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Identification of Promising Bivoltine Breeds based on Multiple Trait Analysis for Future Breeding Program in West Bengal, India

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Thirty five bivoltine breeds were acclimatized under controlled condition for three years during two seasons to evaluate their efficiency in Seri industry of tropical region. Out of thirty five ten breeds had been short listed based on ranking for individual trait. Three breeds out of those ten selected breeds viz. SK6, NB18 and B.Con.4 ranked top in respect of overall performance. The ten breeds based on average Evaluation Index value > 50 considering twelve economically important traits are the resource material for future course of breeding program in West Bengal.

Keywords: Bivoltine, Breed, Acclimatize, Evaluation index

Introduction

The silkworm, *Bombyx mori* is being nurtured all over the world for its economic importance since medieval times under the patronage of man. In silkworm rearing some parameters like cocoon quality, yield and adaptability are considered to be of prime importance. Hence, the exploitation of these traits through hybridization is the main objective of silkworm breeding. The selection of superior parental combinations determines the degree of success of the breeding programme to a large extent. The evaluation index method developed by Mano *et al*. (1993) was found to be very useful in selecting promising parents considering all traits of economic importance for silkworm breeding programme.

Bivoltine silkworms pose great attention to the silkworm breeders for its superior quality as well as high quantity of silk. In West Bengal, India at commercial level farmers use to rear multivoltine × bivoltine disease free layings (DFLs) during October-March only because of non-availability of suitable bivoltine breed which can sustain the ever fluctuating environmental condition prevailed at most of the areas of West Bengal. Females of multivoltine and males of bivoltines are used for production of multivoltine × bivoltine DFLs. Bivoltine cocoons for preparation of multivoltine × bivoltine DFLs are procured from South India incurring high cost towards transportation. Moreover, due to transportation hazards and non-synchronization of emergence of bivoltine and multivoltine average loss of 10-15% is resulted. It is observed that only 35-40% males emerge from which only 30-35% active males are obtained under some adverse conditions or from any particular disease affected lot. All these factors are responsible for increased rate of commercial DFLs. Efficiency of bivoltine male moth determines both the quality and quantity of hybrid layings from unit quantity of cocoons (Sarkar *et al*., 2009). Benchamin *et al*. (1990) recommended bivoltine hybrid male moths over pure its breed ones for preparation of three way cross breed layings [multivoltine × (bivoltine × bivoltine)] to be exploited at commercial level in tropical region of India for better effective rate of rearing.

As tropical region shares a major area in India and has requisite leaf and manpower, a strategy has been adopted to introduce bivoltine rearing in this region aiming to fulfill the requirement of bivoltine seed cocoons. To accomplish this objective, several bivoltine breeds were evaluated for use in future breeding programme with an objective of producing specific breeds suited for tropical atmosphere and to identify promising bivoltine breed/hybrid for utilization as male components for production of better quality and quantity layings and raw silk.

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Table 1. Physical characteristics of the bivoltine silkworm breeds

