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ECOLOGICAL EFFICIENCIES OF LEAF WEBBERING MOTH (*CYANA FORMOSANA HAMPSON*) (LEPIDOPTERA: ARCTIDAE)

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The food consumption and ecological efficiencies of red stripped moth, *Cyana formosana* (Hamp.) were studied in laboratory. It was observed that the food consumption was 10.12±1.20, 15.34±0.74, 20.53±0.96, 23.52±0.70 and 27.06±1.10 mg insect^{-1} day^{-1} in 2nd, 3rd, 4th, 5th and 6th larval instars, respectively. In all five stages leaf assimilation was 6.18, 7.72, 10.42, 11.88 and 13.34 mg insect^{-1} day^{-1}, respectively. The tissue growth was 1.20, 2.69, 3.10, 3.82 and 4.34 mg insect^{-1} day^{-1} in all respective stages. The minimum tissue growth was observed in 2nd instar larvae, which was 7.92% of total tissue growth of all stages. In 6th larval stage, tissue growth was 4.34 mg insect^{-1} day^{-1}, which accounted for 28.64% of total tissue growth. The maximum value (60.84±2.33) of approximate digestibility was recorded for 2nd instar larvae, while the minimum value (49.59±3.44) was recorded for third instar larvae. In *Cyana formosana* the mean value of efficiency of conversion of digested food or assimilated food into body tissue was 29.67%. The value of ECD was minimum (19.77±3.16) in 2nd instar and maximum (35.52±5.08) for 3rd instar larvae. The minimum value (11.97%) of ECI was recorded in 2nd instar larvae, while maximum value (17.79%) was recorded in 3rd instar larvae.

The order Lepidoptera is a large group of insects and comprises butterflies and moths. It is among the most successful groups of insects and inhabits all terrestrial habitats ranging from desert to rainforest, from lowland grasslands to montane plateaus but almost always associated with higher plants or flowering plants[1]. Many species of Lepidoptera damage plants useful to humans, including fruit trees, crops, fabrics, fodder, and timber. The larval stage of many species of moths are very injurious. The damage may involve the leaves, stems, roots, or fruits. The fungus moths eat the woolens, furs, silk, and even feathers. Many Lepidopterans are valuable in biological research, including work in ecology, biogeography, systematics, genetics, and physiology. The habits of different Lepidopterans vary according the adaptations of the species or group to climate, environment, type of food plant, way of feeding, and many other factors. The quantity and quality of food, various abiotic factors, presence of predators, parasites and disease can be regarded as the index of the physiological potential of life performance of the insect[2]. The consumption and efficiency of utilization of food influence all the vital activities viz. metabolism, enzyme synthesis, nutrient storage etc. Studies on ecological energetics and feeding potential of different insects have been carried out by many workers[3,4,5,6] . Many workers have studied the relationship between insects and plants, and observed the efficiency with which insects exploit their food plants. The rate of food ingestion and growth, food utilization efficiency is an important component of herbivore feeding habit[2]. The present paper deals with the ecological efficiencies of leaf webbering moth (*Cyana formosana* Hampson) under laboratory conditions.

MATERIALS AND METHODS

Cyana formosana was observed as the one of the most abundant and defoliator insect in the mango orchards of Haridwar, hence energy. Energy budget of 2nd, 3rd, 4th, 5th and 6th instar larvae of leaf webbering moth, *Cyana formosana* (Hamp.) (Arctiidae: Lepidoptera), was studied in laboratory. Larvae of this insect construct webs on mango leaves and feeds on them. Larvae, which feed on leaves, were collected and experiments were conducted at room temperature.

For removal of faecal matter from alimentary canal, actively feeding caterpillars were kept away from food source for about one hour before the start of the experiment. Before the start of experiment, each larva was weighed and kept in glass jar. After that larvae were allowed to feed on preweighed portion of mango leaves for 24 hrs, thereafter, the remaining portion of leaves and faeces were dried to a constant weight at 80^{o}C. A wet/dry mass ratio was determined for the leaves and the amount of leaves ingested by each larva was estimated.

