Int. J. Indust. Entomol. Vol. 9, No. 1, 2004, pp. 111~115

[Short Communication]

International Journal of *Industrial Entomology*

Nutritional Efficiency in *Antheraea mylitta* D. during Food Deprivation

S. S. Rath*, B. R. R. P. Sinha and K. Thangavelu

Central Tasar Research & Training Institute, Piska Nagri-835 303, Ranchi, India.

(Received 7 June 2004; Accepted 29 July 2004)

Nutrition plays an important role in maintaining the larval health, cocoon quality and reproductive potential in *Antheraea mylitta* D. Nutritional efficiency greatly influenced if food is not adequate and of quality. *A. mylitta* silkworms were subjected to food deprivation for the period of 0 hr to 12 hrs /day to assess its effect on various nutritional parameters and indices, and its manifestation at different levels. Food ingesta, digesta, gain in body weight declined significantly at each level of deprivation, so also food utilization efficiency like consumption index (CI), growth rate (GR), approximate digestibility (AD), and efficiency of conversion of ingested food (ECI). This stress leads to decline in mean daily food ingesta by 16.73% to 39.76% and digesta by 28.98% to 54.01% following a significant reduction in average daily body weight gain (27.68% to 55.09%). Food deprivation also caused significant loss in the silk gland weight, cocoon and shell weight (14.37% to 53.69%), lowered the fecundity (35.86% to 83.59%) and in number of eggs laid per gram body weight, but simultaneously the number of non-chorionated eggs increased significantly.

Key words: *Antheraea mylitta*, Food deprivation, Nutritional efficiency

Introduction

Decreased food abundance in nature prolongs development, reduced metabolism and decreased reproduction (Slama, 1964; Slansky, 1980; Grabstein and Scriber, 1982). The consumption and utilization of food constitute an absolutely essential thing for growth, development and reproduction. The relative reproductive contribution to the next generation resulted from food deprivation place the insect in a position of inability to achieve and maintain the ideal value (Slansky and Scriber, 1985). Food deprivation leading into prolongation of larval period and decrease in final weight, cocoon and shell weight and fecundity were reported in many insects including sericigenous species (McGinnis and Kasting, 1959; Bhanot and Kapil, 1973; Muthukrishnan *et al.*, 1978; Srivastava *et al.*, 1982; Nath *et al.*, 1990).

In *Antheraea mylitta* Drury, a wild and polyphagous sericigenous insect, studies have been carried out on growth, development and food utilization and its effect on adult characters as influenced by different host plants (Rath, 2000; Rath *et al.*, 2000) and on budget allocation of food (Rath *et al.*, 2003). Being wild, the insect is prone to starvation in the nature frequently due to unavailability of foliage in a host plant for different durations until it finds a new host plant. It affects the survivability and growth of the larvae, which ultimately affect the cocoon parameters and reproduction. Quantitative approach in this aspect is still unknown. Hence, it was intended to undertake the study to assess the effect of starvation on nutritional efficiency, silk production and reproductive capacity of *A. mylitta*.

Materials and Methods

The 5th instar larvae of *A. mylitta* (Daba Bivoltine) (Lepidoptera: Saturniidae) were used for the experiment because of the fact that 81–83% of total food is consumed during this instar alone (Rath *et al.*, 2000) and any change in the quantum of food ingestion will directly influence the physiological potential of the insect including silk production.

