J. Biol. Control, 16(1): 5-10, 2002

Food consumption, digestion, tissue growth, egesta and assimilation of *Harmonia dimidiata* (Fabricius) on *Cervaphis rappardi indica* Basu

T. SHANTIBALA DEVI, M. NONITA DEVI and T. K. SINGH
Entomology Laboratory, Department of Life Sciences
Manipur University, Canchipur 795 003, Manipur, India

ABSTRACT: **Food intake, assimilation, tissue growth, approximate digestibility (A.D.), efficiency of conversion of digested (E.C.D.) and ingested food (E.C.I.) of coccinellid, *Harmonia dimidiata* (Fabricius) on *Cervaphis rappardi indica* Basu were studied under laboratory conditions. On this prey, duration of the feeding period, fresh weight of food ingested, faeces produced and weight gain by the predator were recorded for computing quantitative nutritional parameters. The results revealed that food ingestion, egestion, assimilation and tissue growth increased with increase in biomass. The value of A. D. was highest in the first instar and showed a gradual decline as larvae matured. The maximum E.C.D. and E.C.I. were observed in second instar larvae. The consumption rate of predator showed a significant positive relationship with assimilation, egestion and tissue growth.**

KEY WORDS: Assimilation, *Cervaphis rappardi indica*, consumption, *Harmonia dimidiata*

Cervaphis rappardi indica Basu, is an important aphid pest of *Cajanus cajan* (L.) Millsp. It is attacked by several natural enemies such as coccinellids, syrphids and chrysopids. Shantibala (1993) reported 12 species of cocinellid predators of *C. rappardi* from Manipur. Among these, *Harmonia dimidiata* (Fabr.) was reported as the most efficient. Various researchers have studied the developmental rate, life history and larval voracity of *H. dimidiata* on different prey species (Singh and Nigam, 1982; Chakraborti *et al.*, 1988). Assimilation, egesta and tissue growth of *Coccinella septempunctata* Linn. and *Cheilomenes sexmaculata* (Fabr.) on different aphid preys have been worked out by Agarwala *et al.* (1997) and Chitra *et al.* (2000) but information on the above aspects of *H. dimidiata* is lacking. Therefore, the present investigation was undertaken with the objectives to determine the rate of consumption, E.C.I, approximate digestion, assimilation, E.C.D. and tissue growth assimilation of *H. dimidiata.*

MATERIALS AND METHODS

Food intake, tissue growth, A.D., E.C.D. and E.C.I. of *H. dimidiata* on *C. rappardi* were conducted under laboratory conditions at Department of Life Sciences, Manipur university during October, 2000 (18^{0}C & 50% R.H.) by following the standard gravimetric methods of Waldbauer (1968). Newly hatched first instar larvae (0-24 h) of *H. dimidiata* were used for food utilization studies. After measuring the initial weight, the newly hatched larvae were reared in Petri-dishes (13cm diam) by providing known

weight of *C. rappardi*. Five replications each containing initially 5 larvae/Petri-dish (I, II and III instars) and individually in the later stages (IV and adult) were maintained. Another separate set was also maintained in the same fashion in order to replace the dead predators during the period of investigation. Fresh food was provided after every 24h. Weight of the left over food and faecal matter was recorded daily till the experiment was completed. The weight of the predator was also recorded daily to estimate the gain in body weight. Five replications of known weight of aphid prey were kept separately under identical condition to determine the increase in weight of the aphid prey. The gain in weight of aphid was recorded on the next day at the time of weighing the unconsumed food and egesta. All the growth parameters and consumption were measured on fresh weight basis. The food consumption was worked out by subtracting the food remains from the food provided, after correcting the weight gain in the food material. The assimilated food was calculated by deducting the weight of egesta from that of the consumed food and the difference in weight of the predator gave the weight gain (tissue growth) during the feeding period. Various growth indices namely approximate digestibility (A. D.), efficiency of conversion of ingested and digested food to body biomass (E. C. I and E. C. D., respectively), consumption index (C. I.) and growth rate (G. R.) were calculated as given below:

$$\text{A. D.} = \frac{\text{Wt. of food ingested} - \text{Wt. of faeces}}{\text{Wt. of food ingested}} \times 100$$

$$\text{E. C. I.} = \frac{\text{Wt. gain by the predator}}{\text{Wt. of food ingested}} \times 100$$

$$\text{E. C. D.} = \frac{\text{Wt. gain by the predator}}{\text{Wt. of food ingested} - \text{Wt. of faeces}} \times 100$$

$$\text{C. I.} = \frac{\text{Wt. of food ingested}}{\text{Duration of feeding period X mean wt. of larvae}}$$

$$\text{G. R.} = \frac{\text{Wt. gain by the predator}}{\text{Duration of feeding period X mean wt. of larvae}}$$

