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Life cycle and Biology of *Graphium agamemnon* (Tailed jay) on *Polyalthia longifolia* (sonn.)

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Abstract

The Papilionidae butterfly *Graphium agamemnon* (Tailed jay) larval performance and life cycle was studied at Andhra University campus, Visakhapatnam. The leaves of *Polyalthis longifolia* were used in the study of larval growth as host and in laboratory and in natural conditions for morphological and behavioral characters. The life cycle was finished in 4-5 weeks, with egg hatching 3 days, larvae 14-21days, and pupae 11-13 days. The values of consumption index, growth rate and approximate digestibility across the instars decreased as the larvae aged. The average values of the consumption index and growth rate are 0.25-21.54 and 0.5-0.15 respectively, and that of approximate digestibility is 51.86 - 97.76. But, the values of both competence of conversion of digested food and competence of conversion of ingested food are either increased or decreased from instar to instar was observed.

Key words: Life history, *Papilionidae*, *Graphium agamemnon*, Instars, Food utilization indices.

1. Introduction

The phytophagous insects like butterflies are economic and ecological benefits to the human society by living closely related with plants. Butterflies are dependent on complex feeding relationships with green plants in their life cycle as adults and larvae. The butterflies life cycle is holometabolous, it include egg, larva, pupa and adult stages. All these stages depend on nutrient supplements at different stages, at different stages they require and get nutrients from different sources like adult from nectar, larva from plants. But, there is less reports on lifecycle studies and their nutrient supplements at different stages around the world including India (Fenny, 1976; Muthukrishnan, 1990; Appala naidu, 2015). So, the current research is aimed on *Graphium agamemnon* (L.) (Tailed Jay)– (Lepidoptera: Rhopalocera: Papilionidae) life cycle study about its oviposition, larval egg deposition, duration of different stages and food resources on *Polyalthia longifolia* as host plant.

2. Materials and Methods

2.1 Study region

The study was carried out at Department of Botany, Andhra University, Visakhapatnam, Andhra Pradesh in the moths of June and November (monsoon time) during 2011 and 2012 (17^o 42' N latitude and 83^o 20' E longitude). The study region is tropical coastal region in South India and its rain fall is 1000-1500 mm.

2.1 Field study

The field study was carried out on butterflies active period on day light (08:00AM-15:00PM) at 10 day intervals and even daily. During the above said timings flight behavior, foraging, and oviposition activity of the *G. agamemnon* were record. Entire period of adults on wing these activities were observed including nectar resource plants and oviposition of it on plants.

2.3 Laboratory Study

2.3.1 Life history study

Breeding season of *G. agamemnon* females on its host plant was notices. Then, without any damage freshly laid eggs on leaves/twigs were plucked. The

collected eggs were transferred to lined moist blotting paper inserted Petri dishes and kept room temperature with relative humidity 80±10% by providing normal indirect sunlight.

Every 6h incubation eggs hatchability was recorded and fresh tender leaves given as food to the growing larvae. The full grown larvae pupate, and pupae particulars were recorded. 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.

2.3.2 Food consumption and utilization

The food consumption during each stage of *G. agamemnon* mainly during larval stage using gravimetric method because larval stage is main feeding stage. The consumption index (CI), growth rate (GR), assimilation efficiency/ approximate digestibility (AE/AD), gross conservation efficiency/efficiency of conversion of ingested food (GCE/ECI), net conversion efficiency/efficiency of conversion of digested food (NCE/ECD) by measuring the larvae and food weights and remained food, fecal matter after 24hr of feeding using below formulas (Waldbauer, 1968).

$$\text{CI (Consumption index)} = \frac{\text{Weight of food consumed}}{\text{Weight of instar x Number of feeding days}}$$

$$\text{GR (Growth rate)} = \frac{\text{Weight gained by the instar}}{\text{Mean weight of instar x Number of feeding days}}$$

$$\text{AD (Approximate digestibility)} = \frac{\text{Weight of food ingested} - \text{Weight of faeces}}{\text{Weight of food ingested}} \times 100$$

$$\text{ECD (Net conversion efficiency)} = \frac{\text{Weight gained by the instar}}{\text{Weight of food consumed} - \text{Weight of faeces}} \times 100$$

$$\text{ECI (Gross conversion efficiency)} = \frac{\text{Weight gained by the instar}}{\text{Weight of food ingested}} \times 100$$

2.3.3 Statistical analysis

Statistical analysis was done based on Legenders principle by fitting a straight line. Correlation coefficient was calculated in each case along with t value.

