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Study of the morphometric aspects of Muga silkworm (*Antheraea assamensis* H.) reared on the host plant

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Abstract
The environmental conditions play a significant role and influence the quantitative and qualitative characters of silkworm such as larval length, larval breadth and larval weight. Larvae of Muga silkworm (*Antheraea assamensis* H.) were reared on Som leaves (*Machilus bombycina*) in the Chotua season / crop. The data that were recorded for larval length (cm) from first to fifth instar are 0.943 ± 0.021; 1.596 ± 0.006; 2.75 ± 0.022; 5.062 ± 0.032 and 7.31 ± 0.014 respectively, for larval breadth (cm) are 0.2 ± 0.001; 0.276 ± 0.001; 0.5134±0.004; 1.072±0.0043 and 1.471 ± 0.003 respectively and for larval weight (g) are 0.024 ± 0.0; 0.059 ±0.01; 0.63±0.019; 3.28 ±0.062 and 5.88 ± 0.08 respectively.

Keywords: Muga silkworm, larval length, larval breadth, larval weight, chotua crop

1. Introduction
Insects that are commercially used to produce silk are the mulberry silk moth (*Bombyx mori*) and non-mulberry silk moths (*Antheraea* sp. and *Samia* sp.). Assam is the largest state in Northeast India, situated in the foothill of south-eastern Himalayas, and comprises the Brahmaputra Valley and the Barak Valley sideways with the Karbi Anglong and Dima Hasao districts with an area of 30,285 square miles (78,440 km^2). Traditionally, sericulture is a major source of livelihood in the state of Assam. Sericulture has been practiced in Assam from time immemorial and continues to be an important labour-intensive and agro-based cottage industry. Muga is an economically important sericigenous insect and indigenous to Assam, due to its lustrous golden yellow silk. According to Thangavelu *et al.* 1988 [8], the favourable conditions like humidity, rainfall, acidic soil required by the food plants of this silkworm are only found in Assam. More than 97% of Muga silk are produced in Assam and is an important source of livelihood and play a significant role in the economic development of rural Assam, providing employment to 6.5 lakh households as established by Ahmed and Rajan 2011 [1] and Ramesha and Kirsur 1998 [6]. Assam has also achieved the right of 'Geographical Indication' for its thread (Choudhury 1982) [3]. It feeds on three types of primary food plants, *viz*, *Machilus bombycina* (Som), *Listeria polyantha* (Soalu) and *Litsea citrata* (Mejankari). It is a multivoltine silkworm which completes its life cycle 5 to 6 times per year. Each life cycle takes about two months on an average making it possible for 5 to 6 crop production per year. According to Chowdhury 1982 [3]; Gogoi 1984 [4]; Sahu *et al.* 2000 [7], in Assam, Muga farmers have named the crops according to the months, *viz.*, Katia (October to November), Jarua (November to January), Chotua (February to April), Jethua (April to May), Aherua (June to July) and Bhodia (August – September).
Study of developmental stages of a species is very essential. The traits of developmental stages are vital tools for taxonomic identity of the species. Therefore, systematic research on Muga silkworm is very essential for the sustained development of this industry. Thus, in this context, the present study has been conducted with the aim to study the morphometric parameters (length, breadth and weight) of different instars of larvae of Muga silkworm during Chotua crop.

2. Materials and Methods
Taxonomic position of experimental silkworm:
Kingdom – Animalia
Phylum – Arthropoda

Class – Insecta
Order – Lepidoptera
Family - Saturniidae
Genus – *Antheraea*
Species –*A. assamensis*

The study on the growth and development characters of Muga silkworm, *A. assamensis* on Chotua crop and experiments pertaining to some aspects of it were carried out in the Govt. Basic Muga Seed Farm, Khanapara, Assam, India, during (March-April) 2018. Disease-free eggs (Fig. 1) of the silkworm were reared outdoors on "Som" leaves~*Machilus bombycina* King [Lauraceae] plants in the Muga Farm. Rearing was done in the Khanapara farm and all the measurement aspects were carried out in the Department of Zoology, Cotton University, Assam.

