Int. J. Adv. Res. Sci. Technol. Volume 5, Issue 2, 2016, pp.617-622.

IJARST

International Journal of Advanced Research in Science and Technology

journal homepage: www.ijarst.com

ISSN 2319 – 1783 (Print)
ISSN 2320 – 1126 (Online)

Ecobiology of the Common Evening Brown, *Melanitis leda* Linn. (Lepidoptera: Rhopalocera: Nymphalidae: Satyrinae).

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A R T I C L E I N F O

Article history:
Received :23 May 2016
Accepted :13 Aug. 2016
Available online :18 Oct. 2016

Keywords:
Life history,
Sexual diapause,
Population index,
Voltinism,
Nutritional indices.

A B S T R A C T

The common evening brown butterfly, *Melanitis leda* Linn. is seasonal in its occurrence at Visakhapatnam (17° 42' N and 82° 18' E), South India, during September to March. It utilizes *Brachiaria distachya* (Linn.) Stapf. for oviposition and as larval host. It lays eggs singly. The hatched larvae show five instars. It shows light green colour with a pair of horns in the head region. Pupa shows green colour with a mid-dorsal dark green line. The developmental time from egg to adult emergence was 27 – 35 (31.40 ± 3.43) days in the laboratory conditions with 28 ± 2^0 C, 80 ± 10% relative humidity, 12 – 14 h day-length. The early lifestages (eggs, larvae, pupae) are evident on *B. distachya* for a period of 150 days during September to January, thus producing an estimated three to four overlapping broods per year. There was a relatively high frequency of the early lifestages during October to December corresponding to rainy and winter seasons. Probably this Satyrid may require more moist and shady conditions for its occurrence and reproduction throughout the year. Such conditions were not available in the study biotope throughout the year, hence its occurrence over a limited part of the year. The larvae were efficient in consuming and utilizing the host leaves as indicated by the food utilization and nutritional indices of different instars. Approximate digestibility (AD) 96.66% - 57.24%, efficiency of conversion of ingested food to body substance (ECI) 6.66% - 36.52%, efficiency of conversion of digested food to body substance (ECD) 6.89% - 51.76%.

PAPER-QR CODE
IJARST
Volume 5, Issue 2

Citation: *B. Samatha, et. al., A Review on an Important Medicinal Plant Phyllanthus amarus Schum. &Thonn, Int. J. Adv. Res. Sci. Technol. Volume 5, Issue 2, 2016, pp.617-622.*

Introduction:

Evening browns or the Rice butterfly are the common names of the species of the genus *Melanitis* Fabricius. There are about 12 species in the world (Africa, from Sri Lanka through Malaysian region to Australia), of which three (*leda* Linn., *phedima* Stoll, and *zitenius* Herbst) occur in India. *M. leda* feeds on grasses, bamboos, and it is a minor pest on paddy crop (*Oryza sativa)* (Varshney, 1978). It is commonly called The Common Evening Brown. It is mentioned as very common throughout India except in the arid North-West. It is crepuscular being active in the early morning and at dusk. Depending on the wet and dry weather season, the wet and dry forms of *M. leda* are distinctive. To understand its ecological success in the study environment, its flight and reproductive seasonality, life history including particulars of different early life stages, instar wise performance in terms of food consumption; growth and utilization have been studied.

Materials and methods:

The study was conducted during 2010-2011 in the Andhra University campus (168 ha) at Visakhapatnam (17°42' N, 82°18' E) situated in the east coast of India. The natural plant community of the campus was searched for the distribution and reproductive activity of the common evening brown butterfly *Melanitis leda* Linn. Adult butterflies were seen mostly near the larval host plant *Brachiaria distachya* (Linn.) Stapf. Once located detailed observations were made at 10 sites in order to observe the flight activity and abundance of adults, the period of copulation and oviposition, following which we collected fresh eggs to study the life history and the duration of early stages. After oviposition, the leaf with egg(s) was collected in Petri dishes (15 cm x 2.5 cm depth) and brought to the laboratory. The piece of the leaf with the egg was then placed in a smaller Petri dish (10 cm x 1.5 cm depth) the inside of which lined with moistened blotter to prevent the leaf from drying. Five such samples were placed in a cage covered with wire mesh. The laboratory temperature was 28 ± 2° C and relative humidity 80 ± 10% with normal indirect sunlight conditions that varied in duration between 12h during November/January and 14h during June/July. The eggs were then examined at 6h intervals daily for recording time to eclosion. The larvae were subsequently reared on a weighed quantity of fresh leaves supplied daily. The time of each moult was noted. The morphological characters, body measurements, body weight of each instar and the faeces egested were taken daily. The prepupal behavior of the final instar, pupal particulars and the time of adult eclosion were also recorded. Larval performance in terms of food utilization indices were calculated as described by Waldbauer (1968).