RESULTS AND DISCUSSION

Food consumption

Results on the food consumption of *H. dimidiata* on *C. rappardi* are presented in Table 1. It indicated that the food consumption increased according to the weight and maturity of the predator. The food intake varied from 7.31mg / insect/day in the first instar to 42.6mg/insect/day in the fourth instar. A significant positive relationship ($P > 0.5$) was obtained between the food ingested and the biomass of the food supplied. Thus, with increase in biomass the food consumption also increased, the Food consumption, digestion and utilization of *H. dimidiata* maximum being observed in the fourth instar, accounting for 77.84 percent of the total food consumption. Similar result was reported earlier by Chand (1979) in *Diacrisia obliqua*.

Food assimilation

Food assimilation was only 7.02mg/insect/day during the first instar which later increased to 38.35mg/insect/day during the fourth instar. Out of the total assimilation, 52.29 percent took place in the last instar. The assimilation also increased with the increase in age of the predator. A significant positive correlation was obtained between food consumption and assimilated food (Table 2). Similar observations were reported earlier in different insects (Mackey, 1978; Yadava *et al.*, 1983).

Tissue growth

Tissue growth increased from 2.09mg/insect/day in the first instar larvae to 10mg/insect/day during the IV instar. The maximum tissue growth occurred in the last instar (48.80%). A significant positive relationship was found between food consumption and tissue growth (Table 2). A similar result was reported by Yadava *et al.* (1979) in the larvae of *Pieris brassicae*.

Egestion

The rate of egestion increased consistently

Table 1. Food consumption, egesta, tissue growth and assimilation of *H. dimidiata* on *C. rappardi indica* (mean ± S D)

Life stages	Food supplied (mg/day/ individual)	Consumption (mg/day/ individual)	Egesta (mg/day/ individual)	Assimilation (mg/day/ individual)	Tissue growth (mg/day individual)
Ist Instar	16.23^{a}±0.33	7.31^{a}±0.49	0.33^{a} ±0.33	7.02^{a}±0.47	2.09^{a}±0.03
IInd Instar	17.08^{a}±0.53	9.55^{b}±0.26	0.74^{a}±0.11	8.81^{a}±0.17	3.51^{b}±0.08
IIIrd Instar	28.36^{b}±0.49	20.76^{c}±0.09	1.62^{b}±0.07	19.15^{b}±0.15	4.89^{c}±0.04
IV th Instar	54.7^{c}±0.09	42.60^{e}± 1.25	5.26^{d}±0.32	38.35^{d}± 1.13	10.00^{d}± 0.65
Adult	64.78^{d}± 0.72	32.46^{d}± 0.50	2.43^{c}± 0.07	30.03^{c}± 0.54	5.25^{c}± 0.19
SEM ±	0.72	0.81	0.24	2.14	0.42
CD (P=0.05)	1.52	1.72	0.50	4.54	0.90

* Figures followed by the same letter in a vertical column are not significantly different (P=0.05).

Table 2. Correlation coefficients of various nutritional parameters of *H. dimidiata*

Different nutritional parameters		Correlation coefficient (r)	Level of significance
Variable 'X'	Variable 'Y'		
Food supplied	Food ingested	0.911	P>0.05
Food ingested	Food assimilated	0.999	P>0.05
Food ingested	Food egestion	0.952	P>0.05
Food ingested	Tissue growth	0.928	P>0.05

from the first to fourth instar (Table 1). The highest egestion was observed in the fourth instar, which accounted for 66.33 percent of the total egestion. A highly significant correlation existed between the food consumption and the amounts of faecal matter egested (Table 2). Similar observations were also reported in the larval stages in various insects (Yadava *et al.*, 1983; Srinivas *et al.*, 2001).