Food consumption was calculated as the difference between the initial weights of the leaves provided and unconsumed leaves at the end of experiment. Ecological efficiency was

Table-1. Consumption, egesta, assimilation and tissue growth(mg insect^{-1} day^{-1}) in *Cyana formosana* (Hamp.)

S.N.	Stage	Initial Biomass	Consumption	Egesta	Assimilation	Tissue growth
1.	2nd instar	11 .98±0.77	10.12±1.20	3.94±0.26	6.18±0.95	1.20±0.07
2.	3rd instar	23.25±0.75	15.34±0.74	7.62±0.58	7.72±1.23	2.69±0.08
3.	4th instar	28.64±0.56	20.53±0.96	10.26±1.08	10.42±1.82	3.10±0.10
4.	5th instar	33.90±1.65	23.52±0.70	11.64±0.72	11.88±0.86	3.82±0.11
5.	6th instar	38.56±0.931	27.06±1.10	13.38±0.70	13.34±0.54	4.34±0.20

Table-2. Efficiency of food utilization in *Cyana formosana* (Hamp.)

S. N.	Stage	A. D.	E. C. D.	E. C. I.
1.	2nd instar	60.84±2.33	19.77±3.16	11.97±1.45
2.	3rd instar	50.12±5.70	35.52±5.08	17.79±0.72
3.	4th instar	50.18±6.95	28.93±3.94	15.01±0.88
4.	5th instar	50.49±3.10	32.25±2.01	16.24±0.50
5.	6th instar	49.59±3.44	31.92±1.87	16.06±1.11

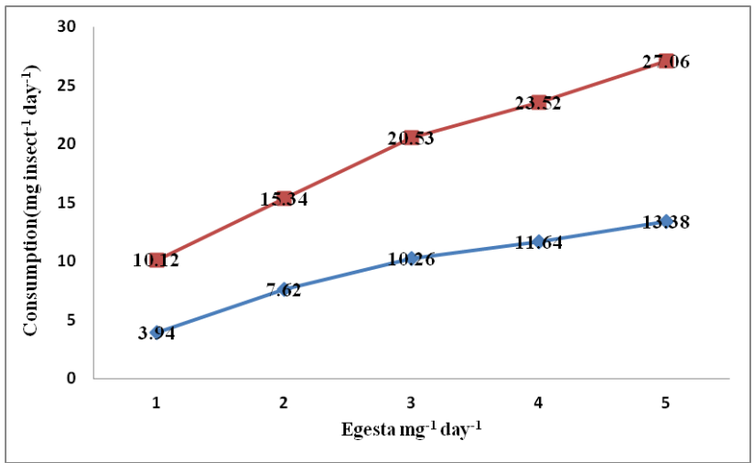

Fig-1. Relationship between Food Consumption and Egesta

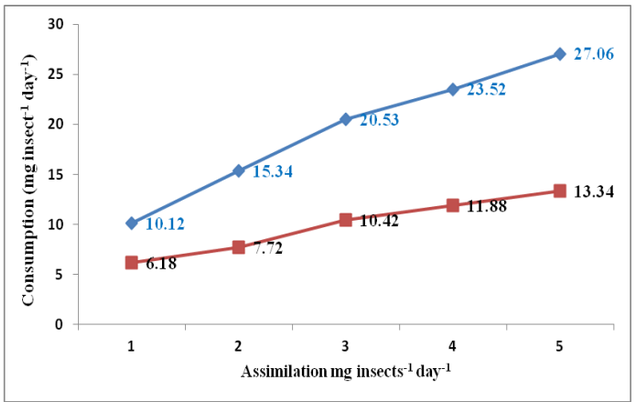

Fig-2. Relationship between Food Consumption and Assimilation

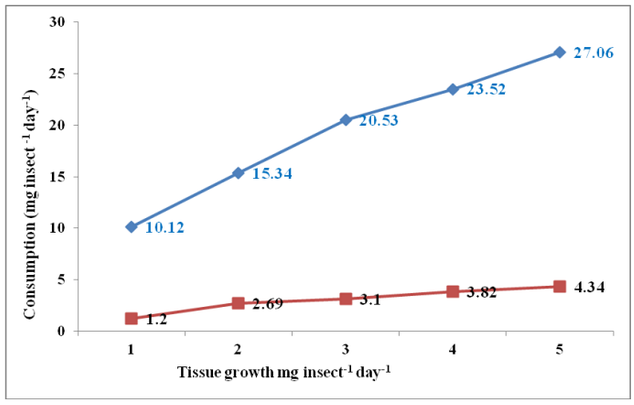

Fig-3. Relationship between Food Consumption and Tissue growth

calculated using Waldbauer's (1968) expressions:

