RESULT AND DISCUSSION

5. Result and Discussion

5. 1. Host Preference

The host plant range selected by a phytophagous insect species is probably one of its major biological characteristics and is constrained by several morphological, physiological and ecological factors. One of the most striking features of insect - plant relationship is the fact that most of these insects are specialists and have strong feeding preferences that result in various degrees of host specificity (Schoonhoven et al., 1998).

The act of host selection depends upon the physical and chemical characteristics of the plants; the selection of a plant involves catenary process of events in response to stimuli elicited from the plants and perceived by the insect. The physical characteristics of plants include thickness, roughness, presence or absence of trichome etc., while the chemical characteristics include both primary and secondary metabolites (Panda and Khush, 1995).

Acceptance and successful utilization of a host plant by phytophagous insects depends upon the coordinated interaction between the insect and the plant (Ananthakrishnan, 1992). The mechanism of host plant selection in phytophagous insects is a complex phenomenon involving host habitat finding, host finding, host recognition, acceptance and host suitability (Dethier, 1954).

Host preference studies with early and late instar caterpillars clearly indicated that *Buzura suppressaria* had a significant preference for Tv_{26} (tea clonal variety) over the other two varieties (Tv_{18} &Tv_1). Preference *of Eterusia* *magnifica* was significantly different for all three varieties where it was evident that both early and late instars had a high preference for Tv_{26} variety. *Euproctis latisfascia* (early and late instars) showed significant preference for Tv_{18}. The three lepidopteran folivores, in general showed less preference for Tv_1 clone. Data on host preference for early and late instars are presented in Tables 3 & 4 respectively.

Insect herbivores possess sensitive receptor systems that allow them to detect a variety of phytochemicals. Within a host range the choice of a particular food is usually dependent on its phytochemical composition. Some specialized insects feed on plants generally containing a particular category of allelochemicals, other more generalized insects may avoid consuming certain plants because of their allelochemical contents and may choose others because of their energy and / or nutrient contents (Slansky, 1992).

Tv_1 has a high non-digestible component in its leaves as compared to Tv_{18} and Tv_{26} (Bhuniya, 1999). The toughness of leaf tissue and the amount of secondary metabolites increase as leaves mature, which decrease the nutritional quality of the leaves for folivorous larvae (Fenny, 1968,70; Swain 1979, Hunter and Lechowicz, 1992). Most insect ecologists agree, that plants with tough tissue generally act as an antiherbivore defense (Fenny, 1970; Feller, 1995). The crude fibre which consists of cellulose and lignin cannot be easily digested by enzyme secreted by insects (Soo Hoo and Frenkel, 1966) as such Tv_1 leaves with higher non-digestible components mainly comprising cellulose fibres and lignin were less preferred by all the three species of folivores.

Table 3. Host preference in percent (Pr) of three folivores (early instars) on three clonal varieties.

Tea Clonal Variety	Looper		Red Slug		Hairy Caterpillar	
	Percent	Mean ± SE	Percent	Mean ± SE	Percent	Mean ± SE
Tv_1	9.69	0.166a ± 0.032	11.49	0.197a ± 0.022	13.20	0.227a ± 0.011
Tv_{18}	7.63	0.131a ± 0.021	17.07	0.292b ± 0.016	30.87	0.510b ± 0.018
Tv_{26}	26.90	0.126b ± 0.063	30.68	0.506c ± 0.025	17.31	0.295a ± 0.023
LSD	0.0470		0.0457		0.0208	

* Values transformed in arc sin for statistical analysis. Means followed by the same alphabet in each column are not significantly different at 5% level using ANOVA and LSD

Table 4. Host preference in percent (Pr) of three folivores (late instars) on three clonal varieties.

Tea Clonal Variety	Looper		Red Slug		Hairy Caterpillar	
	Percent	Mean ± SE	Percent	Mean ± SE	Percent	Mean ± SE
Tv_1	16.02	0.274a ± 0.027	14.90	0.255a ± 0.024	23.13	0.390a ± 0.021
Tv_{18}	15.25	0.261a ± 0.028	20.77	0.353b ± 0.016	41.04	0.647b ± 0.032
Tv_{26}	39.13	0.620b ± 0.034	45.18	0.700c ± 0.027	25.92	0.434c ± 0.024
LSD	0.0314		0.0240		0.0279	

* Values transformed in arc sin for statistical analysis. Means followed by the same alphabet in each column are not significantly different at 5% level using ANOVA and LSD

Tough leaves may take longer time to consume and therefore result in slower growth rates of insect herbivores (Stevenson et al.,1993). Variation in leaf toughness within and among species of the host plants is often associated with variation in levels of herbivory (Speight et al., 1999). Stevenson et al. (1993) negatively correlated between leaf toughness with insect development. Bergivinson et al. (1995a, b) established that leaf toughness was having a negative influence on insect preference and Sagers and Coley (1995) indicated that leaf toughness resulted in less defoliation by insect hervibores. It was further observed that larval and adult insects might avoid individuals or species with tough leaves, thereby leading to lower levels of phytophagy (Roces and Hoelldobler, 1994).

Leaf toughness is also known to be accompanied with a decline in water content, decline in nitrogen content, increase in condensed tannin concentrations and decline in hydrolysable tannin concentrations (Fenny, 1970; Hunter and Schultz, 1995). It is likely that many of these above factors come to play in selection of the tea clone as host. Tv_{26} with higher moisture and less fibre contents than the other two clones (Tv_{18} & Tv_1) was therefore a preferred variety for two of the folivores, *B. suppressaria* and *Et. magnifica*. Please refer to tables on biochemical components and moisture of leaf (Tables 22 & 23).

5. 2. Life-cycle & Morphometrics

5. 2. 1. *Buzura suppressaria*

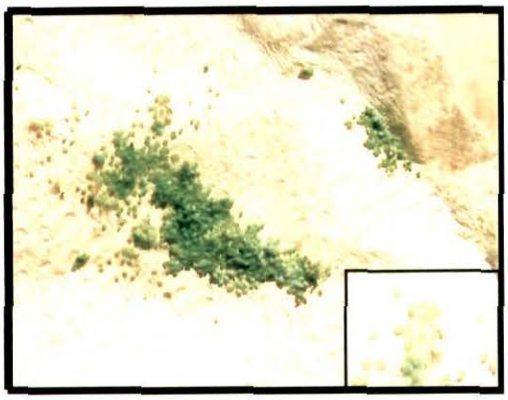
Under the laboratory condition, *Buzura suppressaria* on natural diet laid eggs in clusters on the axils of the leaf or on tissue paper toweling the rearing jars or on the cotton wads used for plugging the mouth of the conical flask containing the tea twig. The freshly laid eggs were bluish green in colour, slightly cylindrical in shape with an average mean of 0.272 mm length and 0.174 mm breadth which became dark before hatching. Incubation period was 3 - 4 days. The life cycle of looper caterpillar was completed through five larval stages. Average mean width of head capsule of I^{st}, II^{nd}, III^{rd}, IV^{th} and V^{th} instar measured 0.302, 1.44, 1.85, 2.31, 2.62 mm respectively.

The neonates after one or two days of hatching became active and spun silken threads, by which they started swinging around. This may be a mode of dispersal when they are in the natural habitat on shade trees of tea plantations. The first instar larva was black with black head and with two white lines running along the dorsal surface from behind the head to the end. Its duration was 5 - 6 days. All the larval stages had three pairs of thoracic legs, a pair of prolegs on the abdominal segment and a pair of claspers at the hind end of the body. The body colour of larva changed with age, it turned from black to green to light brown and finally to dark brown, blending completely with the background colour of the twigs / stems. First and second instar caterpillars were found nibbling the edges of leaves, making tiny holes. Stadial period for II^{nd} and III^{rd} larval stages ranged between 5 - 7 days for both the stages. Third instar larva started chewing margins of the leaves making small cuts and nicks. Fourth instar larval duration was 6 - 8 days. Fifth instar attained the maximum length and its duration was 7-10 days. Mean length of the body of I^{st}, II^{nd}, III^{rd}, IV^{th} and V^{th} measured 2.90, 3.50, 15.15, 19.65, and 30.55 mm respectively. The total larval development took about 33 - 37 days. The larvae stopped feeding, eliminated water, shrunk before entering into prepupal stage which lasted for 3 - 4 days. Pupa was brown in colour and had serrated ridges one on each side of the anterior end and measured on an average 19.43 mm. Pupal period lasted for 9 - 15 days.

Adults of both the sexes exhibited great variety of melanism (Plate 8). It ranged within different shades of brown and creamy white colours. Male moths were smaller in body size 17.25 mm long than females 21.08 mm long. Means of wing span of male and female were 32.50 mm and 43.08 mm respectively. Antenna of female moth was filamentous, while in males it was plumose. Mating took place at night and males died after the mating. Males lived for 4 - 5 days and females for 6 - 7 days. The total life cycle took 52 - 60 days (Table5,Plate 3).

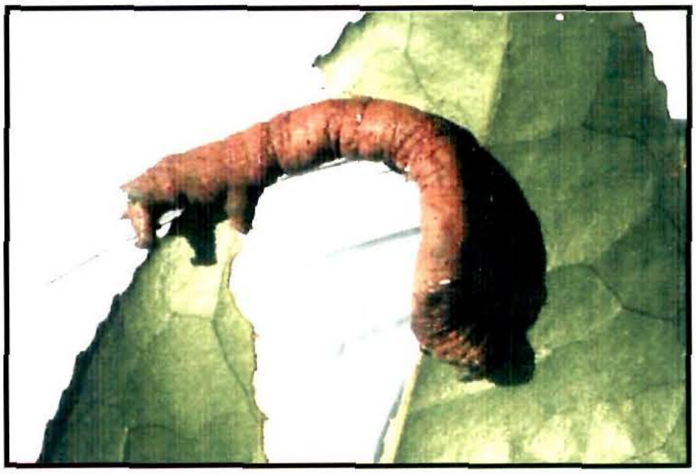
5. 2. 2. *Eterusia magnifica*

Eterusia magnifica laid eggs in masses, covered with buff coloured scales and hairs, on the blade and axils of leaves (TV_{26}) under the laboratory conditions during night. Freshly laid eggs were yellow in colour which turned green before hatching. Eggs were oval in shape and measured on an average 0.957 mm in length and 0.492 mm in breadth. The incubation period was for 5 - 6 days. Red slug developed through five larval instars. The head was dark brown. Head width

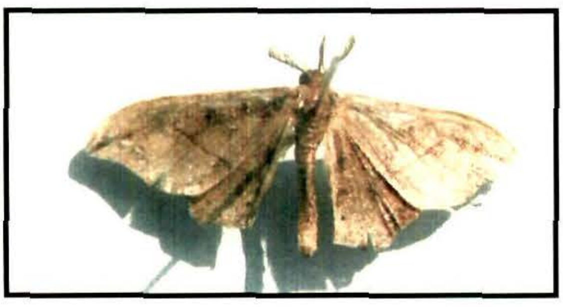


(a)

(b)



(c)



(d)

(e)

Plate 3. Different Stages of *Buzura suppressaria* .

(a). Eggs ; (Mag. X 4).

(b). Ist Instar ; (Mag. X 21).

(c).Vth Instar ; (Mag. X 3).

(d). Adult Male ; (Mag. X 2) and

(e). Adult Female . (Mag. X 1.5).

of I^{st}, II^{nd}, III^{rd}, IV^{th} and V^{th} instars on an average measured 0.232, 0.288, 0.930, 1.56, 2.23 mm respectively.

The first instar larva was brown in colour, having tubercles, bearing hairs and pores on its back. It had three thoracic legs and five pairs of prolegs, the last being the largest and acting as a clasper. Each pair of legs were provided at the end with disc like structures for attachment to the plant surface. The structures of larval stages remained unchanged till it reached the advanced instars. The first and second larval duration were 3 - 4 and 5 - 7 days respectively. The first and second instar larvae were found nibbling the epidermal surface of the leaf. Third instar larvae started feeding from the side of leaf blade, its duration was 6 - 8 days. Brown coloured ring like band appeared on the dorsal surface of the body. Duration of fourth and fifth instars were similar and ranged 7 - 9 days. These could eat entire leaf blade and parts of stem (twig) as well.

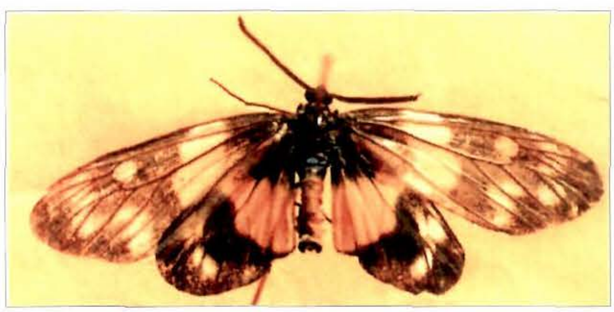
The full grown larvae were slug like and brick red in colour, when disturbed exuded thick clear fluid from the tubercles which was neither poisonous nor irritant to the of a handler. Mean body length of I^{st}, II^{nd}, III^{rd}, IV^{th} and V^{th} measured 1.32, 2.52, 5.35, 10.28 and 20.54 mm respectively. The total larval period ranged from 33 - 41 days. Pupation took place in closely woven, pinkish cocoon usually in the folds of leaves. The pupa was brown in colour and measured on an average 14.8 mm in length. The pupal period lasted for 10 - 14 days. The moth emerged during day or night through one end of the cocoon, leaving the pupal skin projecting out.

(a)

(b)

(c)

(d)



(E)

Plate 4. Different Stages of *Eterusia magnifica.*

(a). Eggs ;
(b). Ist Instar ; (Mag. X 28).
(c). Vth Instar ; (Mag. X 2).
(d). Adult Male ; (Mag. X 1.3) and
(e). Adult Female (Mag. X 1.3).

The moths were brilliantly coloured with an average wing span of 50.6 mm in males and 58.46 mm in females. The males were slightly smaller 17.6 mm than females 20.60 mm in body length. The head, thorax, abdomen and two basal segments of abdomen were black and the remainder of the abdomen were pale yellow except black tip at the end in males. The antenna of male was unipectinate and that of female was long filiform but with a feathery tip. The forewings had a purple brown colour with a greenish tinge, a basal spot, a median white band broken up usually into five spots, a white spot at the end of the cell and an irregular row of submarginal white spots. The hind wing was black at the base followed by a yellow band, wide on the inner margin and had a few sub-apical white spots, the apical area being largely marked with brilliant blue. Male and females lived for 5 - 6, and 6 - 7 days respectively. The total life cycle lasted for 50 - 63 days (Table 5, Plate 4).

