LARVAL PRESENTATIONAND LIFE HISTORY RESTRICTIONS OF SOME PAPILIONIDAE BUTTERFLIES IN SRI LANKAMALLESWARA RESERVE FOREST OF EASTERN GHATS - SOUTHERN ANDHRA PRADESH - INDIA

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ABSTRACT: *Life history stages such as pattern of egg placing, hatching, larval &pupalduration and the total duration from egg to adult emergence of four butterflies, distributed at Sri Lankamalleswarareserve forest, kadapa are described. Larval presentation with respect to CI (Consumption Index), GR (Growth Rate), and nutritional indices estimation like AD(Approximate Digestibility), ECI(Efficiency of Conversion of Ingested Food) and ECD(Efficiency of Conversion of Digested Food)werediscussed.*

Key Words: *Butterflies, larval presentation Life history, Nutritional indices.*

Summary:

Papiliopolytes, *Pachliopta hector*, *Papiliopolymnestor* and *Graphiumdoson* lay solitary eggs. The hatching, larval &pupalduration, and eventually the total duration for the development of egg to the appearance of adult are longer (43 days) in *P. aristolochiae* and then *Pachliopta hector* in other Papilionids, and taxonomic group. The larvae of fourPapilionid species pass through 5 instars, and the last 2 instars have a main share of the total food consumed over the entire larval duration. The consumption index (CI), values of these 2 instars ranged from 0.73 to 1.86. Among the 5 instars, the 1stshows the highest CI in all the 4 species and the values tend to reduced progressively through the consecutive instars. The AD values & food consumption are inversely related. The AD value highest in the first instars a lowest in the fifth instar, the values ranging from 82 - 87. The ECI values range from 5.2 – 28.5% for*P.hector* and from 7.7 – 20.9 % for other, with most falling between 10 to 20%. The ECD values show a general reduction from the early to the late instars.

Introduction:

Abovebillions of years, evolution has recognized a balance in the environmental functioning of various organisms. However, as human societies flourishedand developed, considerable disturbance and destruction of environments of numerousorganisms resulted in the extinctionanddecline of numerousbutterfly species. These are considered as helpful insects are no exclusion to the adverse properties of human civilization. They are significant natural resources as they (1) Support in pollination, a key process in natural proliferation, (2) are significantenvironmental indicators as they are carefully associated with plants both as larvaeandas adults (3) have an significant place in the web of life, and (4) enhance the beautiful value of the atmosphere by their exquisite wing colours. Hence, there was agrowing global attention in conserving and handling butterfly species (New *etal* 1995). A whole key to their positive conservation & management, but such information on Indianbutterfly species was woefully inadequate (Gay *etal* 1992, Atluri*etal* 2002, Arun P.R. 2008, Harinath*etal*2014, Harinath*etal* 2014, Harinath*etal*2015).

Butterfly species are holometabolous, and their generative output depends on the joint effect of larvae & adult derived nutrients (Boggs, 1981). Therefore, exhaustive life history studies to assess the presentation of larvae with respect to food consumption, utilization & growth are necessary. Here we report the consequences from assays of pre-adult phases, and the food consumption, utilization & growth indices of larvae of four Papilionidae butterflies based on laboratory observation conducted in the Yogi Vemana University, Kadapa.

METHODS AND MATERIALS:

Study locality:

The present observation was carried out from 2016 – 2018 at Sri Lankamalleswara forest(79^0 07' – 78^{0}80' E)kadapa district.This reserve forest as an average elevation of 452ft(138 meters). (Fig.01). The basic procedure for captive rearing was to gather eggs from wild-mated females, rearlarvae to adult butterfly species in captivity, and release adult butterfly species and pupae return into wildpopulations (Crone EE, 2007).The reproductive activity of the *Papiliopolytes, Pachliopta hector, Papiliopolymnestor* and *Graphiumdoson*(Fig. 02) wasstudy regularly during 0800 - 1500 h at 2 sites of Sri Lankamalleswara reserve forest,Yogi Vemana University campus and the Botanical garden with an area of 5 km radius. Oncemature butterfly species were located detailed study were made in order to observe the duration ofcopulation &oviposition. Afteroviposition identification, the leaf with eggs was collected inPetriplates (4 x 9 cm) and carried to the laboratory. The pieces of leafswith eggs was then positionedin a smaller Petriplates; that was lined with moisturized blotter to prevent leaf drying. Such Petriplates were kept in a spotless, roomy cage fitted with cable gauge. They were inspected regularlyat 4 h interval for recording the period of hatching. Each of the newly emerged larvae wastransported to a clean Petriplates lined with humidified blotter with the help of a camelhairbrush. The larvae were abounding daily with weighed amount of tender leaves of thehost plant. The faeces& the leftover of the food was collected and weighed each day (24 h).