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

$$\text{Tissue growth efficiency Or Efficiency of conservation of digested food (ECD)} = \frac{\text{Tissue growth}}{\text{Assimilation}} \times 100$$

$$\text{Ecological growth efficiency Or Efficiency of conversion of ingested food (ECI)} = \frac{\text{Tissue growth}}{\text{Consumption}} \times 100$$

Different parameters of energy budget viz. food consumption, assimilation and tissue growth of Cyana formosana were studied in the laboratory. This is the leaf webbering moth, constructs webs on leaves of mango trees from August to November. A generation can be completed in 40 to 45 days under ideal conditions, but most reports from the field suggest about six weeks between generations. The eggs are nearly spherical in shape. Initially they are yellow, but soon become grayish in color. Females commonly produce 40 to 50 eggs in one or more clusters. Eggs hatch in four to five days. There are five to six instars. At the time of hatching, the larvae were about 2 mm in length, brown in color, and bear numerous long hairs over the entire length of the body. During this stage, and the subsequent instars, larvae feed on the leaf surface. Second instars display longitudinal stripes, usually brown, yellowish, and white, and the body hairs become darker. In the fourth and fifth instars, larvae maintain the same general appearance as earlier stages, but grow to a length of about 45 to 55 mm. Larvae usually are dark, but sometimes yellowish brown or straw colored.

RESULTS AND DISCUSSION

The relative values of biomass and egesta, assimilation and tissue growth as percent of consumption have been presented in Tables-1, 2 and Figs.1- 3.

4.1 Food Consumption: The consumption of food was 10.12±1.20, 15.34±0.74, 20.53±0.96, 23.52±0.70 and 27.06±1.10 mg insect^{-1} day^{-1} in 2nd, 3rd, 4th, 5th and 6th larval instars, respectively. The percentage consumption of food for all instars calculated from total consumption for complete developmental period was 10.48, 15.88, 21.26, 24.36, and 28.02%, respectively.

4.2 Egesta: Increased consumption of food in all instars resulted increased production of egesta by larvae. In 2nd instar larva, the production of egesta recorded, was 3.94±0.26, which was 8.41% of total egesta, likewise egesta produced by all stages was 7.62±0.58, 10.26±1.08, 11.64±0.72 and 13.38±0.70 mg insect^{-1} day^{-1}, respectively, which was 16.26, 21.90, 24.85 and 28.57 % of total egesta, respectively.

4.3 Assimilation: Total leaf content assimilated by all stages was 49.54 mg insect^{-1}. In all five stages, leaf assimilated was 6.18, 7.72, 10.42, 11.88 and 13.34 mg insect^{-1} day^{-1}, by I, II, III, IV and V instars, respectively. The relative % assimilation of all stages was 12.47%, 15.58%, 21.03%, 23.98% and 26.92% of total assimilation. Assimilation in all stages

increased due to increased consumption and increased production of egesta. Many workers have reported an increase in amount of food assimilation with increased food consumption[7-12] . Researchers have studied food energy budget in 4 Lepidopteran pest namely Lymantria marginata, Trabala vishnou, Spilosoma obliqua and Plusia orichalcea and revealed that the approximate digestibility decreases, whereas the efficiencies of conversion of ingested food and digested food increase during first to last instar larvae[13]. They also reported that later instars are more efficient in transforming assimilated energy into the caterpillar biomass. Workers also reported that ECI decreased from 28.60±1.84 first instar to fifth instar (0.72±0.02) in Orgyia postica (Walk.) (Lepidoptera: Lymantriidae) larvae on Paulownia leaves[14].