Sl. No.	Breed	Larval marking			Cocoon shape	Cocoon colour
		Eye spot	Crescent	Star		
1	SK6	Absent	Faint	Faint	Dumb bell	White
2	SK7	Absent	Faint	Absent	Dumb bell	White
3	D_6(*p*)N(*p*)	Absent	Faint	Absent	Dumb bell	Faint Pink
4	KPG11	Present	Present	Faint	Oval	White
5	P5	Present	Present	Present	Elliptical	White
6	SH6	Present	Present	Present	Elliptical	White
7	SK4	Present	Present	Present	Dumb bell	White
8	D_6(*p*)	Absent	Absent	Absent	Dumb bell	White
9	D_6(+p)	Present	Present	Present	Dumb bell	White
10	BHR2	Present	Present	Present	Elliptical	White
11	BHR3	Present	Present	Present	Elliptical	White
12	B.Con.1	Absent	Absent	Absent	Oval	White
13	MJ1	Present	Present	Present	Dumb bell	White
14	MJ2	Present	Present	Present	Elliptical	White
15	Chinese(PN)	Absent	Faint	Absent	Dumb bell	White
16	CSR18	Absent	Absent	Absent	Dumb bell	White
17	CSR19	Absent	Absent	Absent	Dumb bell	White
18	YB	Present	Present	Present	Elliptical	Yellow
19	CSN	Absent	Absent	Absent	Dumb bell	White
20	SK3N	Absent	Faint	Faint	Oval	White
21	SK4C	Present	Present	Present	Dumb bell	White
22	D6(*p*)N	Present	Present	Present	Dumb bell	White
23	KPGA	Absent	Absent	Absent	Oval	White
24	KPGB	Absent	Absent	Absent	Oval	White
25	BHR1	Present	Present	Present	Dumb bell	White
26	NB4D2	Absent	Absent	Absent	Dumb bell	White
27	B.Con.4	Absent	Absent	Absent	Oval	White
28	BG(*w*)	Present	Present	Present	Elliptical	White
29	NB18	Absent	Absent	Absent	Dumb bell	White
30	SK3C	Absent	Absent	Absent	Oval	White
31	SK4N	Present	Present	Present	Dumb bell	White
32	D5	Present	Present	Present	Dumb bell	White
33	CSR2	Absent	Faint	Faint	Oval	White
34	SK3	Absent	Absent	Absent	Oval	White
35	JPN(female)	Present	Present	Present	Dumb bell	White
	JPN(male)	Absent	Absent	Absent	Dumb bell	White

Materials and Methods

Rearing condition

Thirty five bivoltine breeds were collected from silkworm germplasm bank of Central Sericultural Research and Training Institute, Berhampore, West Bengal, India and acclimatized under the controlled condition of the Germplasm maintenance laboratory of the centre for three successive years during two seasons July-August and February-March (indoor temperature ranging from 25ºC to 27ºC and RH from 80% to 85%) to evaluate their efficiency in Sericulture industry of tropical region. The breeds were reared following the standard rearing techniques (Krishnaswamy, 1978). After 3rd moult, 300 larvae were kept for each breed.

Table 2. Mean performance of bivoltine breeds for multiple traits

Breed	Fec. (No.)	Hat-ching %	Larval period at 5th Stage (day)	Total larval period (day)	Wt. of 10 matured larvae (g)	ERR (No.)	ERR (wt.) (kg)	Cocoon wt (g)	Shell wt. (g)	Shell %	Fila-ment length (m)	Denier	E.I.	Rank
SK6	473	97.02	7.19	25.25	39.50	8189	11.382	1.544	0.267	18.75	930	2.84	58.35	1
NB18	453	95.65	8.13	29.19	40.39	6617	8.909	1.374	0.280	20.34	891	3.04	57.85	2
B.Con.4	452	95.22	8.00	27.38	38.21	8598	11.564	1.464	0.284	19.29	815	2.56	56.96	3
D6(p)	484	96.52	7.25	27.25	35.93	8265	10.957	1.333	0.262	19.60	866	2.83	56.89	4
KPGB	465	97.40	6.83	26.69	37.30	8342	10.807	1.306	0.248	18.90	917	2.63	54.80	5
D6(+p)	462	96.53	6.75	26.88	35.95	8708	11.540	1.304	0.253	19.39	926	2.77	54.79	6
SK4C	455	96.26	7.49	25.91	36.49	8219	10.459	1.299	0.275	21.10	845	2.08	53.85	7
CSR18	461	96.11	7.51	26.25	39.41	6925	9.515	1.379	0.268	19.36	782	2.98	53.82	8
JPN	483	94.41	7.71	25.79	32.95	8778	10.452	1.317	0.285	21.71	794	2.24	53.65	9
NB4D2	458	96.24	6.85	25.88	39.89	7726	10.566	1.406	0.274	19.39	745	2.68	53.35	10
Maxi-mum	496	97.40	8.13	29.19	40.39	9016	12.095	1.544	0.285	21.71	941	3.04	-	-
Mini-mum	429	94.41	6.50	24.13	29.03	6252	6.671	1.091	0.198	17.03	430	1.67	-	-
Mean	457	96.08	7.23	26.52	35.53	7817	9.835	1.280	0.242	18.86	812	2.48	-	-
CD at 5%	NS	NS	0.71	1.85	3.15	1482	2.137	0.138	0.029	1.08	2.24	0.04	-	-
CV %	5.68	1.18	7.04	4.96	6.32	13.56	15.49	7.69	8.43	4.07	0.20	1.16	-	-