3. Results and Discussion

In the present study life cycle and biology of *Graphium agamemnon* was discussed. The adults *G. agamemnon* were black with bright green spots and streaks on wings with their span 85-100mm and underside was pale brown with black, suffused with lilac or violet-grey. Two red spots near base, each edged with a black crescent, and a small red tornal spot on underside hind wing. Male has scent wool in dorsal fold on upper side hind wing. Basal stripes and discal cells and marginal spots, all are bright green. Long tail present in females than males. They lives in common at well wooded regions with good rainfall regions (Fig 1-A).

In our study we identified different species, that *G. agamemnon* depends for nectar were *Antigonon leptopus, Lantana camara, Eupatorium odoratum, Enterolobium saman, Tagetus erectus, Crotalaria laburnifolia, Hamelia patens, Plumeria alba, Plumeria pudica, Memyzylonedula, Durantarepens, Premna latifolia, Quisqualis indica, Bauhinia purpurea and Santalum album.*

In our study we identified and recorded different species, such as *Unona discolor, Annona muricata, A. Squamosa, Artabotrys reticulate, Artabotrys odoratissmus, Polyalthia longifolia, polyalthia scerasoides, Saccopetalum gaultheria* for oviposition of *G. agamemnon.* This study discussed on the *P. longofolia* plant belong to the family Annonaceae for oviposition and life cycle and biology of *G. agamemnon*.

Single eggs were laid by female under surface of the *P. longifolia* leaves, 1 or 2 eggs at a time during 08:30–12:00h. The newly laid eggs were spherical shaped with creamy white at deposition but changing to light yellow in a day.

In life cycle and biological study of *G. agamemnon* we observed the following observations

in its life cycle on *P. longifolia* leaves in laboratory study.

The whole life cycle was ranged between 4-5 weeks, it include egg stage 3days; larva stage 14-21 days and pupa stage 11-13days.

Egg stage- The *G. agamemnon* exhibited single-egg laying habit. Also the larvae of single-egg laying species are less likely to be exposed to adverse environmental conditions of heat and desiccation because single larvae are less likely to defoliate (Kitching, 1981). The eggs size was 0.90–1.10 (0.96±0.08) mm in length and 1.80–2.10 (1.92±0.16) mm in width. They hatched in 3.00 (3.00±0.48) days of incubation. The larva use to eat its egg shell after emerging and passed through five instars over a period of 28–37 (26.80±2.48) days (Fig 1-B). As previous reports of Opler and Krizek, 1984 the *G. agamemnon* use different plants for feeding at larval stage and it is treated as oligiphagous (Pandian and Marian, 1986). Now, in current study shows that several plant species are suitable for larval growth and oviposition (Scriber, 1979).

Larval stages:

Instar I- This stage for 1 - 2 days. On the first day the larva was 3.50 – 4.60 (3.90±0.43) mm long and 1.10 – 1.50 (1.30± 0.17) mm wide.