The general method of outdoor rearing of Muga silkworm was followed as recommended by Bharali 1970 [2] and Choudhury 1982 [3]. The rearing was conducted in Chotua crop/season and observations were made on different aspects of silkworm growth and rearing performance. First of all, rearing plot was selected in little shady area with plants having quality foliage. Stagnant water was drained out from the plot. Then individual plant was cleaned by removing dry twigs and leaves, spider nets, ant's nest etc. Nylon nets were erected over food plants (trees of Som) to prevent pests and predators (Fig. 2). Rearing equipments *viz.* bamboo chalani (sieve), rearing net etc. were disinfected with 5% bleaching powder solution before the commencement of rearing. The Khorikas (1.5-2 feet long stick made of dried straw) with the hatched worms / larvae were fed with tender leaves to prevent them from crawling off and to let them settle on the leaves. Newly hatched larvae along with the tender leaves were transferred to the food plants early in the morning (Fig. 3). The larvae immediately crawled and started feeding on leaves. When the leaves exhausted, the larvae crawled down and were collected on triangular bamboo sieves with long handles, i.e., 'Chaloni', which are again hanged on a fresh tree. This process was repeated till the larvae attained 5th instar (Fig. 4). A band of straw with little sand was tied around the tree trunk, which were again wrapped by an aluminium foil, 1-1.2 m above the ground to prevent the worms from crawling down the ground (Fig. 5).

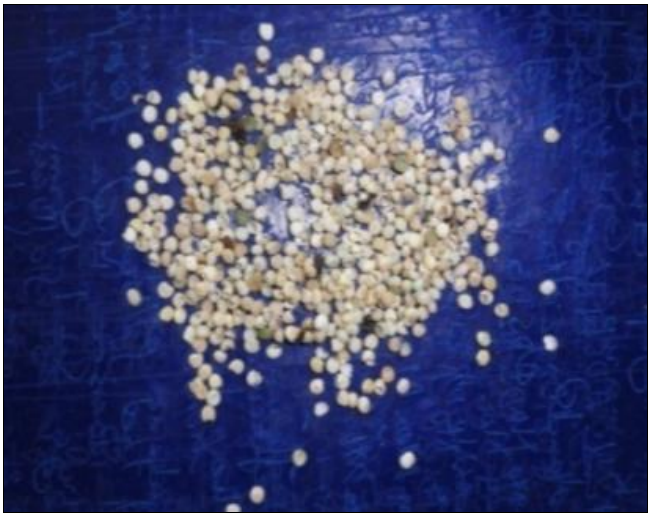

Fig 1: Eggs

Fig 2: Som tree covered with nylon net to prevent from the predators.

Fig 3: Larvae just after hatching (Newly hatched)

Fig 4: Larvae collected with the help of Chaloni, is hanged on a fresh tree.

Fig 5: Tree wrapped by an aluminium foil

In the final stage (5th instar), larvae becomes greenish blue (Fig. 6) and it stops feeding and discharge green coloured semi-solid excreta and comes down from the plant. The ripe worms come down the trees searching for a suitable place for spinning the cocoon. They were then collected and put in baskets called cocoonages and were placed in jails hung and left undisturbed in separate room till cocoons were formed.

Fig 6: Matured 5th instar larvae

2.1 Morphometric analysis

Morphometric analysis of the Muga larvae reared on Som leaves during the Chotua crop were done to determine its growth and development. Three parameters were considered to determine the growth and development, i.e., length (using measuring scale), breadth (using vernier calliper) and weight (using Shimadzu electronic weighing balance, readability - 0.001g) of larvae as well as cocoon. The measurements were taken for all larval stages from first to fifth instar. There were 5 replicates and each replicate consisted of 10 individuals. The length of each of the instars (1st, 2nd, 3rd, 4th and 5th) were taken by measuring scale (Fig. 7). The breadth of each of the instars were taken by vernier calliper (Fig. 8). The weight of each of the instars were taken by using Shimadzu electronic weighing balance, readability - 0.001g (Fig. 9).

Fig 7: Larval length is being taken by a measuring scale.

Fig 8: Vernier calliper

Fig 9: Larval weight taken by Shimadzu electronic weighing balance

3. Results

The present study was undertaken to observe certain larval parameters of Muga silkworm when reared on its host plant. Accordingly, an investigation was carried out during the Chotua crop (March-April) 2018. Rearing was conducted in outdoor conditions on Som plants and the data were recorded for further analysis.

3.1 Larval length

Table 1: Larval length (cm) of Muga silkworm

Larval Stages	Replicates*					Mean (Cm) ± Se
	R1	R2	R3	R4	R5	
L1	0.8775	0.925	0.9675	0.97	0.975	0.943 ± 0.021
L2	1.55	1.6	1.65	1.56	1.62	1.596 ± 0.006
L3	2.83	2.73	2.76	2.74	2.69	2.75 ± 0.022
L4	5.17	4.94	4.99	5.17	5.04	5.062 ± 0.032
L5	7.33	7.35	7.2	7.35	7.32	7.31 ± 0.014

