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LIFE HISTORY AND LARVAL PERFORMANCE OF THE COMMON TIGER BUTTERFLY, *DANAUS GENUTIA* CRAMER (LEPIDOPTERA; RHOPALOCERA; DANAIDAE)

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ABSTRACT
For the first time, the life history of the Common tiger butterfly, *Danaus genutia* and larval performance in terms of food consumption and utilization, and the length of life cycle was described its host plant *Pergularia daemia*. Our study was conducted during 2007 at Visakhapatnam (17º42' N and 82º18' E), South India. *Danaus genutia* completes its life cycle in 19.80 ± 1.10 days (eggs 3, larvae, 8 – 10, pupa 7 – 8 days). The values of nutritional indices across the instars were AD (Approximate Digestibility) 52.23 – 93.88%; ECD (Efficiency of Conversion of Digested food) 2.97 – 50.82, ECI (Efficiency of Conversion of Ingested food) 2.79 – 26.54, measured at the temperature of 28 ± 2^0 C and RH of 80 ± 10% in the laboratory. These relatively high values of ECD and ECI explain at least partially the ecological success of *D. genutia* in the present study environment.

INTRODUCTION

In India butterfly populations declined in the past few decades (Grewal, 1996) and it is often suggested that captive rearing/ breeding and releasing of butterflies in the wild will help restock at-risk populations and serves as a means of conservation (Varshney, 1986; Herms *et al*., 1996; Nicholls and Pullin, 2000; Mathew, 2001; Crone *et al*., 2007; Schultz *et al*., 2008). Such conservation initiatives with respect to butterflies was taken by the American Zoo and Aquarium Association for recovery of 22 butterfly species, largely with captive propagation programs (http://www.butterflyrecovery.org/recovery/). Similarly, for 10 of 25 at-risk British butterfly species is implemented with captively propagated stock (http://www.butterfly-conservation.org/).

For the development of effective breeding/rearing programs and conservation management of butterflies, information on the life history and exact habitat requirements is essential. Further, immature stages of butterflies are of increasing importance as sources of systematic characters and often give important clues as to the placement of species in major groups (DeVries *et al*., 1985; Freitas *et al*., 2002). Haribal (1992) noted that such information is lacking for 70% of the Indian butterflies. In this context the present study furnished the necessary information about immature stages, larval performance on its host plant *Pergularia daemia* (Forsk.) Chiov and the length of life cycle from egg to adult eclosion for the Common tiger butterfly, *Danaus genutia* Cramer. This species is distributed throughout India and rest of the Indian subcontinent, extending to southeast Asia and Australia, but absent in New Guinea.

MATERIALS AND METHODS

The present study was carried out at Visakhapatnam during the calendar year 2007. Visakhapatnam (17º42' N latitude and 82º18' E longitude) is located on the east coast of India in the State of Andhra Pradesh. The basic protocol for captive rearing is to collect eggs from wild-mated females, rear larvae to adult butterflies in captivity and release adult butterflies and/or pupae back into wild populations (Crone *et al*., 2007). The reproductive activity of the Common tiger butterfly, *Danaus genutia* was observed regularly during 0800 to 1500hr at two sites viz. Andhra University campus and the Zoo Park area, 5 km away from the campus. Once adult butterflies were located detailed observations were made in order to observe the period of copulation and oviposition. After detecting ovipositions, the leaf with eggs was collected in Petri dishes (15 cm × 2.5 cm depth) and brought to the laboratory. The leaf piece with eggs was then placed in a smaller Petri dish (10 cm × 1.5 cm depth), that was lined with moistened blotter to prevent leaf drying. Such Petri dishes were kept in a clean, roomy cage fitted with wire gauge. Since ants were never detected, no special protection device was tried to avoid predation of eggs. They were examined regularly at 6hr interval for recording the time of hatching. Each of the freshly emerged larvae was transferred to a clean Petri dish lined with moistened blotter with the help of a camel hairbrush. The larvae were supplied daily with weighed quantity of tender leaf pieces of the host plant. The faeces and the leftover of the food was collected and weighed each day (24 hr). The growing larvae

were observed regularly to note the change of instar and characters including length, breadth and weight measurements. As the larvae grew, they needed more space. Hence, increased space was provided by transferring the growing larvae to bigger Petri dishes (15 cm × 2.5 cm depth). Larval performance in terms of food utilization indices were calculated as described by Waldbauer (1968).

Five replications were maintained for the study of all parameters. Fresh weight measurements were used for the purpose. The development of pupa from full grown larva and particulars of pupa including color, shape, size, weight and the time of adult eclosion were also recorded. Millimetre graph paper was used for taking measurements. The laboratory temperature was 28 ± 2^0 C and relative humidity 80 ± 10% with normal indirect sunlight conditions that varied in duration between 12hr during November/ January and 14 hr during June/July.