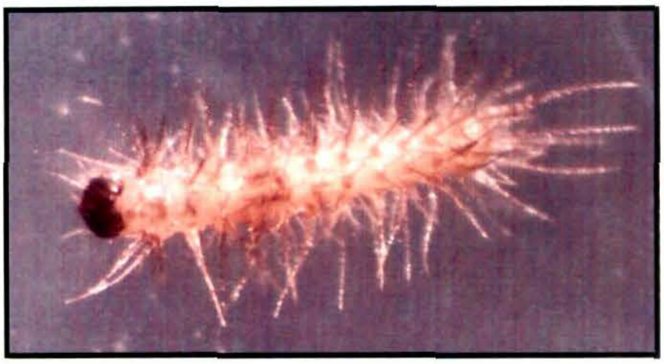
5. 2. 3. *Euproctis latisfascia*

Euproctis latisfascia (Darjeeling Black Hairy Caterpillar) laid eggs in masses covered with buff coloured hairs. The eggs were metallic green in colour, spherical and measured 0.697 mm in diameter. The incubation period was of 7 days. Life cycle of *E. latisfascia* was completed through six larval stages. The head capsule width of I^{st}, II^{nd}, III^{rd}, IV^{th}, V^{th} and VI^{th} instars on an average measured 0.325, 0.418, 1.20, 1.64, 1.76 and 2.64 mm respectively. First instar larvae were brownish in colour with fine black hairs distributed all over the body. There were three pairs of thoracic legs and four pairs of abdominal prolegs with cushions at the end. A pair of claspers were present at the end of the abdomen. The first instar duration was 3 - 4 days.

The larval instars, in general, were brownish black with transverse rows of tubercles on each of the thoracic and abdominal segments. The tubercles were beset with tufts of black hairs. The thoracic segment was circled by two prominent white rings and a reddish patch on the dorso-median surface of the abdomen. Two whitish streaks were also found extending on the entire length of the dorsal surface. Early instars fed mainly on epidermal surface of leaf while the later instars fed on veins and other leaf parts. As the larvae grew, the hairs became profuse. Skin rash was caused by the urticating hairs of the larval forms. The second, third, fourth, fifth and sixth larval duration were of 6 - 9, 7 - 9, 6 – 9, 8 - 10 and 8 - 10 days respectively.

The body length of Ist, IInd, IIIrd, IVth, Vth and VIth on an average was 2.20, 3.20, 8.13, 10.58, 18.81 and 20.20 mm respectively. The total larval period was 49 - 55 days. Pupa was brown in colour, oval in shape and pupal case was woven by brown silken threads and on an average measured 10.33 mm. The pupal duration was 17 - 24 days. Adults emerged at night; males and females were more or less of similar lengths, measuring on an average 16.3 mm and 16.46 mm with an average wing spans of 26.4 mm and 30.5 mm respectively. Life span of the adult male was 3 – 5 days while for the female it was 4 - 6 days. Mating took place during daytime and lasted for 5 - 6 hours. The total life cycle was of 74 - 81 days (Table 5, Plate 5).

(a)



(b)

(c)

(d)

(e)

Plate 5. Different Stages of *Euproctis latisfascia* .

(a). Egg ; (Mag. X 13).
(b). Ist Instar ; (Mag. X 17).
(c). VIth Instar ; (Mag. X 2.5)
(d). Adult Male ; (Mag X 1.2). and
(e) Adults Mating.

Table 5. Morphometric Data (Mean ± SD)* of *Buzura suppressaria*, *Eterusia magnifica* and *Euproctis latisfascia*.

Stage	***B. suppressaria***	***E. magnifica***	***E. latisfascia***
Egg			
a) Length	0.272 ± 0.10	0.957 ± 0.01	0.697 ± 0.00
b) Width	0.174 ± 0.01	0.492 ± 0.01	X
Ist Instar			
a) Body Length	2.900 ± 0.09	1.320 ± 0.04	2.200 ± 0.10
b) Head Length	0.341 ± 0.01	0.285 ± 0.01	0.343 ± 0.00
c) Width of Head Capsule	0.302 ± 0.00	0.232 ± 0.00	0.325 ± 0.00
IInd Instar			
a) Body Length	3.500 ± 0.23	2.520 ± 0.12	3.200 ± 0.26
b) Head Length	1.550 ± 0.05	0.474 ± 0.01	0.462 ± 0.00
c) Width of Head Capsule	1.440 ± 0.05	0.288 ± 0.01	0.418 ± 0.00
IIIrd Instar			
a) Body Length	15.150 ± 1.950	5.350 ± 0.09	8.13 ± 0.81
b) Head Length	1.970 ± 0.08	1.020 ± 0.02	1.27 ± 0.01
c) Width of Head Capsule	1.850 ± 0.05	0.930 ± 0.00	1.20 ± 0.00
IVth Instar			
a) Body Length	19.65 ± 1.100	10.280 ± 0.266	10.58 ± 0.280
b) Head Length	2.29 ± 0.06	2.040 ± 0.12	1.78 ± 0.04
c) Width of Head Capsule	2.31 ± 0.05	1.560 ± 0.07	1.64 ± 0.00
Vth Instar			
a) Body Length	30.55 ± 3.230	20.540 ± 0.270	18.81 ± 1.604
b) Head Length	2.77 ± 0.06	2.720 ± 0.06	2.06 ± 0.02
c) Width of Head Capsule	2.62 ± 0.03	2.230 ± 0.00	1.76 ± 0.00
VIth Instar			
a) Body Length			20.20 ± 0.200
b) Head Length	X	X	2.75 ± 0.02
c) Width of Head Capsule			2.64 ± 0.00
Pupa Length	19.43 ± 0.95	14.80 ± 0.434	10.33 ± 0.36
Adult Moth			
*1. **Male***			
a) Length	17.25 ± 1.89	17.60 ± 2.30	16.30 ± 2.66
b) Wing span	32.50 ± 2.82	50.60 ± 6.50	26.40 ± 4.80
*2. **Female***			
a) Length	21.08 ± 1.56	20.60 ± 1.09	16.46 ± 4.80
b) Wing span	43.08 ± 3.85	58.46 ± 4.04	30.50 ± 0.35

* Standard Deviation of the Mean of 10 Replications.

5. 3. Allometric growth

Matsuda (1960) stressed the importance of allometric growth ratios in his study on Gerridae and further suggested that the growth ratios were more stable characters and that the differences in the growth ratios of the parts of the body of related insects indicate their phylogenetic line. This stable character like colour and structure may be used as a valid criterion on which systematic conclusions may be based.

In the present study the larval growth pattern of the three folivores differed by comfortable margins. The 'b' (slope) and 'k' (intercept) values of the three species, despite feeding on tea leaves were distinct, so also were their regression curves (Figs. 4 & 5). These indicated not only their taxonomic distinctness but also their usefulness in identifying the species based on the larval morphometrics from the field populations of the folivores in question. Many workers such as Ananthakrishnan (1961) on the Thysanoptera; Mohan Rao and Tonabi (1970) on Coleoptera; Mukherjee (1972) on Miridae and Ananthasubramanium and Anathakrishnan (1975) on Membracidae have stressed the importance of differential growth rate as a valid taxonomic tool in study of various insect groups.

The intercept values (b) of the three species of the folivores were found to be more reliable in distinguishing them when head length was computed against their head width, than body lengths against head widths as per data available in Table 6.

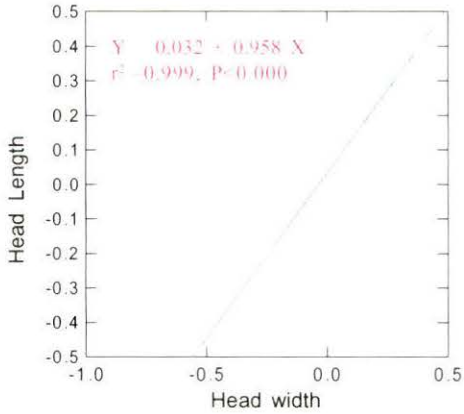


Fig.(a). ***Buzura suppressaria***

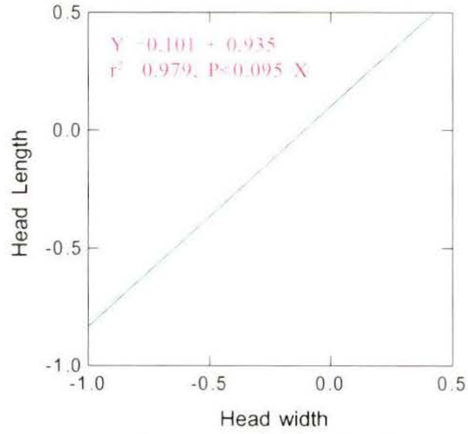


Fig.(b). ***Eterusia magnifica***

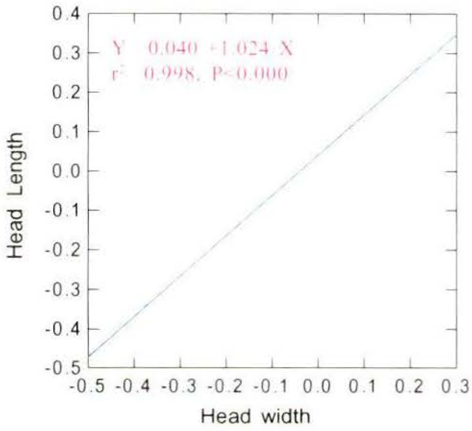


Fig.(b). ***Euproctis latisfascia***

Fig : 4. Comparison of Relative Growth of Body parts (Head Width vs Head Length) of three folivores.

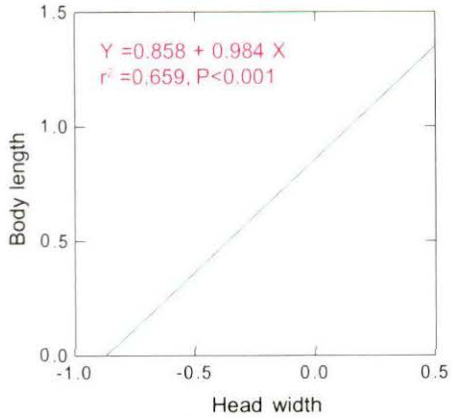


Fig.(a). *Buzura suppressaria*

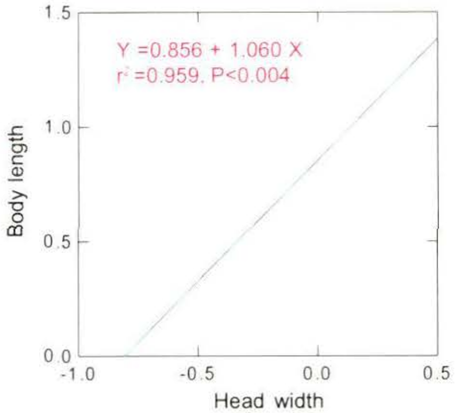


Fig.(b). *Eterusia. magnifica*

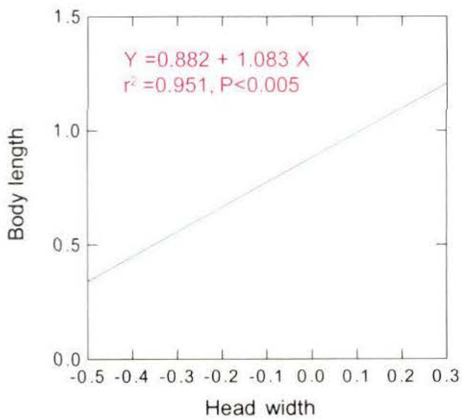


Fig.(c). *Euproctis latisfascia*

Fig : 5. Comparison of Relative Growth of Body Parts (Head Width vs Body Length) of three folivores.

Table 6. Allometric Growth in *Buzura suppressaria* (Looper), *Eterusia magnifica* (Red Slug) and *Euproctis latisfascia* (Black Hairy Caterpillar)

	Head Width					
	Intercept (b)			Slope (k)		
	Looper	Red Slug	Hairy Cat.	Looper	Red Slug	Hairy Cat.
Head Length	0.0324	0.1011	0.0406	0.9577	0.9354	1.0237
Body Length	0.8578	0.8559	0.8820	0.9837	1.0598	1.0834

5. 4. Post-embryonic Development period on Natural and Artificial diets

The length of time an insect spends in a particular life stage and indeed the total time taken for one generation, depend on a wide range of factors that the species or population has encountered during its evolution (Speight, 1994). As compared to natural (tea leaf) diet developmental periods of most of the stages were found significantly shorter on artificial diets in all three folivorous species. Attempts to rear Ist and IInd instars of looper and red slug caterpillars were met with high mortality on artificial diets. However, successful rearing of these (on artificial diet) was possible from third instar onwards. Third and fifth larval and pupal duration of *B. suppressaria* on artificial diet was significantly shorter than on natural diet (Table 7). As a consequence its total larval duration as well as life cycle was also shorter on artificial diet.

Et. magnifica somewhat showed a similar trend with total larval duration and life cycle of the species on artificial diet being shorter as compared to that on natural diet. This was mainly due to a shorter period of development required particularly by the IIIrd and IVth instars on artificial diet (Table 8).

Most of the developmental stages of *E. latisfascia*, particularly the second, fourth, fifth and sixth instar larvae showed significantly longer duration on natural diet. The pupation also took longer for those reared on natural diet. Therefore the total life cycle was shorter on artificial diet than on natural diet (Table 9). Generally insects prolong their development on suboptimal food as has been observed in most lepidopterans feeding on natural diets (host plants) (Waters & Barfield, 1989).

Table 7. Development Period (days) of *Buzura suppressaria* (Guen.) on Natural (tea leaf) and Artificial Diets at 28°C and 75% R. H.

Stages	Duration (days) (mean ± SE)	
	Natural diet	Artificial diet
Eggs	3.300 ± 0.105a	3.300 ± 0.105a
Ist instar	5.200 ± 0.116a	5.200 ± 0.116a
IInd instar	6.100 ± 0.123a	6.100 ± 0.123a
IIIrd instar	5.800 ± 0.117a	4.850 ± 0.167b
IVth instar	6.600 ± 0.152a	6.450 ± 0.135a
Vth instar	8.150 ± 0.196a	7.100 ± 0.124b
Total Larval period	35.150 ± 0.309a	33.000 ± 0.362b
Pre-pupa	3.250 ± 0.990a	3.150 ± 0.082a
Pupa	12.050 ± 0.320a	10.950 ± 0.211b
Adult	6.142 ± 0.274a	5.500 ± 0.341a
Total development period	56.533 ± 0.729a	52.500 ± 0.778b

Means followed by same letter are not significantly different at 5% level.

Table 8. Development Period (days) of *Eterusia magnifica* (Butl.) on Natural (tea leaf) and Artificial Diets at 28°C and 75% R.H.

Stages	Duration (days) (Mean ± SE)	
	Natural diet	Artificial diet
Eggs	5.500 ± 0.115a	5.500 ±0.115a
Ist instar	3.600 ± 0.112a	3.600 ± 0.112a
IInd instar	5.950 ± 0.198a	5.950 ± 0.198a
IIIrd instar	6.800 ± 0.172a	6.200 ± 0.172b
IVth instar	8.100 ± 0.191a	7.350 ± 0.150b
Vth instar	8.250 ± 0.176a	7.750 ± 0.160a
Total Larval period	38.200 ± 0.541a	36.350 ± 0.455b
Pupa	11.300 ± 0.291a	10.800 ± 0.341a
Adult	5.910 ± 0.192a	6.200 ± 0.249a
Total development period	55.580 ± 1.018a	52.800 ± 1.181b

Means followed by same letter are not significantly different at 5% level.

Table 9. Development Period (days) of *Euproctis latisfascia* (Wlk.) on Natural (tea leaf) and Artificial Diets at 28°C and 75% R.H.