Note: *Each replicate consisted of 10 insect

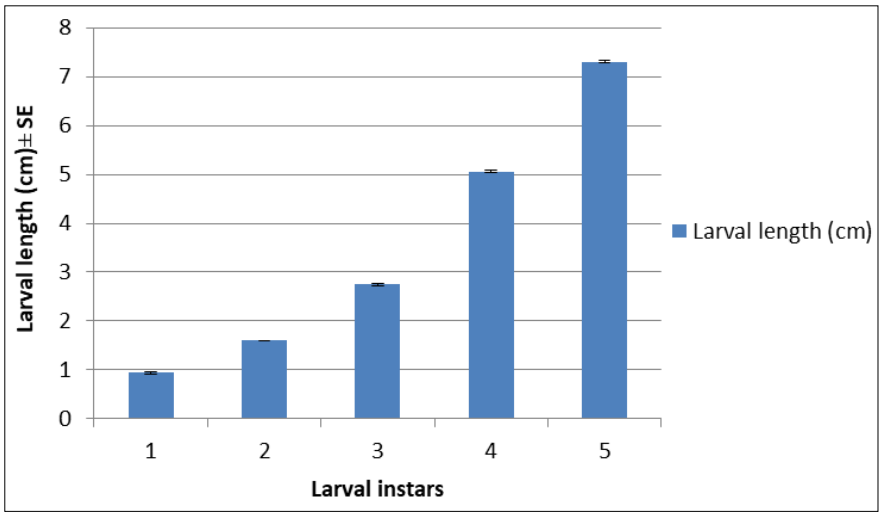

Fig 10: Showing larval length of Muga silkworm

There was increase in the larval length (cm) with every instar, 1st being just 0.94 cm and the last instar measured nearly 7 cm (Table 1 and Fig. 10). There was a gradual increase in the larval length from first instar to third instar but an abrupt increase in length was observed at 4th instar larval length.

3.2 Larval breadth

Table 2: Larval thickness (cm) of Muga silkworm

Larval Stages	Replicates*					Mean (Cm) ± Se
	R1	R2	R3	R4	R5	
L1	0.19	0.2075	0.2025	0.1975	0.2025	0.2 ± 0.001
L2	0.2775	0.2825	0.27	0.27	0.28	0.276 ± 0.001
L3	0.525	0.5175	0.5075	0.5095	0.5075	0.5134±0.004
L4	1.07	1.0675	1.0675	1.0775	1.0775	1.072±0.0043
L5	1.495	1.485	1.475	1.455	1.445	1.471 ± 0.003

Note: *Each replicate consisted of 10 insect

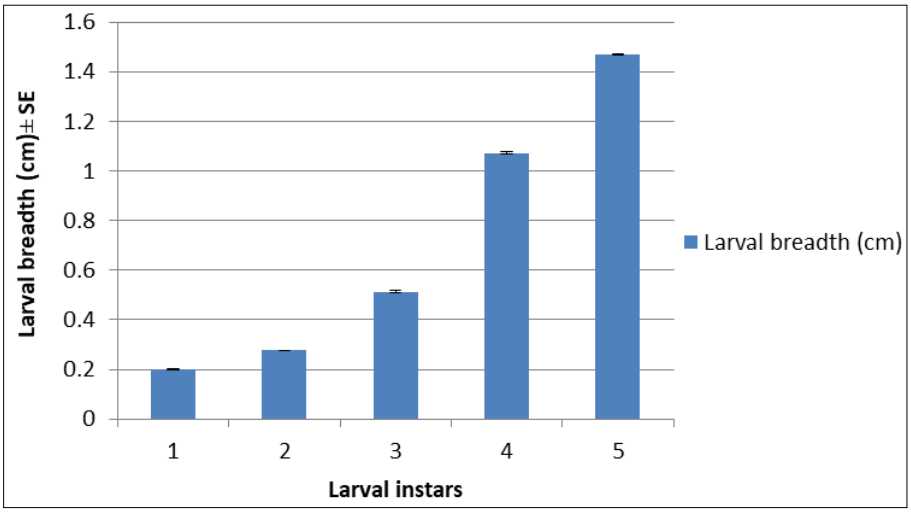

Fig 11: Showing larval breadth (cm) of Muga silkworm

There was not much difference in the larval breadth of first and the second instar larvae (Table 2 and Fig. 11) and also between fourth and fifth larval instar indicating that growth is more evident in the larval length than in its thickness at each larval instar. The larval thickness increased from 0.2 cm to ~1.5 cm from first to fifth instar.

