

Original Research Article

<https://doi.org/10.20546/ijcmas.2020.907.029>

Evaluation of Indigenous Bivoltine Breeds of Silkworm *Bombyx mori* L.

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ABSTRACT

The present investigation was carried out regarding phenotypic and biological/economic parameters of six bivoltine silkworm breeds; ND₂, ND₃, NSP, Udhey-1, CSR₂ and JD₆ of *Bombyx mori* L. suited for sub-tropical conditions. Observations were made on fifteen economically important traits namely; fecundity, hatching percentage, brushing percentage, weight of 10 mature larvae, larval survival percentage, cocoon yield per 10,000 larvae (by weight and by number), good cocoon, pupation, single cocoon weight, single shell weight, shell ratio, total filament length, non breakable filament length and filament size. The data was analyzed using Multiple Trait Evaluation index (E.I.) method. The perusal of the data reveals that the average E.I. value for egg characters ranged between 43.46(ND₂) to 60.80(ND₃). The average E.I. value for larval traits varied in the range of 41.95(JD₆) to 56.10(Udhey-1). For the cocoon parameters, the average E.I. value was recorded from 46.81(JD₆) to 54.00(Udhey-1). The average E.I. values for post cocoon parameters ranged between 43.71(NSP) to 56.53(ND₂). On the basis of pooled E.I. values, Udhey-1(54.59), CSR₂ (51.56), ND₃(50.79) and ND₂(50.20) surpassed the E.I. bench mark value of >50 and are considered suitable breeds for getting more economic returns from silkworm rearing.

Keywords

bivoltine, *Bombyx mori* L, breeds, Evaluation Index (E.I.)

Article Info

Accepted:
05 June 2020
Available Online:
10 July 2020

Introduction

The continued efforts for the improvement of cocoon characters of domesticated silkworm were aimed at increased quality silk production. The main objective of silkworm rearing is to produce qualitatively and quantitatively superior cocoons, which in turn will have a direct bearing on the raw silk production. Therefore, it becomes imperative or essential to develop silkworm breeds/hybrids which can withstand high temperature stress conditions.

Sericulture, the viable agro-based industry aptly matches the socio-economic backdrop of rural India. One of the main aims of the breeders is to recommend silkworm breeds/hybrids to farmers that are stable under different environmental conditions and minimize the risk of falling below a certain yield level.

India is a vast country where majority of the rural population is associated with the various agricultural ventures such as sericulture, which is an important component of the

diversified agriculture and plays a vital role in generating gainful employment opportunities for the masses of the farming community including women and the farmers with small land holdings to land less in the rural areas for livelihood.

The trend of sericulture development in India has shown a quantum jump in mulberry silk production with an annual production of 20,000 MT during the last three decades (Lakshmanan and Kumar, 2012) and it enjoys the comfortable second position for the production of silk in the world next only to China, in which silkworm breeding and development of bivoltine hybrids have played a vital role. India being predominantly a tropical country with marginal sub-tropical and temperate sericulture zones and is the second largest producer of mulberry raw silk in the country and largest silk consumer; it is also the world's largest importers of silk. It is a well-known fact that bivoltine silk excels in quality and productivity; it is inevitable to go in for large-scale production of bivoltine sericulture in the country. Elite bivoltine silkworm breeds are the basic and important input for the production of high-grade raw silk. An extensive study is needed to improve existing strains for commercial purposes and to develop new strains through breeding programs aimed at improving silk productivity, adaptability to local environments, and disease resistance/tolerance capabilities (Sen *et al.*, 1999, Li *et al.*, 2001).

Apart from the climatic conditions, the genetic potential of the silkworm breeds play a vital role in the quality and quantity of the silk produced. Continuous efforts made to introduce bivoltine silkworm hybrids for commercial exploitation in India have met with little success in view of the instability in the rearing performance of bivoltines under tropical climatic conditions.

Further, limitation in the number of robust and productive silkworm breeds suitable to the tropics is one of the constraints for overall development of the industry. Therefore, it is of paramount importance to develop and improve bivoltine silkworm breeds, which can be commercially exploited in order to increase the quality and quantity of the silk. It is possible to evolve and evaluate bivoltine silkworm breeds, which can yield desired results, responding favorably to the sub-tropical climatic conditions, by designing appropriate breeding strategies for reorganizing the genetic background with an emphasis on the cumulative and permanent nature of the genetic improvement. Ultimate results in silkworm breeding are judged by the excellence of the characters of the parental strains that appear in the F1 hybrid (Sukibo *et al.*, 1979; Yokoyama, 1979; Chang *et al.*, 1981; Gamo and Hirabayashi, 1983). In view of this, an attempt has been made in the present study to assess the potential of the new silkworm breeds by performing evaluation experiments using Multiple Trait Evaluation Method (Mano *et al.*, 1993). Since the selection of breeding material is an important step to achieve the desired objective, emphasis was given for evaluation of potential breeds to be utilized in various combinations for getting more economic returns from silkworm rearing.