In describing the details of adult characters, the butterflies that have emerged from the pupae in the laboratory and those caught in the wild were used.

RESULTS

Adult stage (Fig. 1a)

The wings are orangish brown with broad and black veins on the upperside, giving it a striped appearance. The margins of the wings are black with two series of white spots. The underside is similar in color and pattern, but paler as compared to the upperside. The male and female can be distinguished by having a black and white spot on the underside of the hindwing in the male. Head and thorax black with white spots and abdomen is tawny on dorsal surface and white on the ventral surface. Wing span is between 75 – 100 mm. Mating and oviposition took place during 1000 – 1600 hr.

Adult female behavior during oviposition

The gravid female laid eggs singly on the undersurface of the both young and mature leaves of its host plant. About 8-10 eggs were laid at a time but on different leaves. There was no bias for the age of the leaf. Adults were found probing for nectar on the *Tridax procumbens* L. and *Amaranthus viridis* L.

Egg stage (Fig. 1b)

The eggs were creamy, dome shaped with longitudinal ridges and measure 1.00 – 1.10 (1.04 ± 0.05) mm in height. They hatched in three days of incubation. Immediately after hatching the larva ate its egg-shell. It passed through five distinct instars over a period of 8 – 10 (9.00 ± 0.71) days.

Larval stage (Fig. 1c-g)

Instar I lasted for 2 (2.00 ± 0.00) days. On the first day of hatching, the instar measured 2.00 – 2.20 (2.04 ± 0.09) mm in length. It grew to 2.50 – 3.60 (2.76 ± 0.47) mm in length and a width of 0.70 – 0.90 (0.83 ± 0.08) mm. Head capsule black in color and measured 1.30 – 1.80 (1.62 ± 0.19) mm in diameter. Body was light grayish and shining. Three pairs of tentacle initials can be seen under lens but can not be seen with the naked eye. Instar II lasted for 1- 2 (1.20 ± 0.45) days. The larva attained a length of 4.00 – 6.00 (4.80 ± 0.76) mm and a width of 1.00 mm (1.00 ± 0.00). Head capsule measured 1.90 – 2.30 (2.06 ± 0.16) mm in diameter. Tentacles were clear at this stage, each pair at 3rd, 6th and 12th segments and black in color. Body was not shining. On both sides of the body on sub dorsal surface black spots were seen through the length of the body. Dorsal surface of the body was marked with yellow, grey and black colored spots. Instar III also lasted for 1 – 2 (1.40 ± 0.55) days. The larva reached to a length of 7.00 – 8.50 (7.70 ± 0.67) mm and a width of 1.20 – 1.50 (1.37 ± 0.12) mm. Head capsule measured 3.50 – 3.80 (3.66 ± 0.11) mm in diameter. Body was cylindrical. On both sides of the body there were 10 yellow colored spots. Tentacles at 12th segment were robust than remaining two pairs at 3rd and 6th segments. Instar IV also lasted for 1 – 2 (1.40 ± 0.55) days. The larva reached to a length of 10.00 – 16.50 (14.10 ± 2.46) mm and a width of 1.50 – 3.00 (2.52 ± 0.60) mm. Head capsule measured 4.10 – 4.80 (4.52 ± 0.29) mm in diameter. Side black spots merge to form a single line through the length of the body. In between this black line and prolegs (extreme sides of the body) there was a yellow colored wavy line. Prolegs were black in color. Instar V lasted for 3 (3.00 ± 0.00) days. The larva attained a length of 26.70 – 32.30 (29.72 ± 2.26) mm and a width of 4.50 – 5.40 (5.01 ± 0.33) mm. Head capsule measured 6.40 – 7.40 (6.72 ± 0.41) mm in diameter. It was black in color with two rings of white bands and a central triangular spot. The markings on the dorsal side of the body were very distinct at this stage. These markings were with white, yellow and black coloured bands. Bases of the tentacles turned into thick pinkish color, remaining part black. The ventral side the body was black. Side-wise markings were same as previous instar. Body contracted before pupation.

Pupal stage (Fig. 1h)

Pupal stage lasted for 7 – 8 (7.80 ± 0.45) days. It was 18.00 – 19.00 (18.20 ± 0.45) mm in length and 7.00 – 8.00 (7.50 ± 0.35) mm in width at its broadest end. It was attached to the upper part of the Petri plate with a shiny black cremaster. The surface of the pupa was smooth and shining, and either green or brown colored (dimorphism). There was a silver band near tail region and a pair of small shiny golden spots at the abdominal region. Its weight was about 646.10 – 805.40 (710.16 ± 68.45) mg.

