Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

Strategy for Prediapause Energy Management by Larva of Antheraea Mylitta Drury (Saturniidae)

Zoology

KEYWORDS : Antheraea mylitta, energy budget, host plant, instar, Terminalia alata

AMULYA KUMAR DASH

Department of Zoology, Dr. Jadunath College, Asant Road, RaAsanpur, Balasore-756021, Odisha, India

ABSTRACT

Energy budget of larva of Antheraea mylitta Drury living in Terminalia alata W. &A. host plant was prepared in winter season. During fifth instar the rate of food energy consumption, absorption, body growth, silk gland growth and respiration increased suddenly in comparison to other instars. The amount of consumption, absorption, body tissue growth and silk gland growth during fifth instar only was about 82%, 83%, 83%, 97% respectively of the total amount used in the entire larval period. At fifth instar the female larva showed significantly higher overall efficiencies than male larva. There was a gradual increase in amount of energy stored per mg dry body weight from first to fifth instar. Female larva showed higher value than male larva. The absorption and growth efficiency was lowest in 2nd instar. So it is the most vulnerable instar needing more care during rearing. Highest all-round efficiency was observed in case of fifth instar larva. So optimum care during feeding and rearing should be given to fifth instar larva in order to maximize silk productivity.

INTRODUCTION

Antheraea mylitta is a polyphagous insect and its larva feeds on Asan host plant which is considered to be a primary food plant on the basis of cocoon crop performances (Dash *et al* 1992). The lepidopteran larva act as energy transformer and shows certain level of efficiency in particular ecological conditions. So study of energetic parameters of *A. mylitta* is important to trace out clues for optimizing silk production efficiency of larva since it is the only food energy consuming stage of its life cycle. So a thorough knowledge of trend of energy budget of larva is essential for knowing energy allocation for body growth and silk productivity.

Some literatures are available on ecological energetics of some species of silk worm like *Bombyx mori* (Hiratsuka, 1920; Hori and Watanabe, 1985), *Philosamia ricini* (Poonia, 1978; Reddy and Alfred, 1979), *Antheraea proylei* Jolly (Rana *et al*, 1987) and *A. mylitta* raised on secondary host plant *Ziziphus jujuba* Gaertn in rainy season (Dash, 2013). Pattanayak and Dash (2000 a, 2000 b) reported pupal energy budget on some food plants. Dash *et al* (2012) reported the effect of altitude on pupa and Jena *et al* (2015) the effect of altitude on growth of female larva of *A.mylitta* during rainy season. However no concrete literature is available on energy budget of *A. mylitta* feeding on *T. alata* during winter season although it is crucial to know the energy budgeting trend of insect and the costing aspect of insect for different activities during the ensuing diapauses period beginning from January to June of the year. So this investigation was carried out.

MATERIALS AND METHOD

The present study was conducted at State Tasar Research Farm, Durgapur in the District of Mayurbhanj of Odisha state during winter (November-December) season. For energy budget preparation, the methodology suggested by Petrusewicz and Macfadyen (1970) was followed. It is represented as C=P+R+F+U where 'C' is food consumption, 'P' is production, 'R' is energy loss as heat due to metabolism, 'F' is energy loss as faecal matter and 'U' is energy loss as nitrogenous excretory products. *A. mylitta* excretes mainly uric acid combined with faeces egested as solid pellets (Waldbauer, 1968). Here F+U indicate Faeces + Nitrogenous matter.

In this study healthy identical Asan plants (*T. alata*) were selected at random and a huge population of freshly hatched hatchlings of same day was released in the Asan plants to be used as reserve batch for the experiment. The fresh and dry weight of consumed leaves, egested faecal pellets, gained body tissue, cast off exuviae and dissected out silk glands were recorded along with measurement of amount of oxygen consumed during each instar.