3.3 Larval weight

Table 3: Larval weight (g) of Muga silkworm

Larval Stages	Replicates*					Mean (g) ± SE
	R1	R2	R3	R4	R5	
L1	0.023	0.024	0.024	0.024	0.025	0.024 ± 0.0
L2	0.042	0.045	0.057	0.074	0.075	0.059 ±0.01
L3	0.607	0.6109	0.5887	0.6512	0.696	0.63±0.019
L4	2.716	2.878	3.288	3.669	3.856	3.28 ±0.062
L5	5.087	5.229	6.136	6.24	6.702	5.88 ± 0.08

Note: *Each replicate consisted of 10 insect

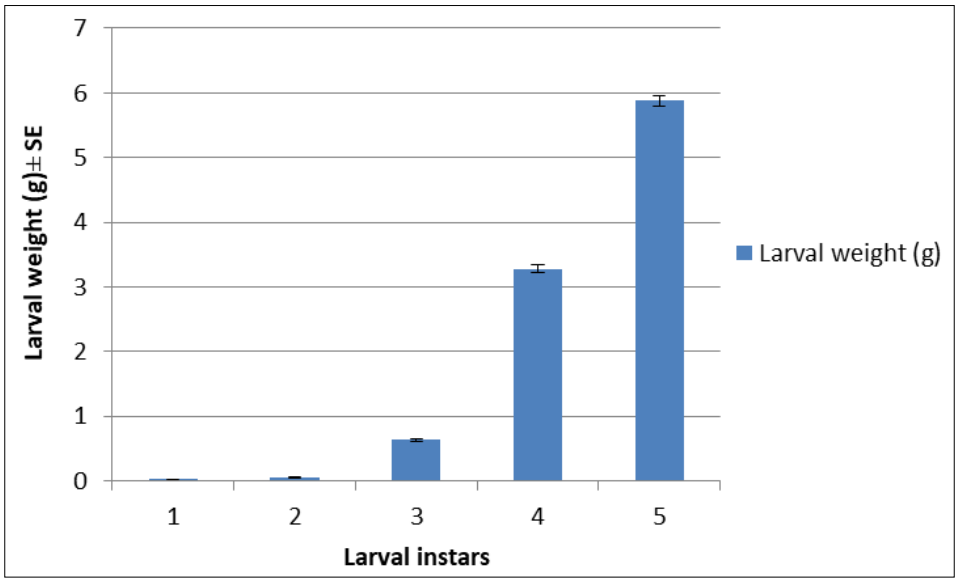

Fig 12: Showing larval weight (g) of Muga silkworm

There was a gradual increase in the larval weight (g) from 1st instar to 4th instar and abrupt increase in the weight in the 5th instar (Table 3 and Fig. 12), which is similar to that of the length.

4. Discussion

For larval length (cm), there was an increase with every instar, 1st being just 0.94 cm and the last instar measured nearly 7 cm (Table 1 and Fig. 10). There was a gradual increase in the larval length from first instar to third instar but an abrupt increase in length was observed at 4th instar larval length and hence the resulting cocoon is an index of the quality of the silk produced. The findings of Khanikar 2001 [5] regarding the length of Muga silkworm on som plants are comparable to our results.

For larval breadth (cm), there was not much difference of first and the second instar larvae (Table 2 and Fig. 11) and also between fourth and fifth larval instar indicating that growth is more evident in the larval length than in its thickness at each larval instar. The larval thickness increased from 0.2 cm to ~1.5 cm from first to fifth instar. Our results corroborates with the findings of Khanikar 2001 [5] where there was not much difference in the larval breadth from one instar to the next instar. According to his findings, the larval breadth of the first instar was 0.15 cm and the last instar was 1.9 cm.

In case of larval weight (g), there was a gradual increase from 1st instar to 4th instar larvae and abrupt increase in the weight in the 5th instar (Table 3 and Fig. 12), which is similar to that of the length. Our results corroborates with the findings of Khanikar 2001 [5] where there was also an abrupt increase from 3rd to 4th and 4th to 5th instar. The increase in food consumption from the fourth instar onwards might have resulted in sudden increase in length and weight at 4th and 5th instar. This weight gain indicates that larval metabolic rate increases as they have to store excess food to prepare itself to enter into the pupal stage where all the feeding activities will be suspended.

5. Conclusion

India is a tropical country and environmental conditions are the limiting factors of Muga silkworm rearing. Majority of Muga silkworm rearers encounters the various environmental problems and lose their crops or produce inferior quality of cocoon and silk. Based on the experiments and findings, the larval length, breadth and weight depends on environmental conditions. Studies were conducted during the months of March – April 2018, to have a hands on training or experience on silkworm rearing and to study its various biological aspects and also to understand various morphometric experiments. This work can further be carried out in future for advanced research, to understand its silk production, difference in the rearing seasons, etc.

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