Stages	Duration (days) (mean ± SE)	
	Natural diet	**Artificial diet**
Eggs	7.000 ± 0.000a	7.000 ± 0.000a
Ist instar	3.250 ± 0.123a	3.400 ± 0.134a
IInd instar	7.700 ± 0.179a	6.150 ± 0.196b
IIIrd instar	7.950 ± 0.170a	7.550 ± 0.170a
IVth instar	8.150 ± 0.196a	7.350 ± 0.182b
Vth instar	9.000 ± 0.162a	7.357 ± 0.213b
VIth instar	9.000 ± 0.196a	8.300 ± 0.213b
Total Larval period	51.800 ± 0.696a	47.100 ± 0.706b
Pupa	22.150 ± 0.629a	16.857 ± 0.962b
Adult	4.250 ± 0.583a	4.200 ± 0.583a
Total development period	78.450 ± 0.660a	68.600 ± 1.860b

Means followed by same letter are not significantly different at 5% level

Shorter duration of different stages of life cycle of the three folivores on artificial diet than on natural diet indicates their greater efficiency in utilizing the artificial diet to the optimum. David et al. (1989) showed that *Platynota idaeusalis* developed faster on semisynthetic diet compared to natural diet in the laboratory. Felland and Hull (1992) also reported that larvae reared on artificial diet survived better, developed faster and produced heavier adults. In Velvetbean caterpillar, larvae taken from laboratory when fed on artificial diet had the shortest development time, whereas larvae taken from laboratory fed on foliage took a considerably longer time to reach the prepupal stage (Slansky and Wheeler, 1992).

Suitability of artificial diet can be gauged by comparing the developmental time, survival rate and pupal weight of larvae reared on the diet with those reared on natural diet. These features have proved to be true for *Spodoptera exigua* when reared on artificial diet (Mu & Chu, 1993 ; Abdullah et al., 2000).

5. 5. Survivorship

Evolution has produced several types of survivorship strategies wherein the rates of mortality vary according to the life stage (Speight et al, 1999). Effects of variation of diets can be measured in terms of growth, development, reproductive performance, mortality, longevity and morphological abnormalities.

Survivorship curves are of three general types although intermediate types may occur. These three types are; Type I, highly convex type; Type II, a diagonal straight line type and Type III, highly concave type. In the Type I curve, the population mortality rate is low until near the end of the life span. In the Type II, the diagonal straight–line curve indicates an age-specific constant survival, in other words, a constant rate of mortality occurs at every age. In the Type III, population mortality is high during the young stages (Pearl 1928) (Fig.6).

In some holometabolous insects the survival rate differs in successive life-history stages and the curve becomes of the stair step type. In the stair step survivorship curve, the initial segments represent the egg population and the two middle flatter segments represent the larval and pupal stages that exhibit less mortality and final steep segment represent the shortlived adult stages (Dash, 1995) (Fig. 6).

Survivorship studies of *Buzura suppressaria* showed high mortality in the I^{st} larval stage of the life cycle. A greater survival was recorded in the subsequent larval stages with only a moderate mortality till pupal stage when the species was reared on natural diet. Third instar looper when introduced to artificial diet showed a higher percentage of mortality at this starting stage than that on natural diet. Rest of the stages indicated similar percentage of mortality till the pupal stage (Table 10).

Number of adults emerging from pupae on both the diets were also more or less similar signifying that the artificial diet used here was equivalent in supporting survival like the natural diet. The survivorship curve of *B. suppressaria* on both natural and artificial diets by and large followed Type II curve (Fig.7).

Eterusia magnifica showed higher mortality in the beginning of the life cycle on natural diet. In the third larval stage, percentage of mortality was also high on artificial diet. Rest of the stages showed more or less similar percentage of mortality till the pupal stage. The number of adults emerged was slightly higher on natural diet than that on artificial diet (Table 11). Survivorship curves of *Et. magnifica* on both natural and artificial diets were closer to Type II curve (Fig. 8). Such curves established that the artificial diet was in no way inferior to the natural diet as far as development and survival were concerned.

Complete rearing of *Euproctis latisfascia* from egg to egg could be successfully done both on natural and artificial diets. However, its survivorship curve showed variation on natural and artificial diets. The percentage of mortality was higher in the first instar on artificial diet than on natural diet which lessened in the advancing instars (II to VI). Mortality of pupal stage on artificial diet was relatively higher. The number of adult emergence was also higher on natural diet than on artificial diet (Table 12). Survivorship curves of *E. latisfascia,* both on natural and artificial diets, were closer to Type II curve (Fig. 9).

Life tables / Survivorship is a convenient form for describing mortality schedule of a population (Krebs, 1978). Host plant significantly influence vital features such as rate of development, survival, reproductive potential of insects which ultimately determine the population build up (Painter, 1951; Kennedy, 1995). In most of the insect species, the mortality rate is a characteristic of the stage that is not uniform for all the developmental stages (Martinez and Katthain, 1999).

Since the larval stages are the active feeding forms in the lepidopterans, it is expected that dietary influence is also maximum on these trophic stages. The survivorship tables and curves of the immature forms in the present study have provided a basis for comparing the performance of the three lepidopteran tea pests on natural and artificial diets; for it is well known that the survivorship or otherwise the rate of mortality throughout these developmental stages is an index of how well the species have adapted itself to the food (natural and artifical). Survivorship curve of *B. suppressaria* was more of a stair step type but in general followed Type II curve on both the diets. Hence, it may be interpreted that there was a constant rate of mortality during its larval and pupal stages.

Survivorship curve of *Et. magnifica* also showed similarity with that of *B. suppressaria* having a closeness to Type II curve. Survivorship of *E. magnifica* was slightly better on natural diet as compared to that on artificial diet. Nevertheless, judging by the significantly lower total larval duration and life cycle on artificial diet, it could be labeled as a more suitable one for supporting post embryonic development of the species.

E. latisfascia could completely be reared on artificial diet as well as on natural diet. Its survivorship curve on artificial diet closely followed the one on natural diet, and both of these curves toed Type II curve, indicating constant rate of mortality in all the stages irrespective of duration and age.

By and large all the survivorship curves studied for the three lepidopteran species on both natural and artificial diets were close to Type II curve, which has been considered ideal for a large number of species by Krebs (1978). In one

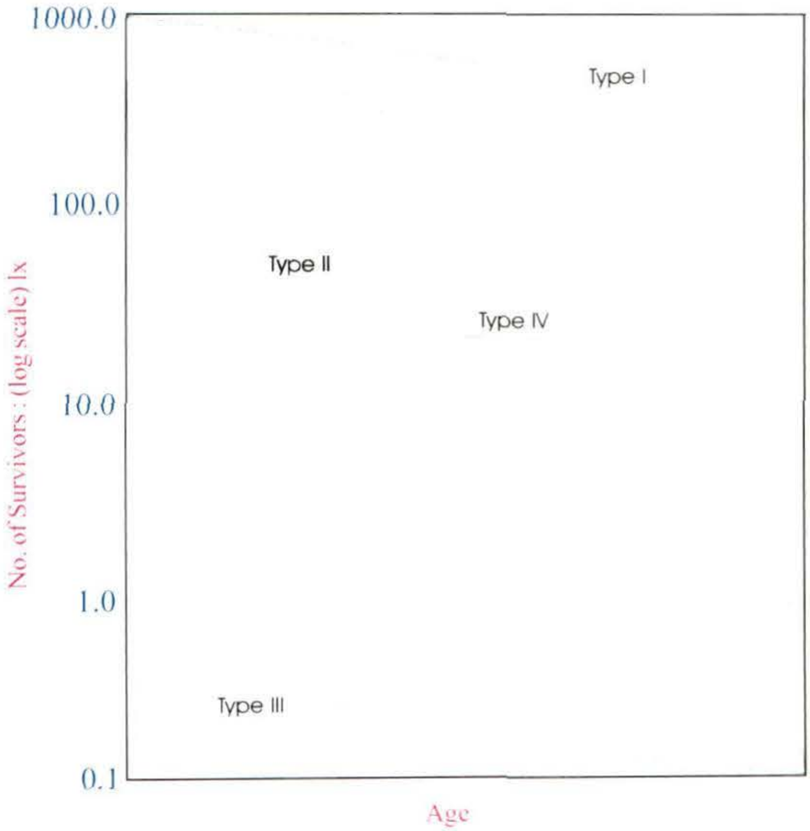


Fig. 6. **Survivorship Curve**: Type I - Convex; Type II - Diagonal Straight line; Type III - Concave ; Type IV - Stairstep.

Table 10. Survivorship of *Buzura suppressaria* on Natural and Artificial Diets.

X Age Interval	Natural diet			Artificial diet		
	lx No. alive at beginning of X	dx No. dying during lx	100qx dx as a %	lx No. alive at beginning of X	dx No. dying during lx	100qx dx as a %
Egg	100	32	32.00	100	32	32.00
Ist Instar	68	12	17.64	68	12	17.64
IInd Instar	56	9	16.07	56	9	16.07
IIIrd Instar	47	8	17.02	47	11	23.40
IVth Instar	39	5	12.82	36	7	19.44
Vth Instar	34	6	17.64	29	5	17.24
Pre-pupa	28	6	21.42	24	3	12.50
Pupa	22	4	18.18	21	4	19.04
Adult	18			17		

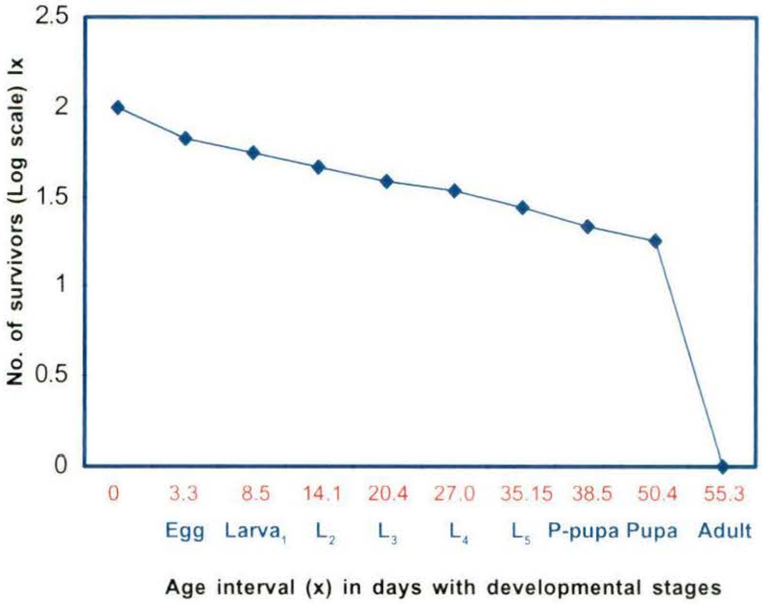


Fig. (a). Natural diet

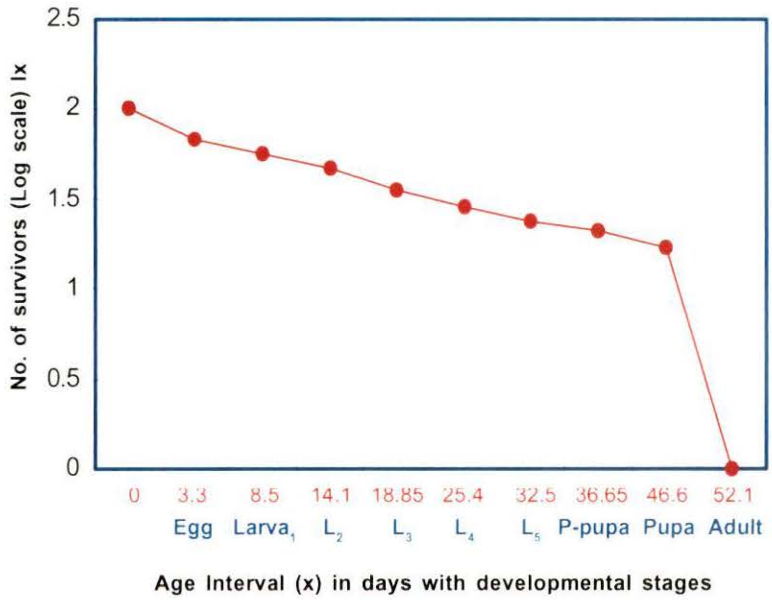


Fig. (b). Artificial diet

Fig : 7. Survivorship Curves of *B. suppressaria* on (a) Natural (tea leaf) & (b) Artificial Diets.

Table 11. Survivorship of *Eterusia magnifica* on Natural and Artificial Diets.

X Age Interval	Natural diet			Artificial diet		
	lx No. alive at beginning of X	**dx** No. dying during lx	**100qx** dx as a %	**lx** No. alive at beginning of X	**dx** No. dying during lx	**100qx** dx as a %
Egg	100	37	37.00	100	37	37.00
Ist Instar	63	11	17.46	63	11	17.46
IInd Instar	52	5	9.61	52	5	9.61
IIIrd Instar	47	9	19.14	47	12	25.53
IVth Instar	38	5	13.15	35	6	17.14
Vth Instar	33	5	15.15	29	5	17.24
Pupa	28	3	10.71	24	3	12.50
Adult	25			21		

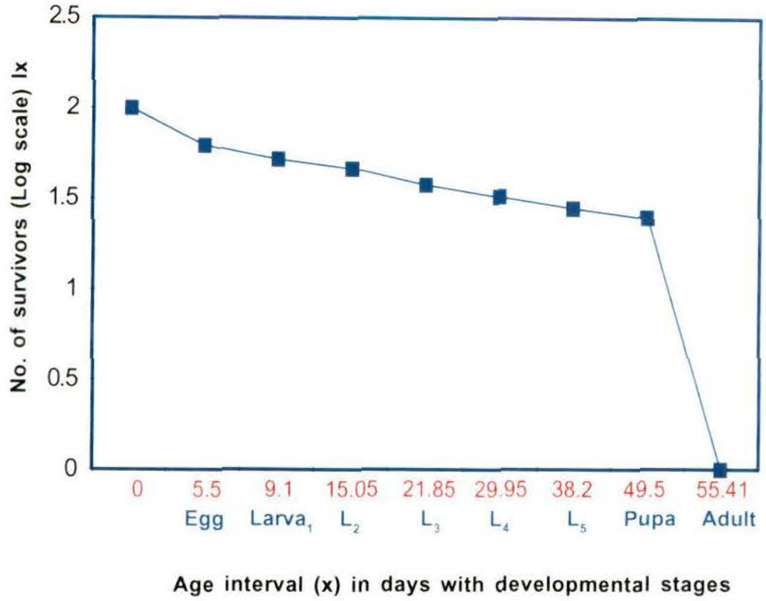


Fig.(a). Natural diet

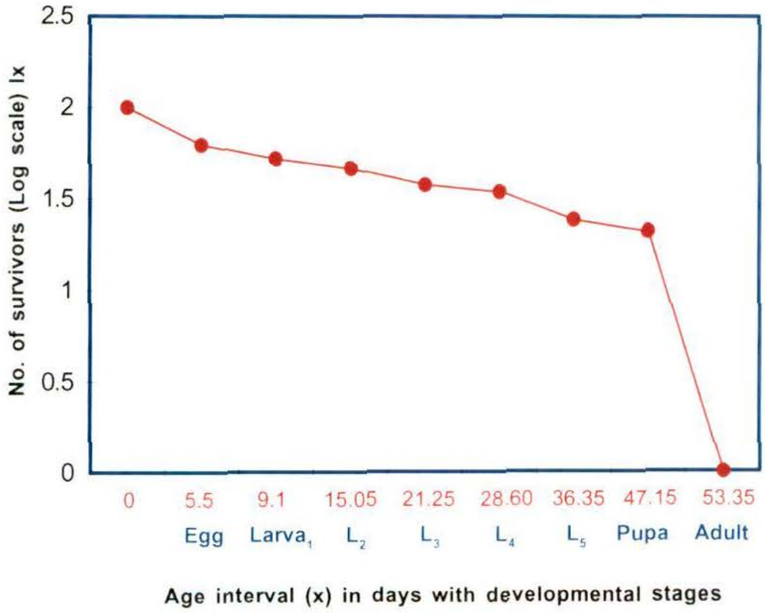


Fig.(b). Artificial diet

Fig : 8. Survivorship curves of *Et. magnifica* on (a) Natural (tea leaf) & (b) Artificial Diets.

