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Evaluation and identification of superior bivoltine silkworm breeds of *Bombyx mori* L.

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ABSTRACT

In this study, fifty six bivoltine silkworm breeds was evaluated for its performance based on quantitative and qualitative traits. These breeds were reared in spring, summer and autumn seasons for three years and evaluated for various economically important traits. Suitable genotypes were selected by based on selection index suggested by Smith (1936). The top 10 ranking genotypes are O4, D6(P), D6(M), MC4(E), C122, CSR2, O3, O2, SK3 and BHR2 and the identified breeds will be used in various breeding programmes.

Keywords: Bivoltine silkworm, Evaluation, Selection Index

INTRODUCTION

The silkworm, *Bombyx mori* L., is one of the genetically well-characterized insects next only to the fruit fly, *Drosophila*, and has emerged as a lepidopteran molecular model system [1]. The well-developed genetics of this species includes more than 400 well described mutations which have been mapped to > 200 loci, comprising 28 linkage groups or chromosomes [2]. In addition, hundreds of geographical races and genetically improved strains are maintained in different countries where sericulture is in vogue. These silkworm varieties include univoltines, bivoltine and polyvoltines.Univoltines and bivoltines are qualitatively and quantitatively superior races whereas polyvoltines are relatively inferior in both the traits but superior in their survival and hardiness.

Evaluation of germplasm is an essential pre-requisite for its effective utilization. As the goals of breeding change rapidly, evaluation needs to be adaptive [3]. The necessity of identification of season specific breeds/ hybrids arises due to variation in quantitative characters during different environmental conditions. Silkworms have been evaluated in many environment and agro-climatic conditions in order to identify the season and region specific breeds for utilization [4]. Series of studies were conducted to identify suitable bivoltine silkworm breed for Kashmir valley particularly for spring and autumn seasons [5], [6]. To select the potential parents for breeding summer varieties bivoltine were evaluated in different seasons and selected based on performance [7] and isozyme variability [8]. Similarly polyvoltine germplasm were evaluated for thermo-tolerance and identified few elite breeds having the thermo-tolerance [9].

In the present study, an attempt was made to evaluate bivoltine germplasm and genotypes were selected based on selection index suggested by Smith [10]. The information generated will be useful for future breeding programmes.

MATERIALS AND METHODS

Silkworm breeds and rearing

Fifty-six bivoltine silkworm (*Bombyx mori* L.) genotypes maintained at Regional Sericultural Research Station, Kalimpong under Central Sericultural Research and Training Institute, Berhampore, West Bengal were used for the present study. These breeds were reared during favourable rearing season i.e. spring (April-May) from 2003-06. The standard rearing techniques [11] and recommended methodology for maintenance of germplasm was followed [12]. The important quantitative traits *viz*., fecundity (Fec.), larval period(LP), yield/10,000 larvae (no.), yield/10000 larvae (wt.-kg), single cocoon weight (SCW), single shell weight (SSW) in g, shell% (SR%), filament length (FL) and denier were recorded in all genotypes during rearing.

Ranking of genotypes

Selection of genotypes or parents is an important step for any breeding programme. The effective method of selection of genotype is by selection index. The selection index for ranking the genotypes was done following Smith index [10], [7] based on the criterion I and II. In criterion I - characters were given different grading based on the preference of higher and lower value of particular trait. For example characters like single cocoon weight, shell weight and filament length, etc., were preferred in higher side, so they were given +3, but in case of larval period, lower one is preferred, so it was given –3. Characters like denier don't have much preference of higher or lower values, so it was given the value of "0" -no preference. In criterion II- characters were given different grading based on the marks provided depending upon preference of characters. Since bivoltine silkworms are known for the quality silk, silk related characters like cocoon shell weight, shell%, etc. were given more marks than others. The characters *viz*., single cocoon shell weight (SCSW), shell %, filament length were given more weightage and other parameters like yield/ 10000 larvae (no.), yield/ 10000 larvae (wt.), fecundity, single cocoon weight were given less weightage.

