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# Silk gland Tissue Somatic Index and Silk Quality Traits of Bivoltine and Multivoltine Races of Silkworm, *Bombyx mori* L.

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**An experiment was conducted to assess the silk gland tissue somatic index (SGTSI) of silkworm races and its impact on silk quality parameters. Higher SGTSI of 57.73 per cent was registered in CSR4 among the bivoltine races and 34.24 per cent in AGL3 among multivoltine races studied. SGTSI had positive relationship with the silk gland and silk qualitative traits in different bivoltine and multivoltine silkworm pure races. The denier showed significantly negative correlation with SGTSI.**

**Key words:** *Bombyx mori*, silk gland, tissue somatic index (SGTSI)

The domesticated silkworm, *Bombyx mori* Linnaeus (Lepidoptera: Bombycidae) spins highly valuable and fascinating silk fibre, making it one of the most beneficial insects to mankind, and is an attractive multifunctional material for both textile and non- textile applications (Tsukada *et al.,* 2005). *B. mori* is monophagous which depends and derives nutrients mainly from mulberry leaves for its normal development (Adolkar *et al.,* 2007).

The silk gland growth entirely depends on the nutrients present in the mulberry leaves during the active feeding stage and productivity is linked with the growth and weight of silk gland (Vijayakumar *et al.,* 2008). The growth of silk gland is unique in the sense that the number of cell remains constant throughout the life period but its volume goes on increasing especially in the fifth instar during which the silkworm consumes more than 85 per cent of leaves. The growth of silk gland corresponds to body weight gain and the silk gland tissue somatic index (SGTSI) can be a useful parameter to ascertain the growth and development of silk gland. Vijayakumar *et al.* (2007) showed that SGTSI greatly varied among silkworm races and it was high in productive races and low in less productive races. In this context, an experiment was undertaken to explore the silk gland tissue somatic index and silk quality traits of bivoltine and multivoltine pure races of silkworm.

## Materials and Methods

Disease free layings of different races of *B. mori* (Table 1) were obtained from Central Sericultural Research and Training Institute (CSR&TI), Mysore. Rearing of silkworm was carried out utilizing irrigated mulberry (cv.V-1) as detailed by Krishnaswami (1978). As a prophylactic measure, bed disinfectant was applied to prevent viral, bacterial and fungal diseases immediately after every moult. Mass rearing was taken up upto third moult and one hundred healthy fourth instar larvae were selected per replication. Four replications were maintained for each race. On fifth day of fifth instar, five larvae per replication were randomly picked up and weighed. Silk glands were dissected out with sterilized surgical scissor, and the weight and length were recorded. SGTSI was calculated by dividing the silk gland weight with larval weight and expressed as percentage. Then silk gland was macerated and protein content was estimated (Bradford, 1976). Five cocoons per replication were randomly selected and reeled with euprovette. The quality traits of silk *viz.,* filament length, denier, raw silk and reelability were recorded. The data were subjected to analysis of variance test to find out the significance between the SGTSI and silk quality parameters of bivoltine and multivoltine races of silkworm.

## Results and Discussion

### *Silk gland traits and SGTSI of silkworm races*

The larval and silk gland weights were higher in bivoltine races as compared to multivoltines. Among the bivoltine races tested, significantly highest larval and silkgland weights of 4.08g and 2.08g, respectively were recorded in CSR2 and was followed by NN6D (3.87 g and 2.07 g). The least larval weight was recorded in CSR4 (3.43 g) and least in CSR6 (1.72 g) (Table 2). Among the mutivoltine races studied, NP1 registered the highest larval and silkgland weights of 3.04 g and 1.02g, respectively. The least larval and silkgland weights were observed in Pure Mysore (2.01g and 0.42 g) (Table 3). The study showed that the rate of silk gland weight to larval weight was proportionate to the rate of increase in the larval weight as observed

