). Total production seems to be directly related to the amount of food consumed and assimilated on the different food plants. Such direct relationship between growth and consumption has been observed in other insects also (Mukerji and LeRoux 1969; Latheef and Harcourt 1972; Sing *et al* 1975).

The order of food plants in their ability to promote the rate of food conversion *T. anguina* (16·88 mg/g live wt/day) followed by *L. acutangula* (16·6 mg/g live wt/day) and *M. charantia* (8·4 mg/g live wt/day). The rate of production is positively correlated with the protein content of the leaves which is significant at 1 % level (table 3). Corresponding relationship between the protein content of diet and growth rate has already been reported in many herbivorous insects (Taylor and Bardner 1968; Schramm 1972; Onuf 1977; Slansky and Feeny 1977).

Table 3. Correlation (r values) between the organic constituents of the three different food plants and feeding parameters of *H. septima*.

Feeding parameters	Protein	Lipid	Sugar
Consumption	0·6842	−0·1250	−0·4661
Assimilation	0·6891	−0·1184	−0·4596
Production	0·9956*	0·5620	0·2798
Metabolism	0·6770	−0·1353	−0·4757

*Significant 1 % level.

The report of Waldbauer (1964) that low growth rate may be due to low rate of feeding, nutritional inadequacy of food or a combination of the two, explains the low production rate of *H. septima* on *M. charantia*.

Gross conversion efficiency (ECI) indicates the efficiency with which the ingested food is converted to body matter. Net conversion efficiency (ECD) represents the efficiency with which the digested food is converted into body matter. Both ECI and ECD are highest in *T. anguina* (5·9 and 6·1) which are due to high nutritious food (SooHoo and Fraenkel 1966). But surprisingly both ECI and ECD are lowest in *L. acutangula* fed groups (3·05 and 3·2 %) and low ECD is due to metabolization of greater digested material which are not used for structural purposes (Hoekstra and Beenakkers 1976). Singhal *et al* (1976) also suggested that the high consumption and assimilation with lower amount of ECD indicates a greater respiratory consumption in these insects. In *M. charantia*, which is the least consumed food and on which the assimilation efficiency is also lowest, the conversion efficiencies are very high (5·5 and 6·09 %) and comparable to those found on *T. anguina*. This may be explained on the basis of the existence of compensatory mechanism suggested by Duodu and Biney (1981). Poor consumption and poor digestion of *M. charantia* is compensated by high conversion efficiencies.

3.3 *Influence of food plants on the biochemical composition of the insects*

Organic constituents of newly emerged adult *H. septima* and *H. septima* fed on three different food plants are given in table 4. Feeding of the freshly emerged adult on different food plants resulted in an increase in the biochemical constituents of the insect to different degrees. In all the adults, the carbohydrate content was uniformly lower than the other organic constituents. Ramdev and Rao (1979) suggested that carbohydrates are utilized by the insects either for maintenance or for conversion to body lipid, rather than being stored. Carbohydrates have been reported to contribute to the building up of protein in *Phormia regina* (Tate and Wimer 1974). The level of carbohydrate increased (11·11 %) when the insects were fed *T. anguina* but there was no increase of sugar when the insects reared on the other food plants. The increase of carbohydrate content when fed on *T. anguina* seems to be influenced by the carbohydrate content of the food plant. In *Heliothis zea* also the carbohydrate content of the diet directly influenced the carbohydrate content of the insect (Nettles *et al* 1971).

There was an increase of protein and lipid in all the fed insects, but the percentage of increase differed according to the nutritive value of the food plant.

Table 4. Organic constituents of adult *H. septima* (in % of dry weight).

Samples of animal tissue analysed	Protein	Carbohydrate	Lipid
Newly emerged adult	20·49 ± 0·24	0·09	18·77 ± 0·14
Adults fed on *L. acutangula* for 10 days	24·96 ± 0·35	0·09	18·91 ± 0·00
Adults fed on *T. anguina* for 10 days	32·74 ± 0·61	0·10	25·38 ± 0·30
Adults fed on *M. charantia* for 10 days	22·11 ± 0·00	0·09	19·87 ± 0·18

The percentage of increase of protein was minimum when fed on *M. charantia* (7·1 %) and maximum when fed on *T. anguina* (59·79 %). The percentage of increase of protein appears to be related to the percentage composition of protein in the food plants. The protein content of the different tissues of *P. americana* showed an increase when fed on protein rich diet (Senthamil Selvi 1982). Maximum increase in lipid content is observed when fed on *T. anguina* (35·22 %) and minimum when fed on *L. acutangula* (0·74 %). Increase of lipid in *H. septima* is not directly correlated with the lipid content of the food is suggested by the fact that though *L. acutangula* and *M. charantia* have almost equal amounts (7·73 % and 7·56 % respectively) of lipid, the insects fed in the former showed an increase of only 0·74 % while those fed on the latter, had an increase of 5·86 %. The higher food conversion efficiency of *H. septima* when fed on *M. charantia* is probably responsible for this.

From the results it is evident that all the organic constituents of the insect increased to a greater degree when fed on *T. anguina*. In the light of these observations, it is suggested that *T. anguina* is the most suitable host plant for *H. septima*, because of its nutritional value with high protein and water content which allow the insects to convert the food materials into body tissues.

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