SELECTION OF PROMISING BIVOLTINE BREEDS AND HYBRIDS OF THE MULBERRY SILKWORM, *BOMBYX MORI* L.

Ravindra Singh*, D. Gangopadhyay* and R. Nirupama*

* Silkworm Seed Technology Laboratory, Kodathi, Bangalore - 560 035, Karnataka, INDIA.

[Singh, R., Gangopadhyay, D. & Nirupama, R. 2015. Selection of promising bivoltine breeds and hybrids of the mulberry silkworm, *Bombyx mori* L.. Munis Entomology & Zoology, 10 (1): 255-258**]**

ABSTRACT: Selection of promising bivoltine breeds and hybrids of the mulberry silkworm, *Bombyx mori* L. was carried out utilizing subordinate function indices method of Gower (1971). Out of six bivoltine breeds, DNB_1 ranked first exhibiting maximum cumulative subordinate function indices value of 8.94 for eleven characters followed by DNB_6 which exhibited higher cumulative subordinate function indices value of 7.14. Among twenty five bivoltine hybrids, $DNB_6 \times CSR_2$ ranked first exhibiting maximum cumulative subordinate function indices values of 8.66 followed by $DNB_1 \times CSR_2$ exhibiting cumulative subordinate function indices values of 8.53. Four bivoltine hybrids *viz*., $DNB_1 \times CSR_4$, $DNB_7 \times CSR_2$, $CSR_2 \times CSR_4$ and $DNB_4 \times CSR_4$ were found promising which exhibited cumulative subordinate function indices values of 8.40, 7.94, 7.34 and7.24, respectively. Application of subordinate function indices method for the selection of silkworm breeds and hybrids has been discussed.

KEY WORDS: Bivoltine hybrids, *Bombyx mori,* performance, silkworm breed, subordinate function indices.

In the mulberry silkworm, *Bombyx mori* L., identification of promising silkworm breeds and hybrids has been carried out through application of subordinate function index method of Gower (1971) by several workers (Ramesh Babu et al., 2002; Rao et al., 2001, 2004, 2006; Lakshmi & Chandrashekharaiah, 2007; Nirupama et al., 2008). Silkworm breeds and hybrids can be selected on the basis of cumulative effect of several economic characters (Narayanaswamy et al., 2002). Short-listing of silkworm breeds and hybrids has been conducted utilizing several statistical tools (Singh & Nirupama, 2012; Singh & Gangopadhyay, 2013). In the present study, an attempt has been made to select promising bivoltine breeds developed utilizing artificial parthenogenesis coupled with conventional breeding techniques and bivoltine hybrids through subordinate function index method.

MATERIALS AND METHODS

In the present study, six bivoltine breeds *viz*., DNB_1, DNB_2, DNB_3, DNB_4, DNB_6 and DNB_7 and twenty five bivoltine hybrids were prepared utilizing four bivoltine breeds *viz*., CSR_2, CSR_4, CSR_{17} and NB_4D_2. Three replications were reared in each hybrid and 250 larvae were retained after IIIrd moult. The performance of bivoltine breeds is presented in Table 1. Data were recorded for eleven characters *viz*, fecundity, hatching percentage, pupation percentage, cocoon yield/10,000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage, filament length, reelability, raw silk percentage and neatness. Data were analyzed through subordinate function index method (Gower, 1971). Subordinate function index method is used to short list breeds / hybrids showing a character with a small range of variation contribute as much as another character with a large variation range. In ranging the smallest value for the character is subtracted from each value

and the results are divided by range. The subordinate function is calculated by utilizing the following formula –

Xu = (Xi - Xmin) / (Xmax - Xmin)
Where,
Xu = Sub ordinate function,
Xi = Measurement of trait of tested breed,
Xmin =Minimum value of the trait among all the tested breeds,
Xmax =Maximum value of the trait among all the tested breeds.