Duration of life cycle: The total development time from egg to adult eclosion ranged between 18 – 21 (19.80 ± 1.10) (Egg:

Table 1: Food consumption, growth and food utilization efficiencies of *Danaus genutia* larva fed with *Pergularia daemia* 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	25.82 ± 03.28	1.58 ± 00.25	0.72 ± 00.08	0.33	11.74	93.88	02.97	02.79
II	31.25 ± 03.14	2.10 ± 00.42	1.68 ± 00.57	0.50	09.37	93.28	05.76	05.38
III	124.32 ± 07.23	8.46 ± 01.53	15.68 ± 02.38	0.61	04.81	93.19	13.53	12.61
IV	202.23 ± 09.46	19.40 ± 05.46	80.86 ± 09.47	0.58	01.45	90.41	44.23	39.98
V	2978.34 ± 88.65	1422.66 ± 58.96	790.54 ± 28.96	0.29	01.11	52.23	50.82	26.54

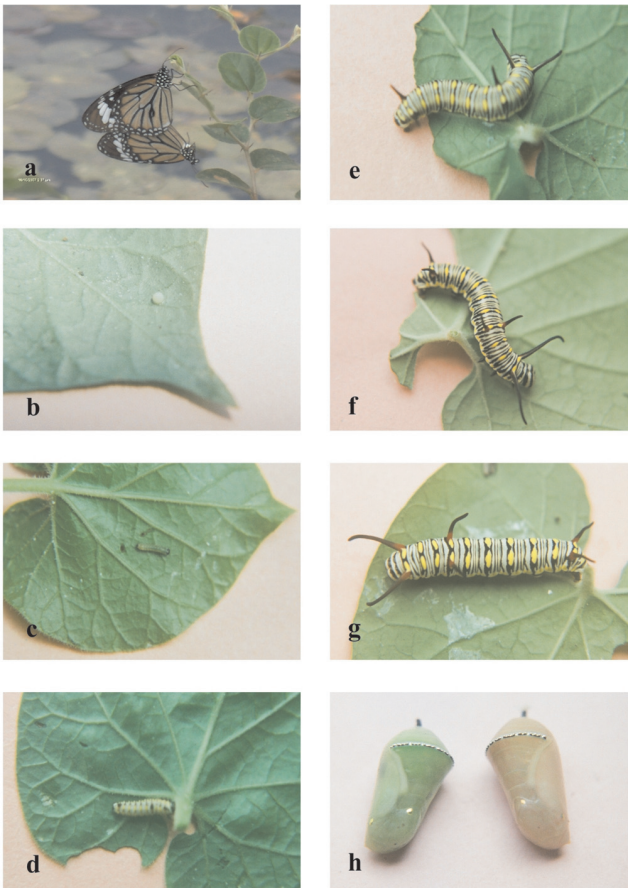

Figure 1: Life stages of *Danaus genutia*
(a)Adult pairing; (b)Egg; (c)Instar I; (d)Instar II; (e)Instar III; (f)Instar IV; (g)Instar V; (h)Pupae showing color dimorphism

3; Larva: 8-10; Pupa: 7-8) days.

Food consumption, growth and utilization

The data on the amount of food consumed by each of the five instars and the corresponding data on weight gained by different instars are given in Table 1. Of the total amount of food consumed, the percentage shares of successive instars were 0.77, 0.93, 3.70, 6.01 and 88.59% and the proportions of weight gained in relation to total weight gained by the successive instars were 0.08, 0.19, 1.76, 9.09 and 88.88%. Thus, there was over 94% of the total food consumption and 97% of total weight gained in the fourth and fifth instars together. There was a direct relationship between food consumption and growth across the five instars (Fig. 2). The values of growth rate (GR) increased till instar III and then decreased to instar V, and consumption index (CI) progressively decreased from instar to instar. The values of GR varied between 0.29 – 0.61 mg/day/mg and those of CI between 1.11 – 11.74 mg/day/mg. Table 1 also included the data on AD, ECD, and ECI. The values of AD from instar to instar decreased from a high of 93.88% in first instar to a low of 52.23% in the last instar. The values of ECD increased progressively from the first instar to the last instar and varied from 2.97 – 50.82%. The values of ECI increased from first to fourth instar and decreased in final instar and ranged between 2.79 – 39.98%.

DISCUSSION

The total development time from egg laying to adult eclosion was 19.80 ± 1.10 days at about 28 ± 2^0 C. This behavior is in line with the expectations of short life cycles in tropical butterflies (Owen, 1971). Since temperature influences instar duration and the overall development time (Mathavan and Pandian, 1975; Palanichamy *et al*., 1982; Pathak and Pizvi, 2003; Braby, 2003), the duration of life cycle may vary from our records depending on the prevailing temperatures. As no temperature extremities occur at Visakhapatnam, the duration of life cycle did not vary much over the overlapping seasons.