At the beginning of each instar (except the fifth), an experimental population of two hundred healthy' larvae were selected randomly from the large reserve batch and were reared on *T. alata* during winter rearing season. During each instar the initial (just after hatching for the first instar and after moulting for the remainder) and the final (just before moulting when the gut was empty) fresh and dry (oven drying; Southwood 1966) body weight of twenty larvae was measured by bomb calorimetry. For the fifth instar larvae the above method was followed separately with each sex. Another twenty larvae at hatchling stage were chosen at random from the experimental batch and were allowed to feed on twenty different branches of *T. alata* having sufficient leaves for the worms to spend their whole larval life. The area of all leaves on each branch was determined by tracing the margin on a graph paper and each leaf was marked serially. The worms were prevented from escaping by encircling the base of experimental branch with a plastic cone. The twenty larvae were kept under continuous observation. The fresh weight of the consumed leaf was determined by taking an identical leaf matching with traced area and calculating the amount of consumption by subtracting the weight of entire identical leaf collected from another plant of same age. The leaf consumption of fifth instar larva was measured separately for each sex since markings of sexual dimorphism appear at this instar. The leaf collected at each instar were oven dried (Southwood 1966), powdered, mixed thoroughly and subjected to bomb calorimetry to know the amount of food energy consumed during each instar.

The faecal pellets egested by the above experimental larvae were collected every day for each instar by tying a polythene sheet below the branch. The fresh and dry weight of the pellets collected for each instar was determined. Then they were powdered, thoroughly mixed and twenty samples were subjected to bomb calorimetry to know the energy lost with faeces during each instar. The absorbed energy was calculated by subtracting 'F+U' from 'C'. For measuring the oxygen consumption, twenty healthy larvae at each instar were collected from the experimental batch every day, and each larva was subjected to respirometry for half an hour during the early morning, noon, evening, night and midnight. The daily rate of oxygen consumption per hour was calculated from the average value so obtained. Thus the total amount of oxygen consumption throughout each instar was estimated. For the fifth instar, the amount of oxygen consumption was measured separately for each sex. The oxyjoulerific conversion (19.64 J/ml; Brown 1964) of consumed oxygen was made to know the energy lost in respiration during each instar.

The exuviae casted off after moulting by the twenty feeding larvae were collected at each instar. The fresh and dry weight of the collected exuviae was measured. Then these were powdered, thoroughly mixed and twenty samples were subjected to bomb calorimetry to know the energy lost in form of exuviae at each instar. For knowing silk budget, twenty larvae at beginning and end of each instar were collected and their silk glands were dissected out. The initial as well as final fresh and dry weight (oven drying, Southwood 1966) of removed silk glands were recorded. The energy content of silk gland of each instar was measured by bomb calorimetry. The efficiency of absorption, body growth, silk gland growth of each instar larva was calculated as indicated in Table 3. The energy budgeting per mg dry body weight (J/mg) at each instar was made as shown in Table 2. The experiment was repeated for five years during winter season. Statistical analysis of data was made following Sokal and Rohlf (1969).

