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A comparative study on rearing performances of three breeds of mulberry silkworm, *Bombyx mori* in Sujapur, malda, West Bengal, India in the Spring season

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Abstract
Establishing mulberry sericulture as a potential substitute for boosting the agro-based economy holds high promise for the rural people in Sujapur, Malda district of West Bengal, India. The present study was aimed to assess the commercial rearing traits such as larval duration, larval weight, cocoon weight, shell weight and larval size in addition to the common barometrical data *viz*., ambient temperature (24℃), relative humidity (49%) and photoperiod (11.20:12.40) of three mostly reared breeds of silkworms in this area *viz*., nistari, SK6×SK7 and F1 (hybrid obtained by crossing nistari and SK6×SK7) in the spring season (February to April, 2022). F1 breed showed significantly greater variation in all parameters studied i.e., larval duration (24.67±0.88), larval weight (33±3.21), cocoon weight (1.63±0.07), shell weight (0.31±0.0058) and larval size (6.10±0.06). Pooled data with respect to different breeds were analyzed statistically resulting in significant variations among the breeds for all the parameters studied. This study documented the suitability of the F1 variety in Sujapur, Malda location for cultivation in Spring and the potentiality for a hybrid program also. SK6×SK7 also could be a promising breed but local unavailability and rearing problems hindered to flourish of the breed.

Keywords: Commercial rearing traits, agro-based economy, spring season, mulberry sericulture

Introduction

Sericulture (derived from Greek word ‘sericos’ = silk), a unique farm-base, labour-intensive (Roy *et al*.), rural cottage industry denotes the practice of growing silkworms for the production of silk as well as the science underpinning industrial application (Yokoyama). The history behind the silk was first reported in 2200 BC in China; Empress XI Ling Shi discovered the process of silk extraction when one cocoon dropped accidentally into her tea bowl. The silk-making process was kept secret by the Chinese for about 2000 years (Goldsmith *et al*.) but they lost their monopoly on making silk as it was disclosed to Korean and Japanese through Chinese immigrants and later on to Tibet and India (140 A.D) (Cherry). In 139 B.C., the spreading of sericulture occurred to Europe and Western countries through Silk Road, the longest highway in the world, connecting the Mediterranean Sea with Eastern China crossed via Central Asia, Northern India, Persian and Roman Empires. Silk is known as the "Queen of Textiles" because of its gleaming brilliance, softness, elegance, durability and tensile characteristics besides its eminent features like resistance to heat, water absorbency, superior dyeing efficiency and luminance. It is a fibrous protein obtained from spittle of solely arthropodan animals; classes like insecta, arachnida and myriapoda are considered as silk producing organism (Taufique). Arthropods produce silk for protective shelter (Lepidoptera produce cocoon), anchorage (mussels), capturing the prey (spiders; arachnids by forming aerial net), foraging (Trichoptera by forming underwater net), dispersal (lepidopteran moth and spiders), reproduction (Thysanoptera, spiders) and structural support (silk egg stalk of neuropteran) (Craig). Seri-biodiversity is the term that means the variety of sericigenous insects and their host plants (Yokoyama). The raw silk of commercial importance is obtained only from 5 types of sericigenous lepidopteran moths like *Antheraea mylitta* (Drury), *Antheraea yamamai* (Guérin-Meneville), *Philosamiacynthia ricini* (Boisduval), *Bombyx mori* (Linnaeus), etc (Yokoyama), in these *B. mori* is mostly cultivated and its breeding process is mightily developed.

India has an illustrious tradition of manufacturing silk with 9.1M people during FY19 were employed in over 52360 villages during FY19 according to Indian Central Silk Board (*CSB » Central Silk Board*). India is successfully ranked second in the world of output in silk production behind only China. In India, sericulture has historically been practiced in areas with tropical climates, like Tamil Nadu, Karnataka, West Bengal and Andhra Pradesh, as well as to a little part of Jammu and Kashmir, a region with a temperate climate. Export of silk and silk byproducts from India reached US$ 291.36M in 2018-2019 and US$ 243.52M in FY 2020 (till Dec 2019). In India, Karnataka is the highest silk-originating state (8483 MTon) next to Andhra Pradesh (5520MTon) and Tamil Nadu (1206MTon). Ramanagara district in Karnataka is the largest cocoon market in India. West Bengal has its eighth (298 MTon) position in FY 2021 (*Vikaspedia Domains*). West Bengal serves a crucial role in the country due to its suitable climatic conditions for bivoltine silk production which is considered to be one of the major sectors of the Silk Industry of India although its output is still falling short of domestic objectives. In contrast to the tropics, temperate sericulture requires the creation wide range of silkworm breeds with genetic adaptability to cushion harsh environments.

