

Gravimetrics of Pupal Weight Loss in the Domestic Silkworm, *Bombyx mori* Linn. (Lepidoptera : Bombycidae)

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A comprehensive study on daily pupal weight loss due to histolysis and histogenesis in *Bombyx mori* Linn., has been undertaken. The percentage of pupal weight loss in the male pupa is higher than the female, confirming that the female pupa require more energy in the form of less pupal weight loss for ovipositional activities. The regression equation clearly shows higher percentage loss of daily pupal weight in male than female with respect to age and, this is also evident from the slope of the regression line. Moreover, analysis of the coefficient of correlation shows that the weight loss of pupa is directly correlated with the age rather than climatic parameters under which the pupa dwells.

Key words : *Bombyx mori*, Climatic factors, Pupal age, Pupal weight loss

Introduction

India is the second largest country, which produce raw silk in the world and the silk industry has been playing an important role in the Indian economy for a long time. Thus, the domestic silkworm, *Bombyx mori* Linn., has been the target of intensive scientific study in various silk producing countries (Tazima, 1978).

The pupal stage is an important phase in the life cycle of *B. mori* where several metabolic activities take place. During the pupation the imaginal analgens grow rapidly and differentiate into adult organs (Tazima, 1978). The gradual pupal weight loss during different developmental phases in a Bihar hairy caterpillar, *Diacrisia obliqua* Wlk. due to histolysis and histogenesis have been recorded by Goel and Kumar (1983). Kumar and Goel (1985) studied the

correlation of daily pupal weight loss in a lepidopterous pupae, *Plusia orichalcea* Fabr., in relation to temperature, relative humidity and age. The sexing and pupal weight loss in other lepidopterous pupae, *Lymantria marginata* Wlk. has been studied by Singh and Goel (1985). Recently, Rao and Goel (1990) studied the gravimetrics of weight loss and sexing in lasiocampid pupae *Trabala vishnu* Lef. So far, such studies have not been carried out in *B. mori*. Therefore, the pupal period and weight loss in both of the sexes of bivoltine and multivoltine silkworm strains of *B. mori* was studied. These parameters are important and sensitive indicators to several physiological activities and can be utilized to predict different physiological changes, which occurs during the growth and development of the pupal stage. Furthermore, the coefficient of correlation between pupal weight loss, climatic conditions and age have also been studied.

Materials and Methods

The disease free layings of the two races of *B. mori*, NB₁₈ (New Bivoltine 18) and PM (Pure Mysore-Multivoltine), were reared using the required laboratory conditions on mulberry leaves until they were transformed into pupae. The pupae were weighed daily from the date of pupal formation until emergence of the adults. Both of the races were reared under the average temperature of $26.60 \pm 1.5^\circ\text{C}$ and relative humidity of $78.90 \pm 1.80\%$. The data for the male and female pupae were collected and analysed statistically. Coefficient of correlation and best fit regression lines were drawn between the age of the pupae and daily percentage weight loss of bivoltine and multivoltine strain of *B. mori* for both of the sexes.

Results and Discussion

The pupal period lasted for about 7.91 ± 0.09 days in the

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Table 1. Average weight loss during the pupal period the domestic silkworm, *Bombyx mori* L.

SEX	Repli- cates	Pupal Period (Days)	Pupal weight (g)		Daily percentage weight loss										Total % wt loss
			Initial	Final	1 st Day	2 nd Day	3 rd Day	4 th Day	5 th Day	6 th Day	7 th Day	8 th Day	9 th Day	10 th Day	
UNIVOLTINE															
MALE	10	9.70 ±0.14	1.279	1.099	0.391	0.921	0.943	1.441	1.481	1.827	1.781	2.956	3.768	-	15.508
			±0.039	±0.039	±0.052	±0.134	±0.088	±0.085	±0.149	±0.133	±0.233	±0.277	±0.205	-	±0.331
FEMALE	10	10.20 ±0.13	1.564	1.374	0.342	0.319	0.807	0.821	1.259	1.240	1.603	1.618	1.954	2.555	12.517
			±0.032	±0.027	±0.044	±0.043	±0.092	±0.556	±0.103	±0.152	±0.241	±0.140	±0.164	±0.340	±0.213
MULTIVOLTINE															
MALE	10	7.91 ±0.09	0.752	0.622	0.630	2.126	2.190	2.264	3.147	3.798	4.851	-	-	-	19.005
			±0.018	±0.018	±0.064	±0.183	±0.121	±0.088	±0.170	±0.265	±0.235	-	-	-	-
FEMALE	10	9.10 ±0.09	0.985	0.832	0.516	1.511	1.665	1.895	1.576	2.367	2.587	3.880	-	-	15.998
			±0.034	±0.034	±0.087	±0.189	±0.209	±0.114	±0.181	±0.199	±0.138	±0.220	-	-	-