A. mylitta silkworms were picked immediately after 4th moult and grouped into four groups each having 5 repli-

*To whom correspondence should be addressed.
Central Tasar Research and Training Institute, Piska Nagri, Ranchi-835 303, Jharkhand, India. Tel: +91-651-2775841; Fax: +91-651-2775629; E-mail: ssrathlee@rediffmail.com

cations of 50 worms each. Feeding treatment were resumed immediately to group 1 (No deprivatio n =control) while the other three groups were subjected to food deprivation for 4 hrs, 8 hrs and 12 hrs every day. During feeding sufficient fresh and pre-weighed *Terminalia tomentosa* leaves were provided to the larvae twice a day till the larvae attained maturity. Buffer stocks were maintained side by side for each group to compensate for mortality. The larvae were allowed to spin cocoons outdoor after the feeding stage. Before initiation of spinning 5 (five) larvae of each group were sacrificed to find out the weight of silkgland. After spinning cocoon weight and shell weight were recorded. The harvested cocoons were kept separately till eclosion and observations on the fecundity, eggs laid/g body weight of female moth and egg chorionation were recorded.

All the data recorded were based on fresh weight basis. The indices of growth, food consumption, digestion, and conversion efficiencies are followed as per Waldbauer (1968): growth rate (GR) = P / TA, consumption index (CI) = E / TA, approximate digestibility (AD%) = 100 (E – F) / E, efficiency of conversion of ingested food (ECI %) = 100 P / E, efficiency of conversion of digested food (ECD %) = 100 P / (E – F) (where, A = mean weight of larva during the feeding period, E = weight of food eaten, F = weight of faeces produced, P = weight gain of larva, T = duration of feeding (days).

The data were analysed using one-way ANOVA test for significance. Correlation of coefficient was also studied to observe the relationship of different parameters to the period of deprivation.

The above study was carried out at Lahunipara (21.49°N, 85°E) during October–November, 1992 in the prevailing environmental conditions (temp. 22–27°C and RH 77–84%.

Results and Discussion

The results are depicted in Tables 1 to 4. All the parameters [except digesta (g) / growth (g), ECD, Qm] studied had a direct relationship with the period of deprivation and the significance level was very high ($P<0.001$).

The food ingested, assimilated and gains in body weight were declined significantly following starvation whereas, the feeding period (phagoperiod) was significantly increased and these changes were directly correlated with the period of deprivation ($P<0.001$). The feeding period was 20.8 days in control group but it was extended to 22.8 days, 25.4 days and 26.8 days in 4 hrs/day, 8 hrs/day and 12 hrs/day of food deprivation groups respectively (Table 1). An extension in larval period was reported in many insects including sericigenous species following food deprivation (Madhavan and Muthukrishnan, 1976; Muthukrishnan *et al.*, 1978; Srivastava *et al.*, 1982; Haniffa *et al.*, 1988; Nath *et al.*, 1990) corroborate our finding. Extension larval period might be required by the insect to fulfill the nutritional requirement so as to reach the intake target to achieve the growth target and allocate the same for various activities (Raubenheimer and Simpson, 1999). The reference ratio (ingesta/excreta) reduced from 1.65 significantly to 1.51, 1.47 and 1.43 upon starvation for 4 hrs, 8 hrs and 12 hrs/day respectively, showing a negative correlation with the period of deprivation. The reference ratio is an indirect expression of absorption and assimilation of food. Higher the reference ratio means greater the rate of digestion and absorption of food in the gut. The decline in reference ratio in the 5th instar larva of *A. mylitta* is an indication that digestion and absorption are affected following starvation (Table 1).

The daily ingesta and digesta per larva experienced a significant decline so also daily average body weight gain.

Table 1. Effect of food deprivation on food ingestion, assimilation, gain in body weight and phagoperiod in *A. mylitta* during 5th instar (Fresh weight basis)

Period of food deprivation (hrs/day)	Food Ingested (g)	Food assimilated (g)	Reference ratio (Ingesta/excreta)	Gain in body weight (g)	Growth efficiency (%)	Phagoperiod (days)
Control (no deprivation)	181.58	70.97	1.65	27.02	267.88	20.8
4	166.09	55.70	1.51	21.05	213.15	22.8
8	155.21	49.36	1.47	20.04	198.68	25.4
12	141.26	42.40	1.43	15.70	148.44	26.8
F	*	*	*	*	*	*
SEm ±	3.15	2.79	0.04	0.86	6.85	0.58
CD at 5%	6.67	5.80	0.09	1.81	14.51	1.24
CD at 1%	8.12	7.21	0.10	2.21	17.68	1.51
r (df =18)	0.9556**	0.9135**	0.7773**	0.9377**	0.9551**	0.9366**

*Significant at 1% level and **Significant at 0.1% level.
Degree of freedom for one way ANOVA studies is 16.