Efficiency of food utilization

The approximate digestibility, efficiency of conversion of ingested and assimilated food into body substances, consumption index and growth rate are presented in Table 3.

Approximate digestibility (A. D.)

It is the ability of an insect to digest food and expressed as per cent food digested. The value of A. D. was highest in the first instar larvae (96.03 ± 0.02) and thereafter gradually decreased. A number of workers also reported a decline in A. D. with maturity of larvae in different insects. Mackey, 1978; Yadava *et al.*, 1979).

Tissue growth efficiency (E. C. D.)

Efficiency of conversion of digested food (E. C. D.) is the amount of energy devoted for maintenance of physiological functions of the body. The results revealed that maximum amount of energy was used by second instar larvae (39.84%) and the least was consumed by the adult predator (17.48%) while the remaining instars showed variation in their E.C.D. values. However, the increase in E.C.D. during the larval development is inconsistent with the findings of earlier workers (Mukherjee and Guppy, 1970; Bailey, 1976).

Efficiency of conversion of ingested food (E.C.I.)

Considerable variation was observed in the efficiency of conversion of ingested food (E. C. I.). It was highest (36.75±1.03) in second instar larvae and lowest in adult (16.18±2.45). Bhat and Bhattacharya (1978) while studying E. C. I. of *Spodoptera litura* at different temperatures, which was fed on soybean, could not explain the reason of variations in E.C.I. value in different larval instars.

Consumption index (C. I.)

Consumption index indicates the rate of food intake per unit weight per day or feeding in relation to the weight of animal in a definite time. The C. I. was highest (5.48 mg/day/mg) in the first instar and lowest (0.24 mg/day/mg) in the adult stage (Table 3). This indicated that the first instar larvae consumed more food relative to their body weight, but the C. I. decreased gradually with the advancement of larval instars. Similar results had also been reported by Bailey and Tara (1988) in *Diacrisia obliqua* Walk. on mulberry leaves and Bora and Dutta (1996) in *Nacoleia vulgaris* Guen. The overall average C. I. of *H. dimidiata* larvae was 2.36 mg/day/mg.

Table 3. Utilization efficiency of *H. dimidiata* when fed on *C. rappardi indica* (mean ± SD)

Life stages	A. D. (%)	E. C. D. (%)	E. C. I. (%)	C. I. (mg./ day/mg)	G.R. (mg./ day/mg)
1st Instar	96.03 ± 0.02	29.77 ± 0.92	28.59 ± 0.38	5.48 ± 0.38	1.43 ± 0.08
2nd Instar	92.25 ± 1.45	39.84 ± 1.67	36.75 ± 1.03	1.62 ± 0.22	0.65 ± 0.15
3rd Instar	92.20 ± 1.42	25.53 ± 0.68	23.54 ± 0.48	1.53 ± 0.15	0.40 ± 0.03
4th Instar	90.02 ± 2.42	26.08 ± 1.44	23.47 ± 1.31	0.80 ± 0.02	0.21 ± 0.01
Adult	92.54 ± 1.09	17.48 ± 1.98	16.18 ± 2.45	0.24 ± 0.03	0.04 ± 0.01

Growth rate (G.R.)

It indicates the rate at which the digested food is available to the animal and ultimately the rate of increase in weight per unit of body weight per day. G. R. was observed to be highest (1.43mg/day/mg) in first instar larvae and decreased gradually in successive larval instars with lowest value of 0.03mg/ day/mg in adult. On an average G.R. of predator larvae was 0.67mg /day/mg. Decreased trend of G. R. in successive larval instars had also been observed by Bailey and Tara (1988) in case of *Spodoptera litura* Walk. and Bora and Dutta (1996) in *Nacoleia vulgaris*.

The finding suggests that food consumption and utilization have direct relationship with the age of the insect. Thus, as the larvae grow older and enter into subsequent instars, they gain comparatively more weight and consumed comparatively more food. The relative growth rate and approximate digestibility in early instar were found to be higher indicating that the food energy is reserved for the future development.

