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Research Article

Morphometry of Mouthparts of Eri Silkworm, *Samia cynthia ricini* Boisduval under Different Food Regimes

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Abstract

Eri silkworm, *Samia cynthia ricini* Boisduval is polyphagous feeding on several plant species. The influence of feed on growth of an animal is evident from literature. Eri larva has biting and chewing type of mouthparts comprising of a pair of mandibles, Labrum and the labio-maxillary complex. The size of these mouthparts increases with larval age. In an experiment conducted to study the influence of host on morphometric changes in mouthparts of Eri silkworm, the local castor variety with greenish petiole found to have significant influence on the length and width of mandibles (0.0803 and 0.0675 cm, respectively), labrum (0.0543 and 0.0735 cm, respectively) and labio-maxillary complex (0.1007 and 0.1145 cm, respectively). Further, there was a sudden increase in the size of mouthparts during fourth instar (85 × 67% gain in mandibles, 95 × 73% gains in LMC and 124 × 58% gain in labrum) irrespective of the host.

Keywords: Eri silkworm, Host plant, Morphometry, Mouthparts, *Samia cynthia ricini*

Introduction

Silk farming, or sericulture, stands as a highly profitable profession, making a significant contribution to the nation's economic prosperity. India enjoys a unique distinction of being the only country around the globe to produce all four varieties of natural silk (Sharma and Kalita, 2013; Swathiga *et al.*, 2019), *viz.*, Mulberry, Eri, Tasar and Muga (Kalita and Datta, 2014; Manjunath *et al.*, 2019). The mulberry silkworm, *Bombyx mori* L. is a monophagous feeding solely on mulberry leaves while the latter three are polyphagous non-mulberry silkworms, of which the Eri, *Samia cynthia ricini* Boisduval is one of the most exploited, completely domesticated and commercialized sericigenous insect (Swathiga *et al.*, 2019).

Ericulture is a tradition and culture of tribal population in North-Eastern India and a subsidiary occupation in the other parts of the country, especially Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Gujarat, Uttar Pradesh, Bihar and Rajasthan (Manjunath *et al.*, 2019; Patil *et al.*, 2009). The Eri larva, *S. cynthia ricini* is a multivoltine polyphagous silkworm feeding on more than 30 different host plants (Arora and Gupta, 1979; Swathiga *et al.*, 2019). Castor, *Ricinus communis* is the most preferred host plant (Swathiga *et al.*, 2019), followed by Tapioca, *Manihot utilissima* and Kesseru, *Heteropanax fragrance* out of several host plants (Chandrashekhar *et al.*, 2012; Nangia *et al.*, 2000; Sharma and Kalita, 2013; Singh and Das, 2006). The leaves of some of the plants like Papaya, *Carica papaya*, Bee bee tree, *Evodia falxinifolia*, Jatropa, *Jatropha curcas*, *etc*. serve as secondary and territory host plants (Devaiah *et al.*, 1985; Manjunath *et al.*, 2019; Swathiga *et al.*, 2019).

Morphometrics is the quantitative characterization, analysis and comparison of biological form (Louise Roth and Mercer, 2000). Morphometric characterizations may be able to provide the relationship between morphology and the genetic, developmental, and evolutionary processes and factors that influence it (Louise Roth and Mercer, 2000). The growth among sericigenous insects is disharmonic, heterogonic and allometric (Dyar, 1895). Rate of growth

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depends mainly on the factor like capacity of food intake, digestion, absorption and assimilation by body tissues, quality of food taken and environmental conditions (Devaiah *et al.*, 1985). The morphological traits of eri have been documented by Ravindranath (2000), while the information on morphometric studies is seldom available.

Larva is the active feeding stage of silkworms with biting and chewing type of mouthparts comprising of a pair of mandibles, a labrum and a Labio-Maxillary Complex. The mouthparts increase significantly in their size with the advancement of larval stage in mulberry silkworm (Girish, 1993). Further, the feed exhibits a profound influence on growth, development and productivity in silkworms. Hence, it is imperative to study the morphometry and growth rate of Eri silkworms. This study attempts morphometry of mouthparts in Eri silkworm at different instars under three dietary regimes.