Table 12. Survivorship of *Euproctis latisfascia* on Natural and Artificial Diets.

X Age Interval	Natural diet			Artificial diet		
	lx No. alive at beginning of X	**dx** No. dying during lx	**100qx** dx as a %	**lx** No. alive at beginning of X	**dx** No. dying during lx	**100qx** dx as a %
Egg	100	27	27.00	100	42	42.00
Ist Instar	73	7	9.58	58	22	37.93
IInd Instar	66	16	24.24	36	8	22.22
IIIrd Instar	50	6	12.00	28	6	21.42
IVth Instar	44	8	18.18	22	4	18.18
Vth Instar	36	7	19.44	18	3	16.66
VIth Instar	29	4	13.79	15	2	13.33
Pupa	25	4	16.00	13	3	23.07
Adult	21			10		

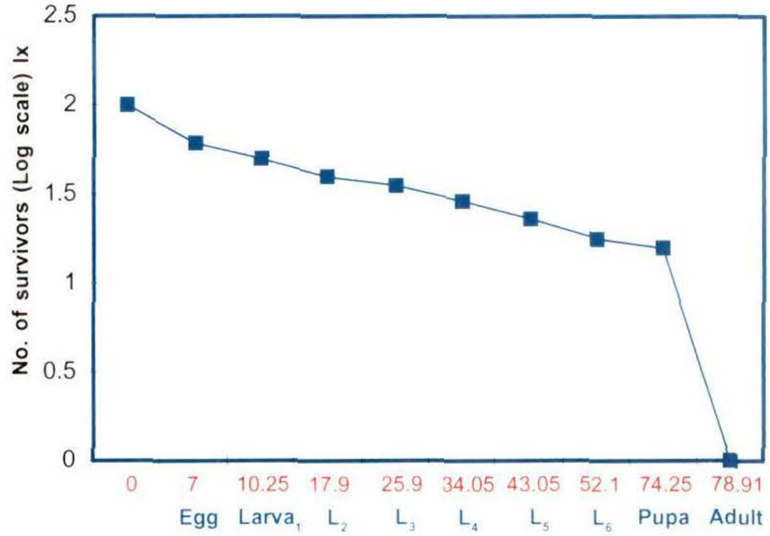


Fig.(a). Natural diet

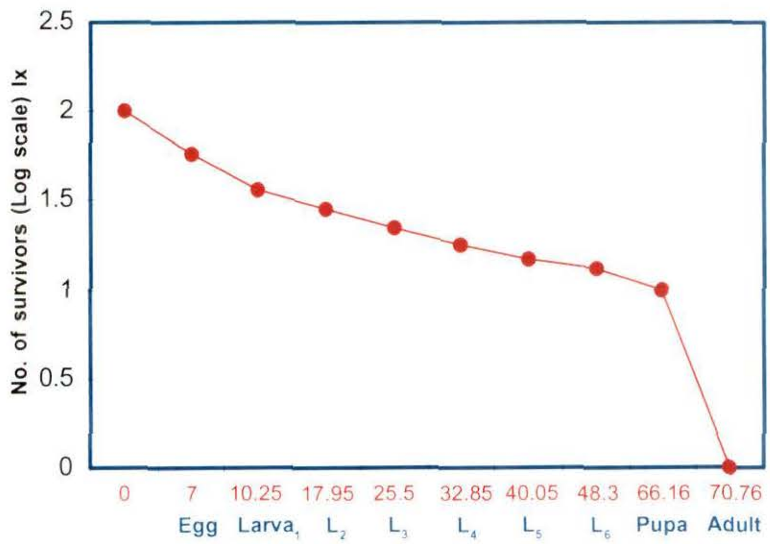


Fig.(b). Artificial diet

Fig : 9. Survivorship curves of *E. latisfascia* on (a) Natural (tea leaf) & (b) Artificial Diets.

word artificial diet appeared to be successful in supporting growth and development of all the three species in question as their survival was at par with that on natural diet. Therefore, artificial diet can be used as an alternative food for laboratory rearing of these three lepidopteran tea pests for further research studies and mass production.

5. 6. Daily food consumption and larval body weight

Daily performance of the three tea pests on natural (tea leaf) and artificial diets were recorded for last two larval instars based on food consumption and larval body weight change. Regression curves of weight gained by fourth and fifth instar larvae of *B. suppressaria* against the food consumed per day (Fig. 10 & 11) on both natural and artificial diets showed a linear relationship between these two variables with co-efficient and determination values r^2=0.923, r^2=0.666 on natural and r^2 =0·882, r^2 =0.591 on artificial diet respectively. Similar regression curves were observed for fifth and sixth instars of *E. latisfascia* on both natural and artificial diets, with values r^2=0.893, r^2 =0.864 and r^2=0.664, r^2 =0.828 respectively (Fig. 14 & 15). Larval body weight and food consumption were found highest in the middle of the stadial period in both the instars on natural and artificial diet. However, for *E. magnifica* though food consumption and the corresponding larval body weight change were apparent, their co-efficient values were relatively less, r^2=0.216 and r^2=0.301 on natural and r^2 =0.248 and r^2 =0.310 on artificial diets for fourth and fifth instars respectively (Fig.12 & 13).

Trichilo and Mack (1989), Sood et al. (1993) and others have reported a high correlation between food consumption and mean larval weight in insects. In

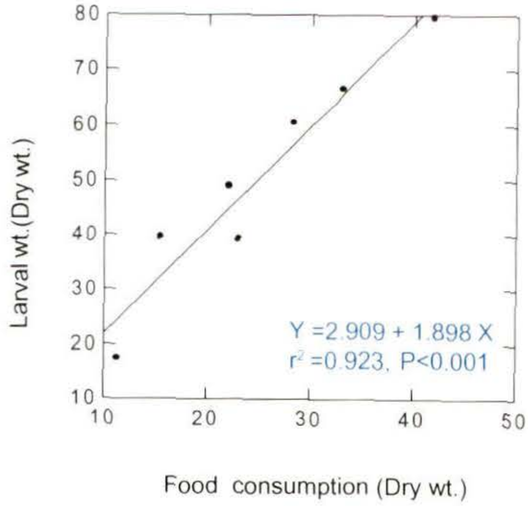


Fig. (a).Natural diet

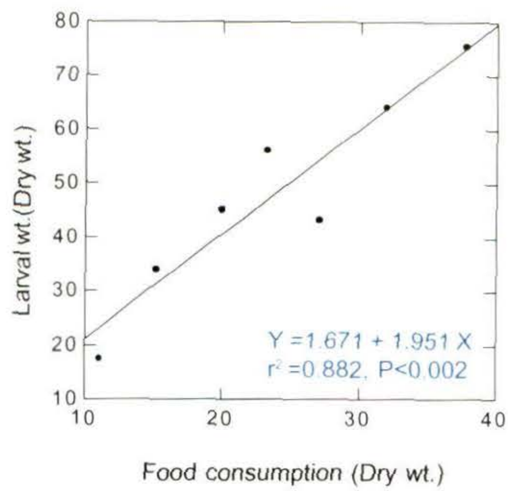


Fig. (b). Artificial diet

Fig:10. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *B. suppressaria* on (a) Natural & (b) Artificial Diets during the Stadial Period of IVth instar.

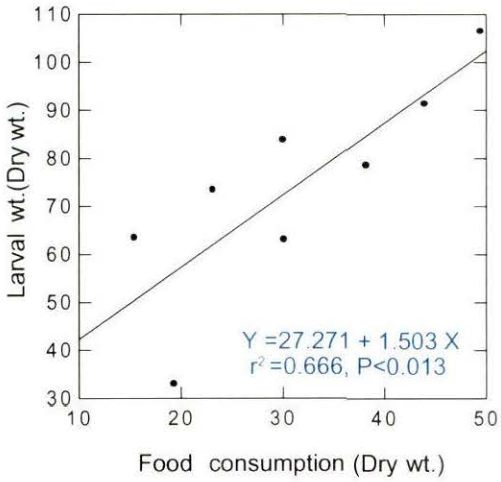


Fig.(a).Natural diet

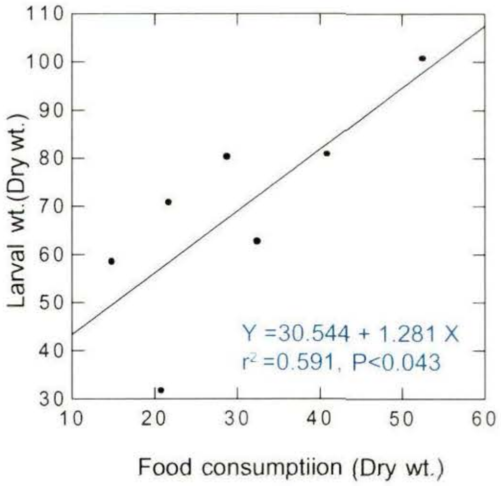


Fig.(a).Artificiai diet

Fig:11. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *B. suppressaria* on (a) Natural & (b) Artificial Diets during the Stadial Period of Vth instar.

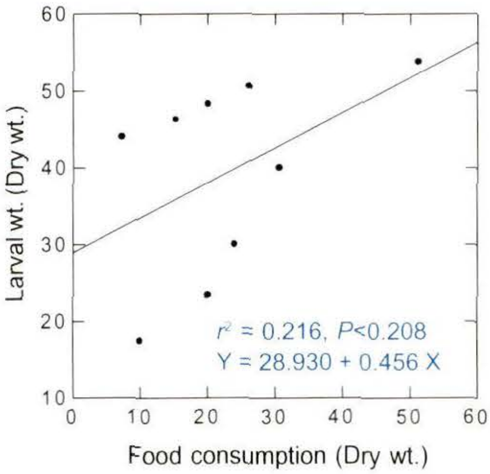


Fig. (a) Natural diet

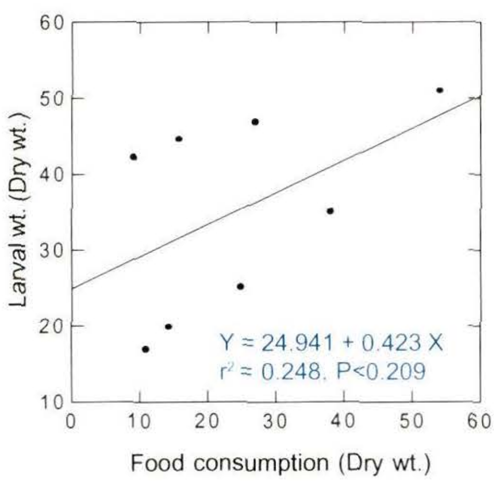


Fig. (b) Artificial diet

Fig:12. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *Et. magnifica* on (a) Natural & (b) Artificial Diets during the Stadial Period of IVth instar.

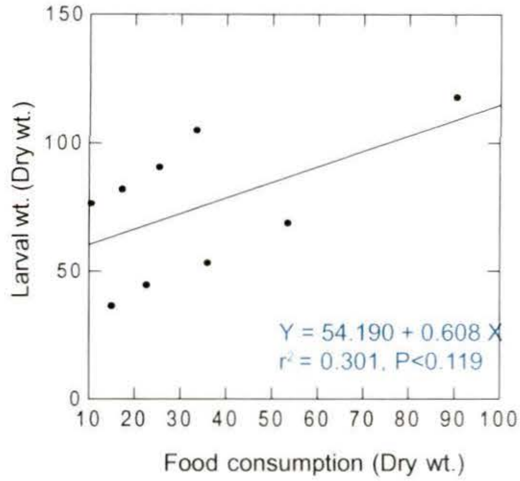


Fig. (a) Natural diet

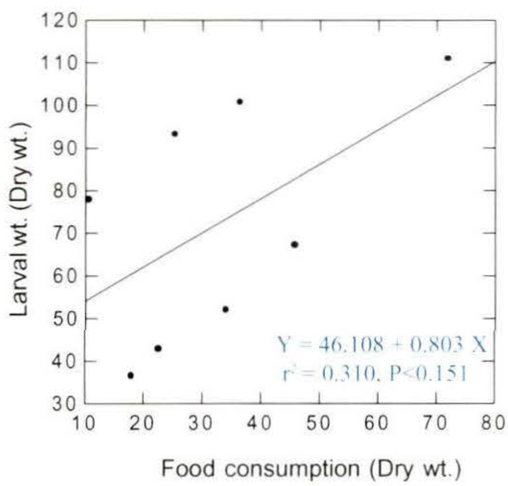


Fig.(b) Artificial diet

Fig:13. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *Et. magnifica* on (a) Natural & (b) Artificial Diets during the Stadial Period of V^{th} instar.

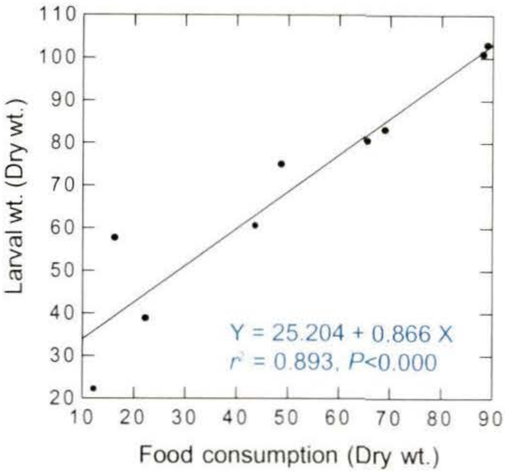


Fig.(a). Natural diet

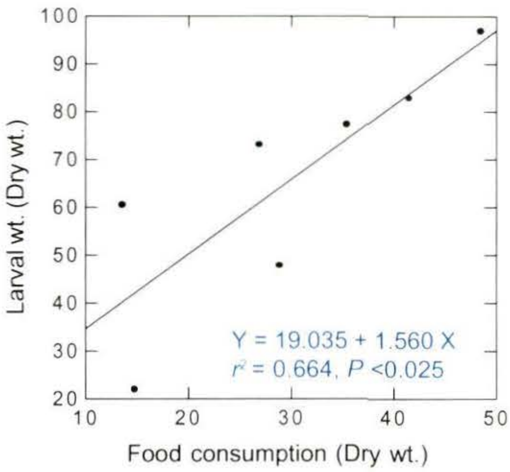


Fig.(b). Artificial diet

Fig:14. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *E. latisfascia* on (a) Natural & (b) Artificial Diets during the Stadial Period of V^{th} instar.