Materials and Methods

In the present investigation, the silkworm rearing trial of six bivoltine silkworm breeds; ND₂, ND₃, NSP, Udhey-1, CSR₂ and JD₆ of *Bombyx mori* L. was carried out in 2018 spring rearing season at Division of Sericulture, Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu regarding phenotypic and biological/economic parameters suited for sub-tropical conditions of northern India. For this purpose, six bivoltine silkworm breeds

were taken and studied so that they can be utilized in various combinations for getting more economic returns from future silkworm rearing. Standard rearing techniques as suggested by (Dandin *et al.*, 2003) were followed. Data was recorded for all the treatments viz., fecundity, hatching percentage, brushing percentage, larval weight, larval survival percentage, cocoon yield per 10,000 larvae (by weight and by number), good cocoon percentage, pupation percentage, single cocoon weight, single shell weight, shell ratio, average filament length, non-breakable filament length and filament size and the data was analyzed using multiple trait index (Evaluation index) method. The Evaluation Index method developed by (Mano *et al.*, 1993) was found to be very useful in selecting potential breeds. Data on the economically important traits was collected, pooled and analyzed. The Evaluation Index (E.I.) was calculated as per the procedure:

$$E.I. = \frac{A-B}{c} \times 10 + 50$$

Where, A = Value obtained for a particular trait of a particular breed/hybrid combination
B = Mean values of a particular trait of all the breed/hybrid combinations
C = Stand deviation of a particular trait of all the breed/hybrid combinations
10 = Standard Unit
50 = Fixed Value

The E.I. value fixed for the selection of breed/hybrid is 50 or >50 for the traits. The breed which scored above the limit is considered to possess greater economic value.

Results and Discussion

Selection, evaluation and synthesis of productive breeds is an important component in the development of sericulture. The main objective of any breeding programme is to

develop new breeds as well as to identify promising hybrids for commercial exploitation with consistent performance with desired environmental conditions (Hallauver, 1987). Hybridization of silkworm hybrids with different genetic constitutions can be made by crossing different breeds depending upon the character that the breeders desire to introduce for improvement of productivity (Mano *et al.*, 1988).

Malik *et al.*, (2001 and 2002) and Ram *et al.*, (2003) suggested that the superiority and the potential of breeds and hybrids among depends on the ranking and considering all the major cocoon yield and silk contributing parameters. In silkworm (*Bombyx mori* L.). Evaluation of different breed/hybrids is undoubtedly the most important method to identify their superiority. This could be achieved precisely by adopting a common index giving adequate weightage to all the commercially important traits (Islam *et al.*, 2005; Seidevi, 2010 and Reddy *et al.*, 2012).

In present study, an attempt has been made to evaluate various bivoltine silkworm breeds in order to identify their superiority for commercial exploitation. The results show high degree of variability by different breeds with regard to various economically important traits.

Fecundity is one of the most important commercial parameter of quality seed, cocoon crop harvest and survival of silk industry. Among breeds, maximum E.I. value for fecundity character was recorded in Udhey-1 (66.99) whereas lowest E.I. value of 37.77 was obtained in JD₆ (Table1). According to Tazima (1957), fecundity mainly depends upon genotype of mother moth and environmental conditions at the time of oviposition. Hatching percentage is an important parameter with regard to viability of seed.

Maximum E.I. value for this trait was obtained in breed JD₆ (56.65) followed by CSR₂ (53.35) and minimum E.I. value was recorded in ND₂ (42.69). For the brushing percentage, E.I. was highest in breed JD₆ (57.32) followed by CSR₂ (53.85) and lowest in breed ND₂ (42.83) (Table 1).

Hatching and brushing being two important seed parameters, commercially show direct co-relation to number of worms brushed and larval population reared that ultimately contribute for cocoon yield. Among all six parental breeds, average E.I. value for important egg parameters ranged between 43.46 (ND₂) to 60.80(ND₃). Breeds ND₂ and NSP scored an average E.I. value of <50 for egg traits (Table 1).

Silkworms are voracious eaters of mulberry during its larval stages and around 80 percent leaf is consumed in the last two instars (Fukuda, 1960). Highlighting the importance of food intake, Horie *et al.*, (1978) reported that for the production of 1g larval dry weight, requirement of ingestion and digestion of food is 4.2 mg and 1.8 mg respectively.

The intake of food during total larval life is also reflected by the larval weight and is a cocoon and shell contributing parameter. A maximum E.I. value of 60.96 for weight of ten mature larvae was observed in breed NSP whereas minimum E.I. value of 39.04 was found in race JD₆. Breed U₁ qualified for highest E.I. value of 64.40 for larval survival followed by CSR₂ (58.22) while as lowest E.I. value of 38.49 was recorded in breed ND₃ (Table 2).