Environmental conditions, particularly air temperature and atmospheric relative humidity act as a chief function in the lifecycle of silkworms (Sisodia and Gaherwal) which is consistent with mulberry sericulture exploration in West Bengal. Late autumn is the best season for silkworm raising, as it is comparable to neighboring regions where sericulture is practiced. Early spring (February to April) can also be used as the second commercial crop-rearing season (Chatterjee and Ray). Thus, it's a matter of concern how to relate the season-wise attainment of silkworm breeds to accomplish the need for products prior to developing any breeding program suitable for the particular season of various silkworm breeds.

Hence, we aimed for

1. Studying important rearing parameters like shell weight, larval weight, larval duration, cocoon weight and larval size of 3 common breeds *viz*., multivoltine nistari, two bivoltine - SK6×SK7 and F1(obtained by crossing nistari and SK6×SK7) in Sujapur.
2. Comparative analysis of three breeds in the Spring season.
3. Choosing the suitable breed at Sujapur.

Materials and methods

1. Location of the study area

Sujapur is in the Malda district of West Bengal at 24.930°N 88.110°E. It is located on the western bank of the river Bhagirathi (old), 17 meters above sea level on average. The weather is typically humid and tropical, as it is in much of Bengal. Temperatures can reach 46 °C during the day in May and June and drop to 4 °C overnight in December and January ("Sujapur, Malda").