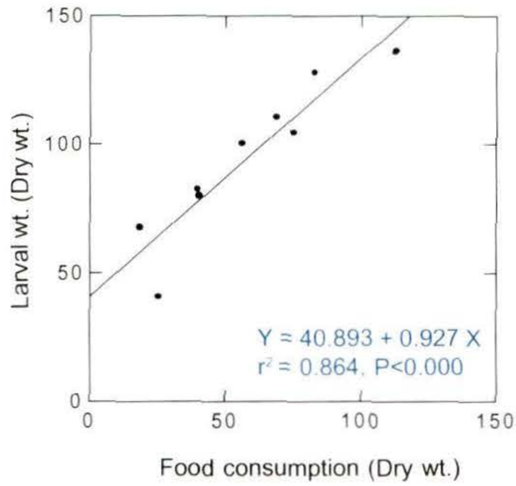


Fig. (a).Natural diet

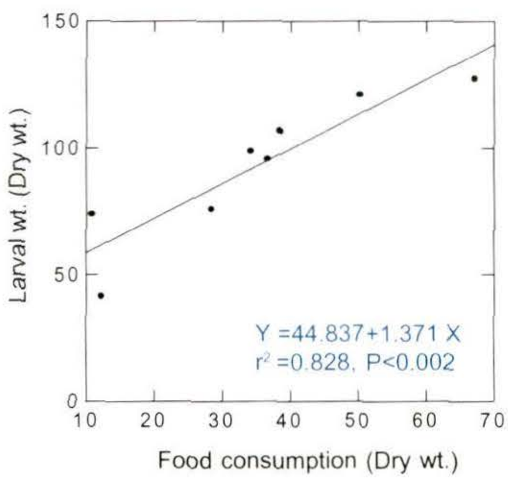


Fig. (b).Artificial diet

Fig:15. Relationship between Daily Food Consumption (mg) and Larval weight (mg) in *E. latisfascia* on (a) Natural & (b) Artificial diets during the Stadial Period of VIth instar.

similar finding Mukerji and Guppy (1973) observed a direct linear relationship between mean daily food consumption and growth in larvae of *Pseudoletia unipunctata* and proposed that growth can be predicted from estimates of feeding. A similar result was observed in the present study. It was also observed that the food consumption decreased towards the end of each larval instar followed by decrease in larval body weight. Daily consumption commonly increases rapidly soon after a moult, and shows a peak near the middle of the instar and declines as the next moult approaches which was found to be true in the present study which was also supported by Srivastava (1983) and Simpson (1982) (Figs. 16, 17 & 18) details of which are available in Tables 13 a & b, 14 a & b, 15 a & b respectively.

The amount of food consumed and consequent growth occurring during the larval stage tend to be a representative of those calculated for the entire larval period (Scriber and Slansky, 1981; Ghosh and Gonchaudhuri, 1996) and facilitates accumulation of sufficient energy to tide over during the non-feeding pupal stage (Pandian, 1973).

5. 7. Reproductive performance

Reproduction is one of the primary events in the life cycle of an insect. This involves an integration of several physiological and behavioural events which in turn involve the consumption and utilization of food. Several component processes of reproduction such as attraction and acceptance of mate, mating act, oogenesis, oviposition, fecundity etc. have a definite relationship with nutrition (Ananthakrishnan, 1990).

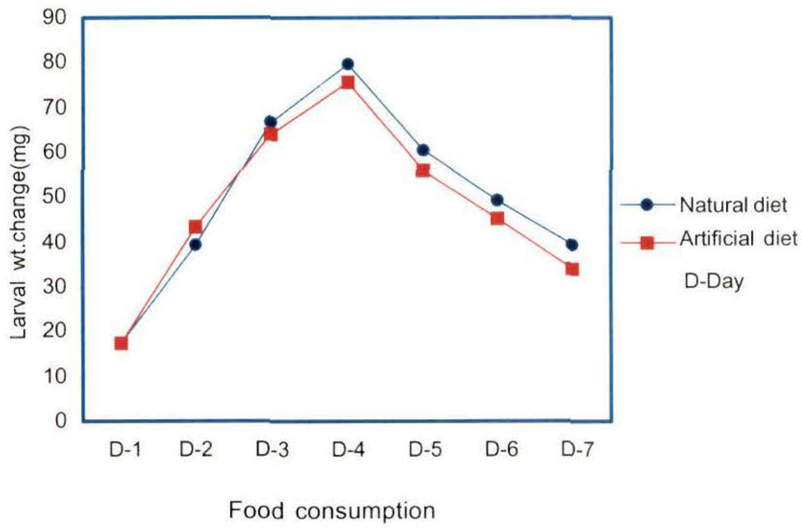


Fig. (a).IV[th] instar

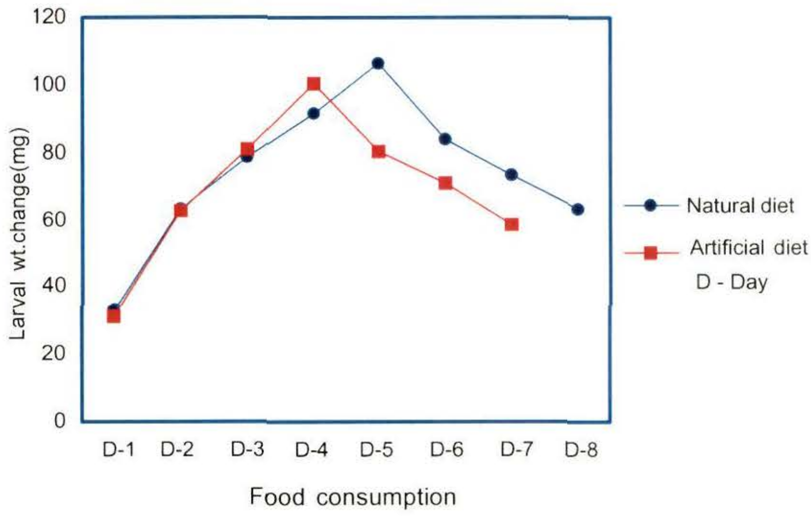


Fig.(b). V[th] instar

Fig:16. Difference in Larval Dry wt. (mg) on Natural & Artificial Diets during Development at (a) IV[th] and (b) V[th] instars of *Buzura suppressaria* recorded daywise.

Table 13 (a). Food Consumption and Larval Weight Change (Mean ± SE) per Day on Natural and Artificial Diets of IVth Instar of *Buzura suppressaria*.

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Larval Weight	17.6 ± 0.305	39.3 ± 0.700	66.6 ± 1.097	79.6 ± 1.077	60.6 ± 1.641	49.1 ± 1.629	39.6 ± 1.400
Food Consumption	11.3 ± 0.366	23.0 ± 0.869	33.0 ± 0.632	41.8 ± 1.200	28.3 ± 1.011	22.1 ± 0.504	15.4 ± 0.845

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Larval Weight	17.5 ± 0.268	43.5 ± 0.909	64.2 ± 1.617	75.6 ± 1.499	56.1 ± 1.224	45.3 ± 1.862	34.0 ± 0.614
Food Consumption	11.1 ± 0.481	27.1 ± 0.504	31.9 ± 0.874	37.7 ± 0.700	23.3 ± 1.145	20.0 ± 0.788	15.2 ± 0.573

Table 13 (b). Food Consumption and Larval Weight Change (Mean ± SE)per Day on Natural and Artificial Diets of Vth Instar of *Buzura suppressaria*.

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Larval Weight	32.9 ± 1.139	63.0 ± 1.163	78.6 ± 1.400	91.4 ± 1.713	106.5 ± 2.400	83.8 ± 1.919	73.4 ± 1.586	63.5 ± 1.351
Food Consumption	19.3 ± 0.667	30.1 ± 0.924	38.2 ± 1.143	43.9 ± 0.566	49.4 ± 1.439	30.0 ± 1.264	23.1 ± 0.546	15.4 ± 0.561

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Larval Weight	31.6 ± 0.581	62.7 ± 1.591	80.8 ± 1.793	100.7 ± 1.738	80.3 ± 1.350	70.7 ± 0.869	58.5 ± 1.408
Food Consumption	20.8 ± 0.533	32.4 ± 0.733	40.9 ± 0.657	52.5 ± 1.002	28.8 ± 0.916	21.7 ± 0.700	14.8 ± 0.512

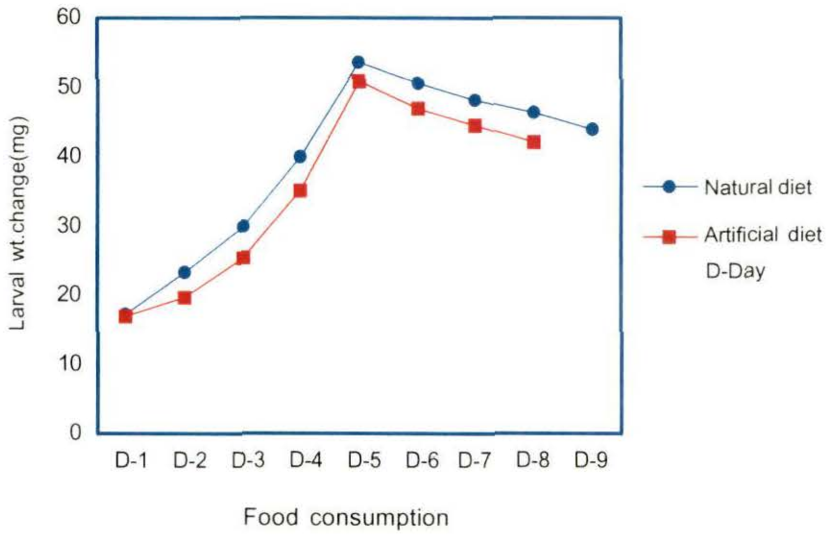


Fig.(a). IVth instar

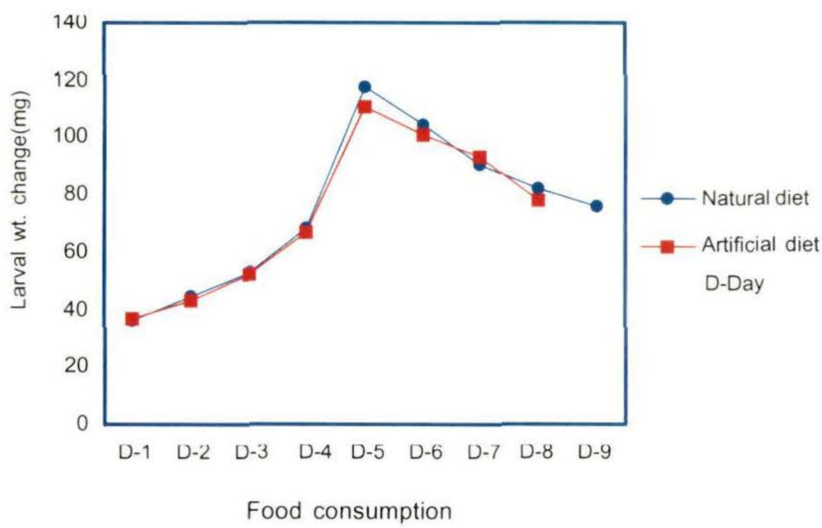


Fig.(a). Vth instar

Fig:17. Difference in Larval Dry wt. (mg) on Natural & Artificial Diets during Develpment at (a) IVth & (b) Vth instars of *Eterusia magnifica* recorded daywise.

Table 14 (a). Food Consumption and Larval Weight Change (Mean ± SE) per Day on Natural and Artificial Diets of IVth instar of *Eterusia magnifica*.

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Larval Weight	17.42 ± 0.939	23.42 ± 1.213	30.00 ± 1.527	40.00 ± 1.479	53.71 ± 1.613	50.57 ± 0.956	48.28 ± 1.273	46.28 ± 0.986	44.00 ± 1.410
Food Consumption	10.00 ± 1.000	20.00 ± 2.576	24.00 ± 1.185	30.60 ± 1.874	51.20 ± 1.860	26.30 ± 0.931	20.10 ± 1.026	15.30 ± 1.136	7.30 ± 0.980

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Larval Weight	16.94 ± 1.156	19.82 ± 1.117	25.11 ± 0.862	35.11 ± 1.773	50.97 ± 1.192	46.91 ± 1.966	44.60 ± 1.481	42.22 ± 1.985
Food Consumption	11.00 ± 0.795	14.40 ± 1.103	24.90 ± 0.932	38.10 ± 1.432	54.00 ± 0.949	27.00 ± 2.675	15.80 ± 2.079	9.10 ± 1.384

Table 14 (b). Food Consumption and Larval Weight Change (Mean ± SE) per Day on Natural and Artificial Diets of V^th^ instar of *Eterusia magnifica*.

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Larval Weight	36.28 ± 0.874	44.57 ± 0.795	53.05 ± 1.234	68.54 ± 1.030	117.48 ± 1.850	104.70 ± 1.390	90.30 ± 1.505	81.90 ± 0.737	76.20 ± 0.416
Food Consumption	15.00 ± 1.751	22.70 ± 2.002	36.10 ± 2.505	53.60 ± 2.789	90.60 ± 1.771	33.50 ± 2.012	25.50 ± 1.002	17.40 ± 1.765	10.60 ± 1.127

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Larval Weight	36.57 ± 0.481	42.85 ± 0.733	52.08 ± 0.727	67.14 ± 1.943	110.94 ± 2.400	100.70 ± 1.247	93.20 ± 1.402	77.90 ± 1.530
Food Consumption	18.00 ± 1.118	22.00 ± 1.920	34.00 ± 2.175	45.70 ± 2.118	71.90 ± 3.778	36.40 ± 4.546	25.30 ± 1.164	10.70 ± 1.390

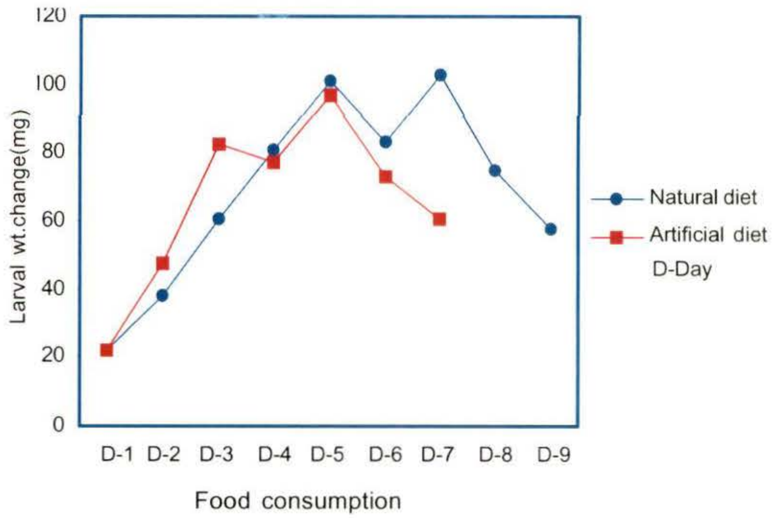


Fig.(a). V^th instar

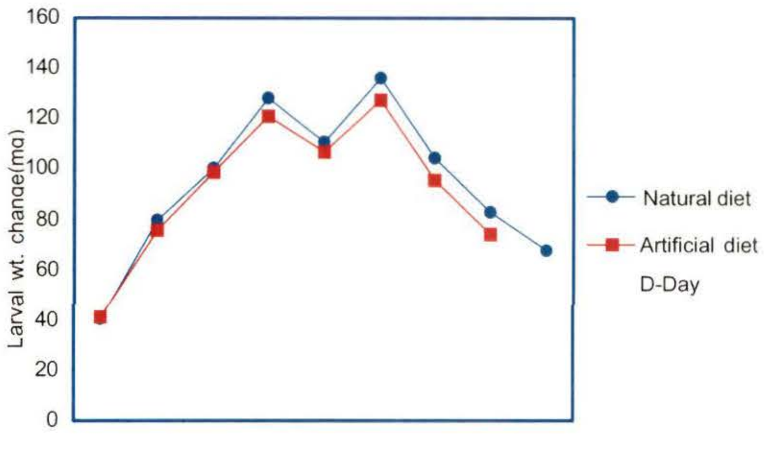


Fig.(b). VI^th instar

Fig:18. Difference in Larval Dry wt. (mg) on Natural & Artificial Diets during Development at (a) V^th & (b) VI^th instars of *Euproctis latisfascia* recorded daywise.

