***Original Research Article***

**Seasonal Performance, Correlation and Heritability Analysis in Some of the Characters of Nistari Lines of West Bengal, India**

**Abstract:**

Mulberry sericulture is one of the important agro industries of West Bengal. Nistari, the multivoltine race, plays an important role in Mulberry sericulture of West Bengal. Nistari Marked and Plain lines are exploited as parental components in developing crossbreeds and Multi x Multi hybrids. The present study has attempted to record the economic traits of the Nistari lines in different seasons and also to evaluate the correlation and heritability study, which will be helpful for future breeding programmes. The study was conducted during 2024-25 at CSRTI, Berhampore, West Bengal, India. Three replications were retained with 300 larvae in each replication. Pupation rate was calculated for all the replications by shaking each cocoon gently for a live pupal sound. Correlation and heritability were calculated using the statistical software/tool called D X D STATFIELD. A dramatic difference in the economic traits like cocoon weight, shell weight, and filament length was not observed; different values of the economic traits in favourable and unfavourable seasons could be observed in the study. There exists an interrelationship among different traits of the silkworm, which is calculated as a correlation. Positive correlations were observed between Cocoon weight vs Cocoon shell weight, Cocoon shell weight Vs Cocoon shell ratio, Cocoon weight vs Filament length. Negative correlation was observed between Cocoon weight Vs Cocoon shell ratio. Estimation of the heritability of traits in silkworms is useful for breeding purposes. High heritability was detected in the economic traits under study. The findings of the study in Nistari lines will be helpful for future breeding and improvement programmes.

**Keywords:** Nistari lines, correlation, heritability, economic traits, sericulture

1. **INTRODUCTION:**

The sericulture industry supports jobs, economic development and begins with the cultivation of mulberry trees with their manifold uses, including the production of leaves as food for silkworms (Altman and Farrell, 2022). Mulberry sericulture, which is an agro-industry, is based on the rearing of the silkworm. Silkworm (*Bombyx mori* L.) is an economic insect reared mainly for its economic traits. It is mainly reared for silk, “the queen of natural fibres”. Over time, this industry has promoted cultural exchange and stimulated the economic growth of different countries. India, with its long past, has become a leader in silkworm farming, cultivating a legacy that spans millennia and is still deeply rooted in its cultural heritage (Naphade et al., 2023; Sujatha et al., 2024). Compared with its wild relatives, long-term artificial breeding and selection have resulted in a high cocoon yield of the domestic silkworm (Xia *et al.,* 2009). The domesticated silkworms are diversified into different evolved breeds and geographical races. The evolved breeds have more pronounced economic traits than the native races, although the native races are known for sturdiness. Native breeds have low production potential in comparison to commercial lines. However, native breeds have high resistance and rare genes that can be used to increase resistance to disease and unfavourable environmental conditions in future breeding programs (Mirhosseini *et al.,* 2010). Though silk accounts for less than 0.2% of the world's textile market (it is difficult to determine the exact worldwide value since most importing countries lack reliable data on completed silk products), the world's production base for silk is distributed across 60 countries (Islam, 2024).

In West Bengal, sericulture is practised since long time in districts like, Malda (Haufique and Hoque, 2018) and Murshidabad in large scale and it creates remunerative employment generation capacity (Chandan Roy *et al.,* 2012). The climatic conditions of the region are broadly classified into favourable and unfavourable seasons based on silkworm rearing. The unfavourable seasons are characterised by high temperature and high humidity. The favourable seasons are amiable for silkworm rearing. Rearing of productive silkworm breed and hybrids is restricted due to a highly variable climatic situation, which causes poor larval growth, moulting disorder, high mortality due to diseases and low cocoon yield (Mukhopadhyay *et al.,* 2013).

Nistari is a multivoltine native race which is broadly classified into Marked lines and the Plain lines based on the larval markings. Nistari Plain lines and Marked lines produced golden yellow colour cocoons. Nistari is recognised for its robustness in terms of disease tolerance, tolerance to high temperature and high humidity. According to a local sericulturist, the name “Nistari” comes from the word “Saviour” as it saves the silk industry due to its high resistance to disease and tolerance to high humidity and temperature. Hence, the mulberry sericulture in West Bengal is dominated by Nistari and its crossbreeds. Nistari is being exploited as a parental breed in evolving many silkworm breeds and for the preparation of Multi x Multi and Multi x Bi Dfls.