Breed U₁ qualified for highest E.I. value of 64.40 for larval survival followed by CSR₂ (58.22) while as lowest E.I. value of 38.49 was recorded in breed ND₃ (Table 2). The average E.I. values of ten mature larvae and larval

survival percentage was >50 in breeds NSP (52.82), Udhey-1 (56.10) and CSR₂ (50.82) whereas E.I. value <50 was scored by ND₂ (46.46), ND₃ (47.53) and JD₆ (41.95) (Table 2).

Cocoon characters are commercially important and do have close relation with mulberry leaves given as food. Minagava and Otsuka (1975) has reported interrelationship between multiple characters in silkworm. Positive correlation for cocoon yield, single cocoon weight with fecundity and hatching parentage has been reported by Jayaswal *et al.*, (1990). Similar results were also recorded by Joge *et al.*, (2003) and Kumar *et al.*, (2012).

Malik *et al.*, (2006) suggested that cocoon yield/10,000 larvae by weight, single cocoon weight, single shell weight and shell ratio percentage are important parameters for quality cocoon crop. Highest E.I. value of 54.78 was recorded in breed ND₃ and lowest E.I. value of 45.86 was depicted by race JD₆ for cocoon yield per 10000 larvae (by weight) (Table 3). Maximum E.I. value of 63.45 for cocoon yield per 10000 larvae by number was recorded in breed CSR₂ followed by Udhey-1 (63.38) whereas JD₆ remained with E.I. value of 39.80 (Table 3).

For good cocoon, breed Udhey-1 recorded maximum E.I. value (71.02) followed by JD₆ (49.64) and for breed ND₃ with minimum E.I. value 41.78 (Table 3). Pupation rate is one of the important economic characters to determine the variability of a breed/hybrid. The genetic and environment interaction gets more reflected in this character. Highest E.I. value of 69.75 was recorded in Udhey-1 followed by ND₃ (58.35) and a low E.I. value of 45.67 was obtained in ND₂ and CSR₂ (Table 3). Single cocoon weight parameter is important from yield/reeling point of view. Breed NSP scored highest E.I. value of 64.60

followed by 63.20, whereas breed JD₆ recorded the lowest E.I. value of 37.00 (Table 3). Single cocoon weight is important from yield/reeling point of view, Breed NSP scored highest E.I. value of 64.60 followed by ND₃ (63.20), whereas breed JD₆ recorded lowest E.I. value of 37.00 (Table 3). For single shell weight, breed NSP scored maximum E.I. value of 62.00 followed by ND₃ (61.00) whereas lowest E.I. value of 36.00 was recorded in breed JD₆ (Table 3).

Maximum E.I. value for shell ratio was recorded in breed ND₂ (71.35) followed by Udhey-1 with the value of 50.27 whereas breed CSR₂ recorded minimum E.I. value of 42.98 (Table 3).

Post cocoon characters have greater significance not only from reeler's point of view but also from industrial point of view. Three post cocoon parameters viz. total filament length, non-breakable filament length and filament size mainly contribute for the end product i.e. silk. The increase or decrease in filament length depends on increase or decrease in the thickness of silk filament and cocoon shell weight of hybrid (Kobari and Fujimoto, 1996; Nagaraju and Kumar, 1995). The evaluation Index value for total filament length was maximum in ND₂

(61.77) followed by NSP (58.67) and whereas minimum value was recorded in Udhey-1 (Table 4). In breeds, Udhey-1 scored maximum non-breakable filament length E.I. (61.09) followed by ND₂ (56.82) while as breed JD₆ scored a minimum E.I. value of 33.79 (Table 4). Filament size denotes thinness/thickness of the filament and an E.I. value of 63.00 was recorded in breed JD₆ followed by CSR₂ (57.00). Breed NSP scored least E.I. value of 31.00 (Table 4). The average cumulative E.I. values for three post cocoon parameters for bivoltine breeds ranged between NSP (43.71) to ND₂ (56.53) (Table 4).

The important commercial traits of silkworm on which silk industry sustains are fecundity, hatching and brushing percentage, weight of ten mature larvae, larval survival percentage, cocoon yield per 10000 larvae (by weight and number), good percentage, pupation percentage, single cocoon weight, single shell weight, shell ratio, total filament length, non-breakable length and filament size. The estimates worked out for these fifteen parameters was done by pooled Evaluation Index. On the basis of this, breed ND₂ scored 50.20, ND₃ (50.79), Udhey-1 (54.59) and CSR₂ (51.56) surpassed the E.I. bench mark value >50 (Table 5).