Materials and Methods

The study was conducted at the Department of Sericulture, University of Agricultural Sciences, Bangalore. The eggs of white plain and zebra races of eri were prepared from the available stock culture as suggested by Reddy *et al.* (2000). Rearing was undertaken as per the standard rearing techniques (Krishnaswami *et al.*, 1973; Renuka and Shamitha, 2014; Sarkar, 1980).

Feeding Regimes

The larvae brushed on tapioca did not survive for a longer time during pre-experimental trial. Hence, the brushing and initial rearing upto third instar was carried out on two Local perennial castor varieties, *viz.*, H_1: Small leaves with dark pink petiole (Plate 1) and H_2: Broader leaves with light green coloured periole (Plate 2). The third group of silkworms were initially fed on H_2 till third moult and then on leaves of Mangalore local variety of Tapioca (H_3; Plate 3). Three consecutive rearings were carried out each with six replications maintaining 50 larvae replication^{-1}. The leaves were fed adlib. Ten healthy larvae were collected two days after each moult for morphometric study of gnathal appendages. The Dissection of mouthparts was carried out under stereoscopic Binocular WILD M-8 microscope with calibrated micrometer. The data were analyzed statistically as mean of six independent replications (± SE). The pooled data was subjected to Factorial CRD (Gomez and Gomez, 1984) and interpreted based on the critical difference (CD).

Plate 1: Local Castor with Red petiole (H_1)

Plate 2: Local Casor with Green Petiole (H_2)

Plate 3: Tapioca

Results and Discussion

The feeding regime and the stage of silkworm found to significantly influence the morphometry of various mouthparts in eri larvae.

Size of Mandibles

The mandible measured longest (0.0803 cm) and widest (0.0675 cm) when fed the larvae on H_2 and shortest when the feed was changed to Tapioca after III instar (0.0428 cm × 0.0597 cm) (Table 1). The size of mandibles increased gradually during I-III stage and recorded a maximum and an abrupt increase during fourth instar with a gain of 0.0528 (85%) and 0.0363 cm (67%) in length and width from third stage, irrespective of the food regime. Though the size of mandibles was maximum the rate of growth was least during fifth instar on all the hosts (15 and 27% respectively, in length and width) (Figure 1).

Table 1: Morphometric variations in the mouth parts of Eri silkworm on different hosts