RESULTS AND DISCUSSION

The amount of energy consumed, absorbed and allocated for body and silk gland growth increased gradually from first to fourth instar and rapidly during fifth instar (Table 1 & Fig. 3). Analysis of ANOVA test indicated significant difference of consumption, absorption, body growth and silk gland growth during fifth instar which was 82%, 83%, 83%, and 97% of the total amount utilized for the entire larval period respectively. The increase was nearly five times of the recorded data for fourth instar for all above energy budget parameters except silk gland budget which was exceptionally forty times more. The t-test indicated significantly ($P<0.01$) higher consumption, absorption, body growth and silk gland growth in female larva than male larva. The loss of energy in faeces and respiration increased gradually from first to fourth instar and suddenly during fifth instar (Table 1 & Fig. 3). ANOVA test indicated significant difference in amount of energy loss in faeces and respiration among different instars. The t-test also showed significantly ($P<0.01$) higher allocation of energy for metabolism in case of female larva than the male larva. The loss of energy in egesta and metabolism during the final instar was about 82% and 83% respectively of the entire larval period. Loss of energy in feaces and respiration suddenly increased towards fifth instar and it was nearly five to six times more than fourth instar. The absorption efficiency (100 A/C), gross growth efficiency (100 P/C), net growth efficiency (100 P/A), gross silk gland growth efficiency (100 S/C) and net silk gland growth efficiency (100 S/A) were usually found lowest in second instar larva among all the instars (Table 3 & Fig. 5). The absorption and growth efficiency of body as well as silk gland increased significantly ($P<0.01$) from third to fourth instar. The t-test indicated significantly ($P<0.01$) higher all round efficiency of female than the male except silk gland gross and net growth efficiency which was higher in male than female larva. During fifth instar about 58 to 60% of the total absorbed energy was allocated for body growth and about 20% and 17% for silk gland growth by male and female larva respectively.

The mean allocation of energy per milligram dry body weight (J/mg) is given in Table 2 and Fig. 4. In general, the second instar showed highest values for all the budget parameters except the case of energy utilized for body growth being highest in fifth instar. Absorption value was highest in second instar and lowest in first instar. The 'P' value was lowest in first instar followed by second, third, fourth and fifth instar. The energy allocated for growth in fifth instar was significantly higher than other instars. The t-test indicated significantly higher energy level per mg dry body weight of the male larva than the female larva for all budget parameters except growth. The 'P' value of female was significantly higher than male. The energy allocated for growth per mg dry body tissue increased from the first to fifth instar. The energy flow budget of male and female larva is presented in Fig. 1 and Fig.2 respectively.

The energy budget allocated for pupal life was 59.31 KJ and 77.75 KJ in male and female larva respectively. The budgetary energy saving for pupal life was more than 65% and 70% of the total body tissue energy budget of male and female larva respectively. This is meant for budgetary allocation during diapauses life (six months from January to June) metabolism and post diapauses reproductive activities. The energy flow budget of both male and female larva is given in Fig.1and Fig.2.

In the present study it was observed that only fifth instar larva consumed more than 82% of the total food energy consumption throughout the entire larval life of *A. mylitta*. Waldbauer (1968) reported that lepidopterans consume more than 70% of total larval consumption during last instar only.

In *A. mylitta* an increasing trend of ingestion, absorption, body tissue production and food oxidation through respiration was found with advance of instars. Similar trends were recorded in *P. ricini* (Reddy and Alferd, 1979) and *A.mylitta* reared on *Z.jujuba* secondary food plant during rainy season (Dash, 2013). Both sexes of fifth instar larva of *A. mylitta* allocated more than 60% of total absorbed energy for body tissue. But 40.28% of total absorbed energy was allocated for body tissue by *A. proylei* (Rana *et al*, 1987). Higher metabolic rate was noticed in larva of *A.mylitta* in later stage. Earlier it was recorded in *A.proylei* (Rana *et al*, 1987).

The consumption of food energy during fourth instar was about 13% of the total food energy consumed throughout its larval life, but in *B.mori* it was approximately 9% (Hori and Watanabe, 1985). The efficiency of utilization of energy for the body growth during fifth instar of male and female *A.mylitta* larvae was 59% and 61% respectively. But in *B.mori* the efficiency of utilization of energy to whole body by the fifth instar male and female larvae ranged between 46.4 – 65.5% and 51.7-61.8% respectively (Hori and Watanabe, 1985). The net growth efficiency (100 P/A) of A.mylitta larva ranged between 56-62%. In *Hyalophora cecropia* larva it was found to be 53.1% (Schroeder, 1971). The gross growth efficiency (100P/C) of A.mylitta ranged between 6-10% during different instars whereas in *H.cecropia* it was 19.4% (Schroeder, 1971).

