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RESEARCH ARTICLE

COMPARATIVE ANALYSIS OF DEVELOPMENTAL STAGES IN SIX DIFFERENT BIVOLTINE RACES OF BOMBYX MORI

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ABSTRACT

Silkworm gives us silk which is acclaimed as the "*queen of textiles*". Sericulture is the production of silk through rearing of silkworm, an important sector in national economy, provides livelihood opportunities for millions of people who produce and process silk. The silkworm *Bombyx mori* is a completely domesticated insect and has a no. of races viz. univoltine, bivoltine and polyvoltine.

The state of Jammu and Kashmir is known for producing bivoltine silk of international quality. Being one of the traditional agro-based industries of the state producing high quality bivoltine silk comparable to international quality helps in improving the economic conditions of landless farmers and weaker sections of the society and providing employment opportunities during pre- and post cocoon activities. Presently about 25500 rural families generating income worth Rs. 1100 lakhs annually and 1 lakh man days in private reeling sector are associated with this profession. Realizing the importance of sericulture, the genetic diversity of the silkworm should be maintained and analyzed for various traits so that it may help in evolving new locally acclimatized, high yielding superior quality silk producing breeds.

In the present study, six bivoltine races of *B.mori* were reared in sub-tropical conditions of Jammu, assuring the same micro-climate conditions, being fed with same variety of mulberry leaves. The egg, larval, and cocoon characters were analyzed for the differences and similarities that may help in selective breeding.

INTRODUCTION

Sericulture is the production of silk through rearing of silkworm. It is a farm based, labour intensive and commercially attractive economic activity falling under the cottage and small-scale sector. It provides income and employment to the rural poor especially, farmers with small land-holding and marginalized and weaker sections of the society. Most silk moths belong to two families of Lepidoptera, bombycidae and saturniidae, which secrete several varieties of silk fibres. They include domesticated silkworm (*Bombyx mori* L.) and the wild silkworms.

The silkworm *B. mori* was domesticated over 5000 years ago (Nagaraju and Goldsmith, 2002) and is well known for its industrial importance in sericulture (Goldsmith *et al*., 2005). It has a number of varieties viz; univoltine, bivoltine, and polyvoltine. *B.mori* has become a model organism for studying other lepidopteron insects that cause serious agricultural damage and is also an important model for scientific discovery in the areas of microbiology, physiology and genetics.

India has the unique distinction of being a producer of all the five commercially traded varieties of natural silks namely, mulberry, tropical tasar, oak tasar, Eri and Muga. The bulk of the commercial silk produced in the world is mulberry silk that comes from *B. mori* which feeds solely on the leaves of mulberry (*Morus* sp.) plant. (Lee, 1999). India is the second largest producer of raw silk after China and the biggest consumer of raw silk and silk fabrics; currently, the domestic demand for silk considering all varieties is nearly 30,000 MT's of which only 23,679 MT's is getting produced in the country and the rest being imported , mainly from China. Due to bulk of inferior quality multivoltine silk produced in India therefore, it is essential to enlarge the production base and improve current productivity levels of bivoltine silk to meet the international standards and quality demands of the power loom sector. J& K state is known for producing bivoltine silk of international quality. Presently about 25,500 rural families generating income worth Rs. 1100 lakhs annually and 1 lakh man-day's in private reeling sector are associated with it (Ganie *et al*., 2012). However, production of quality bivoltine silk is still a challenge in J & K having enormous potential to produce bivoltine silk of international grade, which can help to reduce the import of bivoltine silk in the country.

A great diversity of *B. mori* exists globally through which several breeds are evolved by selection or cross-breeding. More than 1000 inbred *B. mori* strains maintained worldwide exhibit phenotypic diversity in morphology (Banno *et al*., 1993). These races are utilized by silkworm geneticists to programme crossing and selective breeding. A high level of Heterosis / hybrid vigour for various quantitative characters was found to occur in the crosses of highly inbred lines and geographically divergent populations of silkworm. (Jingade *et al*., 2011; Harada, 1957; Harada, 1961; Krishnaswami *et al*., 1964; Hirobe, 1968; Yokoyama, 1963; Gamo and Hirabayashi, 1983; Nagaraju, 1990).