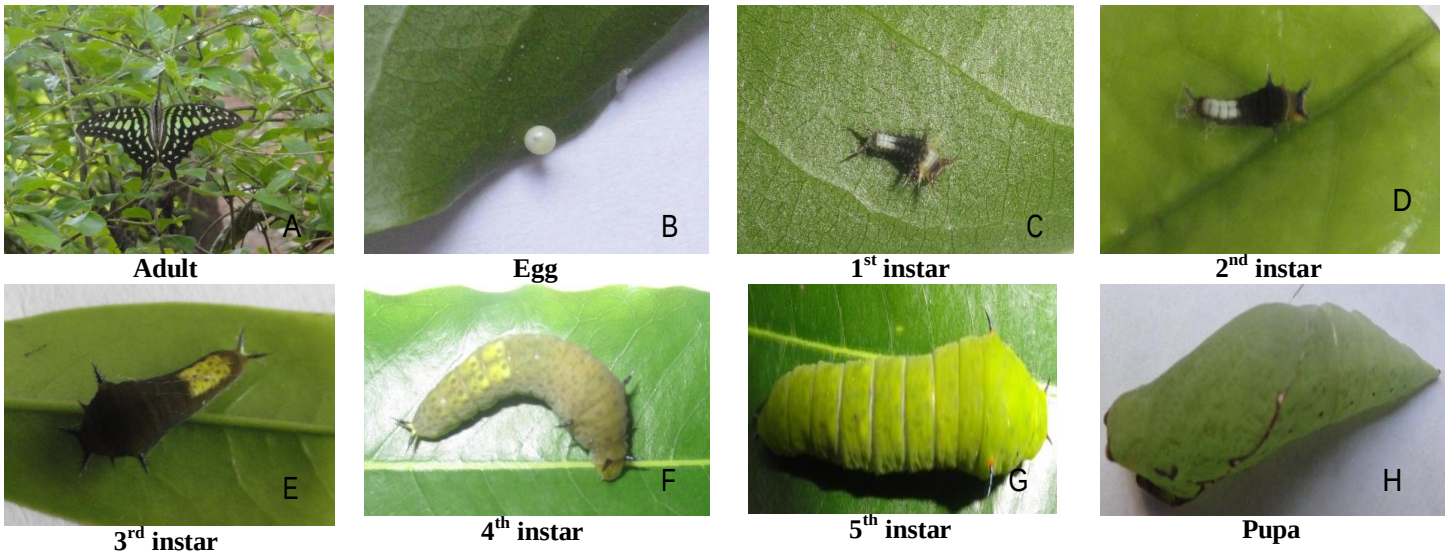

Fig. 1 A. *Graphium agamemnon* (Sonn.) adult butterfly; B. Egg; C. First Instar (larva); D.Second Instar (larva); E. Third Instar (larva); F. Fourth Instar (larva); G. Fifth Instar (larva); H. Pupa.

The body was yellowish brown coloration and looks pumped up. The thoracic segment white dorsal patches have faded away by this time. Black color head, 0.4–0.6 (0.51±0.08) mm wide (Table 1 and Fig 1-C).

Instar II- This stage for 3-5 days. The larva measured 5.20–8.30 (6.80 ± 1.50) mm in length and 2.00– 2.90 (2.50±0.43) mm in width. The thoracic spines and the anal spines are pale yellowish brown. Much enlarged thoracic segments from the 2nd& 3rd segment. Head size increased to 1 mm. It was reddish brown in color, with a pair of dark brown 0.6–0.7 (0.63±0.04) mm long horns (Table 1 and Fig 1-D).

Instar III- The instar III period is around 3-4 days and it attain 12.5 to 17.0 mm (12.70 ± 3.69) length and 2.5-4.30mm width (3.50±0.78). At this stage, posterior abdominal segments will turn from white to yellowish color and thoracic, anal spines turn into black color with bluish sheen at distal end. At the end of this stage several dark markings will appear on body and head measures around 1.6-1.8mm size (1.7 ±0.08) (Table 1 and Fig 1-E).

Instar IV- During this period larva reached a length of 22.5-27.0 (23.00 ± 6.20) mm and a width of 3.20–6.80 (5.40±1.35) mm and this stage is around 3-5days. The posterior abdominal segments lost the yellow color and its boundaries and 3rd thoracic segment becomes orange color. The head turn into light orange color with hair and it measures around 2.5-3.0 (2.76±0.20) (Table 1 and Fig 1-F).

Instar V- This is the long instar stage around 4-6days. The larva attains maximum length 28.20-40.20 mm (36.0±5.08) and 5.80-9.10mm (7.80±0.09) width and the head measures 2.5–3.0mm (2.76±0.20) with light orange colored spots. The larva appear in orche-yellowish color with other characteristic changes at instar IV stage (Table 1 and Fig 1-G).

The pupal stage mainly include pre pupa and pupal stage. The pre pupal stage is only for one day, in this time shortens its length and yellow marks fading away (Fig 1-H). The pupal stage is last for 11-13 days with maximum length 32.0-37.0mm (34.20±1.92) in length and 8.0-9.50mm (8.70±1.92) in width and the pupa turns to black color with apple-green spots on fore wings.

Food consumption and Growth

The previous reports on *G. agamemnon* says it is an oligophagous depends on variety of plant species fed by it (Salanky and Fenny, 1979; Opler and Krizek, 1984) and in the present study also confirms it. The food consumption by larvae on host plant were recorded (Table 2) and the food consumption was increased from larval stage to pupal stage with 7.0, 9.48, 15.22, 23.74 and 44.54%. The weight obtained by them at different stages was successively increased as 0.44, 0.79, 4.25, 28.24, 66.25%. In all stages final instar stage have more growth with 44–57.72% increase (Fig 2). The figure indicates a direct relationship between these two parameters (David and Gardiner 1962; Ghosh and Gonchaudhuri 1996; Atluri *et al.,* 2004; Samatha, 2006). In addition, data were collected on larval performance on the basis of GR, CI, AD, efficiency of ECD and ECI (Janz *et al.,* 1994).