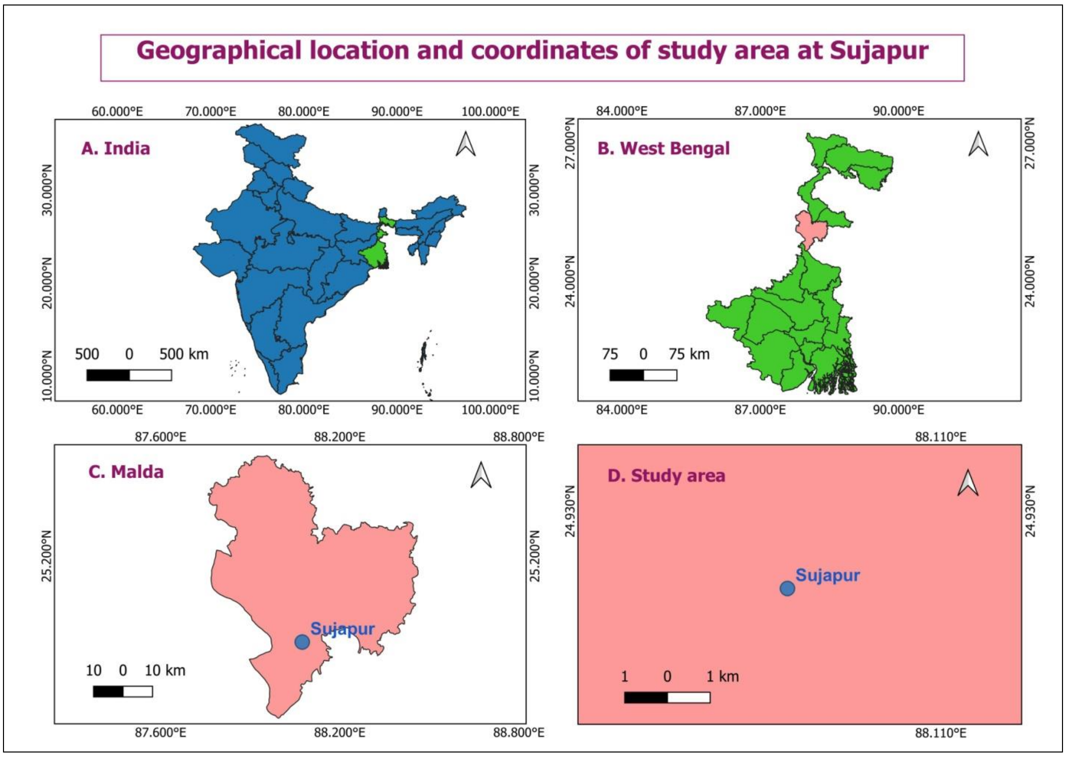

Fig 1: Location of the study area

2. Experiment designing

In the present study, we evaluated the rearing performance of three mulberry breeds of the silkworm, *Bombyx mori*, mostly used in West Bengal for three months (February to April, 2022) in the spring season. These are one multivoltine breed- Nistari, bivoltine (SK6×SK7) and F1 hybrid that is obtained by crossing Nistari and SK6×SK7. The disease-free layings (DFLS) i.e, the larvae to be raised should be disease-free were collected from the local government farm from Kaliachak. They were then put in chandraki and fed with Mandalayan mulberry leaves twice a day. The raising room was painted white and sulfur dioxide gas was fumigated. The incubator, stands, breeding trays, and all other equipment were cleaned with a 2% solution of formaldehyde. Cleanliness and hygiene were maintained throughout the work period. To prevent the mixing of breeds, wax paper was placed around each egg laid on a card two days prior to the anticipated hatching date. After hatching, each breed's larvae were given a brushing with a feather before being placed on a general tray. Each rearing tray was filled with damp newspaper and covered with a plastic sheet to maintain humidity before brushing.

3. Data collection

The metrological data like temperature, humidity, photoperiod and monthly rainfall were recorded at the location using online weather data providers. Data were recorded of the following rearing parameters-

1. Larval duration (days) by counting days from the day the larva hatches out from the egg to the day it enters to cocoon;
2. Larval weight (g) which was calculated by weighing ten randomly selected larvae of the fourth to the sixth day of the final instar by using an electronic balance;
3. Weight of cocoon (g) by randomly pricking ten cocoons (5 male + 5 female cocoons) on the 7th day of spinning and making an average;
4. Larval size (cm) by measuring their length with a normal scale or tape at the end of the last instar larval of randomly selected five larvae
5. Shell weight (g) by weighing 10 randomly selected cocoon single shells and making the average. Another method of measuring shell weight is the weight of the cocoon with pupa minus the weight of the cocoon without pupa.

4. Statistical analysis

Data were collected, assembled, and analyzed through One-Way-ANOVA ($p<0.005$) in MS Excel.

Results and discussion

This study comprises three breeds of silkworm *B. mori* comparing their rearing performances on commercial parameters like larval weight, larval duration, size of larva, cocoon weight and weight of single cocoon shell. Food quality and quantity exhibit a huge effect on rearing performances; hence all of them were fed a single variety of mulberry leaves, all three breeds indicated significant variations in all parameters studied ($p<0.05$), which means they show different responses depending upon environmental condition.

1. Climate condition

Temperature and photoperiod play vital roles in the rearing performance of silkworms (Yokoyama *et al*. 2001). The factors which are responsible for influencing the physiological processes of insects are air temperature and relative humidity (Rahmathulla). The factors which are responsible for influencing the body physiology of insects mostly are air temperature and relative humidity. That's why the adaptation capacity of silkworms in environmental conditions is very different from wild silkworms as well as other various types of insect species. The growth and productivity of silkworms and the quality of silk thread depend on the combined interaction of different environmental factors like temperature, light, air circulation, humidity, gases and the physiology of silkworms (Yokoyama *et al*.). Among these different types of abiotic factors, temperature of the environment acts as a pivotal role in the growth and silk thread production efficiency of silkworms. Low temperature prolonged the larval duration and cocoon weight and it shortens in high temperature (Benchamin and Jolly). High temperature also decreases the feeding quality of larvae. These two parameters were recorded throughout the study period. According to Kumari *et al*. 2001; Sugnana Kumari *et al*. 2011,) [12, 23] a decrease in survival rate with increasing temperature supports that high temperature does not support productivity. During the Spring average temperature was 24℃. The photoperiod was almost (1:1) during the whole study period. Relative humidity also has an important role in the lifecycle of silkworms (Hussain *et al*.). Relative humidity was 49% during the study period which is lower than normal. Temperature, relative humidity and photoperiod were found significantly correlated with each other (Chatterjee and Ray).

Table 1: Meteorological data

Seasons	Temperature (℃)	Relative humidity	Photoperiod	
			Light	Dark
Spring	24℃	49%	11.20	12.40

Table 2: Commercial rearing parameters

	Nistari	SK6×SK7	F1
Larval duration(d)	22±0.58a	24.33±0.33b	24.67±0.88b
Larval weight (g)	23±0.58a	27.33±0.88b	33±3.21c
Cocoon weight (g)	0.89±0.02a	1.62±0.03b	1.63±0.07b
Shell weight (cm)	0.12±0.0088a	0.28±0.0088b	0.31±0.0058c
Larval size (cm)	5.47±0.18a	6.07±0.07b	6.10±0.06b

Data are shown as means SE (n=3), values with different superscripts in the same row are significantly different ($p<0.05$).