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Table 1 Temperature and Humidity conditions at various instars of Silkworm life cycle

Instar	Temperature (℃)	Humidity (%)
I	26-28	85-90
II	26-28	85-90
III	24-26	80
IV	24-25	70-75
V	23-24	65-70

with 18 hrs light till pin head stage, at this stage black –boxing was done to ensure maximum hatching on exposure to bright light. The hatched larvae were reared separately under uniform laboratory conditions as described by Yokoyama (1963) and Krishnaswami (1978).During the entire period of research, same micro-climate and feeding conditions were ensured as per the larval stage (Table 1). The whole evolutive period was studied for Egg, Larval and Cocoon characters as follows:

Table 2 Biological characters of eggs of different races

Race	Colour of hibernating eggs	Shape	Average fecundity per moth	Hatching percentage(%)
Jam 2	Granite grey	Ellipsoid	522	93.96
Jam 11	Granite grey	Ellipsoid	416	93.79
Jam 18	Granite grey	Ellipsoid	355	93.83
Jam 21	Granite grey	Ellipsoid	424	93.80
Jam 23	Granite grey	Ellipsoid	432	94.02
Jam 27	Granite grey	Ellipsoid	471	94.17

Table 3 Biological characters of larvae of different races

Race	Total larval duration(days)	V age larval duration(days)	Larval colour Vage 5 day	Larval marking(V age)
Jam 2	24.33	5.21	Marble grey	Semi-plain
Jam 11	24.04	6.35	Steel grey	Marked
Jam 18	26.16	6.62	Marble grey	Marked
Jam 21	24.16	5.41	Ivory white	Marked
Jam 23	24.04	6.28	Steel grey	Marked
Jam 27	23.22	5.00	Marble grey	Marked

Table 4 Length of different races of V instar larvae from Day 1 to Day 5 in cm (Mean±S.D)

	Jam 2	Jam 11	Jam 18	Jam 21	Jam 23	Jam 27
Day 1	5.00±0.31	4.73±0.43	5.10±0.43	5.27±0.45	5.22±0.36	5.02±0.35
Day 2	5.40±0.24	5.43±0.36	5.67±0.37	5.71±0.28	5.73±0.27	5.51±0.30
Day 3	6.07±0.33	6.15±0.32	6.25±0.28	6.23±0.22	6.12±0.25	6.04±0.28
Day 4	6.54±0.28	6.49±0.34	6.68±0.36	6.60±0.24	6.59±0.25	6.46±0.49
Day 5	6.66±0.27	6.67±0.32	6.83±0.32	6.76±0.25	6.78±0.27	6.86±0.20

Table 5 Weight of different races of V instar larvae from Day 1 to Day 5 in g (Mean±S.D)

	Jam 2	Jam 11	Jam 18	Jam 21	Jam 23	Jam 27
Day 1	1.287±0.16	1.503±0.33	1.538±0.23	1.834±0.39	1.450±0.21	1.307±0.22
Day 2	1.778±0.27	2.100±0.53	2.252±0.35	2.540±0.46	2.078±0.22	1.944±0.30
Day 3	2.458±0.32	2.770±0.51	2.743±0.37	3.032±0.45	2.63±0.21	2.605±0.37
Day 4	3.430±0.63	3.748±0.37	4.280±0.51	4.170±0.47	3.602±0.40	4.275±0.51
Day 5	3.751±0.45	4.108±0.33	4.510±0.50	4.507±0.52	3.910±0.41	4.685±0.55

Table 6 Correlation studies of increase in length and weight gain in day 1 to day 5 of V instar larvae of different races

	Jam 2	Jam 11	Jam 18	Jam 21	Jam 23	Jam 27
Correlation coefficient(r)	0.9865	0.9681	0.9652	0.9806	0.9744	0.9939