male and 9.10 ± 0.09 days in the female of Pure Mysore (multivoltine) silkworm whereas it was 9.70 ± 0.14 days in the male and 10.20 ± 0.13 days in the female of NB₁₈ (Bivoltine) (Table 1). It has been observed that pupal period is longer in female than in male in multivoltine and bivoltine silkworms (Tazima 1978; Tanaka 1964; Krishnaswami *et al.*; 1973 and Ullal and Narasimhanna, 1978). Goel and Kumar (1983) have also observed a longer pupal period in female than in male in a lepidopterous pupae *D. obliqua*. However, pupal duration of male is longer than female in lepidopterous pupae of *P. orichalcea* (Kumar and Goel, 1985) and *T. vishnu* (Rao and Goel, 1990). The equal pupal duration in male and female pupae of a lepidopterous pest of mango, *L. marginata*, was reported by Singh and Goel (1985). The female pupa of *B. mori* was heavier in weight with an initial pupal weight of 0.98 ± 0.034 g and 1.56 ± 0.03 g and subsequent final pupal weight of 0.83 ± 0.03 g and 1.37 ± 0.03 g in the multivoltine and bivoltine, respectively (Table 1). This trend was also found in other lepidopteran pupae such as *D. obliqua* (Goel and Kumar, 1983), *L. marginata* (Singh and Goel, 1985), *P. orichalcea* (Kumar and Goel, 1985) and *T. vishnu* (Rao and Goel, 1990).

The female pupa being larger in size, heavier in weight shows a less percentage weight loss than male in both bivoltine and multivoltine. We observed that the female pupa of bivoltine and multivoltine silkworm shows 12.52 ± 0.21 and $15.99 \pm 0.32\%$ weight loss, whereas male shows 15.51 ± 0.33 and $19.00 \pm 0.47\%$, respectively (Table 1). The higher pupal weight with low percentage weight loss in female than male is also supported by Dixon (1962) in *Cochliomyia hominivora*; Goel and Kumar (1983) in *D. obliqua*; Singh and Goel (1985) in *L. marginata*; Kumar and Goel (1985) in *P. orichalcea* and Rao and Goel (1990) in *T. vishnu*. This probably signifies the accumulation of energy by female for ovipositional activities.

The pattern of weight loss with two demarcated phases during the pupal age of *B. mori*, the first phase with poor weight loss and the later having increased weight loss by several times of the former, probably corroborated the phenomena of histolysis and histogenesis respectively. Similar observations were made on *D. obliqua* (Goel and Kumar 1983) and *T. vishnu* (Rao and Goel 1990). Mahanta (1976) has observed the trend of oxygen consumption in *Barathra brassicae* L., describing less oxygen utilization in an early pupal period than the later aged pupa. Mall and Gupta (1982) observed a sharp decline in total haemocyte count in *Atteva fabriciella* from prepupation to an early pupal stage. However total mitosis occurs at a low rate in early and last pupal stage whereas a higher rate occurs during mid pupal stage. Manifold increase in percentage weight loss at the last day of pupal

period in both sexes of bivoltines and multivoltines of *B. mori* is the result of tremendous metabolism inside the pupa. It further marks the end of the pupal stage and developing imago starts preparations for a dehiscence inside the pupa. Singh and Goel, (1985) also reported the high percentage weight loss at the last pupal day which depicts the high rate of metabolic activities earlier to emergence in *L. marginata*. The larval genital organs differentiate to the imaginal organs during the pupal stage in *B. mori*. The histolysis of larval organs viz. silk gland, abdominal legs, ocelli, molting glands, caudal horns; and the histogenesis of the imaginal organs take place actively in pupa. The mouth parts, thoracic legs, digestive organs, malpighian tubules, muscles and fat body exhibit extensive modifications as a result of histolysis (Tazima, 1978; Kumar and Goel, 1985).