Table 15 (a). Food Consumption and Larval Weight Change (Mean ± SE) per Day on Natural and Artificial Diets of V^th^ Instar of *Euproctis latisfascia*

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Larval Weight	22.1 ± 0.348	38.8 ± 1.209	60.5 ± 1.621	80.6 ± 1.694	100.0 ± 3.504	83.1 ± 2.115	102.9 ± 1.708	74.9 ± 1.595	57.7 ± 0.789
Food Consumption	12.3 ± 0.879	22.4 ± 1.257	43.7 ± 1.350	65.6 ± 1.967	88.2 ± 4.718	69.2 ± 2.528	89.1 ± 2.818	48.7 ± 2.620	16.4 ± 1.076

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Larval Weight	21.9 ± 0.406	47.8 ± 2.559	82.8 ± 3.189	77.3 ± 4.297	96.8 ± 3.431	73.1 ± 2.071	60.5 ± 0.636
Food Consumption	14.8 ± 1.038	28.9 ± 2.002	41.5 ± 3.239	35.4 ± 4.177	48.5 ± 3.953	26.9 ± 1.822	13.9 ± 1.514

Table 15 (b). Food Consumption and Larval Weight Change (Mean ± SE) per Day on Natural and Artificial Diets of VIth Instar of *Euproctis latisfascia*

Natural Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
Larval Weight	40.8 ± 0.904	79.8 ± 2.772	100.3 ± 2.890	127.9 ± 2.262	110.4 ± 2.539	136.3 ± 2.662	104.6 ± 3.927	82.4 ± 2.463	67.8 ± 0.573
Food Consumption	25.6 ± 1.674	40.3 ± 2.944	56.4 ± 2.171	83.0 ± 2.236	68.9 ± 1.991	112.7 ± 3.467	74.9 ± 4.691	39.8 ± 2.153	18.8 ± 1.466

Artificial Diet

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
Larval Weight	41.33 ± 0.333	75.8 ± 1.466	98.7 ± 1.183	120.9 ± 2.349	106.7 ± 3.062	127.4 ± 1.557	95.6 ± 2.629	73.9 ± 1.873
Food Consumption	12.2 ± 1.028	28.4 ± 2.362	34.2 ± 1.919	50.3 ± 3.154	38.4 ± 2.828	67.2 ± 2.031	36.7 ± 1.825	10.9 ± 1.079

Pupal weight of *Buzura suppressaria* (for both male and female) was found to be significantly heavier on natural diet than on artificial diet. Such significantly heavier pupal weight on natural diet possibly resulted from a longer development period. Larvae reared on natural and artificial diets yielded about same number of males and females, the males showing no significant difference in weight when reared on the two different diets. Fecundity was also found to be close on both the diets. Eggs were laid in two or three batches per day for two or three days on both the diets (Table 16).

In a similar finding male and female pupae of *Et. magnifica* were significantly heavier on natural diet. The number of males and females emerging did not differ significantly on the two diets so also their longevity. However, a higher fecundity was noted on natural than on artificial diet. Similarly, eggs were laid in two or three batches per day for two or three days on both the diets (Table 17).

Performance of *E. latisfascia* was almost similar on both the diets, but in a departure from the above two species, the female pupae and adults were heavier when reared on artificial diet than on natural diet. Emergence ratio of male and female adults were slightly different on both the diets. Longevity of adults were similar when developing on both the diets. Fecundity was also not affected by the difference of diet. Eggs were laid in two to three batches per day for one or two days on both the diets (Table 18).

Feeding and development in the larval stage may also influence performance of the adult through effects on adult size, nutrient reserves and timing of oviposition (Barbosa et al., 1981; Moscardi et al.,1981a). A positive relationship between pupal or adult weight and fecundity in case of lepidopterans has been observed by Marshall (1990) and Kamata and Igarashi (1995).

In general female pupal weight was significantly higher than that of male on all diets. Feeding on artificial diet resulted in higher female pupal weight in *E. latisfascia* as had also been observed in *Diatraea saccharalis* Fab. by Parra and Mithsfeldt (1992) and in *Platynota idaeusalis* (Walker) by Oscar and Bruce (1997). Pupal weight may be regarded as index of larval food consumption (Rafes, 1967). Body weight of male was significantly lower than the weight of females. This may presumably be due to greater nutrient accumulation associated with egg production and which is achieved through the increase in consumption of the female larval form (Scriber and Slansky, 1981). Moreover, the type of food consumed by larvae has a significant influence on pupal weight, adult weight, fecundity and hatchability.

Feeding can have biologically significant costs. This is most likely to occur in those species in which energy stored by a caterpillar is critical for pupal survival and / or adult performance (Slansky, 1993). The lepidopteran species studied fall in the category where the adults are non feeding and the only source of nutrition and energy is through the feeding activity during their larval stages.

The higher pupal and adult female weight of *B. suppressaria* and *Et. magnifica* on natural diet establishes the natural diet as more suitable diet as compared to artificial diet used in the present study. Irrespective of the diet used for rearing, no significant difference was found in the weight of males in

Table 16. Reproductive Performance of *Buzura suppressaria* on Natural (tea leaf) and Artificial Diets (Mean ± SE).

Diet	Pupal Dry wt. (mg)		Adult Emergence		Longevity (days)		Adult Dry wt. (mg)		Fecundity
	Male	Female	Male	Female	Male	Female	Male	Female	
Natural Diet (Tv_{26})	33.000a ± 0.447	38.000a ± 0.730	25%	45%	5.167a ± 0.307	6.667a ± 0.333	23.333a ± 0.667	28.667a ± 0.667	422.500a ± 21.611
Artificial Diet	31.000b ± 0.719	34.000b ± 0.730	20%	30%	4.833a ± 0.401	6.167a ± 0.401	21.333a ± 1.430	26.332b ± 0.615	360.500a ± 23.086

Means followed by the same letter are not significantly different at 5% level.

Table 17. Reproductive Performance of *Eterusia magnifica* on Natural (tea leaf) and Artificial Diets (Mean ± SE).

Diet	Pupal Dry wt. (mg)		Adult Emergence		Longevity (days)		Adult Dry wt. (mg)		Fecundity
	Male	Female	Male	Female	Male	Female	Male	Female	
Natural Diet (Tv_{26})	54.167a ± 1.701	74.333a ± 1.308	30%	40%	5.500a ± 0.224	6.333a ± 0.211	23.833a ± 0.543	42.833a ± 4.308	643.500a ± 18.439
Artificial Diet	45.167b ± 0.833	51.833b ± 2.400	25%	25%	5.500a 0.245	6.667a 0.211	22.667a ± 0.615	26.167b ± 0.543	516.667b ± 13.480

Means followed by the same letter are not significantly different at 5% level.

Table 18. Reproductive Performance of *Euproctis latisfascia* on Natural (tea leaf) and Artificial Diets (Mean ± SE).

Diet	Pupal Dry wt. (mg)		Adult Emergence		Longevity (days)		Adult Dry wt. (mg)		Fecundity
	Male	Female	Male	Female	Male	Female	Male	Female	
Natural Diet (Tv_{18})	24.303a ± 0.615	31.833a ± 0.615	30%	35%	3.833a ± 0.307	4.667a ± 0.374	20.000a ± 1.555	26.167a ± 0.543	248.833a ± 7.485
Artificial Diet	25.667a ± 0.955	33.667a ± 0.615	25%	25%	3.833a ± 0.401	4.833a ± 0.374	22.333a ± 0.955	29.333b ± 0.843	230.333a ± 9.160

Means followed by the same letter are not significantly different at 5% level.

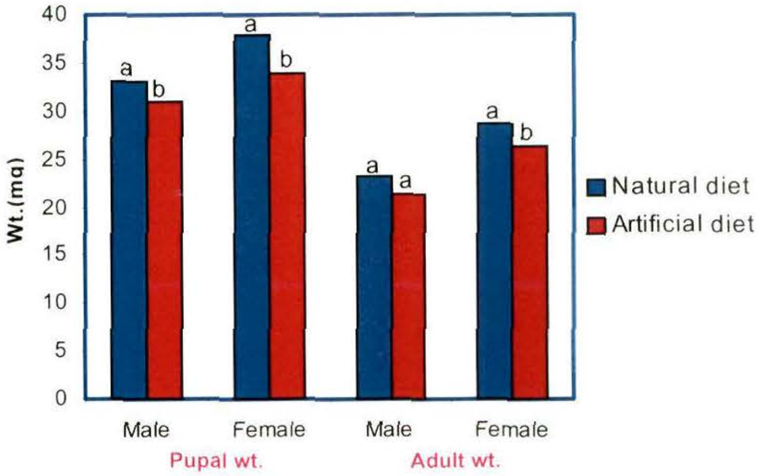


Fig.(a). ***Buzura suppressaria***

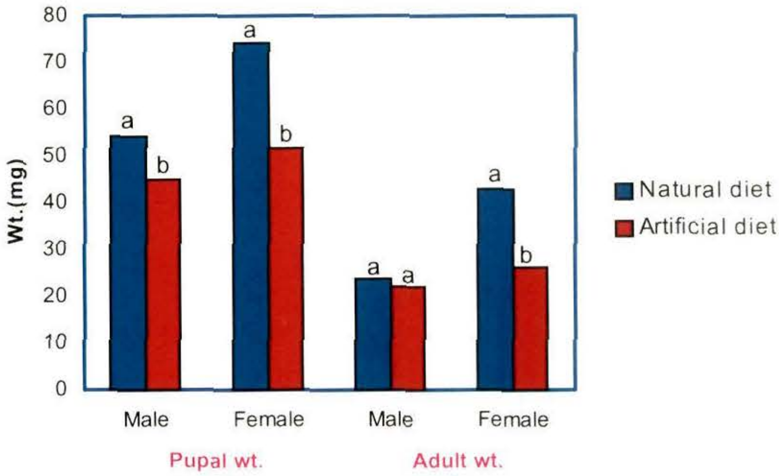


Fig.(b).***Eterusia magnifica***

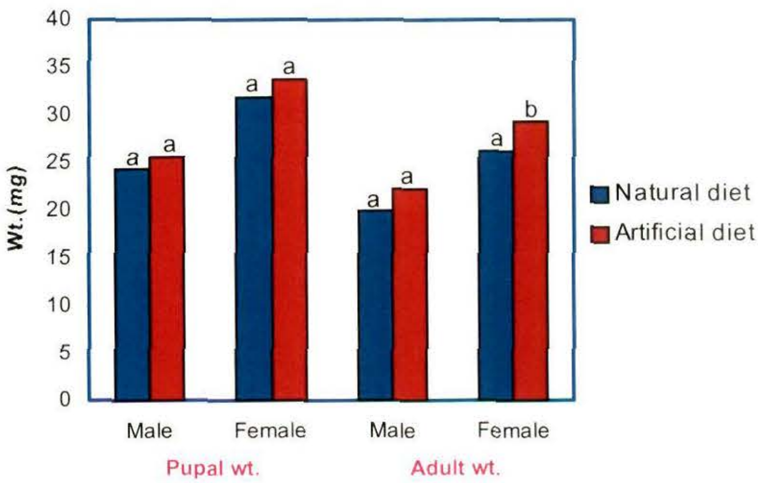


Fig.(c). ***Euproctis latisfascia***

Figs.19. Comparison of Dry weights of various stages of : (a) *B. suppressaria*, (b) *Et.magnifica* and (c) *E.latisfascia* on Natural (Tea leaf) & Artificial Diets.

B. suppressaria, Et, magnifica and *E. lastifascia* which indicates the adequacy of the artificial diets as far as male nutritional requirements are concerned. Longevity of adults (both sexes) were similar on both the diets in all three folivores. Number of eggs laid were also more or less similar on both the diets in *B. suppressaria* and *E. latisfascia* but as an exception to this, fecundity of *Et. magnifica* was higher on natural diet. Fecundity of females is highly correlated with both pupal and adult weight (Roland and Myers, 1987; Tammaru, 1997) and is dependent on the quality of the host plant. However, similarity in male adult weight, longevity of male and female adults and fecundity on both the diets indicated the suitability of the artificial diet (Fig. 19).

5. 8. Dry mass budget

5. 8. 1. Relative Consumption Rate (RCR) & Relative Growth Rate (RGR)

Quantity of food consumed / ingested is influenced by a number of exogenous and endogenous factors. Among the host of factors (eg. nitrogen, water and energy content) food quality is an important one that affects consumption (Muthukrishman and Pandian, 1987). In the present study food utilization efficiencies are discussed on the basis of quality of food consumed by these three lepidopteran tea pests.

Buzura suppressaria showed considerable changes of the quantity of food ingested, faecal matter egested and changes in body mass during development of fourth and fifth instars. This was found true both on natural and artificial diets. In fourth and fifth instars the Relative Consumption Rate (RCR) was found to be higher on artificial diet as compared to that on natural (leaf) diet. However, Relative Growth Rate (RGR) showed variation, it being higher on natural diet in the fourth and just the reverse in the fifth i.e. higher on artificial diet (Table 19).

In *Eterusia magnifica* there was a general trend of decrease in RCR and RGR in last two instars on both the diets. In fourth instar the RCR values was significantly greater on natural diet when compared to that on artificial diet, although it was similar in the fifth instar. Interestingly, a greater RGR was recorded in fifth instar than that on fourth instar on artificial diet (Table 20).

The RCR in *Euproctis latisfascia* was higher on natural diet than that on artificial diet. It however, showed the decreasing trend in the subsequent stages (V^{th} to VI^{th}) on both the diets and was found to be significantly lower in the sixth instar than that recorded in the fifth instar. RGR also showed a decrease of its values from fifth to sixth instar (Table 21). Similar findings have been reported by Chaterjee and Chaudhuri (1989) for *Diacrisia casignetum* Kollar (Lepidopter: Arctiidae) on different host plants.

Many factors affect a herbivores feeding rate which include not only environmental conditions but also attributes of food (especially its allelochemical and nutrient contents) and the conditions of the animal (eg. age, size, sex, reproductive state and activity level) (Slansky, 1992).