At fifth instar stage the male and female larva of *A. mylitta* on average, consumed 277.71 and 240.61 joules of food energy per mg dry body weight respectively. Similar studies on male and female larva of *B.mori* showed consumption of 26.00 and 25.54 joules of food energy per mg dry body weight respectively (Hori and Watanabe, 1985). The male *A. mylitta* larva was found to show higher consumption of energy per mg dry body weight than female larva. Hori and Watanbe (1985) also found this trend in larva of *B.mori.* During fifth instar of *A.mylitta* the average absorption and metabolic loss of energy per mg dry body weight of male and female larvae was 38.91 and 38.43 and 15.91 and 14.93 J/mg respectively. It was observed that the average absorption and metabolic consumption per mg dry body weight of male and female larva of *B.mori* in fifth instar were 12.54 J/mg and 4.37 J/mg respectively (Hori and Watanabe, 1985). So from above data it appears that the amount of absorption and metabolic cost per mg dry body weight of *A. mylitta* larva is much higher than *B. mori* larva.

An increasing trend of stored energy per mg dry body weight was observed in successive instars of *A. mylitta* larva. Hiratsuka (1920) reported a similar trend in *B. mori.* He stated that it might be due to an increase in relative amount of fat deposition in successive instars. It was observed that the fifth instar of *A.mylitta* larva is very important of all instars and especially for silk production. Because the energy utilized for silk production during fifth instar was about 97% of the total amount gathered over the entire larval period. Similar trend was observed earlier in case of *A.mylitta* feeding on *Z.jujuba* (Dash, 2013) and also in *B.mori* (Hori and Watanabe, 1985) and *P.ricini* (Joshi and Mishra, 1979). The female larva of *A.mylitta* utilized more energy for to-

Volume : 4 | Issue : 12 | December 2015 • ISSN No 2277 - 8179

tal silk synthesis than male larva. The gross and net silk gland growth efficiencies of *A.mylitta* larva at fifth instar ranged between 3-4% and 20-24% respectively, and it was also higher in male than female larva. Hori and Watanabe (1985) reported higher net and gross silk gland growth efficiency in male larva of *B.mori* than female larva and its ranged was within 23-27%. The male and female *A.mylitta* larva allocated about 34% and 29% of the accumulated body energy for silk gland respectively. The allocation of absorbed energy for silk preparation was 20% and 17% by male and female larvae respectively. Yokoyama (1962) reported that about 25% of absorbed energy of *B.mori* larva is contributed for silk production. Hori and Watanabe (1985) recorded that 34% of total amount of body energy is diverted for silk matter.

The amount of energy utilized for silk production gradually increased along with increase in silk gland growth efficiency in successive instars. Suddenly the value became highest in fifth instar. Similar trends were also observed in *B.mori* (Hori and Watanabe, 1985) and in case of *A.mylitta* raised on secondary host plant *Z.jujuba* during rainy season (Dash, 2013).

Conclusion

It was observed that the fifth instar of *A.mylitta* larva is the crucial stage of all instars for optimum silk production, since the energy utilized for production of silk during fifth instar was about 97% of the total amount utilized over the entire larval period. The commercial aim of the tasar crop is to yield possibly highest amount of raw silk for the economic benefit of the farmers. So, maximum care is suggested for the fifth instar period of larval life.

Table 1: Mean energy (joules ± SD) budget of different instars of *A.mylitta* larva living in host

plant *T.alata* during winter season.