The correlation coefficients of daily percentage pupal weight loss with climatic parameters viz., temperature and humidity were low and non-significant in all the cases (Table 2). The results indicate that the environmental conditions do not have any impact on the loss of pupal weight in *B. mori* as reported in various lepidopterous pupa (Goel and Kumar, 1983; Singh and Goel, 1985; Kumar and Goel, 1985; Rao and Goel, 1990). The continuous decrease in the daily pupal weight has been observed throughout the pupal development of *B. mori* (Table 1). A very high positive correlation coefficient is found between daily percentage pupal weight loss and pupal age which is significant at 1% level in all the cases viz., bivoltine male and female (0.939; 0.962) and multivoltine male and female (0.962; 0.912), respectively (Table 2). The high positive correlation coefficient indicates the direct linear relationship between the pupal weight loss and age, and average regression equation present for bivoltine male and female (Fig. 1) and multivoltine male and female (Fig. 2). The comparative study of the regression equation of male and female in both the cases clearly indicate that the rate of daily pupal percentage weight loss is higher in male than

Table 2. Correlation coefficient of daily percentage weight loss with environmental conditions and age in both the sexes of *B. mori*

Daily % wt. loss/ Envi. Conditions	Temperature (°C)	Humidity (%)	Age (in days)
BIVOLTINE			
MALE	0.215 (N.S.)	0.150 (N.S.)	0.939**
FEMALE	0.170 (N.S.)	0.564 (N.S.)	0.976**
MULTIVOLTINE			
MALE	0.573 (N.S.)	0.732 (N.S.)	0.962**
FEMALE	0.595 (N.S.)	0.356 (N.S.)	0.912**

N.S. = Non-significant, ** = Significant at 1% level

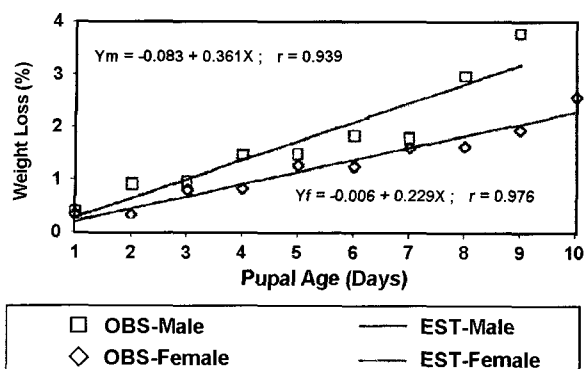


Fig. 1. Relationship between pupal age and weight loss of bivoltine silkworm, *Bombyx mori*.

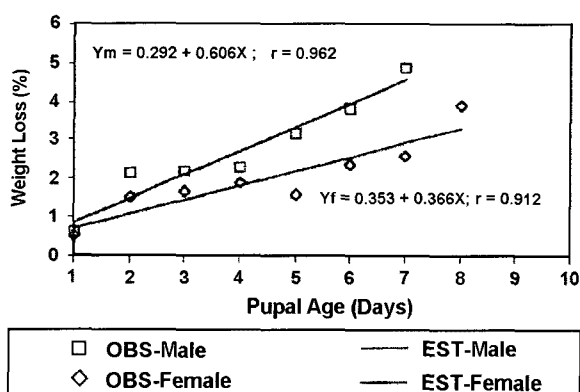


Fig. 2. Relationship between pupal age and weight loss of multivoltine silkworm, *Bombyx mori*.

in female pupae with respect to age which is evident from the slope of the regression line. The similar observations were made by Goel and Kumar (1983) in *D. obliqua*, Singh and Goel (1985) in *L. marginata*, Kumar and Goel (1985) in *P. orichalcea* and Rao and Goel (1990) in *T. Vishnu*. Therefore, the pattern of the pupal weight loss is an important and sensitive indicator to several physiological activities, and can be utilized to predict different physiological changes that take place during the growth and development of an insect at its pupal stage.

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