2. Larval duration

Insects must rely on nature for their survival and development, their biological and developmental processes are limited by the current ecological actions and rather by their genetic construct (Buhroo). Larval duration is the period calculated as the days taken from puffing to the mounting of ripe worms. This character is regarded as an influential budgetary value aspect in sericulture since it not only helps to reduce the amount of food consumed by the insect but also helps to complete the larval period in a desirable period, hence reducing labor requirements. (Rahmathulla and Suresh). The shorter larval duration of a breed fairly represents its genetic variation for this trait and differs from other breeds. The development of breeds depends on both environmental and genetic factors (Rayar). Depending on the current temperature, the larval duration changes. High ambient temperatures in the summer tend to shorten the larval life span by a few hours to two days, whereas little lower temperatures in the spring and fall lengthen the larval life span. (Daniel *et al*.). In this study, nistari shows the least and F1 shows significantly ($p<0.05$) the highest larval duration among these three. Bivoltines showed better performance than multivoltine.

3. Larval weight

The current study also found a considerable fluctuation in the larval weight among breeds over the spring. Larval weight is a crucial characteristic feature that is responsible to influence both the larvae's well-being and the standard of the produced cocoon spun (Nguku *et al*.). The differences in the weight of larvae among the breeds which have been studied are due to the differences in races and the amount and quality of diets taken by the larvae and the degree of assimilation between breeds and all of these factors directly influence the larval growth and development (Buhroo). This study shows the difference from the previous study (Chatterjee and Ray) in dealing with the larval weight; which claims the highest weight in the case of F1 followed by SK6×SK7 and nistari. Higher larval weight obtained in this season in the present study assures that studied silkworms have good genetic make-up and hence potential to be used in breeding programs in this locality.

4. Larval size

The three races of *B. mori* displayed convincing diversity in the full-grown larval mean size (cm). The maximum size of full-grown larvae on average was 6.1 cm was recorded in the F1 race, while a minimum of 5.4 cm was in the nistari race. The mean size of full-grown larvae differed significantly between the three breeds of *B. mori*, indicating that they responded differently to identical environmental conditions and with the same diet. (Ahmad 1987) discovered that the mean size of full-grown *B. mori* larvae was 80-60 mm for bivoltine races and for multivoltine races it becomes 70-53 mm.

5. Cocoon weight

Cocoon weight, the weight of the shell and shell ratio have been reported as particularly transmitted and familial attributes that have a substantial role to figure out the reeling quality, quantity and efficiency. Cocoon weight is a significant commercial attribute that is used to estimate the amount of raw silk that can be looped. (Rahmathulla; Singh and Kour). Unlike the previous study (Chatterjee and Ray) present study showed F1 has the significantly highest cocoon weight (1.63g) than the other two having a large difference with nistari (0.89g). (Sharma *et al*.) concluded that environmental conditions negatively affect economic features like the weight of the shell and the weight of the cocoon in addition to the physiology of insects. Winter, spring, autumn and rainy seasons had the highest weight of single shell cocoon weight and weight of the cocoon shell, and shell ratio, as well as ultimate production silk production, while summer crops saw the lowest in the case of *Phylosamia ricini* (Kar *et al*.).

6. Shell weight

Cocoon weight, which is generally heavily emphasized in selection procedures, has a favorable association with shell weight (Petkov; Singh *et al*.). In sericulture, cocoon weight and cocoon shell weight are considered as major productive traits. (Gaviria *et al*.; Nguku *et al*.; Zanatta *et al*.). Silk weight can also be determined by cocoon shell weight. During the spring, the mean single cocoon weight was found to be substantially larger in the case of F1 (0.31g) followed by SK6×SK7 (0.28g) and nistari (0.12g). (Masarat *et al*. 2014) have also revealed that increased shell ratio and cocoon shell weight in any breed suggest that the breed is more adaptable to specific seasonal conditions.

Conclusion

Absolute silk content and yield are the main concern for the farmers. It could be higher if the length and weight of the worm become high. It has been observed that the F1 breed showed the highest results in all the parameters studied in this season than the other two. So it could be used in any breeding program in this locality or may use in hybrid production. Performances of other seasons should be examined in that case. SK6 x SK7 is not far behind. It also competed with F1 with a very small gap. SK6 x SK7 also could be a suitable breed to cultivate in this area but local availability, disease, lack of knowledge in rearing and above all the apathy regarding this breed hindered cultivation in the Sujapur area.

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Conflict of interest: none

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