To determine the developmental success of each of the early stages, a number of eggs were placed in Petri dishes in each month and the number of larvae hatched, pupae formed and the adults eclosed were recorded. To record the different early stages on the natural host plant, five patches (each a square meter) was thoroughly searched at 10 day intervals each month and the early stages found were enumerated and pooled for each month. During the same visits, the flight frequency of adults was also noted using the arbitrary scale of rare, less common, and common.

Results:

Adult stage (Figure: 1. a, b):

Both male and female adults are almost identical in external morphology. Wing span ranges between 65 – 80 mm. Body is brown. It measures 22.0 – 25.0 (23.3 ± 0.12) mm in length. Eyes are dark brown. This butterfly exhibits seasonal variation in wings character. The wet season form is dorsally brown in colour with bigger, single white pupilled dark brown ocelli bordered with light orange colour on forewing. Hindwing has three ocelli towards outer discal area. Ventrally the wings are light brown in colour and traversed by dark and light brown numerous stripes. The ocelli are more prominent and darker on ventral side. Forewing has four small ocelli, two at outer discal area and two at apex region and hindwing has six ocelli throughout its termen region; the first and fifth ocelli from apex region are bigger in size. Dry season form is more darker in colour. There is a single bigger ocelli towards apex on forewing with white pupil surrounded by orange patches. The apex of the forewing is angular. On hindwing there are indistinct cream coloured spots in place of ocelli. Ventrally the wings are little paler with dark and light brown patches; there are also white patches here and there. Ocelli are completely absent and replaced with indistinct cream coloured spots on both the wings. They were crepuscular being active during dawn and before dusk, with a weak flight. They were found mostly at low heights flying in jerky way. They rested on ground, or among bushes, or in verandahs, or on fallen dried leaves. It was difficult to recognize it when it settled on ground or on dried leaves because of perfect camouflage. Being attracted to electrical light at night, it mostly entered houses and alighted near the tube lights. It did not come to flowers for nectar, but fed mostly on over ripe or rotten fruits, and sap oozing from wounds on tree trunks. Although reported to use almost all the grasses (Poaceae) for oviposition, this butterfly was found using only Brachiaria distachya (Linn.) Stapf. for oviposition in the study area.

Egg stage (Figure: 1. c):

The breeding female laid eggs singly on underside of leaf surface of *Brachiaria distachya*. The eggs were round or spherical in shape, white in colour, soft in texture and measured 0.90 – 1.00 (0.93 ± 0.04) mm in height. Incubation period was 3 - 4 days. Immediately after hatching, the larva ate its egg-shell. The larva passed through five distinct instars over a period of 17 – 22 days.

Larval stage (Figure: 1. d-h):

Instar I – IV last for 3 – 4 days each. On the first day of hatching, the instar measured 3.00 – 3.30 (3.13 ± 0.12) mm in length. Instar I grows to a length of 4.00 – 4.50 (4.28 ±0.20) mm and a width of 0.70 – 0.80 (0.76 ± 0.04) mm. Larvae were light green in colour. Head was black in colour. Instar II attains a length of 5.00 – 6.00 (5.33 ± 0.47) mm and a width of 0.80 – 0.90 (0.85 ± 0.04) mm. Larva was light green with mid-dorsal longitudinal dark green stripe. Posteriorly there was a pair of pointed projections. Instar III reaches a length of 8.00 – 11.00 (9.66 ± 1.24) mm and a width of 1.00 – 1.10 (1.03 ± 0.04) mm. Head measured 1.00 – 1.10 (1.03 ± 0.04) mm with a pair of black coloured head horns. Both head and head horns were hairy. Body became little darker and its surface rough. On either side of mid-dorsal dark green stripe, there were two light green longitudinal stripes developed. The larva appeared wrinkled. The posterior pointed projections with light green colour measured 0.7 – 1.0 (0.86 ± 0.12) mm in length. Segmentation was clear. Instar IV grows to a length of 15.00 – 20.00 (17.30 ± 0.20) mm and a width of 1.50 – 2.00 (1.78 ± 0.20) mm. Body was bright green with tubercles and minute white hairs. The pointed projections on the posterior end were also bright green in colour; they measured 1.0 – 1.5 (1.29 ± 0.21) mm in length. Head was hairy and measured 2.00 – 2.50 (2.23 ± 0.20) mm in size. Head turned to green colour with black coloured stripe on the cheeks and a triangular shaped marking. Head horns measured 1.0 – 1.5 (1.25 ± 0.20) mm in length. Hairs on head and head horns were more profuse than on body. There were no changes in other characters from the previous instar. Instar V attains full growth in 5 – 6 days. It grew to a length of 33.00 – 45.00 (38.60 ± 0.49) mm and a width of 4.00 – 5.00 (4.66 ± 0.47) mm. Mid-dorsal dark green line was very lightly seen on the body, and with three light green coloured lines developed on both lateral sides. Head was little darker than the body. It measured 2.50 – 3.00 (2.76 ± 0.20) mm in size. The stripe on the cheek turned to reddish brown, and by its side a white stripe also developed. Head horns measured 1.5 – 2.5 (2.03 ± 0.41) mm in length; the horns and their hairs were maroon red in colour. The pointed projections on the posterior end measured 2.0 – 3.0 (2.33 ± 0.47) mm in length and were also hairy. Appendages were green in colour.