Data collection

After harvesting the cocoons, data on number of good cocoon, double cocoons, flimsy or melted cocoons were recorded. The weight of good cocoon and double cocoons were also collected for determination of total yield. Twenty five each of male and female cocoons were randomly selected from each breed for assessment of its single cocoon weight, shell weight and cocoon shell percent.

Physical characteristics

Out of 35 bivoltine breeds, JPN, that was collected by earlier researchers from Japan is auto sexed i.e. female larvae are marked while male larvae are plain. The cocoons of breed YB and $D_6(p)N(p)$ are yellow and faint pink respectively while colour of the cocoons which are produced by rest of the bivoltine breeds mentioned in this study are white. The different shapes of cocoons were dumbbell, oval and elliptical. The physical characteristics of each breed in respect of larval marking, cocoon shape and cocoon colour are presented in Table 1.

Yield attributes

The yield attributes viz. fecundity, hatching percentage, larval period at 5th stage, total larval period, weight of 10 matured larvae, effective rate of rearing (ERR) by number and weight, single cocoon weight, single shell weight, shell percent, filament length and denier were assessed.

Statistical analysis

The pooled data of 2 seasons over 3 years for each individual trait were statistically analysed using technique of analysis of variance (ANOVA). The method of Mano *et al*. (1993) to work out Evaluation Index (E.I.) for ranking of each breed was applied on their individual mean data for each trait.

Results and Discussion

The farmers of West Bengal are found to have a preference of dumbbell shaped bivoltine cocoons because of their good performance in reeling and hence higher demand among reelers. The male components of bivoltine are utilized for production of multivoltine × bivoltine DFLs. This is because they are in the opinion that combination with this type of cocoons results better yield with good reeling characteristics.

The overall mean performance of short listed 10 best breeds, selected on the basis of multiple trait evaluation index along with grand mean, range, critical difference at 5% level and coefficient of variation (%) calculated for all 35 breeds are presented in Table 2. It is revealed that except for fecundity and hatching percent, effect of breeds was highly significant for all other characters. This is in accordance to the view of Murakami (1994) that “racial

Table 3. Ten top ranking bivoltine breeds in response of twelve economical traits