The mean daily ingesta declined upon food deprivation by 16.73% (in 4 hrs/day), 30.16% (in 8 hrs/day) and 39.76% (in 12 hrs/day), and the digesta declined by 28.98%, 43.58% and 54.01% respectively over control group (Table 1). The percentage decline in average body weight gain per day upon food deprivation was 27.68% (in 4 hrs/day), 39.63% (in 8 hrs/day) and 55.09% (in 12 hrs/day). Growth efficiency (GE%) in fed control was 267.88% but it declined significantly upon food deprivation to 213.15% (in 4 hrs/day), 198.68% (in 8 hrs/day) and 148.44% (in 12 hrs/day) (Table 1).

Changes in ingesta requirement for unit growth and for gram cocoon shell were significantly higher in the starved groups over fed controls. Digesta requirement for gram cocoon shell was also found significantly higher for larvae under food deprivation. Food deprivation leads to an increase in ingesta value for producing one gram larval weight during 5th instar by 14.97% (in 4 hrs/day), 15.11% (in 8 hrs/day) and 34% (in 12 hrs/day), whereas, the digesta value initially declined marginally by 1.56% (in 4 hrs/day) and 6.31% (in 8 hrs/day) but subsequently increased by 3.2% in 12 hrs/day of food deprivation. Ingesta required to produce one-gram cocoon shell increased following food deprivation to the tune of 7.53%, 47.85% and 67% in 4 hrs/day, 8 hrs/day and 12 hrs/day respectively. However, the digesta requirement registered a marginal decline by 7.51% in 4 hrs/day and then increased by 25.58% and 28.63% in 8 hrs/day and 12 hrs/day respectively (Table 2).

The food utilization efficiency suffers a setback upon starvation. The consumption index (CI), growth rate (GR), approximate digestibility (AD%) and efficiency of conversion of ingested food (ECI) declined significantly but efficiency of conversion of digested food (ECD) and coefficient of metabolism (Qm) did not. The CI declined from 0.37 to 0.35 in 4 hrs/day, 0.31 in 8 hrs/day and 0.30 in 12 hrs/day of food deprivation. The values for growth rate were 0.06, 0.05, 0.04 and 0.03 respectively (Table 3). The decline in AD value due to short supply of food enable the larva to convert the digested food (*i.e.*, ECD) more efficiently (Slansky and Scriber, 1985). The same was prevalent in *A. mylitta* where comparatively higher ECD (although non-significant) were recorded. The decline in CI, GR, and AD% obtained in *A. mylitta* upon food deprivation are in conformity with the findings in *Prodenia eredania* (Soo Hoo and Fraenkel, 1966) and *B. mori* (Nath *et al.*, 1990).

Silk production and reproduction capacity too suffered to a great extent following short supply of food. Significant declining trend prevails in silkgland weight, cocoon and shell weight, fecundity and number of eggs laid per gram body weight of female moth owing to food deprivation. The reduction percentage for silkgland weight was 10.82, 41.39 and 47.05, for shell weight in male 15.47%, 41.66% and 53.69%, in female 14.37%, 42.51% and 53.05% in 4 hrs/day, 8 hrs/day and 12 hrs/day respectively. Fecundity was recorded to be reduced by 35.86%,

Table 2. Effect of food deprivation on mean daily food ingesta, digesta, ingesta/growth, digesta/growth, ingesta/cocoon shell and digesta/cocoon shell in *A. mylitta* (Fresh weight basis)