Parameter		Mandibles		Labio maxillary complex (LMC)		Labrum	
		Mean Length (cm)	Mean width (cm)	Mean Length (cm)	Mean width (cm)	Mean Length (cm)	Mean width (cm)
Host	H_1	0.0732	0.0621	0.0973	0.1099	0.0504	0.0714
	H_2	0.0803	0.0675	0.1007	0.1145	0.0543	0.0735
	H_3	0.0428	0.0597	0.0912	0.1050	0.0498	0.0700
F test		*	*	*	*	*	*
SEM ±		0.0000	0.0000	0.0000	0.0000	0.0002	0.0000
CD		0.0001	0.0001	0.0001	0.0001	0.0007	0.0001
Instar/Stage	S_1	0.0234	0.0212	0.0358	0.0417	0.0134	0.0314
	S_2	0.0428	0.0338	0.0578	0.0688	0.0246	0.0461
	S_3	0.0621	0.0545	0.0641	0.0790	0.0381	0.0605
	S_4	0.1149	0.0908	0.1247	0.1363	0.0852	0.0956
	S_5	0.1315	0.1152	0.1995	0.2231	0.0962	0.1246
F test		*	*	*	*	*	*
SEM±		0.0000	0.0000	0.0000	0.0001	0.0003	0.0000
CD		0.0001	0.0001	0.0001	0.0002	0.0009	0.0001
Interaction	$S_1 \times H_1$	0.0235	0.0215	0.0360	0.0420	0.0135	0.0317
	$S_1 \times H_2$	0.0235	0.0209	0.0356	0.0415	0.0135	0.0313
	$S_1 \times H_3$	0.0232	0.0211	0.0358	0.0416	0.0132	0.0313
	$S_2 \times H_1$	0.0433	0.0334	0.0582	0.0694	0.0263	0.0465
	$S_2 \times H_2$	0.0424	0.0331	0.0578	0.0688	0.0238	0.0460
	$S_2 \times H_3$	0.0427	0.0328	0.0575	0.0683	0.0239	0.0458
	$S_3 \times H_1$	0.0633	0.0551	0.0645	0.0783	0.0320	0.0615
	$S_3 \times H_2$	0.0621	0.0541	0.0639	0.0793	0.0397	0.0601
	$S_3 \times H_3$	0.0609	0.0544	0.0640	0.0793	0.0401	0.0599
	$S_4 \times H_1$	0.1127	0.0882	0.1274	0.1392	0.0848	0.0947
	$S_4 \times H_2$	0.1248	0.1005	0.1329	0.1440	0.0904	0.0990
	$S_4 \times H_3$	0.1074	0.0838	0.1139	0.1258	0.0804	0.0933
	$S_5 \times H_1$	0.1230	0.1122	0.2003	0.2204	0.0954	0.1242
	$S_5 \times H_2$	0.1480	0.1269	0.2134	0.2388	0.1044	0.1312
	$S_5 \times H_3$	0.1229	0.1066	0.1848	0.2101	0.0887	0.1184
F test		*	*	*	*	*	*
SEM±		0.0001	0.0001	0.0001	0.0001	0.0005	0.0001
CD		0.0002	0.0002	0.0002	0.0003	0.0015	0.0002

[H: Host; S: Stage of the worm; *Significant at 5%]

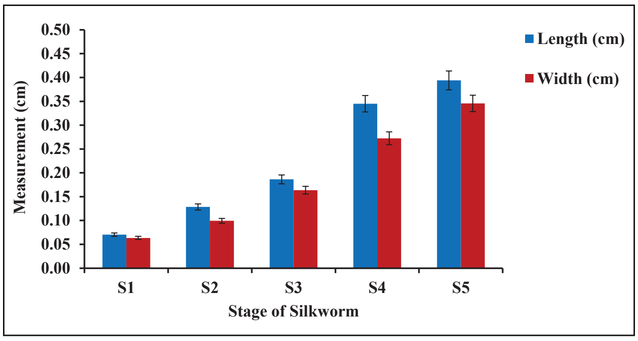


Figure 1: The size of mandibles of the Eri silkworm, *Samia cynthia ricini* Boisd.

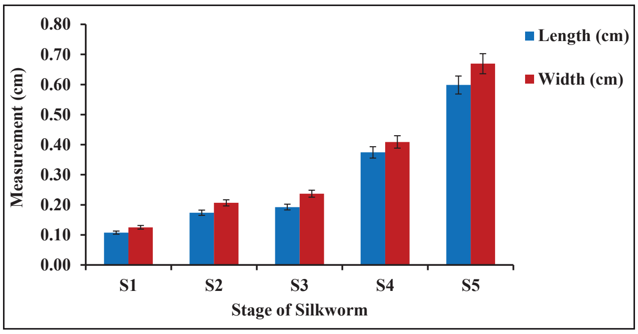


Figure 2: The size of LMC of the Eri silkworm, *Samia cynthia ricini* Boisd.

Size of Labio-Maxillary Complex (LMC)

The LMC measured highest during fifth instar on all hosts regimes, significantly longer and wider on H_2 (0.1007 and 0.1145 cm, respectively) (Table 1). The gain in size was highest during fourth instar on all the hosts, *i.e.*, 95% in length and 73% from previous stage that reduced to 60 and 64%, respectively in length and width of LMC during fifth instar. Unlike mandibles, the rate of growth in size of LMC was least during third instar (11 and 15% respectively in length and width) than fifth instar irrespective of the host (Figure 2).