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**Table 1. Details of silkworm races used for the experiment**

| S.No. | Race | Parentage/ Origin | Larval marking | Cocoon colour and shape |
|---|---|---|---|---|
| A. | Bitivoltine | | | |
| 1. | CSR2 | Shunrei x Shogetsu | Plain larva with bluish white body | Bright white and Oval |
| 2. | CSR4 | (BN18 x BCS25) x NB4D2 | Plain larva with bluish white body | Bright white and Dumbell |
| 3. | CSR6 | Shunrei x Shogetsu | Marked larva with reddish tinge | Dull white and Dumbell |
| 4. | CSR27 | Thaihei x Choan | Plain larva with bluish white body | Bright white and Oval |
| 5. | NN6D | Nan Nung 6 D | Plain larva with bluish white body | Dull white and Elliptical |
| B. | Multivoltine | | | |
| 1. | Pure Mysore | Indigenous to India | Plain larva | Greenish yellow and Spindle with one end pointed |
| 2. | Nistari | Indigenous to India | Marked larva | Golden yellow and Spindle |
| 3. | AGL3 | (Bl68 xBl69)X Nistari | Plain larva | Greenish yellow and Elongated |
| 4. | NP1 | BN18 x BCS25 | Plain larva | Greenish yellow and Spindle |
| 5. | BL67 | BL24 x BL27 | Plain larva | Light greenish yellow and Elongated |

by Koul *et al.,* (1979). One (1957) has reported that weight of silk gland increased by 1,60,000 times and weight of larva increased by 10,000 times which is the characteristic feature of silk gland growth. The present observations were in agreement with the findings of Govindan *et al.* (1990) who explored the variability in weights of larva and silk gland in four bivoltine races and reported higher value in CSR races. Sanjeeva Reddy (2004) also reported higher larval weight of 3.09g in CSR2 and lower larval weight of 1.04g in Pure Mysore.

**Table 2. Silk gland traits and SGTSI of bivoltine races of *B. mori***

| Race | Larval weight \|(g) | Silkgland weight (g) | SGTSI (%) | Silkgland length (cm) | Silkgland Protein content (mg/g) |
|---|---|---|---|---|---|
| CSR2 | 4.08 | 2.08 | 50.98 | 32.00 | 2.82 |
| CSR4 | 3.43 | 1.98 | 57.73 | 26.13 | 2.31 |
| CSR6 | 3.63 | 1.72 | 47.38 | 29.80 | 3.10 |
| CSR27 | 3.67 | 1.74 | 47.41 | 29.20 | 3.89 |
| NN6D | 3.81 | 2.07 | 54.33 | 26.60 | 2.36 |
| S.Ed. | 0.07 | 0.09 | 1.55 | 0.34 | 0.15 |
| C.D. (0.05) | 0.15 | 0.18 | 3.20 | 0.72 | 0.30 |

Among the bivoltines, the SGTSI was maximum in CSR4 (57.73 %). This was followed by NN6D (54. 33 %) which statistically differed from CSR4. The minimum SGTSI was recorded in CSR6 (47.38 %) and CSR27 (47.41 %) (Table 2) . Among the multivoltines, maximum SGTSI was recorded in AGL3 (34.24 %) and NP1 (33.55 %) and both were statistically on par and superior over all other races used in the experiment. The minimum SGTSI was observed in Pure Mysore (20.90 %) (Table 3). Venkataramireddi and Benchmin (1989) reported that bimodal peaks in the larval weight and silkgland weight gain, and SGTSI were parallel with the silkgland weight changes. Studies conducted by Vijayakumar *et al.* (2007) showed that the SGTSI varied among races and was positively correlated with silk productivity. Vijayakumar *et al.* (2009) reported that the SGTSI was the highest in the bivoltine race, NK2 (25.90 %) which was followed by CSR2 (25.30 %).These findings are in accordance with the present observations.

Trager (1935) showed that the increase in cellular and nuclear size results in the growth of larva. In *B. mori,* the number of cells in silk gland is fixed and race specific (One, 1951). The growth of silkgland is through increase in the volume of cells but not through increase in the number. Sakurai and Maruta (1927) observed that the growth of silkgland is at its peak during the later stage of fifth instar particularly fifth day which led to higher SGTSI.