The emergent larvae were studied regularly to note the alterationin instars, and features including weight, width and lengthmeasurements. As the larvae grew, they required more space hence, amplified space was provided by shifting thegrowing larvae to bigger Petriplates (15 cm × 2.5 cm depth).Larval presentation in terms of food utilization indices werecalculated as designated by the formulae given by Waldbauer (1968).

Fig. 01: Study area: Sri Lanakamalleswara Reserve Forest

Breeding season, oviposition and larval host plants of the butterflies were observed at two sites. (1) The Yogi Vemana University campus spread over 0.5 sq. km. it enjoys both wild and cultivates flora and (2)SriLankamalleswara reserve forest protected forest area, spread over one sq.km. Representative samples of butterflies were collected at 10 day intervals from both the sites, by stalking of chasing the fast flying species. The specimens collected were identified from Wynter – Blyth (1957); Varshney (1980, 1985), Suryanarayana*etal* 2016was preferred to for nomenclature. For each of the 4 butterfly species of the present study, ovipostiong activity was observed and larval host plants recorded.

Laboratory study:

Life History:

The breeding females were hatched during the breeding period, and the new eggs laid were collected in petriplates (9.5 cm diameters) along with the plant material on which they were placed. These were gestated at room temperature (28^{0}C) in the laboratory. Irrespective of the numeral of eggs placed, only single leaf was kept in each petriplates and watched at 4hrsintermission to record the hatching time. The breaks were shortened if necessary after initial observations. The larvae that hatched were also study at fixed interval for moulting until they pupated. Based on the quantity of mount, the number of instars for each species was determined. As the larvae finished their 1st& 2ndinstar stage, each was maintained in a larger petriplates (15.5 cm) to facilitate free association. The egg, separate larval instar, pupal & egg to adult duration were documented. five replicates were maintained for each butterflies.

Food consumption and utilization:

Food was altered daily and the petriplates were kept clean by eliminating the food remains and faecalmaterial, which were laterweighed & disposed of. For every instar, its initial and final weight was taken & the weight and given the larvae, 5 to 10 leaves were weighed and supply to the larvae. The entire food consumed by the larvae was measured at the end of each instar duration. Mean &standard deviation (S.D) were estimated for food consumed, weight increased by the larvae.

RESULTS AND DISCUSSION:

The Papilionidaebutterfly species have been examined for their oviposion, plant species used for ovipositionand pattern of egg laying (Table 1). Egg, larval and pupal duration and total egg to adult development time are summarized in table 2. Food consumption and growth and utilization indices are given table 3 to 8.

Egg laying pattern and hatching duration:

Of the four Papilionidaebutterfly species were studies; these were laid single eggs. solitary egg laying butterflies dominates over bunch laying practice among butterfliesof most geographical areas. (Thompson &Pellmyr 1991). Through the number ofbutterflies examined in the current study was low, this study suggest a related tendency. Based on the evidenceprovided by Ford (1957), Stamp (1980) projected that 2.5% of the butterflies in India are mass layers, while the others lay single eggs. However, several reports show the effect of environmental conditions on egg laying configuration (Larsen 1988, Davies and Gilbert 1985). As such a closer observation was compulsory on the pattern of egg laying in different environmental situations.

Table 01: List of the four butterfly species studied, their oviposition plants and egg laying pattern

S.No	Butterfly species		Oviposition plants	Pattern of egg laying
	Scientific name	Common name		
1	*Papiliopolytes*	Common mormon	*Murrayakoenigii*	Single
2	*Pachliopta hector*	Crimson rose	*Aristolochiaeindica*	Single
3	*Papiliopolymnestor*	Blue mormon	*Citrus limon*	Single
4	*Graphiumdoson*	Common jay	*Polyalthialongifolia*	Single

Fig. 02: Papilionidae Butterfly species

According to Chew and Robbins (1984), "the species with a single egg laying habit generally use small plants as larval host, and single laying egg habitat was advantageous to exploit isolated plants, preventing the possibility of larval starvation, egg clustering improves larval host resource exploitation"

The hatching or incubation duration was in *P.polytes, P. hector, P. polymnestor* and *G.doson*was 27 – 33 days, 38 – 45 days, 43 days and 33- 40 days respectively. Incubation duration may depend on the size of the egg rather than on the egg placing pattern, the bigger egg taking a comparatively longer period. This needs to be tested under similar conditions of incubation.