The performance of the economic traits of Nistari Marked and Plain lines varies according to favourable and unfavourable seasons. Differences in the performance of the Nistari lines can be seen in the same season, too. Both the Nistari lines show degradation in the economic characters, and improvement programmes of the economic traits were conducted (Devi *et al*., 2024). Silkworm breeders have uncovered that some characters or aspects of them affect other characters (Nagaraju J., 2002), which means an economic trait can change as other traits change, which is termed as correlation. Characters showing high heritability as well as high genetic advance respond better to simple phenotypic selection, while those having low heritability and low genetic advance may respond better to mass selection (Singh *et al*., 2011). So there arises a need to determine the correlation and heritability test for improvement and selection processes. The present study has attempted to record the economic traits of the Nistari lines in different seasons and also to evaluate the correlation and heritability study, which will be helpful for future breeding programmes.

**2. MATERIAL AND METHODOLOGY:**

The rearing and mounting of mature larvae were conducted as per the standard rearing procedure by Krishnaswamy (1978). The study was conducted during 2024-25 at CSRTI, Berhampore, West Bengal, India. Hygienic conditions were maintained during the young and late age rearing. Three replications were retained with 300 larvae in each replication. After harvesting, selection was conducted as per the racial characters like cocoon shape, uniform colour, moderate grains and build. Pupation rate was calculated for all the replications by shaking each cocoon gently for a live pupal sound. 25 cocoons each for male and female were subjected to cocoon assessment for cocoon weight, cocoon shell weight and cocoon shell ratio by using an electronic balance. The filament length of the Nistari, Marked and Plain lines was evaluated by cold reeling as described in Devi *et al*., 2024. Correlation and heritability were calculated using the statistical software/tool called D X D STATFIELD developed by Dr. D. S. Dhakre & Prof. D. Bhattacharya, Department of Agricultural Statistics, Visva-Bharati, Santiniketan (<https://dsdhakre.in/des_stat.html>).

**3. RESULT AND DISCUSSION**

**3.1 Rearing performance of Nistari lines:**

The rearing performances of some of the economic traits (cocoon weight, shell weight, filament length) of the Nistari lines Marked and Plain were evaluated in two unfavourable (May-June, July-August) seasons and three favourable seasons (February-March, October-November, December-January). It could be observed that the mean values of the economic traits, cocoon weight, shell weight, and filament length performed well in favourable seasons compared with the unfavourable seasons, in both the Nistari lines (Tables 1 & 2). The survival percentage of both the Nistari lines was above 95% in both the unfavourable and favourable seasons.

Table 1: Mean values of some of the economic traits of Nistari Marked lines in different seasons. The filament length was estimated by mono cold reeling

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seasons | CW  (g) | CSW  (g) | SR% | FL  (m) |
| Feb-Mar | 1.192 | 0.190 | 15.940 | 435 |
| May June | 1.162 | 0.170 | 14.630 | 409 |
| July-Aug | 1.169 | 0.168 | 14.370 | 405 |
| Oct-Nov | 1.220 | 0.181 | 14.840 | 411 |
| Dec-Jan | 1.196 | 0.188 | 15.719 | 416 |

.

\*\*CW-Cocoon weight; CSW- Cocoon shell weight; SR%-Cocoon shell ratio; FL- Filament length

Table 2: Mean values of some of the economic traits of the Nistari Plain line in different seasons. The filament length was estimated by mono cold reeling.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Seasons | CW  (g) | CSW  (g) | SR% | FL  (m) |
| Feb-Mar | 1.197 | 0.177 | 14.790 | 437 |
| May June | 1.178 | 0.168 | 14.261 | 407 |
| July-Aug | 1.170 | 0.162 | 13.850 | 394 |
| Oct-Nov | 1.263 | 0.175 | 13.855 | 417 |
| Dec-Jan | 1.180 | 0.177 | 15.000 | 435 |

\*\*CW-Cocoon weight; CSW- Cocoon shell weight; SR%-Cocoon shell ratio; FL- Filament length.

Improved economic traits like cocoon weight, shell weight, cocoon shell ratio, and filament length are among the factors for a successful silkworm crop. The seasonal differences in the environmental components considerably affect the genotypic expression in the form of phenotypic output of the silkworm crop, such as cocoon weight, shell weight, and cocoon shell ratio (Rahmathulla VK, 2012). Nistari lines, one of the parental breeds of Multi x Multi and Multi x Bi, which dominate the mulberry sericulture in West Bengal, also face a similar fate. During the period under study, the economic traits like cocoon weight, cocoon shell weight, and filament length were comparatively lower in the unfavourable seasons than the favourable seasons.