Size of Labrum

A significantly larger labrum was observed when the worms were fed on H_2, measuring 0.0543 cm in length and 0.0735 cm in width. When the feed was changed to tapioca from castor, the size of labrum differed significantly measuring 0.0887 × 0.1184 cm in size during IV instar against that of H_2 measuring 0.1044 × 0.1312 cm (Table 1). Similar to that of LMC, the gain in size of labrum was maximum during fourth stage increasing 124% and 58% respectively in length and width while least during fifth instar (13% and 30% in length and width, respectively) (Figure 3).

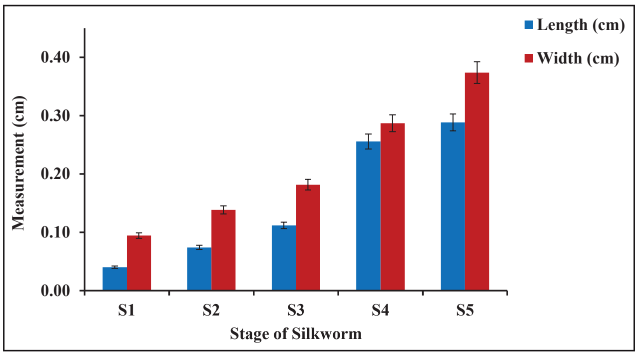
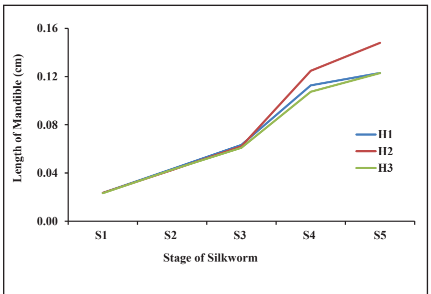
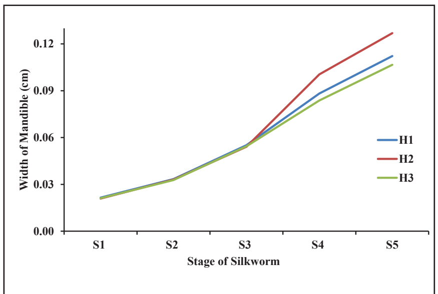


Figure 3: The size of Labrum of the Eri silkworm, *Samia cynthia ricini* Boisd.

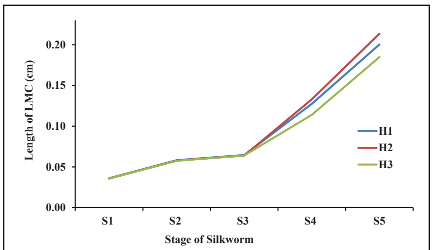
Silkworms scrape the chlorophyll and feed soon after hatching. The mouth parts become large, chitinized and strong enough to bite and chew the leaf lamina as the larval growth advances (Chapman, 1969). The mouthparts increase significantly in their size with the advancement of larval stage in mulberry silkworm (Girish, 1993) as well as Eri silkworm (Ravindranath, 2000). The morphometry of mouthparts of Eri silkworm exhibit an abrupt pattern of growth on all the hosts (Figure 4). The growth of imaginal



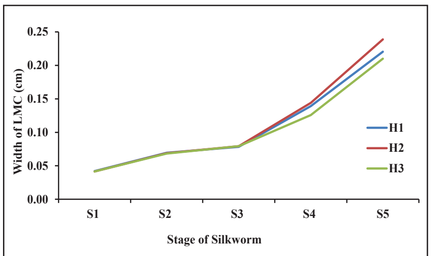
a) Length of Mandible



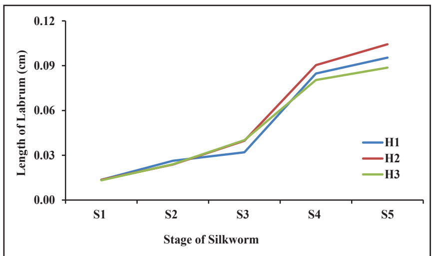
b) Width of Mandible



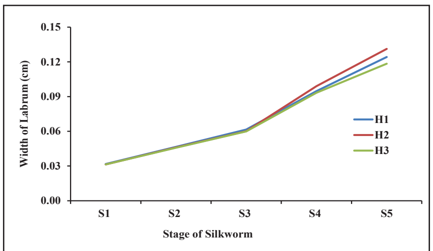
c) Length of Labio-maxillary complex (LMC)