Larval and pupal duration and total development time:

The duration of the dissimilar instars of the four papilionids butterflies was to be similar. The period of instar varied between 1 – 2 days, of instar II & III each 2-3 days, of Instar IV 2 – 3 days and instar V 3-5 days. Only instarVof2papilionids*P.hector*and *P. polymnestor*have relatively longer period and 6-7 days. The total larval duration ranged between 11-20 days. The pupalduration of *P.polytes*was small ranging from 10-11 days and residual species duration days 13-18 days. The duration of egg to adult growth time also had 2 groups, one showing a shorter duration of 27-33 days and the other a longer duration of 43 days (Table 2). The longest duration was for *Papiliopolytes*(43 days) and for *P.hector*(39-47 days) and the shortest duration of 20 – 27 days was observed in *Pachliopta hector*&*Graphiumdoson*. Relevant data from other areas in India are required for aexpressive comparison & interpretation. However, temperature effects instar period (Palanichamy et al 1982) and the overall developing time from egg to adult (Owen 1971). Hence, the larval &pupalperiod and egg to adult growth time of these four butterflies in other regions may vary according to the usual weather conditions. The present data, however, aggress with Owen (1971), who states that egg to adult development time was much shorter in the tropics.

Table 2: Duration in days of different stages in the life history of the four butterfly species under study

S.NO	Stages		Butterfly species			
			P. polytes	*P. hector*	*P. polymnestor*	*G. doson*
1	Egg		3	7	4	3
2	Larva	Instar I	2-3	2-3	2-3	2-3
		Instar II	3-4	3-4	3	2-4
		InstarIII	3-4	3-4	5	3-4
		InstarIV	3-4	4-5	5-6	3-4
		Instar V	3-4	6-7	6-7	4-5
3	Pupa		10-11	13-15	15-18	15-17
4	Total		27-33	38-45	43	33-40

Table 3: Instarwise food consumption and growth of four Papilionids butterfly species

Butterfly species	Instar number	Wt. of food consumed (mg)	Wt. of faeces (mg)	Wt. gain by larva (mg)
Papiliopolytes	I	31.0 ± 0.92	0.21 ± 0.02	3.21 ± 0.19
	II	1543 ± 2.70	3.90 ± 0.27	19.60 ± 0.31
	III	4832.7 ± 3.90	61.40 ± 1.40	150.30 ± 2.90
	IV	1683.0 ± 6.10	126.20 ± 1.40	256.80 ± 3.10
	V	2714.2 ± 9.70	375.80 ±3.90	452.90 ± 3.60
Pachliopta hector	I	47.5 ± 0.12	0.30 ± 0.02	2.5 ± 0.06
	II	93.5 ± 0.19	4.21 ± 0.08	19.7 ± 0.12
	III	1426.3 ± 1.20	122.80 ± 0.20	71.0 ± 0.14
	IV	2189.7 ± 4.20	189.50 ± 0.23	453.1 ± 0.41
	V	4320.6 ± 12.40	540.10 ± 0.41	1232.0 ± 1.10
Papiliopolymnestor	I	40.3 ± 0.21	0.19 ± 0.02	3.87 ± 0.10
	II	113.0 ± 0.80	4.20 ± 0.19	22.80 ± 0.19
	III	1546.0 ± 2.90	111.80 ± 0.82	302.50 ± 1.70
	IV	2474.1 ± 6.10	322.40 ± 1.90	478.30 ± 2.10
	V	4524.2 ± 14.50	818.60 ± 4.80	840..70 ± 4.20
Graphiumdoson	I	21.6 ±0.34	0.15 ± 0.09	2.2 ± 0.10
	II	88.5 ± 0.84	3.42 ± 0.18	18.0 ± 0.21
	III	1397.5 ± 8.40	1105 ± 0.91	222.6 ± 1.80
	IV	2371.6 ± 11.20	194.5 ± 1.90	321.3 ± 2.40
	V	3497.3 ± 16.40	528.2 ± 5.30	678.4 ± 3.80

Table 4: Values of Consumption Index (CI) for successive instars of 4 butterfly species