RESULTS

A considerable amount of variation was observed between the genotypes for many of the quantitative traits. The analysis of variance (Table 1) revealed significant differences among genotypes for fecundity (no.), larval period (hrs), yield/ 10,000 larvae (no.), yield/ 10,000 larvae (wt.), single cocoon weight, single shell weight, shell% and filament length indicating variability among the breeds. However, no significant variation was observed for denier.
Mean performance of 56 genotypes reared for three years showed varying performances for different characters (Table 2). C122 showed highest fecundity (693) followed by D6(M) (674) and CSR2 (664). Lowest fecundity was observed in SK7 (452) followed by BP(C) (545). Lowest larval period was found in J112 and PAM105 (550 hrs each). Longest larval period was observed in CSR19 (621) followed by KPG-6 and NB18 (608 each). Genotype O2 showed highest yield/ 10000 larvae (no.) of 9553 cocoons followed by BHR1 (9480). The lowest yield (no.) was obtained in CSR19 (6972) followed by YS3 (7320). As far as cocoon yield/ 10000 larvae by weight is concerned, O4 showed highest yield of 18.19 kg followed by D6(P) (17.62kg). The lowest yield was obtained in BP(B) (9.73 kg) followed by CSR19 (10.03 kg). In case of single cocoon weight, highest value was observed in D6(P) (2.013 g) followed by D6(M) (1.955 g). The lowest single cocoon weight of 1.292 g was observed in BP(B). Highest shell weight of 0.400 g was observed in O4 followed by 0.397g in D6(P) and lower shell weights of 0.122 g and 0.183 g were observed in BP(B) and BP(C), respectively. Highest shell% was noticed in CSR2 (21.87%) followed by CSR4 (20.64%). The lowest value was observed in BP(B) (9.37) followed by BP (C) (12.88%). Highest filament length was obtained in CSR2 (1007 m) followed by CSR5 (979 m) and the lowest in BP(B) (465 m) followed by BP(C) (525 m). Highest denier was observed in NB18 (3.04) followed by O4 (2.93) and the lowest in SK7 (2.56) followed by MC1 (2.61).

Since, no genotype showed consistently better performance over other genotypes for most of the characters, the genotypes were ranked giving different weightages to different characters based on model suggested by Smith (1936) for selection of better performing genotypes for desirable characters (Table 2). The top 10 ranking genotypes were: O4 ranking first with low scoring of 335, D6(P) ranked 2nd (338), D6(M) ranked 3rd (339), MC4(E) ranked 4th (349), C122 ranked 5th (364), CSR2 ranked 6th (366), O3 ranked 7th (386), O2 ranked 8th (390), SK3 ranked 9th (415) and BHR2 ranked 10th (431).

Table 1. Analysis of variance for different quantitative traits in fifty six genotypes

Characters	SS	MSS	F value	CD at 5%	CV%
Fecundity (no.)	634599.08	11538.16	1.53**	108.39	14.87
Larval Period (hrs.)	58298.004	1059.96	1.95**	29.051	3.96
Yield/ 10,000 larvae (no.)	104371964.15	1897672.0	2.23**	1150.6	10.57
Yield/ 10,000 larvae (kg.)	891.01	16.20	2.56**	3.13	17.10
Single cocoon weight (g)	6.51	0.12	3.09**	0.24	11.42
Single shell weight (g)	0.62	0.01	7.45**	0.048	12.18
Shell (%)	919.64	16.72	14.64**	1.33	5.74
Filament length (m)	1373940.95	24980.75	2.88**	115.97	10.56
Denier	2.64	0.05	0.83	NS	8.59