Relative consumption rate (RCR) may change both within and between instars presumably reflecting physiological changes during development. Late instars tend to have lower RCR values than earlier ones (Slansky and Scriber, 1985; Mohanty and Mitra 1991; Atluri et al., 2002) but only a few species have been studied and these must be interpreted with caution. The finding in the present study on *B. suppressaria, Et. magnifica* and *E. latisfascia* on both natural and artificial diets corroborated the above observation i.e. reduction in RCR values with advancement of instars. Similar results had also been reported by Bailey and Tara (1988) for *Diacrisia obliqua* Walk. on mulberry leaves and Bora and Dutta (1996) for *Nacoleia vulgaris* Guen.. A reduction in consumption rate may also be due to enhanced utilization of the energy required for development of body structure and spinning activity in the final instar larva (Muthukrishnan and Pandian, 1987).

The RCR value of *E. latisfascia* was recorded to be higher than the other two folivorous species (*B. suppressaria* and *Et. magnifica*). Such a difference may be accounted for by leaf quality. Tv_{18} which was the preferred host was provided as natural diet to *E. lastisfascia*. This variety as compared to Tv_{26} is known to have more amount of non-digestible component (Bhuniaya, 1999) and less amount of moisture which possibly reduced the available nutrients, thus forcing *E. latisfascia* to eat more than the other two folivores in question.

Leaves of different plants / varieties differ in their suitability as insect food because of variations in nutrient content, water content, type and concentration of secondary plant compounds and degree of sclerophyll (toughness / fibre) (Gullan and Cranston, 1994). It has also been observed that an increase in leaf toughness (Fenny, 1968, 70 ; Hunter and Lechowicz, 1992) and lowering of water content of foliage (Scriber and Slansky, 1981 ; Martin and Van't Hof, 1988) decreased the leaf quality resulting into a higher feeding rate or RCR (Farrar et al., 1989 ; Lindroth et al., 1997) but a lowering of RGR value was observed in the present case of *E. latisfascia*. This situation may be compared with the nutritional indices of the other two folivores feeding on a nutritionally richer variety, Tv_{26} and showing higher RGR values.

The two folivores, *B. suppressaria* and *Et. magnifica* that fed on the preferred host variety, Tv_{26} showed a tendency to attack two different quality of leaves. While *B. suppressaria* consumed younger leaves of upper tier, the other folivore, *Et. magnifica* preferably fed more on mature leaves of middle tier of a tea bush (Fig. 3). The nutritional performance (RCR and RGR values) of *B. suppressaria* was in general, higher than that of *Et. magnifica* both in fourth and fifth instars. A better consumption and growth rate of *B. suppresssaria* may be due to consumption of leaves of higher nutritional quality, in which the percentage of nitrogen and moisture is more than the leaves (mature) consumed by *Et. magnifica* (Table 22, 23). In a similar finding Scriber and Fenny (1979) showed that Swallow tails had a higher consumption rate on nitrogen and moisture rich forbs than when feeding on tree foliage having relatively less values of nitrogen and moisture.

As the growth rate is related to approximate digestibility (AD) and assimilation, an enhanced RGR value for *B. suppressaria* is matched here with a higher AD. A higher AD and assimilation are known to be influenced by quality, specially of nitrogen, water and toxin contents of the plant food (Muthukrishnan and Pandian, 1987). The role of moisture content (eg. Tabashnik, 1982) and nitrogen content (Fox and Macauley, 1977; Slansky and Fenny, 1977) is significant in regulating insect growth rate.

Further, Panda and Khush (1995) found that total organic nitrogen (N), water content and allelochemicals of plant species exerted a strong influence on the 'bioavailability' of nutrients to phytophagous insects.

Food quality can be compared by measuring the body weight gained by insect. This parameter is an indication of the amount of food converted into body biomass. Foods on which insects gain greater body weight are always classified as a better source of energy (Ananthakrishnan, 1992). In the present study, the RGR values were higher for *B. suppressaria* and *Et. magnifica* on artificial diets clearly indicating a better adaptation of these folivores to artificial diets at the advanced stages.

In *E. latisfascia* a comparatively higher RGR values of both the stages on artificial diet proved artificial to be superior to the natural diet (Tv_{18}). Though, comparatively RCR was lower in all the three folivores on artificial diet but a higher RGR indicated nutritional adequacy of the artificial diet. It is known that Relative growth rate of herbivorous insects is assumed to be nutrient-limited (Wiegert and Petersen, 1983) and dietary factors such as nitrogen, water, minerals and toxin contents of the food significantly influence the overall growth rate through feeding rate (Larsson and Tenow, 1979; Mattson, 1980). So a higher relative growth rate is an indication of higher utilization of ingested food for growth.

5. 8. 2 . Approximate Digestibility (AD), Efficiency of Ingested Food (ECI) & Efficiency of Digested Food (ECD).

Food quality, water and toxin contents of plant food of herbivores, are some of the factors responsible for influencing assimilation efficiency (Muthukrishnan and Pandian (1987).

A comparative study on approximate digestibility (AD) on natural (leaf) diet showed it to be highest for *B. suppressaria* followed by that on *Et. magnifica* and then *E. latisfascia*. The value of approximate digestibility and efficiencies of food conversion, are generally higher among the larvae feeding on foliage having high nitrogen content (Barbosa and Greenblatt, 1979). Higher AD recorded for *B. suppressaria* which preferred nitrogen rich food with high percentage of water confirms the above finding. However, on artificial diet, the AD value of *Et. magnifica* was found to be the lowest in last two instars in reference to the values of the other two species. Increase in approximate digestibility may be compensating for reduced consumption of artificial diet in order to maintain good growth (Slansky and Scriber, 1985). This relation of AD and RCR values was found to hold good both in the fifth and sixth instars of *E. latisfascia*. But in the other two species this relationship was observed to be variable.

In all the three species efficiencies of conversion of ingested (ECI) and digested food (ECD), in general, were higher for those on artificial diet than the ones on natural diet. The only exception was the fourth instar of *B. suppressaria*. Further, a comparison of ECD values of the three species showed that *B. suppressaria* and *E. latisfascia* had lower values as compared to that of

Et. magnifica on both the diets, indicating a low efficiency of conversion of digested food to body tissues in the former two species. Such low values of ECD are not unusual (Waldbauer, 1968) (Table 19, 20 & 21).

A reduction in ECD associated with allelochemical ingestion is a common (although not universal) occurrence (Koul et al., 1990; Apple and Martin, 1992), which is evident in the two species, *B. suppressaria* and *E. latisfascia* when feeding on natural diet than on artificial one. This may be due to the direct interference of the allelochemical of the natural diet with some metabolic processes of caterpillars (Slansky, 1992) resulting in slowing of growth and due to diversion of a large part of the absorbed food to respiration (Apple and Martin, 1992).

The ECD values in the last two instars (IV^{th} to V^{th} of *B suppressaria* and *Et.magnifica* & V^{th} to VI^{th} of *E. latisfascia*) showed a general reduction on natural as well as artificial diets (demonstrating some exceptions in the case of *B. suppressarria* on artificial diet, where it showed an enhancement from fourth to fifth instar) (Table 19). Such exceptions have also been reported by Mukerji and Guppy (1970) and Bailey (1976), wherein increase in ECD during larval development was found to be inconsistent. The decline in ECD and ECI may be due to internal changes and extra expenditure of energy prior to pupation as explained by Soo Hoo and Fraenkel (1966) for the last instar larva of the tree feeder southern armyworm, *Prodenia evidamia*.

Amongst the three lepidopteran tea pests ECI was found to be lowest for *E.latisfascia* on natural diet which may be due to low water in the food which has a strong effect in the ECI of insects as inferred by Panda and Khush (1995). Low dietary water impairing the conversion efficiencies have also been reported in several lepidopteran larvae (Scriber, 1977; Martin and Van't hof, 1988 ; Deb et al. 2000).

5. 8. 3. Maintenance Cost and Production index.

In all the three folivores, in general, the assimilation (As) and production (P) values on natural diet by far exceeded the ones on artificial diet (with an exception of *E. latisfascia*) however, the cost of maintenance (R / P) was found higher on natural diet except for *B. suppressaria* in its fifth larval stage. In all the three species (in last two instars), *B. suppressaria, Et. magnifica and E. latisfascia,* the assimilation values on natural diets were 85, 127 ; 84.33, 129; 143, 167 mg., similarly, values on artificial diets were 78.86,114; 67.13, 112.8; 102.93,143.20 mg. respectively. The production values on natural diets were 22.20, 31.46; 26.64, 40.27; 35, 27.73 mg. and values on artificial diets were 17.00, 28.46; 26.01, 41.27; 37.8, 36.06 mg. respectively.

The dry mass budget of *Et. magnifica* indicated almost similar values of assimilation and production on both the diets. The higher maintenance cost on natural diet compared to artificial diet may be an indication that the utilization of the former is combined with expenditure of energy. Judging by the lower maintenance cost on artificial diet the same can be a good supporting diet for rearing *Et. magnifica* (Table 20). The facts that a higher nutritional quality involves lower maintenance cost has also been substantiated by the work of Karowe and Martin (1989).

Table 19. Comparison of Nutritional Indices of *Buzura suppressaria* (IVth and Vth instars) on Natural (tea leaf) and Artificial Diets (Mean ± SE).

IVth instar:

	RCR	RGR	ECI	ECD	AD	Main.cost	Prod.index
Natural diet	0.871a ± 0.013	0.110a ± 0.173	12.602a ± 0.518	25.799a ± 0.834	48.709a ± 0.725	2.948a ± 0.164	0.257a ± 0.008
Artificial diet	0.933b ± 0.011	0.093b ± 0.007	10.034b ± 0.178	21.810b ± 0.394	46.650b ± 0.520	3.664b ± 0.076	0.215b ± 0.004

Vth instar:

	RCR	RGR	ECI	ECD	AD	Main.cost	Prod.index
Natural diet	0.630a ± 0.008	0.078a ± 0.002	12.355a ± 0.246	24.761a ± 0.453	49.904a ± 0.441	3.056a ± 0.070	0.247a ± 0.005
Artificial diet	0.680b ± 0.006	0.089b ± 0.002	13.162a ± 0.373	24.996a ± 0.602	52.809b ± 0.579	3.047b ± 0.095	0.249a ± 0.006

Means followed by the same letter are not significantly different at 5% level.

Table 20. Comparison of Nutritional Indices of *Eterusia magnifica* (IVth and Vth instars) on Natural (tea leaf) and Artificial Diets (Mean ± SE).

IVth instar:

	RCR	RGR	ECI	ECD	AD	Main.cost	Prod.index
Natural diet	0.718a ± 0.009	0.098a ± 0.002	13.611a ± 0.210	31.724a ± 0.802	43.092a ± 0.606	2.177a ± 0.080	0.317a ± 0.008
Artificial diet	0.688b ± 0.011	0.097a ± 0.001	14.223a ± 0.258	38.957b ± 0.862	36.814b ± 1.030	1.579b ± 0.051	0.389b ± 0.008

Vth instar:

	RCR	RGR	ECI	ECD	AD	Main. cost	Prod.Index
Natural diet	0.574a ± 0.004	0.080a ± 0.001	13.879a ± 0.212	31.241a ± 0.509	44.453a ± 0.243	2.212a ± 0.051	0.312a ± 0.005
Artificial diet	0.585a ± 0.009	0.090b ± 0.002	15.509b ± 0.500	36.648b ± 1.066	42.326b ± 0.668	1.759b ± 0.076	0.366b ± 0.010

Means followed by the same letter are not significantly different at 5% level.

Table 21. Comparison of Nutritional Indices of *Euproctis latisfascia* (V^{th} and VI^{th} instars) on Natural (tea leaf) and Artificial Diets (Mean ± SE).

V^{th} instar:

	RCR	RGR	ECI	ECD	AD	Main.cost	Prod.index
Natural diet	1.244a ± 0.013	0.098a ± 0.002	7.860a ± 0.142	24.506a ± 0.627	32.303a ± 0.369	3.111a ± 0.099	0.245a ± 0.005
Artificial diet	0.681b ± 0.010	0.132b ± 0.002	19.417b ± 0.335	36.799b ± 0.733	52.843b ± 0.578	1.728b ± 0.051	0.367b ± 0.007

VI^{th} instar:

	RCR	RGR	ECI	ECD	AD	Main.cost	Prod.index
Natural diet	0.885a ± 0.083	0.056a ± 0.002	5.637a ± 0.216	16.486a ± 0.572	34.084a ± 0.624	5.136a ± 0.200	0.165a ± 0.005
Artificial diet	0.616b ± 0.105	0.076b ± 0.000	12.451b ± 0.191	25.224b ± 0.315	49.340b ± 0.320	2.971b ± 0.050	0.251b ± 0.002

Means followed by the same letter are not significantly different at 5% level.

(a)

(b)

(c)

Plate 6. Rearing of Adults .
(a). *Buzura suppressaria* ;
(b). *Eterusia magnifica* ; and
(c). *Euproctis latisfascia*.

(a)

(b)

(c)

Plate 7. Rearing on Artificial Diet.
(a) *Buzura suppressaria* ;
(b) *Eterusia magnifica* ; and
(c) *Euproctis latisfascia* .

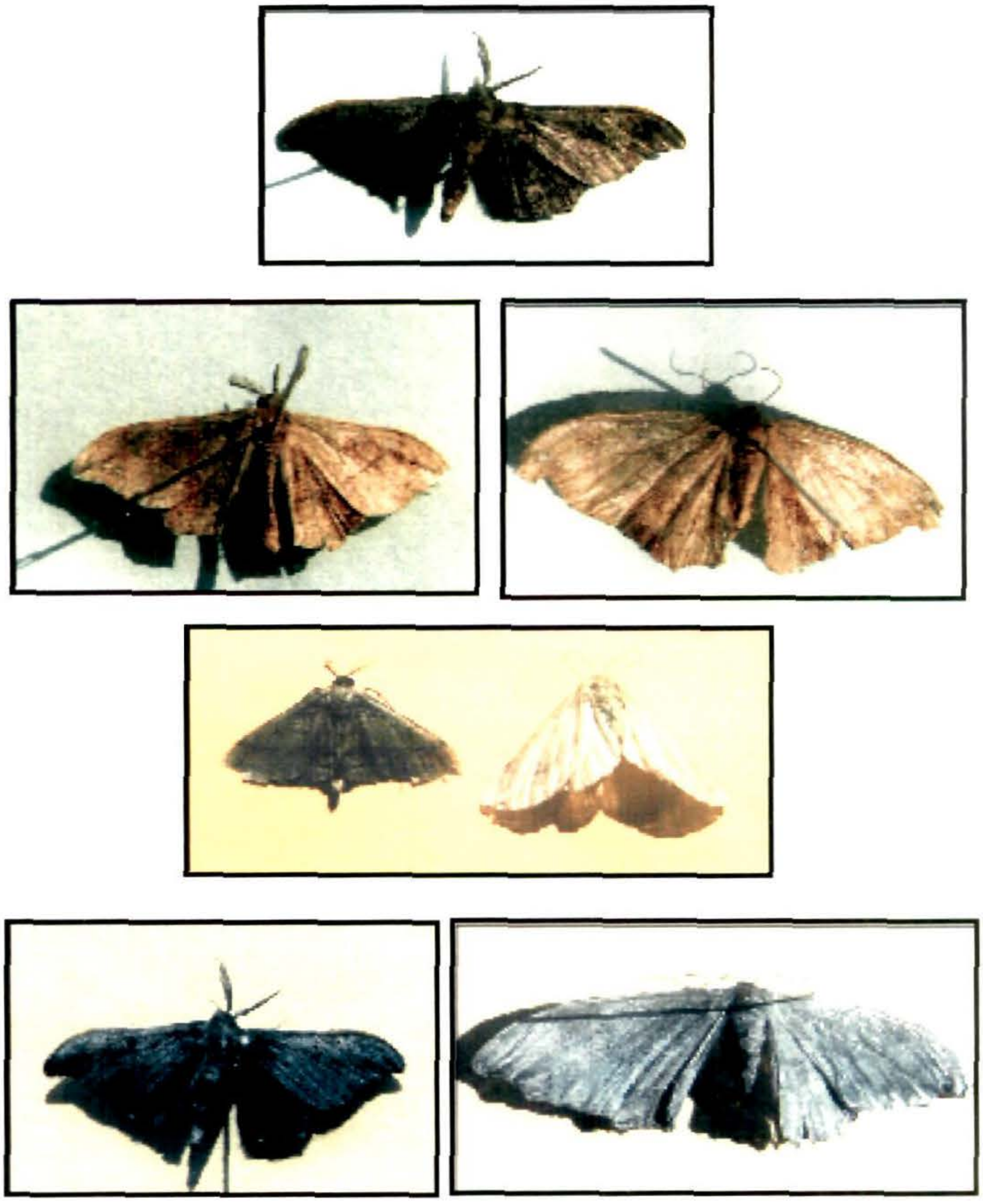


Plate 8. Melanism in Adults of *Buzura suppressaria*.