Parameters	Period of food deprivation (hrs/day)				F	SEm	CD		r
	Control (no deprivation)	4	8	12			5%	1%	
Mean daily food ingesta (g/larva)	8.76	7.29 (−16.73%)	6.12 (−30.16%)	5.28 (−39.76%)	*	0.24	0.51	0.62	0.9606**
Mean daily food digesta (g/larva)	3.44	2.45 (−28.98%)	1.94 (−43.58%)	1.58 (−54.01%)	*	0.17	0.37	0.45	0.9176**
Ingesta (g)/growth (g)	6.75	7.76 (+14.97%)	7.76 (+15.11%)	9.04 (+34.00%)	*	0.37	0.78	0.95	0.7968**
Digesta (g)/growth (g)	2.63	2.59 (−1.56%)	2.46 (−6.31%)	2.71 (+3.20%)	NS	0.10	-	-	NS
Av. weight gain/day (g)	1.31	0.95 (−27.70%)	0.79 (−39.63%)	0.59 (−55.09%)	*	0.06	0.13	0.16	0.9371**
Ingesta (g)/cocoon shell (g)	85.05	91.46 (+7.53%)	125.74 (+47.85%)	142.03 (+67.00%)	*	4.09	9.06	10.56	0.9428**
Digesta (g)/cocoon shell (g)	33.20	30.71 (−7.51%)	41.63 (+25.38%)	42.71 (+28.63%)	*	2.60	5.50	6.70	0.6931**

Figure in parentheses indicate percentage change over fed control.
*Significant at 1% level and **Significant at 0.1% level.
Degree of freedom for one way ANOVA studies is 16.

Table 3. Effect of food deprivation on food utilization efficiency in *A. mylitta* larva during 5th instar

Parameters	Period of food deprivation (hrs/day)				F	SEm	CD at		r
	Control (no deprivation)	4	8	12			5%	1%	
CI	0.37	0.35	0.31	0.30	*	0.011	0.02	0.08	0.8607**
GR	0.06	0.05	0.039	0.03	*	0.002	0.004	0.01	0.9435**
AD (%)	39.10 (38.69)	33.60 (35.40)	31.81 (34.30)	30.02 (33.22)	*	1.00	2.11	2.57	0.7879**
ECI	14.92 (22.69)	13.60 (21.63)	12.92 (21.03)	11.10 (19.43)	*	0.52	1.11	1.35	0.8334**
ECD	38.20 (38.17)	38.65 (38.45)	40.68 (39.60)	37.01 (37.59)	NS	0.87	-	-	0.0452 NS
Qm	61.80 (51.83)	61.16 (51.45)	59.32 (50.35)	62.99 (52.54)	NS	0.84	-	-	0.0786 NS

Figures in parentheses are angular transformed values.
*Significant at 1% level and **Significant at 0.1% level.
Degree of freedom for one way ANOVA studies is 16.

Table 4. Effect of food deprivation on weight of silk gland, commercial characters of cocoon, fecundity and egg chorionation in *A. mylitta*

Hrs of food deprivation/day	Silk gland weight (g)	Cocoon weight (g)		Shell weight (g)		Fecundity	No. of eggs laid/g body weight	Dechorionated egg (nos.)
		Male	Female	Male	Female			
Control (no deprivation)	2.44	12.66	18.06	1.98	2.30	251.0	40.46	4.8
4	2.18 (−10.82%)	10.81 (−14.61%)	13.96 (−22.72%)	1.67 (−15.47%)	1.97 (−14.37%)	161.0 (−35.86%)	32.12 (−20.64%)	31.0 (+545.83%)
8	1.43 (−41.39%)	9.77 (−22.84%)	10.82 (−40.12%)	10.15 (−41.66%)	1.32 (−42.51%)	108.4 (−56.81%)	24.93 (−38.40%)	44.6 (+829.17%)
12	1.29 (−47.05%)	7.78 (−38.54%)	9.42 (−47.85%)	0.92 (−53.69%)	1.08 (−53.05%)	41.2 (−83.59%)	11.93 (−70.51%)	66.6 (+1287.50%)
F	*	*	*	*	*	*	*	*
SEm	0.05	0.32	0.47	0.04	0..09	6.98	1.24	3.43
CD at 5%	0.10	0.68	1.00	0.07	0.19	16.30	2.24	7.28
CD at 1%	0.13	0.83	1.22	0.09	0.24	18.03	3.21	8.87
r	0.9563**	0.9621**	0.9595**	0.9838**	0.9529**	0.9862**	0.9772**	0.9708**