d) Width of LMC



e) Length of Labrum



f) Width of Labrum

Figure 4: Morphometry of mouthparts of eri larva during different stages under different host regimes

structures in the holometabolous insects is abrupt and within essentially a closed system as the animal does not feed during metamorphosis (Huxley, 1932; Louise Roth and Mercer, 2000; Nijhout and Wheeler, 1996). The models of growth involving body parts in competition for resources produced a diverse array of allometric curves with many of the complex features characteristic of holometabolous insects (Klingenberg and Nijhout, 1998; Louise Roth and Mercer, 2000), which is well reflected in the present study also.

The growth pattern varies significantly among different mouthparts irrespective of the host plant. The gain in both length and width LMC is maximum in both fourth and fifth instars while that of Mandibles and labrum shows maximum during fourth instar (Figure 5 & 6). This difference in the growth pattern may be attributed to the reason that the feed rate reduces as the larva starts maturing and stops completely upon metamorphosis into pupa. However, the LMC changes into reduced proboscis, a typical characteristic of silkmoth (Chapman, 1969).

A notable difference in the size of mouthparts was noticed in accordance with the host that could be attributed to the nutritional quality of leaf feed acceptability by the worm. The development of gonads and silkglands gain momentum during later part of third and beginning of fourth instars, which perhaps may stimulate the larva to consume more food. This physiological change might have resulted in sudden increase in the size of mouthparts to increase the surface area for biting and chewing the feed.

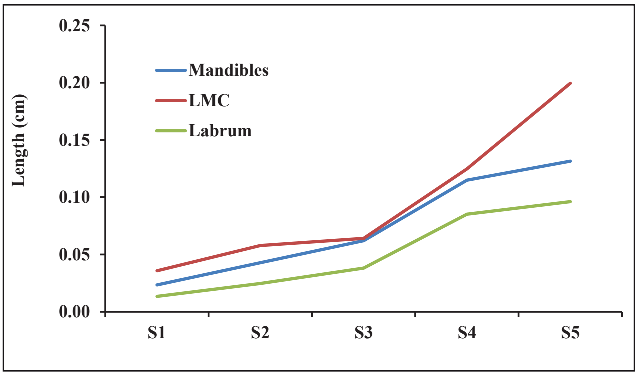


Figure 5: The length of different mouthparts of Eri silkworm, *Samia cynthia ricini* Boisd.

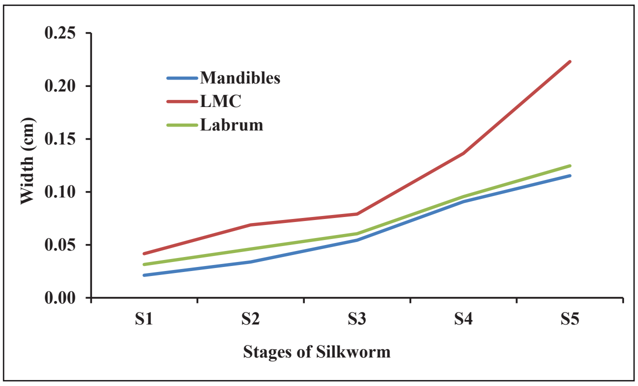


Figure 6: The length of different mouthparts of Eri silkworm, *Samia cynthia ricini* Boisd.

Conclusion

Eri silk is the major non-mulberry silk produced in India. Apart from silk, the pupae are consumed as traditional food in several parts of the country. Thus ericulture provides financial and nutritional security to the farmer and hence the breed improvement of eri is imminent for development of the industry. The morphometry would establish the relationship between morphology and the genetic, developmental and evolutionary processes and factors that influence it (Louise Roth and Mercer, 2000).

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