**3.2 Estimation of correlation of economic traits:**

The correlation between the economic traits under study was evaluated (Table 3). Significant positive correlations were observed between CW-CSW, CSW-SR%, and CW-FL. Negative correlation was observed between CW-SR%.

Table 3. Correlation coefficient among the economic traits under study.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Nistari Line | CW-CSW | CW-SR% | SW-SR% | CW-FL |
| Marked | .420\*\* | -.258\*\* | .767\*\* | .297\*\* |
| Plain | .690\*\* | -.458\*\* | .326\*\* | .358\*\* |

\*\*CW-Cocoon weight; CSW- Cocoon shell weight; SR%-Cocoon shell ratio; FL- Filament length

As described by Nagaraju 2002, there exists an interrelationship between characters in the silkworm, which is termed as correlations. In the silkworm, the correlation between many traits has been worked out. In the present study, correlation analysis of Nistari lines has been evaluated. Positive correlations were observed between cocoon weight and cocoon shell weight, cocoon weight and filament length, and cocoon shell weight and cocoon shell ratio. Negative correlation could be observed between cocoon weight and cocoon shell ratio. The correlation study in Nistari lines is crucial from a breeder’s point, for improvement studies/programmes of economic traits, as excessive exploitation, inbreeding depression and fluctuating climatic conditions have deteriorated the economic traits.

**3.3 Analysis of Heritability of Economic Traits**

Heritability analysis was conducted for the economic traits like cocoon weight, shell weight and filament length (Table 4). In Nistari, Marked lines heritability was highest for cocoon shell weight, followed by cocoon weight and filament length. In Nistari Plain, line heritability was highest for cocoon weight and lowest for filament length.

Table 4. Heritability analysis of three economic traits in Nistari Marked & Plain lines

|  |  |  |  |
| --- | --- | --- | --- |
| Nistari Line | Cocoon Weight | Cocoon Shell Weight | Filament Length |
| Marked | 84.68% | 92.78% | 79.28% |
| Plain | 87.11% | 98.04% | 85.54% |

Improvement programmes of economic traits of silkworm breeds and races are vital for improving sericulture. Heritability of quantitative traits plays a very vital role in the selection strategies (Singh *et al.,* 2011). The characters with low values of heritability are of little importance in selection strategies because most variations are non-transmissible (Singh *et al.,* 2011). Characters with high heritability as well as high genetic advancement indicate possible operation of additive gene action and hence respond better to simple phenotypic selection than those having low heritability and low genetic advancement (Narasimharaju *et al.,* 1990). Heritability is also useful in predicting the outcome of artificial selection among the clones, inbred lines, and varieties, besides the production of superior genotypes (Singh 2004; Seidavi 2009). Selection is an important tool employed in silkworm breeding. The information on heritability plays a crucial role in the selection process, thereby acting as a player in silkworm breeding programmes. The estimation of the heritability of important economic traits is regarded as one of the quickest means to get an insight into the depth of gene-environment interactions. The genetic mechanism involved in the expression of various traits in *Bombyx mori* pure races and hybrids has been studied through heritability studies by several workers (Giridhar *et al*., 1995; Narasimharaju, 1990; Gamo, 1983; Sen, 1976). In the present study, the heritability of economic traits: cocoon weight, shell weight, and filament length has been estimated in the Nistari lines. High heritability could be observed in the characters under study in the Nistari lines. The information can be utilised in the selection process and improvement programmes of the Nistari lines.

**4. CONCLUSIONS:**

Performances of Nistari Marked and Plain lines were evaluated for cocoon weight, shell weight, and filament length in different seasons. Performances of these economic traits in favourable seasons were observed to be improved in comparison with the unfavourable seasons. In both the Nistari lines, positive correlations were observed between Cocoon weight – Cocoon shell weight, Cocoon shell weight - Cocoon shell ratio, Cocoon weight-Filament length. Negative correlation was observed between Cocoon weight and Cocoon shell ratio. Heritability of cocoon weight, shell weight and filament length was observed to be above 75% in the Nistari lines under study. The study on seasonal performances, correlation and heritability will help in future breeding programmes of both the Nistari lines.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS:

Authors have declared that no competing interests exist.