Butterfly species	Consumption Index (CI)				
	Instar I	Instar II	Instar III	Instar IV	Instar V
Papiliopolytes	9.30	3.53	3.50	1.80	1.30
Pachliopta hector	8.60	2.20	1.96	1.69	0.73
Papiliopolymnestor	10.0	2.40	2.80	1.39	1.17
Graphiumdoson	7.47	2.41	3.48	1.86	0.97

Table 5: Values of Growth Rate (GR) for successive instars of 4 butterfly species

Butterfly species	Growth Rate (GR)				
	Instar I	Instar II	Instar III	Instar IV	Instar V
Papiliopolytes	0.96	0.45	0.48	0.27	0.21
Pachliopta hector	0.45	0.45	0.39	0.35	0.20
Papiliopolymnestor	0.96	0.48	0.54	0.27	0.21
Graphiumdoson	0.57	0.49	0.55	0.25	0.18

Table 6: Values of Approximate digestibility (AD) for successive instars of 4 butterfly species.

Butterfly species	Approximate digestibility (AD) %				
	Instar I	Instar II	Instar III	Instar IV	Instar V
Papiliopolytes	99	97	94	92	86
Pachliopta hector	99	94	92	91	87
Papiliopolymnestor	99	96	92	87	82
Graphiumdoson	99	95	92	91	84

Table 7: Values of Efficiency of conversion of ingested food (ECI) for successive instars of 4 butterfly species

Butterfly species	Efficiency of conversion of ingested food (ECI) %				
	Instar I	Instar II	Instar III	Instar IV	Instar V
Papiliopolytes	10.3	12.7	13.8	15.2	16.6
Pachliopta hector	5.2	20.9	14.9	20.6	28.5
Papiliopolymnestor	9.96	20.1	19.5	19.2	18.5
Graphiumdoson	7.7	19.3	15.9	13.3	19.3

Table 8: Values of Efficiency of conversion of digested food (ECD) for successive instars of 4 butterfly species

Butterfly species	Efficiency of conversion of digested food (ECD) %				
	Instar I	Instar II	Instar III	Instar IV	Instar V
Papiliopolytes	10.4	13.0	14.7	16.5	19.3
Pachliopta hector	18.8	21.9	15.4	22.6	32.5
Papiliopolymnestor	9.6	20.9	21.2	22.2	22.6
Graphiumdoson	7.7	20.3	17.2	14.7	22.8

Food consumption and utilization:

The data on the quantity of food consumed by the 5 instar of each of the 4 butterfly species indicates that the IV, V instar had major share of the total amount of food consumed over the entire larval duration. Similar results have been described for other species (David and Gardiner 1962; Waldbauer 1968; Mathavan and pandian 1975; Scriber and Slansky 1981; Palanichamy et al 1982; Selvasunderam 1992; Ghose and Gonchaudhuri 1996). The increase in consumption might be a strategy to compensate for the energy requirement in the non – feeding pupalphase (Delvi and pandian 1972; Pandian 1973). The consumption index (CI) of instar I was the highest in all the 4 species and CI decreases gradually across the instars. CI depends on the conversion efficiency of the food consumed (ECI) (Slansky and Scriber 1985), and was inversely proportional to ECI. Thus the high CI of instar I of all the 4 butterfly species may be because of low conversion efficiency (ECI) (Table 07) The values of consumption index (CI) of any instar of the 4 butterfly species are within the ranges reported for Lepidoptera in general (Slanskyand Scriber 1985) and correspond well with the values of swallowtails (Scriber and Feeny 1979; Sriber 1986).

The values of GR of the 4 butterfly species reducedprogressively in general and were highest in instar I as lowest in Instar V (Table 05). A similar trend has been recorded for the moth *Pericalliaricini* (Ghose and Gonchaudhuri 1996). Penultimate instar had a higher growth rate than the final instar in some Papilionids and moths (Scriber ad Feeny 1979). The GRs of penultimate and final instars now obtained are in line with the above decreasing trend. The larvae reared on tree foliage show higher growth rates than the larvae maintained on herbaceous foliage (Scriber and Feeny 1979). The host plant *Polyalthialongifolia* utilized by *G.doson* and *Citrus limon* utilized by *Papiliopolytes* was tree species, whereas *Aristolochiaeindica* used by *Pachliopta hector* was herbaceous, while the growth rates *Pachliptapolymnestor*larval instars II to V are greater than those of other tree foliage feeders, those of*Pachliopta hector* are not different from other tree foliage feeders, hence the data was considered inadequate to consider the issue of different growth rates on the two kinds of foliage.