The increase in food consumption which enhanced the cost of maintenance of *E. latisfascia* on natural diet, may be due to its food quality (Table 21). Higher expenditure of energy may result from higher quantity of consumption through a longer time (Slansky, 1992, 1993). In *E. latisfascia* presumably most part of the ingested food has been utilized in basal metabolism, resulting in low conversion for growth. Mukerji and Guppy (1970) observed a similar phenomenon in the lepidoptera, *Pseudaletia unipuncta* (Haw.). The suboptimal availability of nutrient often nitrogen or water reduces growth rate, increases maintenance costs and causes a lower metabolic efficiency (Shoonhoven et al., 1998).

In the last two stages of all the three species in question, production index was found to be higher on artificial diet than on natural diet except for the fourth instar of *B. suppressaria* (Table 19). The higher production index can be considered as an indicator of better suitability of the artificial diet in supporting the advanced life stages of all the three species. Based on these findings, the artificial diets can be considered as an alternative food for supporting partial or complete rearing of the three lepidopteran pests of tea in concern.

5. 9. Biochemical analysis

In an estimation done for the three lepidopteran tea pests, *Buzura suppressaria, Eterusia magnifica* and *Euproctis latisfascia* with regard to their biochemical profile specially basic nutrients along with moisture and ash content, clear reflections of the plant nutrients and the corresponding body mass chemistry of the larvae were evident.

5. 9. 1. Nitrogen

The analysis also gives us an insight into the efficiency by which the nutritional components present in the natural and artificial food have been utilized by the above lepidopteran larvae to support their development and activity. Since we know herbivores are likely to be nitrogen limited, seeking to concentrate it as rapidly as possible (McNeil and Southwood , 1978; Slansky & Scriber, 1985), the present data (Table 22, 23, 24) on nitrogen shows that a conversion from natural / artificial diet to body mass of the larva may take place in the proportion of 2 - 4 times, while from the natural diet the concentration of nitrogen in the final instar of the above species are in the proportion of 2.60, 2.68 and 2.35, whereas the proportion of conversion was much higher from artificial diet which were in the range of 3.15, 3.13 and 3.82 for *B. suppresssaria, Et. magnifica* and *E. latisfascia* respectively (Figs. 20, 21, 22). Such increase in the proportion of nitrogen has been documented by Muthukrishnan and Pandian (1987).

It is not a surprise that a conversion of the nitrogen present in tea leaves (natural diet) to the nitrogen of the larval body mass is at a reduced proportion as compared to that on the artificial diet. Phenolic compounds are ubiquitous in plants. Many colourless representatives of these groups are often considered significant as insect toxicants. Besides this, the phenolic compounds like tannins that are found in fair proportion in the tea leaves bind to almost all soluble proteins, producing insoluble polymers. Enzymes complexed in this way show a marked reduction in activity. Also proteins bound to tannins cannot be degraded by enzymes in the digestive tract and tannins are therefore generally thought to decrease the nutritional value of plant tissues (Shoonhoven et al., 1998).

Hence, it can be inferred that artificial diet, despite having a lower nitrogen content than tea leaves has a higher proportion of conversion to the larval body mass due to the absence of any such polyphenolic compound interfering with the available nitrogen in the diet (Fig. 20, 21 & 22).

5. 9. 2. Lipid

An analysis of the lipid content of the natural and artificial diets alongwith larval body mass of the three lepidopteran species showed that there is an increase in the conversion of the quantum of lipid ranging from about 2 - 7 times. Such higher proportion of conversion of lipid suggests that the lipid was selectively accumulated by the artificial diet reared larvae, which was also found true in *Anticarsia gemmatalis* and *Heliothis virescens* (F) by (Cookman et al., 1983 ; Dikeman et al. (1981) mediated through fatty acids. The enrichment of the proportion of lipid in the body mass apparently is necessary for maintenance of certain physiological processes like the ecdysis, specially that of pupa as has been established in several lepidopterans like *Ephestia, Spodoptera littoralis* (Levinson and Navon, 1969). Hence a high proportion, ranging from 14.32 to 19.7 %, of lipid in the body mass of the three lepidopterans was found to be present. This was always found to be, in most cases, several times higher than the percentage in which they occur in the diets (Table 22, 23, 24).

Carbohydrate

Carbohydrates are the common source of energy and although not always essential, are usually necessary for normal growth (Berlinger, 1992). In the three species the percentage of carbohydrate found in the larval body mass (5 to 6%) were lower than that found in their diets (both natural and artificial) which has been reported in the tune of 30 % in natural diet (Mulky, 1993) and found to be in the tune of 12 to 16 % as evident from the formulation of the artificial diets (Table I & Table II). This phenomenon appears to be a general rule for insects (Clercq, 1993). A plausible explanation for this may be the interference of the allelochemicals specially polyphenols and tannins that are present in the leaves influencing the uptake of carbohydrate. Such an interpretation has also been furnished by Schoonhoven et al., (1998) where cross finding of tannins with polysaccharides and the consequent lowering of their physiological function and nutritional value has been hypothesized.

5. 9. 3. Moisture

Water is the cradle of life. Amount of water in the food of lepidopterous larvae provides a surprisingly useful index of its nutritional value and thus growth performance. Significantly better growth occurred on plants with higher water content. The relevance of dietary water was confirmed in experiments with artificial diets varying in water content (Scriber, 1984). The percentage of moisture present both in natural (leaf) and the artificial diets offered to the lepidopteran species in question were quite high ranging between 50 - 70 %, while it is reported that the water content in the foliage usually varies between

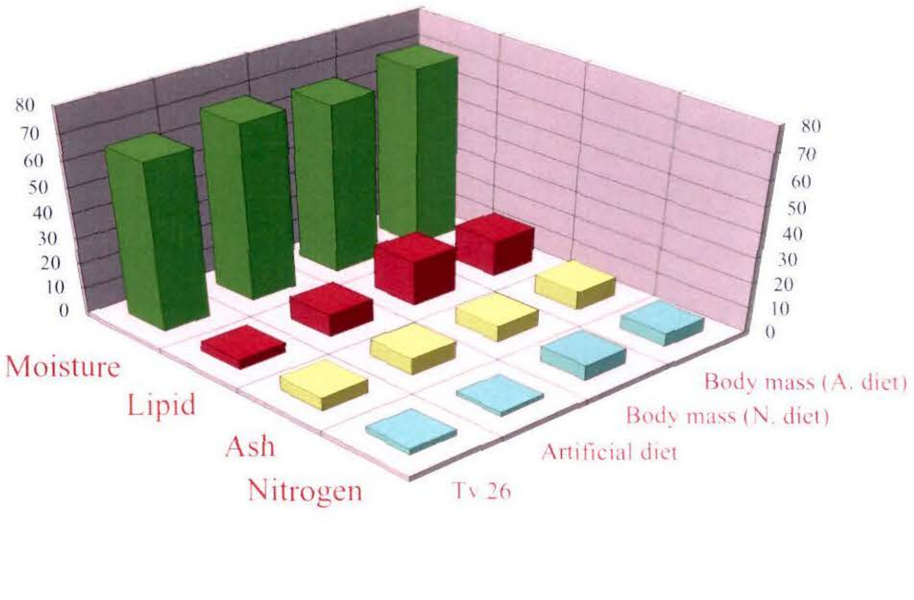


Fig. 20. Comparison of Biochemical components present (Mean Dry wt. % Value) in Natural & Artificial Diets and Larval Body Mass of *B. Suppressaria* and Moisture (Mean Fresh wt. %)

Table 22. Comparison of Biochemical Components present (Mean Dry wt. % value) in : Natural (tea leaf) and Artificial Diets and Larval Body mass of *Buzura suppressaria* and Moisture (Mean Fresh wt. % value).

B.suppressaria	Tv_{26}	Artificial diet	Body mass (Natural diet)	Body mass (Artificial diet)
Nitrogen	2.281	1.650	5.954	5.199
Lipid	3.880	8.880	17.960	14.380
Ash	5.350	6.780	6.420	7.480
Moisture	66.20	70.000	66.980	70.795

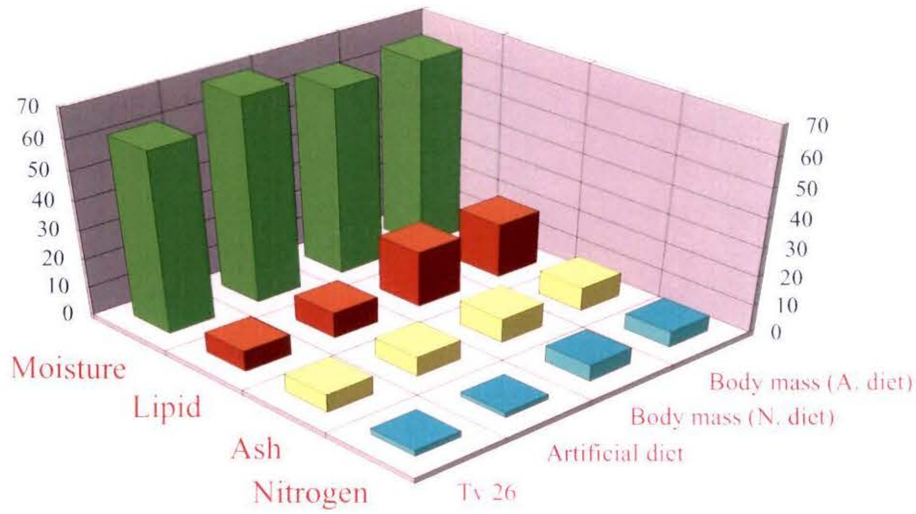


Fig. 21. Comparison of Biochemical components present (Mean Dry wt. % Value) in Natural & Artificial Diets and Larval Body Mass of *Et. magnifica* and Moisture (Mean Fresh wt. %)

Table 23. Comparison of Biochemical Components present (Mean Dry wt. % value) in : Natural (tea leaf) and Artificial Diets and Larval Body mass of *Eterusia magnifica* and Moisture (Mean Fresh wt. % value).

Et. magnifica	Tv_{26}	Artificial diet	Body mass (Natural diet)	Body mass (Artificial diet)
Nitrogen	2.111	1.650	5.642	5.471
Lipid	7.050	8.880	19.550	18.950
Ash	6.300	6.780	8.430	8.250
Moisture	62.000	70.000	64.177	65.249

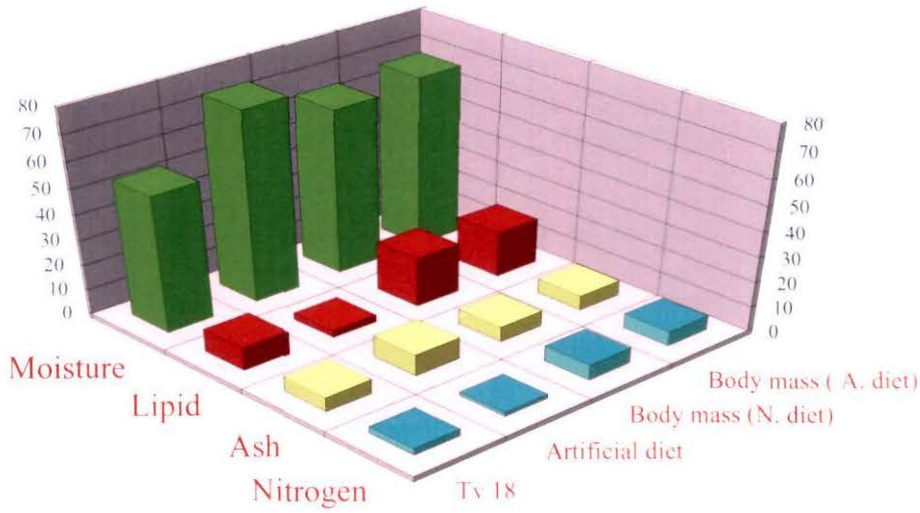


Fig. 22. Comparison of Biochemical components present (Mean Dry wt. % Value) in Natural & Artificial Diets and Larval Body Mass of *E.latisfascia* and Moisture (Mean Fresh wt. %)

Table 24. Comparison of Biochemical Components present (Mean Dry wt. % value) in: Natural (tea leaf) and Artificial Diets and Larval Body mass of *Euproctis latisfascia* and Moisture (Mean Fresh wt. % value).

E. latisfascia	Tv_{26}	Artificial diet	Body mass (Natural diet)	Body mass (Artificial diet)
Nitrogen	2.607	1.537	6.142	5.823
Lipid	9.030	2.680	19.700	18.040
Ash	5.820	8.560	6.130	5.830
Moisture	54.060	75.000	65.244	67.877

45 - 95 % of the fresh weight (Shoonhoven et al., 1998). So, the presence of adequate moisture had a definite influence on the nutritional value and vis-à-vis of the performance of the three concerned lepidopteran species.

In an experiment with 16 species, when fed upon exercised leaves without water supplementation via petioles, their relative growth rates (RGR) showed reduction upto 40 % even when the food did not show any indication of desiccation. Such effects were more pronounced on tree leaf feeders (Shoonhoven et al., 1998). In the present study, RGR values of the penultimate larval instars were found to be at par (with an exception of *E. latisfascia*) on both the diets which indicates that the moisture provided through their diets had been adequate in supporting their development and growth activity. (Table 22, 23, 24 & Fig. 20, 21, 22).

(a)

(b)

(c)

(d)

(e)

Plate 9. Various studies on feeding.

(a) Host Preference with Leaf Discs ;
(b) Darjeeling Black Hairy Caterpillar feeding on Tea Leaf ;
(c) Red Slug Caterpillar feeding on Epidermal Surface of Tea Leaf ;
(d) Skeletonised Tea Leaf ; and
(e) Rearing on Artificial Diet.