Pupal stage (Figure: 1. i):

The fully grown fifth instar stops feeding, contracts its body and pupates in 12-24 hours. It measures 15.00 – 18.00 (16.30 ± 0.12) mm in length and 6.00 – 7.00 (6.33 ± 0.47) mm in width at its broadest region. It attaches to the substratum at its posterior end. Pupa is completely green in colour with mid-dorsal dark green line. It was plain in texture with no markings. It was narrower anteriorly and broader posteriorly. Pupal weight is 238.0 mg. It lasts for 6 – 8 days including the prepupal period.

Development success and Population index:

The eggs of *Melanitis leda* could be located on its host plant during September – January. The success rate of hatching of eggs varied between 75% (November) – 100% (January, September, and December), that of larvae becoming pupae between 66% (December) – 100% (January, September, October and November) and that of pupae resulting in adult emergence between 50% (January) – 100% (October, November, and December) (Table 1).

The occurrence and numerical frequency of three life stages (eggs, larvae and pupae) on two patches (each a square meter) of the host plant showed that *M. leda* could reproduce during September – January. The adults were found from September till March. There was higher frequency during October – December in terms of the three early stages and the adults (Table 2 and Figure 2).

Food consumption, growth and utilization:

The data on the amount of food consumed by each instar and the corresponding weight gained by the larvae are included in Table 3. The amount of food ingested increased as the larvae passed through different instars, with consequent increase in body weight. The relation between food consumption and growth is shown in Figure 3. The proportions of food consumed by different instars in the total amount of food consumed were 0.87, 1.58, 3.61, 6.98, and 86.94%. Thus, the last two instars consumed a greater amount of food (over 94%). The proportions of weight gained by each instar in the total weight were 0.35, 0.78, 2.98, 15.62, and 80.24%. Thus, the last two instars consumed more food and gained greater weight (over 96%) than other instars. An irregular pattern occurred in the values of GR and CI across the instars. The values of GR varied between 0.25 – 0.41 mg/day/mg and those of CI between 1.14 – 5.00 mg/day/mg. Table 3 also includes the values of AD, ECD and ECI. The values of AD decreased as the larval age advanced; the values ranged between a high of 96.66% in the first instar and a low of 57.24% in the final instar. The values of ECD and ECI in general increased as the larvae aged except from instar IV to V where there was a decrease. Values of ECD ranged from 6.89 – 51.76% and those of ECI from 6.66 – 36.52%. The lowest values were associated with the first instar, and the highest values with the fourth instar in respect of these two indices.

$$\text{CI: Consumption Index} = \frac{\text{Weight of food ingested}}{\text{Mean weight of insta} \times \text{Number of feeding days}}$$