**Table 3. Silk gland traits and SGTSI of multivoltine races of *B. mori***

| Races | Larval weight \|(g) | Silkg land weight (g) | SGTSI (%) | Silkg land length (cm) | Silkgland Protein content (mg/g) |
|---|---|---|---|---|---|
| Pure Mysore | 2.01 | 0.42 | 20.90 | 18.80 | 1.63 |
| Nistari | 2.40 | 0.57 | 23.75 | 24.80 | 2.89 |
| AGL3 | 2.95 | 1.01 | 34.24 | 30.50 | 1.67 |
| NP1 | 3.04 | 1.02 | 33.55 | 29.70 | 1.69 |
| BL67 | 2.89 | 0.74 | 25.60 | 27.00 | 1.28 |
| S.Ed. | 0.12 | 0.06 | 1.40 | 0.28 | 0.08 |
| C.D. (0.05) | 0.26 | 0.12 | 2.95 | 0.59 | 0.17 |

The length of silk gland of bivoltine races was maximum in CSR2 (32 cm) which was statistically superior over other four races. This was followed by CSR6 and CSR27 which were on par (Table 2). The length of silk gland of multivoltine races varied significantly from 18.80 cm (Pure Mysore) to 30.50 cm (AGL3) (Table 3). The observations are in line with the findings of Yang Mingying *et al.* (2000) who showed that the length of silk gland was high in Japanese bivoltine races. Basavaraja (2001) also reported similar results for CSR races.

**Table 4. Silk qualitative traits of bivoltine pure races**

| Race | Filament length (m) | Denier | Raw silk (%) | Reelability (%) |
|---|---|---|---|---|
| CSR2 | 1072.13 | 1.71 | 27.85 | 81.44 |
| CSR4 | 1118.53 | 1.25 | 21.40 | 76.62 |
| CSR6 | 863.72 | 2.27 | 24.60 | 90.98 |
| CSR27 | 1028.53 | 2.20 | 22.43 | 80.95 |
| NN6D | 861.19 | 1.91 | 20.61 | 77.12 |
| S.Ed. | 11.48 | 0.45 | 0.15 | 1.47 |
| C.D. (0.05) | 22.96 | 0.90 | 0.32 | 3.00 |

In case of bivoltine races, the protein content was significantly higher in CSR27 (3.89 mg/ g) and lower in CSR4 (2.31 mg/g) (Table 2), whereas it ranged from 2.89 mg/ g to 1.28 mg/ g with the highest

**Table 5. Silk qualitative traits of multivoltine pure races**

| Race | Filament length (m) | Denier | Raw silk (%) | Reelability (%) |
|---|---|---|---|---|
| Pure Mysore | 306.00 | 2.50 | 8.60 | 73.75 |
| Nistari | 320.35 | 2.25 | 8.25 | 74.25 |
| AGL3 | 652.50 | 1.78 | 9.78 | 68.17 |
| NP1 | 636.19 | 2.24 | 9.43 | 67.43 |
| BL67 | 602.44 | 2.71 | 11.00 | 67.10 |
| S.Ed. | 7.53 | 0.04 | 0.18 | 2.40 |
| C.D. (0.05) | 15.06 | 0.08 | 0.40 | 4.80 |

in, Nistari, in case of multivoltine races (Table 3). According to Prakash *et al.* (1987), food consumption and conversion efficiency in bivoltine was two times more than multivoltine. The quantum of ingesta and digesta had a direct relationship with the growth and silk production in *B. mori* (Takeuchi and Kasaka, 1962). These findings support the present observations.

***Silk qualitative traits***

The results of various qualitative parameters of different bivoltine and multivoltine silkworm races are given in the Tables 4 and 5. Variations in the quality traits of silk produced from different silkworm races were explored in detail by various authors (Jolly *et al.,* 1983; Basavaraja, 2001). Bivoltines generally produce more quality of silk compared to multivoltines. Among the five bivoltine races, significantly the highest filament length of 1118.53 m was recorded in CSR4 which was followed by CSR2 (1072.13 m) and the lowest in NN6D (861.19 m). Among the five mulvoltine races, maximum filament length was registered in AGL3 (652.50 m) which significantly differed from rest of the races. The minimum filament length of 306 m was recorded in Pure Mysore. These observations are in agreement with the reports of Basavaraja (2001) and Dandin *et al.* (2001) who, showed that CSR races exhibited 1100-1200m of single filament length. Sanjeeva Reddy (2004) also observed maximum filament length of 1165.02m in CSR2 and minimum filament length of 306.58m in Pure Mysore.

