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NUMBER OF FEEDS AND SOME PHYSIOLOGICAL ASPECTS IN THE SILKWORM *BOMBYX MORI* L.

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ABSTRACT

When the number of feeds was restricted from eight to one per day, *Bombyx mori* L. prolonged its larval duration. However, the pupal duration showed slight negative relation with the larval duration. These supplied one feed/day suffered heavy mortality. Increasing number of feeding enhanced the larval weight, the rates of assimilation, metabolism and conversion. It also produced elevated values in weight, length and diameter of coconuts. Restriction of feed number resulted in reduced fecundity.

INTRODUCTION

Adverse effects of restrictions of feeding (duration and/or ration level) on Lepidoptorans have been reported by several authors (Mathavan and Muthukrishnan, 1976; Muthukrishman *et al*., 1978; Pandian *et al*., 1978; Evangelista and Takahashi, 2000) and most of them accumulated data on bioenergetics and neglected aspects with regard to reproduction. The fact that the number of eggs produced depends upon the amount of ingested food has been demonstrated by a few authors in Lepidoptrans (Eid and Salaem, 1977,b,c; Eid *et al*., 1989), in heteropterans (Khalifa, 1952; Slansky, 1980), hemiptrans (Friend *et al*., 1965). Such studies are still limited and the present study examines larval nutrition and autogeny in silkworm *B. mori*.

MATERIALS AND METHODS

Fresh egg of *B. mori* were brought from a local sericulture laboratory (Ministry of Agric.), which are acclimated to laboratory conditions. After hatching, the first instar larvae were collectively raised on mulberry leaves. One week later, the larvae were weighed individually and then grouped by five replicates each containing five series, each containing 100 larvae. Five series of feeding experiments were commenced with the five groups; 1,2,4,6 and 8 times/day old uneated leaves were removed before each fresh feeding.

Faecal pellets from the different groups were separately collected daily and dried to constant weight at 80^{o}C. From the mean dry weight of faeces egested/larva/day, food consumption/larva/day in the different groups was calculated following the methods suggested by Mathavan *et al.,* (1987) and Haniffa *et al*., (1982). The scheme of energy budget followed here is the modified formula: C=P + F + Cl, where: C= food energy consumed- P: the growth - R: the lost energy in metabolism, F: undigested food and U: the nitrogenous end products.

The final dry weight of larvae minus the respective initial dry weight gave the amount of dry food converted. Rats of feeding, assimilation and conversion were calculated according to Waldbauer (1968). Cocoons were weighed; length and diameter were measured. After emergence males and females of different groups were allowed to mate in different combination for an optimum mating duration of 6 hours (Haniffa *et al*., 1982; Thomas *et al*., 1986). Number of eggs per female were recorded. Preoviposition and post-oviposition periods were recorded.

RESULTS AND DISCUSSION

Mortality was considerably reduced with increase of feeds from 57 to 5% for larvae and from 43 to 2% for pupae (Table 1). With the increase of feeds, a decrease in larval period was recorded in all instars. For instance the second instar duration was 96 hrs for *B. mori* received 1 feed/day and it decreased to 71 hrs. for these supplied 8 feeds/day.

Table 1: Effect of feed number on mortality and averageduration of larvae and pupae of *B. mori*.

Fee/day	Mortality %		Instar duration hr.					Pupal duration hr.
	Larvae	Pupae	2nd	3rd	4th	5th	Total	
1	57	43	96	183	201	183	663	-
2	43	11	90	165	189	173	637	216
4	12	11	83	139	151	161	534	230
6	8	7	78	122	136	143	479	243
8	5	2	71	118	127	121	437	246

*** Each value represents average of 5 replicates each 5 series and each 100 individual.**

The corresponding decreases in the 3rd, 4th , 5th instars and total larval duration were from 183 to 118, 201 to 127, 183 to 121 and 663 to 437 hours, respectively (Table 1). The pupal duration showed slight negative relation with the larval duration it increased from 216 to 246 hrs for these fed 2 to 8 feeds per day. Mathavan and Muthukrishman (1976); Mathavan *et al*., (1987); Asherkar *et al*. (1991) and Mishra and Upadhyay (1996), too, reported extension of larval period but with a constant pupal period in the silkworm *B. mori* as a function of feed number.

Table II reports the energy budget of *B. mori* as a function of feed number. Increase in feeds enhanced the rates of feeding (174 to 299 mg/g/day), assimilation (98.3 to 147.6 mg/g/day) conversion (18.7 to 36.6 mg/g/day) metabolism (81.2 to 97.2 mg/g/day) and conversion efficiency (16.2 to 20.8%). It also produced elevated values in weight (560.0 to 2449 mg.),length (2.1 to 3.8 cm)and diameter(1.1 to 1.9 cm. of cocoons (Table III).