The values of approximate digestibility (AD) of the four butterfly species declined as the larvae aged (Table 06). The larvae may have consumed a larger proportion of indigestible crude fibre as they grew older which caused AD values to decrease along the successive instars (Slansky and Scriber 1985). This decrease could also be the reason of the decreased growth rate (GR) decreased earlier. The AD values are inversely related to the food consumed by different instars. It was highest in instar I, the corresponding percentages of each of the 04 papilionidae species are: *Pachlioptapolymnestor*99, 86;*P.hector*99, 87;*Papiliopolytes*99,82;*Graphiumdoson*99, 84, The AD was lowest in instar V, the corresponding percentages are *Pachlioptahector* 87, *Papiliopolytes* 86. Such a relationship between approximate digestibility and food consumption was also evident from the data compiled by Waldbauer (1968). The AD values of the 4 species ranging between 84 to 82% appear to be higher than those reported for several Lepidopteron larvae (Pandian and Marian 1986; Ghosh and Gonchaudhuri 1996). The larvae were given tender leves daily. Tender leaves are usually rich in nitrogen and the larvae may have assimilates them more efficiently resulting in high values of AD. The values of efficiency of conversion of digested food (ECD) showed a general increase from early to late instars, and the values are very low compared to AD values, indicating poor utilization of the digested food (table 06)

The value of efficiency of conversion of consumed food (ECD) of*Pachliopta hector*ranged between 9.6 to 22.6 % and those of the other 3 species varied between 7.7 – 22.8 % most of these values fall between 10% and 20%. These values indicate low conversion efficiency, but are comparable with the ECD values reported for swallowtails (Scriber &Slansky 1981). Excised foliage was used for rearing the larvae, and such foliage was likely to be deficient in water. Since leaf water content was directly related to conversion efficiency (Muthukrishnan 1990) the larvae had to spend energy to produce metabolic water, which may have resulted in low conversion efficiency. While it was indicated that the ECI values across the instars show a decreasing trend, and follow the pattern of decline in AD (Waldbauer 1968), the ECI pattern of the Four species does not conform to the above relation (Table 08). The ECIs showed definite trend of increase or decrease across the instars, thus supporting the predicted inconsistency in ECI pattern (Slanskyand Scriber 1985). The various nutritional indices of the four butterfly species wereenable a proper understanding of the tropic interactions of these species.

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References:

1. Gay, T., I.D.Kehimkar& J.V. Pandian (1992), Rates of feeding and assimilation in the grasshopper Poeciloceruspictus. J. Insect. Physiol. 18;1829-1843.
2. Atluri, S.P.VenkataRamana, and C,Subba Reddy (2002), Autecology of common mormon butterfly Papiliopolytes(Lepidoptera – Rhopalocera - Papilionidae) Journal of Environmental biology, 23 (2), 199-204
3. Arun, P.R (2008), Seasonality of Swallowtail butterfly community (Lepidoptera: Papilionidae) ofSiruvani forest, Western Ghats, Southern India. Proc. Sem. "Wonderful world of Insects", 3rd Dec 2008.
4. P. Harinath, K.Suryanarayana, V. Prasanna Kumar andS.P. VenkataRamana(2014). Biodiversity of Papilionidae Butterflies in the hill regions of Southern Andhra Pradesh. Journal of Research in Biology, 2: 73-81.
5. P. Harinath, V. Prasanna Kumar, K. Suryanarayana and S. P. VenkataRamana (2014) InsectDiversity of Sri Lankamalleswara Reserve forest in the Eastern Ghats of Southern Andhra Pradesh. Journal of Entomology and Zoology Studies; 2 (6): 198-212.
6. Harinath. P, Venkata Reddy. M, Suryanarayana. K, and VenkataRamana S.P.*(2015) Eco-biology of the spot swordtail Graphiumnomius (Esper) (Lepidoptera: Rhopalocera: Papilionidae) from the Eastern Ghats of

Southern Andhra Pradesh. International Journal of Plant, Animal and Environmental Sciences, Volume-5, Issue-3, July-Sept-2015.