4.4 Tissue growth: Tissue growth in all stages increased with increased consumption, increased production of egesta and assimilation. The tissue growth was 1.20±0.07, 2.69±0.08, 3.10±0.10, 3.82±0.11 and 4.34±0.20 mg insect-1 day-1 in all respective stages. The minimum tissue growth was observed in 2nd instar larvae, which was 7.92% of total tissue growth of all stages. In 6th larval stage, tissue growth was 4.34 mg $insect^{-1}$ day^{-1}, which accounted for 28.64% of total tissue growth.It was found that 70%, 67.37% and 71.64% tissue growth in fourth and fifth instar of Pieris brassicae (Lepidoptera: Pieridae) on cabbage, cauliflower and mustard, respectively[12].

4.5 Approximate digestibility (AD): The maximum value of approximate digestibility (60.84±2.33) was recorded for 2nd instar larvae, while the minimum value (49.59±3.44) was recorded for 6th instar larvae.The gradual decrease in approximate digestibility with increasing age was probably due to the fact that older nymphs and adults feed on leaves, which are more fibrous. Workers reported that approximate digestibility (AD) declines with age in Bombyx mori (Linn.)[19]. Researchers worked out on feeding performance of Clostera fulgurita (Walk.) (Lepidoptera: Notodontidae) on three clones of Populus deltoids (Bartram) and observed a gradual decline in AD in successive instars[15]. He recorded the maximum value of AD in third instar (55.28%), followed by fourth instar (52.48%) and 5th instar (48.05%). Workers have studied energy budget of Pieris brassicae (Linn.) (Lepidoptera: Pieridae) and reported, the maximum values of approximate digestibility (AD) for the first instar and minimum for the fourth instar larvae[12].

4.6 Efficiency of conservation of digested food (ECD): The ECD gives a measure of the efficiency with which absorbed food material is used in promoting growth by expressing the increase in dry weight as a proportion of the weight of food assimilated.In Cyana formosana (Hamp.) the mean value of efficiency of conversion of digested food or assimilated food, into body tissue was 29.67%. The value of ECD was minimum (19.77±3.16) in 2nd instar and maximum (35.52±5.08) for 3rd instar larvae.Workers have reported a gradual increase in ECD for young fifth instar larvae of Pieris brassicae[11]. Other reports revealed that efficiency of conversion of digested food (ECD) increased with increase in age of the larvae. He reported minimum value of ECD (37.42%) for the 3rd instar and maximum (41.54%) for the 5th instar larvae[15].

4.7 Efficiency of Conversion of Ingested food (ECI): The efficiency of conversion of ingested food to unit of body substance (ECI, also termed "growth efficiency") is an index measure of food fuel efficiency in animals. The ECI is a rough scale of how much of the food ingested is converted into growth in the animal's mass. It can be used to compare the growth efficiency as measured by the weight gain of different animals from consuming a given quantity of food relative to its size. The ECI effectively represents efficiencies of both digestion (Approximate Digestibility or AD) and metabolic efficiency, or how digested food is converted to mass (Efficiency of Conversion of Digested food or ECD). During present study, no any set pattern was found in Efficiency of Conversion of Ingested food into body tissue (ECI). The mean value of ECI for larvae, recorded was 15.41%. The minimum value (11.97%) of ECI was recorded in 2nd instar larvae, while maximum value (17.79%) was recorded in 3rd instar larvae. Researchers studied the energy budget of Mamestra configurata (Walk.) (Lepidoptera: Noctuidae) and reported no set pattern for ECI[16]. Workers has made studies on feeding performance of Clostera fulgurita on clones of Populus deltoids and reported that efficiency of conversion of ingested food (ECI) decreased with the increase in the age of the larvae[15]. Other researchers made studied food utilization efficiency in Anthraea mylitta fed on Terminalia arjuna leaves and reported that absolute values for dry matter ingested, digested, efficiency of conversion of digested food and biomass gain were increased with the advancement of larval development, while, the the relative consumption rate was declined. He also reported that the relative growth rate was maximum in IInd instar (0.488) and declined significantly thereafter[17].

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