Over the entire period of its growth, a larva consumed on average over 3.36 g of leaf material, with increased consumption in the last two instars. This tendency of greater consumption by the last two instars has been reported in lepidopterous larvae in general (Waldbauer, 1968; Mathavan and Pandian, 1975; Scriber and Slansky, 1981; Palanichamy *et al*., 1982; Selvasundaram, 1992; Gosh and Gonchaudhuri, 1996) and it compensates the energy expenditure of non-feeding pupal stage (Pandian, 1973). The values of CI are near to the range (0.27 – 6.90) predicted for forb foliage chewers (Slansky and Scriber, 1985). 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 and Scriber, 1985). In this sense, the high CI value (11.74) 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 and Feeny, 1979). The GRs of penultimate and final instars of *Danaus genutia* are in line with the above decreasing trend.

The values of AD that were obtained in this study are comparable with the range of AD values 19 – 81% appear to be slightly higher side of the range for lepidopterous larvae (Pandian and Marian, 1986). The average AD percentage is over 84.60 and this high AD substantiates the statement of Slansky and 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 and Marian, 1986). Similar results were repeated with *Pieris brassicae* (Yadava *et al*., 1979), *Euploea core* (Venkata Ramana *et al*., 2001) and *Ariadne merione merione* (Atluri *et al*., 2010).

The values of ECD increase from early to last instars (Slansky and Scriber, 1985). Such a trend is also observed with the ECDs of *Danaus genutia*, with the lowest value in instar I and the highest in instar V. The ECDs obtained are low compared to the ADs and such low values are not unusual (Waldbauer, 1968). This is indicative of low efficiency of conversion of digested food to body tissues. This poor utilization of food is often attributed to deficiency in some essential nutrient in food (Bailey and Mukerji, 1976) or a factor causing an increase in energy expenditure on metabolism (Muthukrishnan, 1990). The values of ECI (2.79 – 39.98) obtained are comparable with the range of values expected for forb foliage chewers (1 – 78%) (Slansky and Scriber, 1985). Although the pattern of ECI is expected to follow that of AD (Waldbauer, 1968), the two indices of *D. genutia* have no similarity and there is no definite

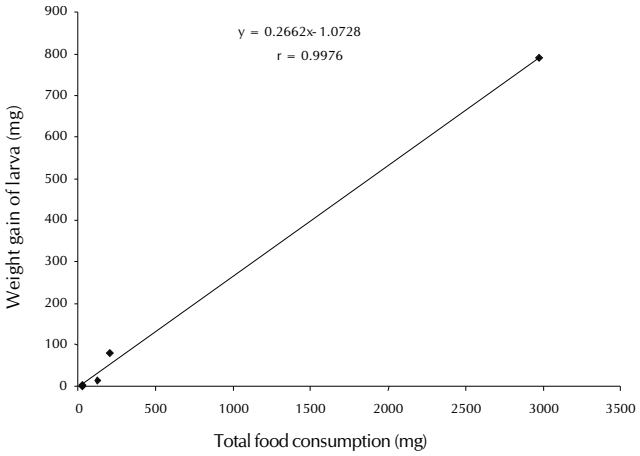

Figure 2: Relationship between food consumption and growth in *Danaus genutia* on *Pergularia daemia*

trend of increase or decrease in ECI values as suggested by Slansky and Scriber (1985). The values of ECD and ECI, particularly those of the last two instars, are also relatively high (44.23, 50.82; 39.98, 26.54), thus indicating tissue growth efficiency and ecological growth efficiency respectively, which enabled *D. genutia* to thrive successfully in the present study environment.

Danaus genutia exhibited pupal color dimorphism by producing green and brown colored pupae (4:1) (Fig. 1h). Though the present study was not designed to deal with this special case of pupal color dimorphism, it can be interpreted that the brownish grey colored floor of the cage that was used to rear the larvae may influence the formation of brown pupae and the leaves that were used to feed the larvae for formation of green pupae and strongly support Wood's (1867) contention that pupal coloration is highly positively correlated with the color of the background upon which a pupa is formed. In green house populations of *Papilio polytes* and *P. demoleus* Smith (1978) found that there is a greater probability of green pupae to be formed amongst green vegetation and brown ones on brown stems.

The information on the oviposition, larval host and larval performance in terms of food consumption, growth and utilization, and the length of life cycle from egg to adult eclosion of *Danaus genutia* in the present study may be profitably utilized in the successful conservation management of this butterfly species either in parks, Zoos and butterfly houses or in the field. 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 indicted that captive rearing of larvae at about 28 $\pm$ 2^{0}C permits enough stock of adults for restocking the areas poor in populations of the Common tiger butterfly.

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