**References:**

Altman GH and Farrell BD. 2022. Sericulture as a sustainable agroindustry. Cleaner and Circular Bioeconomy. 2 (100011), 1-9.

Chandan R, Sanchari RM, Ghosh S. 2012. Sericulture as an Employment Generating Household Industry in West Bengal (A Study on its Current Problems & Prospects). Artha Beekshan : Journal of Bangiya Arthaniti Parishad., 21,131–155.

Devi, TR, Chakrabarty S, Kishor Kumar CM. 2024. Adoption of cold reeling as a tool of selection in the breeding of ‘Nistari’: a multivoltine breed of mulberry silkworm (Bombyx. Mori) in West Bengal, India”. International journal of environment and climate change.14 (10):40-45.

Gamo T and Hirabayashi T.1983. Genetic analysis of growth rate, pupation rate and some quantitative characters by diallel cross in silkworm Bombyx mori L. J. Breed., 33: 191-194.

Giridhar, Nirmal Kumar S, Nair Jula S & Datta RK, Heritability, genetic and phenotypic correlation studies on fitness and quantitative traits of bivoltine silkworm Bombyx mori L. Indian. J. Seric, 34 (1995) 22-27.

Hoque A. and Taufique M. 2018. Status and performance of sericulture in west Bengal. India: a geographical analysis. Asian profile, 46, 181–193

Mirhosseini SZ, Nematollahian S, Ghanipoor M, Seidavi AR.  
2010. Comparison of phenotypic and genetic performance of local silkworm groups and two commercial lines. Biol  
Res. 43:411–416.

Mukhopadhyay TK, Bhattacharya SS, Kundu JK. 2013. Backcross breeding and directional selection of two multivoltines, N+p and Np of silkworm, *Bombyx* *mori* L. for higher viability and productivity in Eastern India. Journal of entomology and zoology studies. 1 (4): 7-19

Nagaraju J. 2002. Application of genetic principles for improving silk production. Current science, 83(4): 409-414.

Narasimharaju R, Govindan R, Ashoka J, Rayar SG. 1990. Genetic variability for quantitative traits in silk-worm, *Bombyx mori* (L)*.* Entomon. 15:197-201

Rahmathulla VK. 2012. Management of Climatic Factors for Successful Silkworm (Bombyx mori L.) Crop and Higher Silk Production. Psyche. 1-12.

Seidavi A, Mirhosseni Z, Mavvajpour M, Ghanipoor M, Bizhannia A, Qotbi A, Chamani M. 2009. Additive genetic variations and selection index changes of economic traits of the silkworm commercial pure lines against parent selection pressure. *American-Eurasian Jour- nal of Agriculture and Environmental Sciences*, 6 (4): 460- 465.

Sen SK, Sengupta AK, Das MG, Jolly MS.1976. Studies on variability, correlation, pathcoefficient analysis and discriminate functions in tasar silkworm, (Antheraea mylitta D.). Indian J. Seric.,15(1): 9-14.

Singh T and Saratchandra B. 2004. Principles and techniques of silkworm seed production. Discovery Publishing House, New Delhi, 342.

Singh T, Bhat MM, Khan MA. 2011. Critical analysis of correlation and heritability phenomenon in the silkworm, *Bombyx mori* (Lepidoptera: bombycidae). Advances in Bioscience and Biotechnology. 2: 347-353

Xia, Q. *et al*. 2009. Complete resequencing of 40 genomes reveals domestication events and genes in silkworm (*Bombyx*). *Science* 326:433–436.

Zambrano-Gonzalez G, Almanza-Pinzon MI, Vélez-T M. 2022. Genetic parameters in traits of productive importance in lines of Bombyx mori L. *J Anim Breed Genet.*;139:136–144.

Naphade, S. R., Hiware, C. J., & Chavan, R. J. (2023). A review on status of the sericulture industry. *International Journal of Entomology Research*, *8*(10), 29-35.

Islam, T. U. (2024). The Historical Journey of Sericulture: Insights into Sustainability from Past to Present. *International Journal of Emerging Knowledge Studies*, *3*(09), 719-726.

Sujatha,G S., Kumar, G. A., Teja, K. S. S., Devi, D. L., E, V. M., Panda, A., J S, R., & Gautam, S. K. (2024). A Comprehensive Review of the Effect and Mitigation of Climate Change on Sericulture. *International Journal of Environment and Climate Change*, *14*(7), 776–788.