Figure - **I**

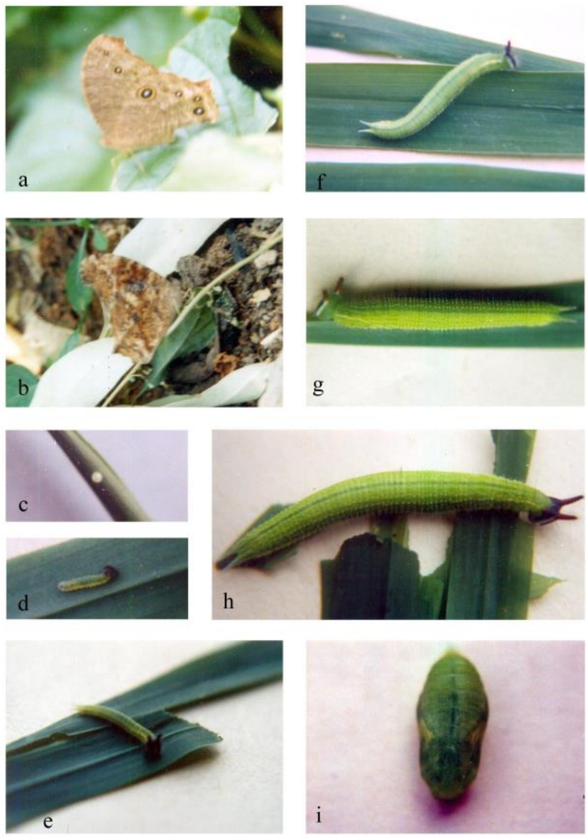

Figure 1: (a) Adult (wet form), (b) Adult (dry form), (c) Egg, (d) Instar I, (e) Instar II, (f) Instar III, (g) Instar IV, (h) Instar V, (i) Pupa

Table: 1. Development success of eggs, larvae and pupae of *Melanitis leda* on *Brachiaria distachya* leaves in the laboratory.

Life cycle stage	**Calendar Months**											
	J	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
# eggs studied	0	0	0	9	15	12	9	4	0	0	0	0
# larvae hatched	0	0	0	9	12	9	9	4	0	0	0	0
# pupae formed	0	0	0	9	12	9	6	4	0	0	0	0
# adults emerged	0	0	0	6	12	9	6	2	0	0	0	0

Table: 2. Population index of different life stages of *Melanitis leda* on *Brachiaria distachya* leaves in the field.

Life cycle stage	**Calendar Months**											
	J	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**
Adult abundance	-	-	-	**	***	***	***	**	*	*	-	-
# eggs	0	0	0	6	18	18	16	9	0	0	0	0
# larvae	0	0	0	6	15	12	9	6	0	0	0	0
# Pupae	0	0	0	3	9	6	6	2	0	0	0	0

*Rare, **Less common, *** Common

Table: 3. Food consumption, growth and food utilization efficiencies of *Melanitis leda* larva fed with *Brachiaria distachya* leaves.

Instar number	Wt. of food ingested (mg)	Wt. of faeces (mg)	Wt. gained by larva (mg)	GR (mg/day/mg)	CI (mg/day/mg)	AD (%)	ECD (%)	ECI (%)
I	15.0 ± 01.69	0.5 ± 0.08	1.0 ± 0.04	0.33	5.00	96.66	06.89	06.66
II	27.3 ± 00.92	2.2 ± 0.23	2.2 ± 0.10	0.25	3.10	91.94	08.76	08.05
III	62.1 ± 04.54	6.4 ± 0.47	8.4 ± 0.45	0.33	2.46	89.69	15.08	13.52
IV	120.2 ± 04.64	35.4 ± 1.63	43.9 ± 0.85	0.41	1.14	70.54	51.76	36.52
V	1495.0±46.96	639.2 ± 22.10	225.5 ± 6.35	0.25	1.69	57.24	26.34	15.08

Discussion:

The climate in the tropics which is less seasonal with little change in temperature is expected to permit the butterflies to fly and breed all through the year, with certain favourable periods (Owen, 1971; Owen *et al.* 1972). The adults of common evening brown, *Melanitis leda* found from September till March. The reproductive peak was observed during October to December i.e. corresponding to rainy and winter seasons. Mathew and Rahamathulla (1993) reported that this butterfly was found abundantly throughout the year in the dense forests of silent valley with a typical humid tropical rain forest. Probably this satyrid may require more moist and shady conditions for its occurrence and reproduction. Such conditions were not available in the study biotope throughout the year, hence its occurrence over a limited part of the year. The adults are probably in a reproductive diapause during the remaining part of the year.