Table 2. Mean performance and ranking of bivoltine silkworm breeds

SL No	Breeds	Fec	LP (hrs)	YTL (no.)	YTL (kg)	SCW (g)	SSW (g)	Shell %	FL (m)	Deni-er	Score	Rank
1	KPG-A	590	598	8290	14.564	1.857	0.350	18.84	941	2.80	532	20
2	KPG-B	542	602	8226	14.232	1.680	0.310	18.65	917	2.63	826	46
3	KPG-6	554	608	8253	15.198	1.834	0.347	19.14	870	2.77	645	32
4	KPG-7	612	611	8880	15.491	1.794	0.333	18.56	912	2.87	568	26
5	P5	578	598	8587	14.893	1.874	0.344	18.42	933	2.97	543	23
6	NB18	594	608	9003	17.104	1.911	0.388	20.37	891	3.04	449	12
7	SH6	600	582	8440	14.419	1.709	0.306	17.95	902	2.69	628	30
8	JD6	598	589	9160	14.308	1.707	0.315	18.51	899	2.88	574	27
9	YS3	611	587	7320	12.904	1.720	0.305	17.78	716	2.88	982	52
10	SF19	626	598	9346	15.876	1.720	0.296	17.23	910	2.93	611	29
11	CC1	598	586	8813	14.751	1.662	0.330	19.86	873	2.86	560	25
12	BP(C)	545	582	9100	12.945	1.391	0.183	12.88	525	2.83	1659	55
13	BP(B)	475	579	8840	9.730	1.292	0.122	9.37	465	2.85	2392	56
14	MJI	500	581	9013	13.458	1.652	0.311	18.73	754	2.62	647	33
15	MJ2	591	585	9247	14.480	1.667	0.287	17.23	859	2.67	701	39
16	MC1	493	578	9197	12.253	1.443	0.267	18.53	884	2.61	949	50
17	MC2	555	578	8387	14.129	1.677	0.318	18.93	887	2.89	886	47
18	MC3	497	577	9220	13.140	1.569	0.305	19.47	817	2.69	666	35
19	MC4(O)	613	598	8243	16.203	1.817	0.328	18.18	949	2.89	531	19
20	MC4(E)	642	589	9156	17.408	1.782	0.360	20.22	925	2.84	349	4
21	BHR1	592	577	9480	14.918	1.752	0.325	18.54	878	2.85	509	15
22	BHR2	630	593	9133	15.720	1.858	0.348	18.78	916	2.76	431	10
23	BHR3	593	566	7817	13.078	1.719	0.320	18.64	847	2.81	691	37
24	SK1	581	591	8000	12.076	1.613	0.298	18.56	919	2.93	792	43
25	SK3	612	595	9003	15.231	1.812	0.370	20.30	925	2.74	415	9
26	SK4	521	567	8610	13.150	1.500	0.289	19.23	879	2.67	592	28
27	SK4(II)	579	575	9200	13.946	1.471	0.274	18.68	937	2.74	700	38
28	SK4(III)	545	581	9373	13.938	1.514	0.287	19.08	884	2.81	723	40
29	SK6	521	580	7433	10.433	1.545	0.304	19.58	916	2.85	545	24
30	SK7	452	573	9190	12.739	1.506	0.297	19.66	830	2.56	938	49
31	O1	553	594	9060	14.520	1.644	0.320	19.47	855	2.79	661	34
32	O2	611	602	9553	16.987	1.892	0.374	19.75	895	2.82	390	8
33	O3	589	586	9297	16.518	1.919	0.366	19.09	902	2.85	386	7
34	O4	611	593	9310	18.197	1.993	0.400	19.96	875	2.93	335	1
35	D3SL	611	577	8273	14.743	1.740	0.339	19.51	901	2.87	512	18
36	D4	562	595	8793	15.015	1.867	0.362	19.38	913	2.92	500	14
37	D5	531	594	8433	14.977	1.820	0.367	20.11	911	2.75	543	22
38	D6(P)	609	583	8633	17.625	2.013	0.397	19.66	866	2.83	338	2
39	D6(M)	674	604	9186	16.792	1.955	0.386	19.79	928	2.77	339	3
40	D7	573	599	9390	17.478	1.786	0.351	19.60	901	2.80	459	13
41	BL1	563	598	9260	16.494	1.831	0.323	17.68	945	2.99	541	21
42	C110	623	560	8798	14.873	1.636	0.270	16.51	920	2.71	677	36
43	J112	553	550	9410	15.462	1.674	0.307	18.35	864	2.77	804	44
44	Howlak	624	572	9289	15.863	1.578	0.271	17.17	913	2.86	790	42
45	C108	612	588	8719	14.830	1.741	0.291	16.72	892	2.79	814	45
46	J122	624	567	8247	13.828	1.776	0.303	17.12	938	2.78	935	48
47	B37	636	586	9185	15.705	1.848	0.316	17.15	880	2.79	510	16
48	PAM105	574	550	8947	13.229	1.490	0.248	16.64	800	2.94	951	51
49	C.Nang	665	573	8605	16.286	1.831	0.330	18.10	874	2.83	432	11
50	C122	693	578	9401	16.311	1.849	0.339	18.36	916	2.79	364	5
51	NB4D2	566	600	9136	15.894	1.831	0.350	19.20	881	2.69	511	17
52	CSR-2	664	589	7976	15.463	1.756	0.384	21.87	1007	2.68	366	6
53	CSR-4	578	603	7963	12.983	1.719	0.355	20.64	951	2.82	641	31