**Table 6. Correlation between SGTSI and silk quality traits in different silkworm races**

| | Larval weight (g) | Silkgland weight (g) | SGTSI (%) | Silkgland length (cm) | Silkgland Protein (mg/ g) | Filament length (m) | Denier | Raw silk (%) | Reelability (%) |
|---|---|---|---|---|---|---|---|---|---|
| Larval weight (g) | 1.000 | | | | | | | | |
| Silkgland weight (g) | 0.948** | 1.000 | | | | | | | |
| SGTSI (%) | 0.899** | 0.986** | 1.000 | | | | | | |
| Silkgland length (cm) | 0.741* | 0.545 | 0.493 | 1.000 | | | | | |
| Silkgland Protein (mg/ g) | 0.518 | 0.534 | 0.502 | 0.301 | 1.000 | | | | |
| Filament length (m) | 0.917** | 0.939** | 0.937** | 0.618 | 0.484 | 1.000 | | | |
| Denier | -0.506 | -0.667* | -0.734* | -0.327 | -0.193 | -0.654* | 1.000 | | |
| Raw silk (%) | 0.898** | 0.925** | 0.880** | 0.490 | 0.654* | 0.886** | -0.479 | 1.000 | |
| Reelability (%) | 0.558 | 0.618 | 0.584 | 0.204 | 0.776** | 0.508 | -0.180 | 0.806** | 1.000 |

** Correlation is significant at the 0.01 level (2-tailed); * Correlation is significant at the 0.05 level (2-tailed).

Multivoltines and bivoltines exhibited distinct variations with regard to the denier. Among the bivoltines tested, the fine denier of 1.25 was registered in CSR4 and coarse denier was noticed in CSR6 (2.27). Among the multuvoltines tested, minimum denier was noticed in AGL3 (1.78) and maximum was in Pure Mysore (2.50). On the contrary, Dandin *et al.* (2001) reported lesser denier in multivoltine silk filament than in bivoltine silk filament with 1.04 in Pure Mysore and 3.03 in CSR2.

The quantity of raw silk was the highest in CSR2 with 27.85 per cent which was followed by CSR6 (24.60 %) and the lowest in NN6D (20.61 %) among the bivoltines studied. Significantly highest quantity of raw silk of 11 per cent was recorded in BL67 and lowest in Nistari (8.25 %) among the multivoltines studied. Rao *et al.* (2003) reported significant increase in raw silk percentage in newly evolved breeds exhibiting their superiority over the traditional breeds. Dandin *et al*. (2005) recorded 19 to 20 per cent of raw silk in CSR breeds. These findings corroborate with the present observations.

Higher reelability of 90.98 per cent was registered in CSR6 which significantly differed from all other races in case of bivoltines. The reelability ranged from 67.10 to 74.25 per cent with maximum in Nistari and lowest in BL67 in case of multivoltines. Yang Mingying *et al.* (2000) reported that the reelability was high in Japanese bivoltine races. Dandin *et al*. (2005) recorded the reelability of 80 to 85 per cent in CSR hybrids. Present observations are similar to the above findings.

***Correlation between SGTSI and silk qualitative traits***

The SGTSI had positive significant correlation with filament length and raw silk percentage with coefficient of 0.937 and 0.880, respectively. Significantly negative correlation between SGTSI and denier was recorded (-0.734). There was no significant correlation between SGTSI and silkgland length, protein content and reelability. In all the parameters analyzed, the negative correlation coefficient ranged from (-0.180 to -0.734) (Table 6).

The significant variations observed in the phenotypic manifestation of both multivoltines and bivoltines for the characters analyzed can be attributed to the genetic endowments and their degree of response to the environmental conditions to which they were exposed during growth and development. The present study shows that both silkgland weight and larval weight varied with silkworm races. Thus, the silkgland somatic tissue index responds differently to different silkworm pure races and may be controlled by the genetic architecture of the silkworm. The qualitative traits of raw silk such as filament length, raw silk and reelability are having positive correlation with SGTSI. Thus, the SGTSI can be a useful trait in assessing the qualitative parameters of silk.

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