Table (III) shows the fresh weight of a larvae as a function of feeds. Individuals supplied 8 feeds/day increased from a mean initial weight of 560 mg to 2249.0 mg. at the end of the larval period, whereas these supplied 4, 6, 2 and 1 feed/day attained 2049, 1476, 1159 and 750 mg., respectively. Samson *et al*., (1990) reported the effect of starvation for different instars of *B. mori* and confirmed that starvation decreased the larval weight and increased the larval duration.

Table (II): Effect of feed number on the energy budget of the silkworm *B. mori*.

Feed/ day	Food Consumed mg/g/day	Food Assimilated mg/g/day	Food converted mg/g/day	Food Metabolized mg/g/day	Conversion efficiency %
1	174.2±27.8	98.3±5.9	18.7±3.2	81.2±3.7	16.2
2	209.3±31.2	111.2±9.7	21.1±5.4	89.7±4.6	17.6
4	261.5±26.2	138.4±12.6	31.2±3.1	86.2±3.8	18.2
6	279.0±19.2	140.8±16.4	36.6±2.1	90.1±6.1	20.6
8	299.0±21.3	147.6±13.2	36.2±3.1	97.2±5.2	20.8

Table (III): Effect of feed number on mean weight of cocoon diameter and weight of *B. mori* larvae.

Feed/ day	Cocoons			Weight of larvae (mg)
	Weight (mg.)	Length (cm.)	Diameter (cm.)	
1	560±9.4	2.1±0.3	1.1±0.2	750±19.8
2	879±11.2	3.1±0.9	1.2±0.9	1159±15.0
4	1078±3.6	3.2±0.3	1.5±0.2	1476±3.4
6	2018±2.1	3.6±0.8	1.5±0.3	2049±5.1
8	2449±2.3	3.8±0.4	1.9±0.3	2749±7.2

***Each value represents average of 5 replicates each containing 5 series.**

Table IV reports the data on fecundity of *B. mori* supplied different number of feeds/day and mated in different combinations. Virgin *B. mori* supplied 8 feeds/day took 13.4 hrs to lay eggs after Preoviposition period, whereas those fed twice took 17.1 hrs for eggs laying. They laid 181.4 eggs, when supplied 8 feeds and 143.6, 128.3 and 72.8 eggs when fed 6, 4 and 2 feeds/day, respectively. The post oviposition span also showed a decrease from 251.8 to 122.0 hrs.

Total number of eggs laid after mating was the highest (580.2) for pairs given 8 feeds/day and the least (218.0) for those supplied 2 feeds/day. Whereas increase in feed accelerated the egg output in all combinations, decrease in feed enhanced the pre-oviposition period. Johanson (1958) found that restricted feeding of virgin females *Oncopeltus fasciatus* to 3 hrs or less/day resulted in delayed onset of oviposition and reduced fecundity. Eid and Salem (1977a,b,c), Eid *et al*., (1989) and Samson *et al*., (1990) reported that the percentage of eggs laid and weight of eggs decreased due to underfeeding.

Table IV: Effect of feed number on mean of pre-oviposition period, egg output, hatching, postoviposition period and body weight of 1st instar of *B. meri*.

Feed/day Male	Parameter Female	Pre-oviposition period (hrs)	Number of laid eggs	% of hatching	Post-oviposition hrs.	Body weight of 1st instar (mg)
				Virgin females		
	8	13.4±3.17	181.4±11.3	0.0	251.8±29	-
	6	14.5±2.26	143.6±9.7	0.0	201.7±41	-
	4	16.9±3.81	128.3±14.2	0.0	190.0±5	-
	2	17.1±1.36	72.8±7.6	0.0	122.0±5	-
			Mated females			
8	8	6.9±0.23	5802±41.61	92.6	232±21	3.56±0.002
8	6	8.1±1.0	491.3±36.14	91.3	191±16	3.35±0.004
6	6	7.5±0.8	486.8±31.17	89.2	186±21	3.36±0.008
8	4	8.1±0.5	396.7±18.20	97.8	152±14	3.18±0.007
6	4	9.1±0.61	380.2±27.30	96.4	170+16	3.19±0.006
4	4	8.9±0.92	390.7±30.10	100.0	168±7	3.02±0.005
2	3	8.8±1.8	218.0±38.17	99.1	123±3	2.68±0.008

It is possible to suggest that the number of eggs and egg weight seemed to be buffered against the changes due to food limitation and hence more time was required to accumulate sufficient energy and nutrients to produce a similar egg number/biomass with low food intake. The reduction in egg production in *B. mori* could not be due to the interruption of vitellogenesis with subsequent oosorption (Dewild and Deloof, 1973. Slansky (1980) also suggested that the delayed onset and reduced rate of egg production by pairs of *Oncopeltus fasciatus* on low feeding caused a high proportion of the assimilated food to be metabolized for maintenance and resulted in the low gross egg production efficiency.