54	CSR-5	569	604	7521	14.415	1.548	0.311	20.08	979	2.80	1071	53
55	CSR-18	611	606	7576	16.361	1.681	0.334	19.85	797	2.84	759	41
56	CSR-19	592	621	6972	10.030	1.554	0.300	19.28	833	2.72	1137	54
Criterion 1		3	-3	3	3	3	3	3	3	0	-	-
Criterion 2		7	6	8	8	9	10	9	10	5	-	-

Fec- Fecundity; LP- Larval period; YTL (no)- Yield/10,000 larvae (no.); YTL (kg)- Yield/10000 larvae (wt.-kg); SCW- single cocoon weight; SSW(g)- Single shell weight; FL(m)- Filament length.

DISCUSSION

Evaluation of germplasm promotes effective and higher utilization of the germplasm, particularly in breeding and crop improvement programme. As the goal of breeding changes rapidly, the evaluation needs to be adaptive. Evaluation of genetic resources is the most important aspect of germplasm management, which determines the use of genotypes in various programmes of race improvement. The germplasm stocks can be utilized for direct utilization as local breeds or as a parent material, whereas the international need focuses towards germplasm systems that emphasize the use and employment of materials rather than mere acquisition and storage. Improvement of silk productivity depends on the magnitude of genetic variability and the extent to which the associated traits are heritable in silkworm. In this study the silkworm genetic resources are evaluated for rearing parameters. Results revealed that a great deal of variation was observed among the genotypes for many of the traits. The analysis of variance indicated significant differences among genotypes for fecundity (no.), larval period (hrs), yield/10,000 larvae (no.), yield/10,000 larvae (wt.), single cocoon weight, single shell weight, shell% and filament length indicating variability among the breeds. However, no significant difference was observed for denier. The silk yield is contributed by more than 21 traits [13] and there exists an interrelationship between multiple traits in silkworm. Any effort to improve the yield requires consideration of cumulative effect of the major traits, which influences the silk yield impartially. To judge the superiority of the silkworm breeds, a common index method is required [14]. A selection index makes it possible to select for a character by selecting simultaneously for two or more characters related to it. In doing so, appropriate weightage are given to different characters [15]. Hence these are called as simultaneous selection models. Several indices could be formulated and finally, those expected to be more efficient (relative efficiency) than direct selection for the dependent character (under consideration) could be culled out, and among them, one with maximum relative efficiency and case of application can be chosen for actual use. In this study the genotypes were subjected to multivariate analysis following Smith [8], and ranked the genotypes giving different weightage to different traits considering their heritability and correlation existing between the traits [16].

CONCLUSION

Fifty six bivoltine silkworm breeds were evaluated and based on selection indices ; breeds were ranked and selected. The selected breeds [O4, D6(P), D6(M), MC4(E), C122, CSR2, O3, O2, SK3, BHR2] would be utilized in different breeding programme.

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