Instar	N	Energy Consumed (C)*	Energy lost in Faeces(F+U)*	Energy Absorbed (A)*	Oxygen respired (ml± SD) &energy (J) lost in respiration (R)*	Energy utilized for body growth (P)*	Energy lost in exuviae (E)*	Energy utilized for silk gland growth (S)*
First	100	1638.68±1.45	1425.16±2.04	213.52±0.32	3.95±0.09 (77.57)	127.94±0.32	6.05±0.18	3.40±0.07
Second	100	8356.68±4.18	7314.55±4.42	1042.13±1.86	21.67±1.69 (425.59)	584.29±0.88	23.52±0.52	21.96±0.39
Third	100	41417.44±9.87	35527.88±9.22	5889.56±3.81	119.54±2.08 (2347.76)	3437.15±2.84	88.06±0.78	148.44±2.65
Fourth	100	141460.83±30.85	120298.29±24.57	21162.54±9.93	382.32±9.97 (7508.76)	12659.43±10.78	939.39±8.65	653.17±7.58
Fifth ♂	100	896143.82±60.41	770594.07±63.32	125549.75±32.45	2607.86±13.75 (51218.37)	74187.35±19.35	------	29801.40±24.21
Fifth ♂	100	959023.79±83.84	805867.69±86.49	153156.10±46.65	3021.61±15.90 (59344.42)	93624.33±40.27	-----	30800.53±26.81

*indicates significant (P<0.01) values between the instars and sexes

Table 2: Allocation of energy budget per milligram dry body weight (J/mg) of *A.mylitta* larva living in host plant *T.alata* during winter season

Instar	N	Energy Consumed (C)	Energy lost in Faeces(F+U)	Energy Absorbed (A)	Oxygen Respired (ml/ mg) &energy (J) lost in respiration (R)	Energy utilized for body growth (P)
First	100	268.20	233.25	34.94	0.65 (12.77)	20.94
Second	100	313.22	274.16	39.06	0.81 (15.91)	21.90
Third	100	274.01	235.05	38.96	0.79 (15.52)	22.74
Fourth	100	257.79	219.23	38.56	0.70 (13.75)	23.07
Fifth ♂	100	277.71	238.80	38.91	0.81 (15.91)	22.99
Fifth ♂	100	240.61	202.19	38.43	0.76 (14.93)	23.49

Table 3: Efficiency of utilization of food energy in different instars of *A.mylitta* larva living in host plant *T.alata* during winter season

Instar	N	Gross growth efficiency (100 P/C)	Net growth efficiency (100 P/A)	Absorption efficiency (100 A/C)	Gross silk gland growth efficiency (100 S/C)	Net silk gland growth efficiency (100 S/A)
First	100	7.81	59.92	13.03	0.21	1.59
Second	100	6.99	56.07	12.47	0.26	2.11
Third	100	8.30	58.36	14.22	0.36	2.52
Fourth	100	8.95	59.82	14.96	0.46	3.09
Fifth ♂	100	8.28	59.09	14.01	3.32	23.74
Fifth ♂	100	9.76	61.13	15.97	3.21	20.11

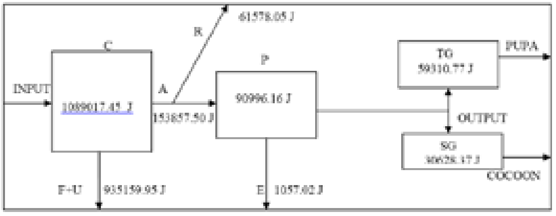

Fig.1. Winter season energy flow budget of male larva of Indian tasar silkmoth *A.mylitta* living in

Asan (*T.alata*) host plant.
TG – Tissue Growth
SG – Silk gland Growth

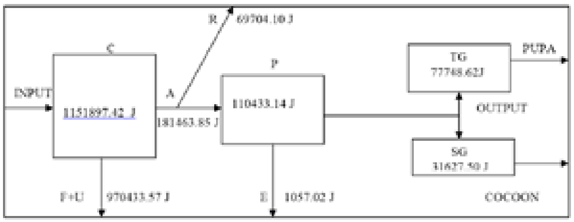

Fig.2. Winter season energy flow budget of female larva of Indian tasar silkmoth *A.mylitta* living in Asan (*T.alata*) host plant