The total developmental time from egg laying to adult eclosion was determined as 31.40 ± 3.43 days at about 28^0 C, thus permitting 3 – 4 overlapping broods per year. This behaviour is in line with the expectation of tropical butterflies to have a short life cycle, and multiple broods over the year (Owen *et al.* 1971). Since temperature influences instar duration and the overall development time (Mathavan & Pandian, 1975; Palanichamy *et al.*, 1982; Pathak & Pizvi, 2003; Braby, 2003), the brood number in other parts of *M. leda* distribution may vary from our records depending on the prevailing temperatures. As no temperature extremes occur at Visakhapatnam, especially at the Andhra University site, the duration of life cycle did not vary much over the overlapping seasons.

Adult feeding on the over-ripe or rotten fruits and sap oozing from wounds on tree trunks helps them to obtain proteins and carbon sources (Levey & del Rio, 2001), with such nutrient uptake improving egg productivity (Fischer *et al*., 2004).

The food consumption index (CI) of most forb chewing Lepidoptera are reported to vary between 0.27 – 6.90 (av. 2.03) (Slansky and Scriber, 1985), and the average CI of 2.68 estimated for *M. leda* is well accommodated in this range of CI. Food consumption rate depends on the conversion efficiency of ingested food to biomass (ECI), the rate increasing as the conversion efficiency decreases or vice versa (Slansky&

Scriber, 1985). In this sense, the high CI value (5.00) of instar I is probably due to low conversion efficiency and this character is reflected in the low values of ECI for instar I compared to other successive instars. Higher growth rates occur with penultimate than with final instars (Scriber & Feeny, 1979). The GRs of penultimate and final instars of *M. leda* are in line with the above decreasing trend.

$$\text{ECI: Efficiency of Conversion of Ingested food} = \frac{\text{Weight gained by the instar}}{\text{Weight of food ingested}} \text{X100}$$

(Also called Gross Conversion Efficiency)

The values of AD that were obtained in this study are comparable with the range of AD values (19-81%) for lepidopterous larvae (Pandian & Marian, 1986). The average AD percentage is over 81.21% and this high AD substantiate the statement of Slansky & Scriber (1985) that foliage chewers often attain high AD values. Such high AD values also are expected when food item is rich in nitrogen (and also water) (Pandian & Marian 1986). Similar results were repeated with *Pieris brassicae* (L.) (Yadava *et al*., 1979), *Ariadne merione merione* (Cramer) (Atluri *et al*., 2009) and *Phalanta phalantha* Drury (Bhupathi Rayalu *et al*., 2014).

$$\text{AD: Approximate digestibility} = \frac{\text{Weight of food ingested} - \text{Weight of faeces}}{\text{Weight of food ingested}} \text{X100}$$

(Also called Assimilation Efficiency)

In generally it is believed that the values of ECD tend to increase form early to late instars (Slansky & Scriber, 1985). The ECD values of *M. leda* increased form early to penultimate instars but showed sharp decrease in the ultimate instar and the values generally agree with the range of values reported for *Danaus chrysippus* by Mathavan and Bhaskaran (1975). The decline in ECD in the V instar might be ascribed to some factor which caused an increase in energy expenditure on metabolism (Muthukrishnan, 1990; Krishnan *et al*., 1997). The pattern of ECI values followed closely the pattern of ECD. The values (6.66-36.52) obtained are comparable with the range of values expected for forb foliage chewers (1-78%) (Slansky& Scriber, 1985). The values of ECD and ECI, particularly those of the last two instars, are also relatively high (51.76, 26.34; 36.52, 15.08), thus respectively indicating tissue growth efficiency and ecological growth efficiency, which enabled *M. leda* to thrive successfully in the urban environment.

$$\text{ECD: Efficiency of Conversion of Digested food} = \frac{\text{Weight gained by the instar}}{\text{Weight of food ingested} - \text{Weight of faeces}} \text{X 100}$$

(Also called Net Conversion Efficiency)

Thus, the present study provides information on the oviposition larval host, *B. distachya*, population index and larval performance in terms of food consumption, growth and utilization, and the length of life cycle from egg to adult eclosion of the Common evening brown butterfly, *M. leda*. The present data may be profitably utilized in the successful conservation management of this butterfly species either in parks, Zoos and butterfly houses or in fields. Butterfly houses are popular exhibits in Zoos and have an immense educational (Veltman, 2009) and conservational potential (Mathew, 2001; Veltman, 2009). The present study also indicated that captive rearing the larvae at about 28 ± 2 °C permits enough stock of adults for restocking the areas poor in populations (Schultz *et al*., 2009) of the Common evening brown butterfly.

Acknowledgements:

We thank Professor Frances S. Chew of Tufts University, Medford, USA, for review and appreciation.

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