Figures in parentheses indicate percentage change over fed control.
*Significant at 1% level and **Significant at 0.1% level.
Degree of freedom for one way ANOVA studies is 16.

56.81% and 83.59% following starvation for the same periods respectively. These findings showed that nutritional stress beyond manageable limits can cause physiological disturbances in budgeting, which were manifested at different levels. Shell weight in *B. mori* also declined following starvation (Radhakrishnan *et al.*, 1885; Haniffa *et al.*, 1988; Nath *et al.*, 1990). Reproductive capacities of autogenous insects rely upon larval nutrition. Delayed oviposition and reduced fecundity are the resultant of restricted feeding in insects. The fall in shell weight and fecundity were supported by the earlier findings in lepidopteran and other insects too (Bhanot and Kapil, 1973; Walker, 1976; Muthukrishnan *et al.*, 1978; Slansky, 1980; Ives, 1981; Haniffa *et al.*, 1988; Nath *et al.*, 1990). Egg chorionation was also suffered due to food deprivation. Number of non-chorionated eggs increased significantly upon food deprivation (Table 4). This might be due to the fact that corpus allatum fails to produce hormone for yolk deposition in the ovary following food deprivation (De Wilde, 1964). It further strengthens the relation

between nutrition, endocrine system and reproduction.

From the present study it is observed that food deprivation in *A. mylitta* affects ingestion of food and its digestion and consequently retards growth and reproductive potential. Because of starvation *A. mylitta* larvae could not reach the intake target and hence fails to achieve the growth target following which the efficiency of food utilization declined and ultimately affects the shell weight and fecundity of the insect. Hence it is urged that necessary care should be taken during the rearing of the insect so that the silk production can be increased with restoration of reproductive capacity of the insect of economic importance.

References

Bhanot, J. P. and R. P. Kapil (1973) Effect of starvation on fecundity and hatchability of the eggs of *Acaropsis docta* (Berlese). *Indian J. Entomol.* **35**, 67-69.

De Wilde, J. (1964) Reproduction-Endocrine Control; in *The Physiology of Insecta*. Vol. 1. Rockstein, M. (ed.), pp. 59-90, Academic Press, New York.

Grabstein, E. M. and J. M. Scriber (1982) The relationship between restriction of host plant consumption, and post-ingestive utilization of biomass and nitrogen in *Hyalophora cecropia*. *Ent. Exp. App.* **31**, 202-210.

Haniffa, M. A., T. Punitham and S. Arunachalam (1988) Effect of larval nutrition on survival, growth and reproduction in silkworm, *Bombyx mori* L. *Sericologia* **28**, 563-575.

Ives, P. M. (1981) Feeding and egg production of two species of Coccinellids in the laboratory. *Can. Ent.* **113**, 999-1005.

Mathavan, S. and J. Muthukrishnan (1976) Effects of ration levels and restriction of feeding duration of food utilisation in *Danaus chrysippus* (Lepidoptera:Danaidae). *Ent. Exp. Appl.* **19**,155-162.