REFERENCE

Brown, G.W.Jr. (1964) In: Physiology of amphibian, Academy press, Newyork, pp.253. Dash, A.K., Nayak, B.K. & Dash, M.C. (1992) The effect of different food plants on cocoon crop performance in the Indian tasar silkworm Antheraea mylitta Drury (Lepidoptera : Saturniidae). J.Res.Lepid, 31(1-2) : 127-131. Dash, A.K., Jena, L.K. & Behera, B.(2012) Altitudinal effect on growth of pupa of Indian tasar silk insect, Antheraea mylitta Drury (Saturniidae) reared in rainy season. Bull. Ind. Acad. Seri, 16(2) : 81-88. Dash, A.K.(2013) Bioenergetics of larva of Antheraea mylitta Drury (Saturniidae) living in secondary host plant Ber (Ziziphus jujuba), Bull. Ind. Acad. Seri, 17(1 & 2): 73-82. Hiratsuka, E. (1920) Researches on the nutrition of silkworm. Bull. Seric.Exp.Sta.Tokyo, 1: 257- 315. Hori, Y. & Watanabe, K. (1985) Daily utilization and consumption of energy in food by silkworm. Bombyx mori (Lepidoptera: Bombycidae). Appl.Entomol. Zool, 20: 62-72. Jena, L.K., Dash, A.K. & Behera, B. (2015) Development of fifth instar female larva of Antheraea mylitta D. (Saturniidae) on different food plants at different altitudes during rainy season. Int.J.Scientific Res, 4(8) : 36-38. Joshi, K. L. & Mishra, S.D.(1979) Studies on live weights of larvae, cocoons and pupae and silk contents of eri silkworm, Philosmia ricini (Hutt.) (Lep: Saturniidae) reared on interchanged two host plants. Trans. Isdt & Ueds, 4(2): 97-100. Petrusewicz, K. & Macfadyen, A. (1970) In: productivity of terrestrial animals, IBP Hand Book, No. 13. Oxford Black well Scientific Publication, UK, pp.190. Poonia, F.S. (1978) Food utilization and rate of growth during the developmental stages of eri silkworm, Philosama ricini Hutt. (Lepidoptera:Saturniidae). Ind.J.Seric, 17: 48-60. Pattanayak, J. & Dash, A.K. (2000a) Allocation of energy for cocoon and pupal life of matured larva of Antheraea mylitta (Drury) (Saturniidae), the Indian tasar silk insect. Sericologia, 40(4):1-4. Pattanayak, J. & Dash, A.K. (2000b) Energy allocation by mature larva of Antheraea mylitta (Saturniidae) towards cocoon preparation and pupal life. Int. J. Wild Silkmoth & Silk, 5:61-63. Rana, B., Prasad, B. & Nigam, M.P. (1987) Consumption and utilization of food by oak-tasar silkworm, Antheraea proylei Jolly (Lepidoptera: Saturniidae). Sericologia, 27(1): 11-19. Reddy, M.V. & Alfred, J.R.B. (1979) Utilization of castor (Ricinus communis Linn.) leaves by the last instar larvae of the silkmoth, Philosamia ricini Hutt. (Lepidoptera; Saturniidae). Sricologia, 27(1): 11-19. Schroeder, L. (1971) Energy budget of larvae of Hyalophora cecropia (Lepidoptera) fed Acer negundo. Oikos, 22: 256-259. Sokal, R.R. & Rohlf, F.J. (1969) In: Biometry - The principle and practices of statistics in biological research, W.H. Freeman & Co., San Francisco, pp. 1-776. Southwood, T.R.E. (1966) Estimation of productivity and construction of energy budget. In: Ecological methods with particular reference to the study of insect populations, Chapman & Hall Ltd., London, pp. 354-368. Waldbauer, G.P. (1968) The consumption and utilization of food by insects. Adv. Insect Physiol, 5:229-288. Yokoyama, T. (1962) Morphology and physiology of silkworm. In:Syntesised Science of Sericulture. Central Silk Board, Bombay, India, pp.224-238.