Keeping in view the food consumption and utilization of *H. dimidiata*, it could be concluded that on an average the larvae consumed 20.05mg/ larva/day and at the maximum of 42.60 mg/larva/ day, thus this species can be utilized in suppression of *C. rappardi indica* population on pigeonpea.

ACKNOWLEDGEMENT

The authors are grateful to the Head, Department of Life Sciences, Manipur University for providing necessary facilities to carry out the work.

REFERENCES

Agarwala, B. K. and Bardhanroy, P. 1997. Oviposition behaviour and reproduction efficiency in ladybird beetles (Coleoptera: Coccinellidae). A case study of *Menochilus sexmaculatus* (Fabr.). *Journal of Aphidology*, **11**: 49-59.

Bailey, C. G. 1976. A quantitative study of consumption and utilization of various diets in the Bertha armyworm *Mamestra configurata* (Lepidoptera: Noctuidae). *Canadian Entomologist*, **108**: 1319-1326.

Bailey, S. and Tara, J. S. 1988. Comparison of consumption and utilization of mulberry leaves in two moths, *Spodoptera litura* (F.) and *Diacrasia obliqua* Walk. *Indian Journal of Entomology*, **50**: 336-342.

Bhat, N. S. and Bhattacharya, A. K.1978. Consumption and utilization of soyabean by *Spodoptera litura* (Fabricius) at different temperatures. *Indian Journal Entomology*, **40**: 16-25.

Bora, N. C. and Dutta, S. K. 1996. Nutritional indices of *Nacoleia vulgaris* Guen. larvae fed on greengram leaf. *Geobios*, **23**: 69-71.

Chakrabarti, S., Ghosh, D and Debnath, N. 1988. Development rate and larval voracity in *Harmonia (Leis) dimidiata* (Coleoptera: Coccinellidae), a predator of *Eriosoma lanigerum* (Homoptera: Aphididae) in Western Himalaya. *Acta Entomologiea*, **85**: 335-339.

Chand, P. 1979. Utilization of food by the Bihar hairy caterpillar, *Diacrisia obliqua* Walker. *Indian Journal of Entomology*, **41**: 237-239.

Chitra Devi, L., Shantibala Devi, T. and Singh, T. K. 2000. Food consumption, assimilation, tissue growth and ecological efficiency of a ladybird beetle, *Coccinella septempunctata* Linn. on *Lipaphis erysimi* (Kalt.). *Seventh National Symposium on Aphidology*, Gorakhpur, Abstract No. **63**, pp. 56-57.

Mackey, A. P. 1978. Growth and bioenergetics of the moth, *Cyclophragma leucosticta* Grunberg. *Oecologia*, **32**: 367-376.

Mukherjee, M. K. and Guppy, G. C. 1970. A quantitative study of food consumption and growth in *Pseudaletia unipunta* (Lepidoptera: Noctuidae). *Canadian Entomologist*, **102**: 1179-1188.

Singh, K. C. and Nigam, M. P. 1982. Biology of the ladybird beetle, *Harmonia (Ballia) eucharis* (Mulsant) (Coleoptera: Coccinellidae) when fed on oak aphid (Homoptera: Aphididae) in Manipur. *Oriental Zoologist*, **2**: 77-80.

Shantibala, K.1993. Studies on bio-ecology of two species of Cervaphidini (Homoptera: Aphidoidea) related to their predatory insects in Manipur. Ph. D. thesis, Manipur University, Imphal, Manipur, 204 pp.

Srinivas, V., Reddy, K. D. and Sreedhar, Y. 2001. Study on food consumption and utilization parameter of rice moth, *Corcyra cephalonica* (L.). *Shashpa*, **8**: 51-53.

Waldbaurer, G. P. 1968. The consumption and utilization of food by insect. *Advances in Insect Physiology*, **5**: 229-288.

Yadava, P. S., Vats, L. K. and Kaushal, B. R. 1979. Food consumption, assimilation and growth in the larvae of *Pieris brassicae* Linn. *Journal of Animal Morphology & Physiology*, **26**: 257-264.

Yadava, P. S., Bhattacharjee, N. and Kakati, L. N. 1983. Food consumption, assimilation, tissue growth and ecological efficiencies in the larvae of *Antheraea prolei* Jolly. *Proceedings of Symposium on Insect Ecology & Resource Management*, pp. 204-214.