Table.1 Evaluation Index values of bivoltine silkworm breeds for different egg traits

Breeds	Fecundity	Hatching percentage	Brushing percentage	Total	Average E.I.
ND ₂	44.87	42.69	42.83	130.39	43.46
ND ₃	50.20	43.62	44.30	138.12	60.80
NSP	43.69	50.95	50.13	144.77	48.25
Udhey-1	66.19	52.55	51.55	170.29	56.76
CSR ₂	57.31	53.55	53.85	164.71	54.90
JD ₆	37.77	56.65	57.32	151.74	50.58

Table.2 Evaluation Index values of bivoltine silkworm breeds for two larval traits

Breeds	Weight of 10 mature larvae	Larval survival percentage	Total	Average E.I.
ND ₂	52.19	40.73	90.92	46.46
ND ₃	56.57	38.49	95.06	47.53
NSP	60.96	44.68	105.64	52.82
Udhey-1	47.81	64.40	112.21	56.10
CSR ₂	43.43	58.22	101.65	50.82
JD ₆	39.04	44.87	83.91	41.95

Table.3 Evaluation Index values of bivoltine silkworm breeds for different cocoon traits

Breeds	Cocoon yield/ 10000 larvae		Good cocoon percentage	Pupation percentage	Single cocoon weight	Single shell weight	Shell ratio	Total	Average E.I.
	By weight	By number							
ND ₂	53.91	42.11	44.06	45.67	57.00	71.35	71.35	500.88	50.08
ND ₃	54.78	44.60	41.78	58.35	61.00	45.14	45.14	513.74	51.37
NSP	54.28	46.69	47.68	47.68	62.00	44.33	44.33	497.95	49.79
Udhey-1	50.57	63.38	71.02	69.75	42.00	50.27	50.27	540.07	54.00
CSR ₂	54.54	63.45	45.89	45.67	46.00	42.98	42.98	512.68	51.26
JD ₆	45.86	39.80	49.64	49.68	36.00	46.76	46.76	468.17	46.81

Table.4 Evaluation Index values of bivoltine silkworm breeds for different post-cocoon traits

Breeds	Total filament length	Non-breakable filament length	Filament size	Total	Average E.I.
ND ₂	61.77	56.82	51.00	169.59	56.53
ND ₃	56.81	55.11	48.00	159.92	53.30
NSP	58.67	41.47	31.00	131.14	43.71
Udhey-1	36.99	61.09	50.00	148.08	49.36
CSR ₂	47.53	55.11	57.00	159.64	53.21
JD ₆	38.85	33.79	63.00	135.64	45.21

Table.5 Cumulative E.I. values of bivoltine silkworm breeds

		E.I. of bivoltine breeds					
Parameters		ND ₂	ND ₃	NSP	Udhey-1	CSR ₂	JD ₆
Fecundity		44.87	50.20	43.69	66.19	57.31	37.77
Hatching percentage		42.69	43.62	50.95	52.55	53.55	56.65
Brushing percentage		42.83	44.30	50.13	51.55	53.85	57.32
Wt. of 10 mature larvae		52.19	56.57	60.96	47.81	43.43	39.04
Larval survival percentage		40.73	38.49	44.68	64.40	58.22	44.87
Cocoon yield/10000 larvae	By weight	53.91	54.78	54.28	50.57	54.54	45.86
	By number	42.11	44.60	46.69	63.38	63.45	39.80
Good cocoon		44.06	41.78	47.68	71.02	45.89	49.64
Pupation percentage		45.67	58.35	47.68	69.75	45.67	49.68
Single cocoon weight		46.00	63.20	64.60	41.40	49.00	37.00
Single shell weight		57.00	61.00	62.00	42.00	46.00	36.00
Shell ratio		71.35	45.14	44.33	50.27	42.98	46.76
Total filament length		61.77	56.81	58.67	36.99	47.53	38.85
Non-breakable filament length		56.82	55.11	41.47	61.09	55.11	33.79
Filament size		51.00	48.00	31.00	50.00	57.00	63.00
TOTAL		753.00	761.95	748.81	818.97	773.53	676.03
Average E.I.		50.20	50.79	49.92	54.59	51.56	45.06

The obtained data showed that there are highly significant differences among the breeds for all the studied characters.. The differences in obtained results are due to the variability. On the basis of cumulative E.I. values, NSP(41.47) and JD₆ remained <50 whereas Udhey-1(54.59),CSR₂ (51.56),ND₃ (50.79) and ND₂ (50.20) surpassed the E.I. bench mark value of >50 and are considered suitable breeds for getting more economic returns from future silkworm rearing.

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How to cite this article:

Kritika Sharma and Kamlesh Bali. 2020. Evaluation of Indigenous Bivoltine Breeds of Silkworm *Bombyx mori* L.. *Int.J.Curr.Microbiol.App.Sci*. 9(07): 272-280.
doi: <https://doi.org/10.20546/ijcmas.2020.907.029>