The gross production efficiency of egg (egg number/ingestion x 100) and/or young one (total weight of newly hatched/ingestion x 100) remained high (10.1 and 34.9%) for pairs fed on 6 feeds/day, only a little less than that or pairs on 8 feeds/day (10.4 and 37.2%) indicating that it was the rate but not the efficiencies of assimilation and conversion of food into eggs which reduced and resulted in the decreased rate of egg production of pairs on 2 and 4 feeds/day (Table V).

Engelman (1970); Calow (1973); Rajanna and Puttaraju (2000) reported that normal reproduction in adult insects is a physiological syndrome with nutritional and neuroendocrine interactions and ecological implications. In several species of insects (Engelman 1970) copulation is a stimulus that triggers the hormones responsible for vitellogenesis. On the other hand, nutrition can act equally on the endocrine system which in turn releases the gonadotrophic hormones. Hence in the present investigation copulation was allowed for an optimum period of 6 hours (Thomas *et al*., 1986). Food limitation effects the onset and extent of egg production indirectly through the neuroendocrine system (Ralph, 1976; Rankin, 1978) and directly through limiting the supply of energy (Walker, 1976; Eid and Salem a,b,c, 1977; Slansky, 1980; Eid *et al*., 1989).

Table V: Mean food consumption and conversion (egg and young one) by mated *B. mori* females offered increased feeds.

Fee/day	Ingestion (dry mg.)	Number of eggs*	Wt. of newly hatched*	Production Efficiency (P.E.)	
				Egg**	Young one***
2	2991.2	211	2.66	6.8	18.9
4	4002.8	391	3.11	8.9	27.8
6	4919.7	489	3.30	10.1	34.9
8	5387.2	510	3.51	10.4	37.2

* per female
** Gross egg production efficiency in relation to number.
*** Gross (young one) production efficiency in relation to weight.

The fact that hatching was nearly cent per cent in underfed groups and decreased to 93% in maximum fed individuals, was quite intersting and unexpected. From Table IV, it seems that percentage of hatching was not much affected by feeds even though a negative trend was noticed. Maximum body weight of 3.56 mg. Fresh weight was noticed for the first instar larvae belonging to 8 feeds pairs and it decreased to 2.68 mg. for 2 feeds pairs. Post oviposition life span also showed a decrease from 232 hrs to 123 hrs with the decrease in feeds from 8 to 2/day. In the present experiment food intake of pairs given 4 to 8 feeds/day was sufficient to stimulate the normal onset of egg production normally, but pairs given 2 feeds/day was not sufficient to stimulate the normal onset not to achieve and maintain the normal rate of egg production.

Mated females of *B. mori* laid more eggs than virgins. This observation was supported by the reports of previous authors, (Johansson 1958; Gardon and Lother, 1968; Ralph, 1976; Walker, 1976; Walker, 1978; Thomas *et al*., 1986). It seems that the effects of food limitation upon reproduction in *B. mori* are due to the effect upon females rather than males. This is clear from the number of laid eggs (Table IV) which was dependent on females irrespective of males.

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عدد مرات التغذية وبعض النواحي الفسيولوجية في دودة الحرير التوتية ***Bombyx mori* L.**

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طالت فترة العمر اليرقي لدودة الحرير التوتية *B. Mori* L. عند تقليل عدد مرات التغذية من ثمانية مرات إلى مرة واحدة فقط كل يوم . وكذلك فإن عمر العذارى قد أنخفض تبعاً لانخفاض عمر اليرقات. وقد كابدت اليرقات التي غذيت لمدة واحدة كل يوم نسبة عالية من الموت ، وأدت زيادة عدد مرات التغذية إلى زيادة الوزن اليرقي ومعدل التمثيل الغذائي والأيض والتطور. كما نتج عنها أيضا قيما مرتفعة في وزن وطول وقطر الشرانق. بينما سبب تحديد عدد مرات التغذية نقص في خصوبة الحشرة.