McGinnis, A. J. and R. Kasting (1959) Nutrition of pale western cutworm Agrotis orthogonia, morr (Lepidoptera: Noctuidae). 1. Effect of under feeding and artificial diets on growth, development and a comparison of wheat sprouts of Thatcher, *Triticum aestvum*, L. and Golden ball *T. durum*. Desf, as food. *Can. J. Zool.* **37**, 259-266.

Muthukrishnan, J., S. Mathavan and Jothi V. Navarathina (1978) Effect of restriction of the feeding duration on food utilisation, emergence and silk production in *Bombyx mori* L. (Lepidoptera: Bombycidae). *Monitor, Zool. Ital.***12**, 87-94.

Nath, T. N., Shiv Nath, M. Shamsuddin and G. Subba Rao (1990) Effect of food deprivation on dry matter utilization, shell and cocoon weight and fecundity of multivoltine silkworm, *Bombyx mori* L. Race Nistari. *Indian J. Seric.* **29**, 174-181.

Radhakrishnan, S., R. Narayanaprakash and K. Periasamy (1985) Effect of food deprivation on silk production in *Bombyx mori* L. (Lepidoptera: Bombycidae). *Sericologia* **25**, 349-356.

Rath, S. S. (2000) Studies on growth and development of *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) fed on three different natural food plants. *Int. J. Wild Silkmoth & Silk* **5**, 99-103.

Rath, S. S., B. R. R. P. Sinha and K. Thangavelu (2000) Comparative food utilization and adult characters in *Antheraea mylitta* D. fed on different host plants; in *Non-mulberry Sericulture, Silk Technology, Sericulture Economics and Extension*. Chinnaswamy, K. P., R. Govindan, N. K. Krishnaprasad and D. N. R. Reddy (eds.), pp. 12-16, Department of Sericulture, University of Agricultural Sciences, Bangalore and Seri 2000, Swiss Agency for Development and Co-operation, Bangalore, India.

Rath, S. S., R. Narain, B. C. Prasad, G. C. Roy and B. R. R. P. Sinha (2003) Food allocation budgeting in tropical tasar, *Antheraea mylitta* D. fed on *Terminalia tomentosa*. *Seicologia* **43**, 557-564.

Raubenheimer, D. and S. J. Simpson (1999) Integrating nutrition: a geometrical approach. *Ent. Exp. App.* **91**, 67-82.

Slama, K. (1964) Hormonal control of respiratory metabolism during growth, reproduction and diapause in female adults of *Pyrrhocoris apterus* L. (Hemiptera). *J. Insect Physiol.* **9**, 283-303.

Slansky, F. Jr. (1980) Effect of food utilization on food consumption and reproductive allocation by adult milkweed bugs, *Oncopeltus fasciatus*. *J. Insect Physiol.* **26**, 79-84.

Slansky, F. Jr. and J. M. Scriber (1985) Food consumption and utilization; in *Comparative Insect Physiology, Biochemistry and Pharmacology*. Vol. 4. Kerkut, G. A. and L. I. Gilbert (eds.) pp. 88-163, Pergamon Press, New York.

Soo Hoo, C. F. and G. Fraenkel (1966) the consumption, digestion and utilization of food plants by a polyphagus insect, *Prodenia eridania* (Cramper). *J. Insect Physiol.* **12**, 711-730.

Srivastava, D., S. D. Misra and F. S. Poonia (1982) Effect of food deprivation on larval duration, cocoon shell weight and fecundity of Eri silkmoth, *Philosamia ricini*, Hutt. (Lepidoptera, Saturniidae). *Indian J. Seric.* **21**, 11-15.

Waldbauer, G. P. (1968) The consumption and utilization of food by insects; in *Advances of Insect Physiology*. Vol. 5. Beament, J. W. L., J. E. Treherne and V. B. Wigglesworth (eds.), pp. 229-288, Academic Press, New York.

Walker, W. F. (1976) Juvenoid stimulation of egg production in *Oncopeltus fasciatus* in non-host diets. *Env. Ent.* **5**, 599-603.