Sl. No.	Parameters	Range	Name of breed
1	Fecundity (No.)	429-496	SH6, D_6(*p*), JPN, D_6(*p*)N, SK3, SK6, MJ2, SK7, BHR1, KPGB
2	Hatching (%)	94.41-97.40	KPGB, SK6, MJ1, SK3, SK4, D_6(+p), D_6(*p*), CSN, D_6(*p*)N, SH6
3	Larval period at 5th stage (days)	6.50-8.13	Chinese(PN), MJ1, BHR1, D_6(+p), KPG 11, KPGB, NB4D2, KPGA, D_6(*p*)N(*p*), BHR3,
4	Total larval period (days)	24.13-29.19	SK7, BHR3, BHR2, SK6, D_6(*p*)N(*p*), B.Con.1, BHR1, JPN, NB4D2, SK4C
5	Weight of 10 matured larvae (g)	40.39-29.09	NB18, P5, NB4D2, SK6, CSR18, BHR1, B.Con.4, B.Con.1, BHR2, SH6
6	ERR by No.	9016-6252	Chinese(PN), CSN, JPN, BHR2, SK4N, SK3C, SK7, D_6(+p), B.Con.4, B.Con.1
7	ERR by weight (kg)	12.095-6.671	B.Con.1, BHR2, B.Con.4, D_6(+p), BHR3, SK6, D_6(*p*), SK7, D_6(*p*)N, KPGB
8	Single cocoon weight (g)	1.544-1.091	SK6, B.Con.4, NB4D2, CSR18, NB18, B.Con.1, P5, BHR2, KPGA, D_6(*p*)
9	Single shell weight(g)	0.285-0.198	JPN, B.Con.4, NB18, SK4C, NB4D2, CSR18, SK6, D_6(*p*), P5, B.Con.1
10	Shell %	21.71-17.03	JPN, SK4C, NB18, D_6(*p*)N(*p*), D_6(*p*)N, D_6(*p*), Chinese (PN), NB4D2, D_6(+p), CSR18
11	Filament length (m)	941-430	KPGA, SK7, P5, SK6, D_6(+p), KPGB, BHR2, CSR2, SK3, SH6,
12	Denier	1.67–3.04	YB, CSN, SK4N, BHR1, SK6, D_6(*p*), BHR3, KPGA, CSR19, D_6(+p)

differences in various biological characters are due to adaptation in the particular places over long generation". This also coincides with the findings of Khan *et al*. (2003) and Suresh Kumar *et al*. (2006) that most of the economically important traits of silkworm are polygenic in nature and are greatly influenced by environment.

Ten best breeds that were short listed for each individual trait based on ranking are presented in Table 3. The breed SK6 showed superiority in respect of 9 characters except larval period at 5th stage, ERR by number and shell% followed by D_6(*p*) and D_6(+p) which showed superiority in respect of 7 characters. The popular breed NB4D2 mainly used to prepare multivoltine × bivoltine DFLs in West Bengal showed superiority in respect of 6 characters viz. larval period at 5th stage, total larval period, weight of 10 matured larvae, single cocoon weight, single shell weight and shell %. BHR2, one of the thermo-tolerant breeds, also showed superiority in 6 characters viz. total larval period, weight of 10 matured larvae, ERR by number and by weight, single cocoon weight and filament length.

Results in Table 2 show that response of the breeds under discussion to different economical characters is different. This has insisted to explore the performance of the breeds during February-March and July-August for 3 years to identify the potential bivoltine breeds based on evaluation index considering most of the economic traits used by the breeders in the tropical region. According to Mano *et al*. (1993) "it will be fair and precise to take the decision based on the multiple traits spanning the entire growth period so that adequate weightage is assigned to various characters that are manifested in the entire growth phase of the silkworm". But it is necessary to maintain all the acclimatized bivoltine breeds in their original form for their effective use in different breeding programmes and other research purposes (Mukharjee *et al*., 1999; Rao *et al*., 2006). Performance of the breeds varies depending on climatic condition. There is a profound role of genotype × environment interaction on yield attributes (Khan *et al*., 2001; Kobayashi *et al*., 1986; Orozoco, 1976). These observations establish the fact that the breeding materials should be evaluated under the agro-climatic condition where they are to be exploited. This is in conformity with Naseema Begum (2008). The difference in breeds in respect of various genetical characters may be due to the potential adaptability under fluctuating environmental condition of Berhampore, the place of study. The genetic variation observed in different breeds for various traits form a genetic resource for evolving new breeds. Since eastern and north eastern region of India is endowed with highly fluctuating environmental condition, systematic evaluation of all breeds considering all economical characters has of immense importance in generating data for future breeding programmes. The short listed ten breeds with average E.I. value > 50 may be used as resource material for future breeding program under tropical condition in West Bengal, India.

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