The CI from instar I to Instar V was decreases as stages were progressed (Table 2), it may be due to the larval weight gain and increase in size or may be increase in ECI. As earlier studies, when ECI increase the CI will decrease or *vice-versa*(Slansky and Scriber, 1985; Atluri *et al.,* 2004; Samatha, 2006) (Table 2).

Table 1. Biological observations of early life stages of *Graphium agamemnon* on *Polyalthia longifolia.*

Stage	Length(mm)			Width (mm)			Duration (days)	
	Min.	Max.	AV.±S.D.	Min.	Max	AV. ±S.D.	Range	AV.±S.D.
Egg	0.90	1.10	0.96±0.08	1.80	2.10	1.92±0.16	3	3.00±0.00
I	3.50	4.60	3.90±0.43	1.10	1.50	1.30±0.17	1-2	3.25±0.55
II	5.20	8.30	6.80±1.50	2.00	2.90	2.50±0.43	3-5	4.20±0.19
III	12.50	17.00	12.70±3.69	2.50	4.30	3.50±0.78	3-4	3.80±0.44
IV	22.50	27.00	23.00±6.20	3.20	6.80	5.40±1.35	3-5	4.20±0.52
V	28.20	40.20	36.00±5.08	5.80	9.10	7.80±1.27	4-6	5.60±0.58
Total larval Period							14-21	18.00±3.31
Pupa	32.00	37.00	34.20±1.92	8.00	9.50	8.70±0.57	11-13	12.00±0.70

Table 2. Food consumption, growth and food utilization efficiencies of *Graphium agamemnon* larva fed with *Polyalthia longifolia.*

Instar	Wt. of food ingested (mg)	Wt. of faeces (mg)	Wt. gained by larva (mg)	GR (mg/day)	CI (mg/day)	AD (%)	ECD (%)	ECI (%)
I	203.72±97.26	1.2±0.29	2.94±4.89	0.8	21.54	99.2	0.43	0.43
II	275.98±173.62	6.70±5.0	5.24±3.98	0.15	10.28	96.95	2.37	2.28
III	442.92±185.94	64.40±39.63	28.24±11.97	0.6	0.36	86.49	9.09	7.86
IV	690.94±217.64	192.20±116.39	187.26±86.33	0.9	0.25	73.87	39.65	29.63
V	1296.04±563.85	754.10±260.88	439.24±115.27	0.5	0.25	38.59	58.34	39.57

GR is also size dependant, and its values declined as the instar larvae progress in gaining weight and size (Atluri *et al.*, 2004; Samatha, 2006).

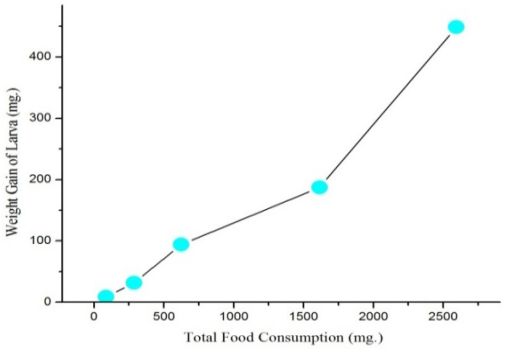

Fig. 2 Relation between food consumption and growth in *G. agamemnon* on *P. longifolia.*

The AD is also declined from intial instar to final instar and is ranged from 51.86-97.76% (Table 2). The ECD values (6.6–46.9%) are low compared to AD values (16.2-22.1%), but are mostly within the range of 2-87% and 2-93% estimated for Lepidoptera feeding on forb and tree foliage respectively (Slansky and Scriber, 1985). The ECI is in between 0.43–39.57% (Table 2), this indicates that the ECI is continuous raise and in previous studies of Slansky and Scriber (1985) also indicated that as age and size of larvae increased ECI value may increased. Finally, by the present study the life cycle and biology of *Graphium agamemnon* on *Polyalthia longifolia* generally understood on their leaves.

Conclusion

The present study carried out to study the life cycle of *Graphium agamemnon* on *Polyalthia longifolia*. We observed the different food utilization indices about the *G. agamemnon* and studied the characters of the instar stages. The present study helps the researchers about the study of butterfly fauna and in-situ conservation of the butterflies those are endangering due to the environmental changes.

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Conflicts of interest

Author has none to declare.

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