7. Boggs, C.L. (1981), Nutritional and life history determination of resource allocation in holometabolous insects. Amer. Nat. 117; 692-701
8. Crone EE, Pickering D, Schultz CB. (2007), Can captive rearing promote recovery of endangered butterflies? An assessment in the face of uncertainty, Bio. Conservation. 2007; 139:103.
9. Waldbauer GP.(1968) The consumption and utilization of foodby insects, Advances in insect physiology, AcademicPress, London and New York, 229pp.
10. Wynter – Blyth M.A (1957); Butterflies of the Indian region. Bombay Natural History Society, Bombay. 523pp.
11. Varshney, R.K. (1980); Revised nomenclature for taxa in Wynter Blyth's book on the butterflies of Indian region. J. Bombay Nat. Hist. Soc.76; 33-40.
12. Varshney, R.K. (1985); Revised nomenclature for taxa in Wynter Blyth's book on the butterflies of Indian region- II. J. Bombay Nat. Hist. Soc.82;309-321.
13. Thompson J.N. &J.N.Pellmyr (1991) Evolution of Oviposition behavior and host preference in Lepidoptera. Ann. Rev.Entomology. 36; 65-89.
14. Ford.E.B. (1957), Butterflies collins. London. 368 pp.
15. Stamp.N.E. (1980) Egg deposition pattern in butterflies. Why do some species cluster their eggs rather than deposit them singly? Amer. Nat. 115: 367-380.
16. Larsen T.B. (1988). Differing Oviposition and larval feeding strategies in Two Colotiesbutterfliessharingtha same food plant. J.Lepi.Soc 42; 57-58.
17. Chew F.S. & R.Robbins (1984),Egg laying in Butterflies. Pp. 65-80.
18. Palanichamy, S.R. Ponnuchamy& T. Thangaraj (1982); Effect of temperature on food intake, growth and conversion efficiency of Eupterotemollifera (Insecta; Lepidoptera). Proc. Indian Acad. Sci. (Anim. Sci.) 91; 417 – 422.
19. Owen D.F. (1971) Tropical butterflies, Clarendon Press, Oxford 205pp.
20. David W.A.L. &B.O.C.Gardiner (1962) Oviposition and hatching of the eggs Pierisbrassicaen in a laboratory culture. Bull Ento. Res. 53; 91-109.
21. Mathavan. S & T.J. Pandian (1975). Effect on temperature on food utilization in the in the monarch butterfly Danauschrysippus. Oikos 26; 60-64.
22. Scriber J.M. &F.J.Slansky (1981). The nutritional ecology of immature insects. Ann. Rev. Ento. 26; 183-211.
23. Slansky .F.J & J. M. Scriber (1985) Food consumption and utilization pp. 85-163. In Comprehensive Insect Physiology. Biochemistry and Pharmacology (Eds. Kerkut, G.A. & L. I.Gilbert). Pergamon , Oxford.
24. Suryanarayana, K., Harinath, P., Appala Naidu, S. VenkataRamana, S. P. (2016). Checklist of Butterflies inSeshachalam Bio-reserve forest - Eastern Ghats of AndhraPradesh – India. European Academic Research. Vol. IV,Issue 5/ August.
25. Selvasunderam R. (1992). Food Utilization and Bioenergetics of Caloptiliatheivora (Walsingham) (Lepidoptera; Gracillaridae)infesting tea. Hexapoda 4(2); 119 – 128.
26. Ghosh, D. & S. Gonchadhuri (1996). Biology and food utilization efficiency of Pericalliaricini (Fab.)(Lepidoptera; Arctiidae)in Tripura, Uttar Pradesh, J. Zool. 16 (3); 119 – 122.
27. Delvi , M.R. &T.J. Pandian (1972): Rates of feeding and assimilation in the grasshopper Poeciloceruspictus. J. insect. Physiol. 18, 1829- 1843.
28. Pandian, T.J. (1973), Food intake and energy expenditure patterns in two insect primary consumers. Curr.Sci. 42: 423 – 425.
29. Scriber J.M. &P.Feeny (1979). Growth of herbivorous caterpillars in relation to feeding specialization and to the growth form of their food plants. Ecology 60; 829 – 850.
30. Scriber 1986. Origins of the regional feeding abilities in the tiger swallowtail butterfly ecological monophagy and the PapilioGlaucusaustralis subspecies in Florida Oecologia71; 94-103.
31. Muthukrishnan J (1990), Bioenergetics in Insect plant interaction3. Proc. Indian Acad. Of Sci. (Ani. Sci.) 99 (3): 243 – 255.