Table 7 Biological characters of cocoon of different races

Breed	Shape	Colour	Grain
Jam 2	Peanut	White	Coarse
Jam 11	Peanut	White	Medium
Jam 18	Peanut	White	Coarse
Jam 21	Constricted	White	Medium
Jam 23	Peanut	White	Medium
Jam 27	Peanut	White	Coarse

In the present study, six bivoltine races evolved in Jammu were assessed for the phenotypic diversity at Egg, Larval, and cocoon level. Correlation studies of increase in length and weight gain during V instar was also carried out so that it may help in evolving new locally acclimatized, high yielding superior quality silk producing breeds.

MATERIAL AND METHODS

The study was conducted in Regional Sericulture Research Station, MiranSahib (RSRS, Miran Sahib) and Department of Zoology, University of Jammu simultaneously during Feb-Apr 2013. For the present study, two disease free layings (DFL's) each of six races (Jam 2, Jam 11, Jam 18, Jam 2, Jam 23, Jam 27) evolved in Jammu were obtained from RSRS, MiranSahib, Jammu and incubated for 9-12 days in a neat and clean, disinfected room at 80-85 % Humidity and 24-25ºC Temperature

At egg stage: egg shape, egg colour, hatching percentage and average fecundity per female moth were studied.

At larval stage: larval colour, markings, mean length and mean weight of 10 larvae on each day of V instar were studied and analyzed. Correlation of larval length and weight was done and changes in length and weight of larvae of different races were compared.

The statistical analysis was done with the help of software PRIMER. Length of larvae was measured with the help of vernier calipers and weight of larvae was measured with electronic balance.

At cocoon stage: cocoon shape, cocoon colour and cocoon grain were noted.

RESULTS AND DISCUSSION

Egg Stage: Analyzing the biological parameters of eggs, colour and shape of eggs of different races being same, the highest average fecundity per moth was 522 in Jam 2 and lowest was 355 in Jam 18. The lowest hatching percent (93.79%) was obtained in Jam 11 race and the highest (94.17%) was obtained in Jam 27 race, with a mean of 93.92% in all studied races. (Table 2).

Larval stage: The biological characters of larval stages were recorded as given (Table 3). Under ideal conditions it has been reported that the total larval duration is 25-30 days (Raina, 2000). The total larval duration in the studied races was 23-27 days with maximum in Jam 18 (26.16 days) and minimum in Jam 27 (23.22days). The V age larval duration was also maximum in Jam 18 (6.62 days) and minimum in Jam 27 (5 days). The V age 5 day larval colour was steel grey and marble grey in all except in Jam 21 which was ivory white in colour. All the larvae were marked with semi-plain in Jam 2. Measurements performed for the determination of length and weight of 10 larvae, were done at each day of V instar larvae at 11:00 a.m. for five days before cocooning (Table 4 and Table 5). The length of each race was correlated with the weight on each day. The results obtained show high homogeneity in different races with highest correlation coefficient in Jam 27 (0.9939) and lowest in Jam 18 (0.9652) (Table6).

Cocoon stage: Of these few phenotypic characters studied, all the races have peanut shaped cocoons except Jam 21 having constricted shape, cocoon colour being white as of bivoltine races and cocoon grain medium to coarse (Table 7).

Varietal differences for studied traits in *B.mori* has been reported by Ahsan *et al*., 2000, Li *et al*., 2001; Furdui *et al*., 2010. Similar studies on varietal diversity have also been sustained by the findings of Reza *et al*.,1993, Mistri and Jayaswal, 1992; Ahsan *et al*.,1999; Umashankara and Subramanya, 2002; Nezhad *et al*., 2009; Nguku *et al*., 2007; Nguku *et al*., 2009; Zannata *et al*., 2009; Pal and Moorthy 2011).

CONCLUSION

The obtained data showed that there are highly significant differences among the races for all the studied characters. There is a high positive correlation between larval length and weight during V instar. The differences in obtained results are due to the variability and genotype characters for each individual of every race.

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