RESULTS

Mean rearing performance of six bivoltine silkworm breeds has been presented in Table 1. Data demonstrated variation for various characters among the different bivoltine breeds. Subordinate function index values in bivoltine breeds for eleven characters are given in Table 2. Two breeds DNB_1 and DNB_6 recorded higher subordinate function index values of 1.00 for six and three characters respectively. DNB_1 and DNB_6 showed their superiority by exhibiting cumulative subordinate function index value of 8.94 and 7.14 respectively. Mean rearing performance of twenty five bivoltine hybrids is given in Table 3. Three hybrids namely, $DNB_1 \times CSR_2$, $DNB_1 \times CSR_4$ and $DNB_6 \times CSR_2$ exhibited higher performance for most of the economic characters. Subordinate function index values in twenty five bivoltine hybrids for eleven characters are given in Table 4. As per the subordinate function index method, $DNB_6 \times CSR_2$ exhibited maximum cumulative subordinate function index value (8.66) followed by $DNB_1 \times CSR_2$ (8.53) and $DNB_1 \times CSR_4$ (8.40). In addition, four bivoltine hybrids *viz*., $DNB_1 \times CSR_4$, $DNB_7 \times CSR_2$, $CSR_2 \times CSR_4$ and $DNB_4 \times CSR_4$ were found promising which exhibited cumulative subordinate function indices values of 8.40, 7.94, 7.34 and7.24, respectively.

DISCUSSION

Data pertaining to this study revealed superiority of three bivoltine hybrids $DNB_1 \times CSR_2$, $DNB_1 \times CSR_4$ and $DNB_6 \times CSR_2$ exhibiting significant increase in most of the characters over the control $CSR_2 \times CSR_4$. No hybrid was found to excel in all the eleven characters under study. Therefore, it is necessary to adopt reliable statistical method to identify promising breeds / hybrids which give weight-age to all the economic characters. In this direction, efforts have been made to identify promising silkworm hybrids utilizing subordinate function index method (Ramesh Babu et al., 2002; Rao et al., 2001, 2004, 2006; Lakshmi & Chandrashekharaiah, 2007; Nirupama et al., 2008).

In the present study, the indices obtained from subordinate function index method were worked out both for bivoltine silkworm breeds and bivoltine hybrids. Recently, short-listing of silkworm breeds and hybrids has been carried out by using several statistical tools (Singh & Nirupama, 2012; Singh & Gangopadhyay, 2013). The results demonstrated the superiority of two bivoltine silkworm breeds DNB_1 and DNB_6 among six breeds and three bivoltine hybrids $DNB_1 \times CSR_2$, $DNB_1 \times CSR_4$ and $DNB_6 \times CSR_2$ which excelled among twenty five hybrids and exhibited high subordinate cumulative index values (8.53, 8.40 and 8.66). In view of the results obtained, DNB_1 and DNB_6 can be further utilized in future breeding programmes for the development of outstanding bivoltine breeds and three promising bivoltine hybrids $DNB_1 \times CSR_2$, $DNB_1 \times CSR_4$ and $DNB_6 \times CSR_2$ may be recommended for commercial exploitation in the field.

LITERATURE CITED

Gower, J. C. 1971. A general co-efficient of similarity and some of its properties. Biometrics, 27: 857-871.
Lakshmi, H. & Chandrashekharaiah 2007. Identification of breeding resource material for the development of thermo-tolerant breeds of silkworm, *Bombyx mori* L. J. Exp. Zool.India, 10: 55-63.
Narayanaswamy, T. K., Govindan, R. & Ananthanarayana, S. R. 2002. Selection of multivoltine × bivoltine cross breeds of the silkworm, *Bombyx mori* L. through evaluation indices. Indian J. Seric., 41: 176-178.
Nirupama, R., Singh, R. & Gangopadhyay, D. 2008. Identification of promising multivoltine × bivoltine hybrids of the silkworm, *Bombyx mori* L. Entomon, 33 (2): 147-150.
Ramesh Babu, M., Chandrashekharaiah, Lakshmi, H. & Prasad, J. 2002. Multiple traits evaluation of bivoltine hybrids of the silkwotm, *Bombyx mori* L. Internat. J. Indust. Entomol., 5: 37-44.
Rao, C. G. P., Chandrashekharaiah, Ramesh, C, Ibrahim, B. K., Seshagiri, S. V. & Nagaraju, H. 2004. Evaluation of polyvoltine hybrids based on silk productivity in silkworm, *Bombyx mori* L. Int. J. Indust. Entomol., 8 (2): 181-187.
Rao, C. G. P., Seshagiri, S. V., Ramesh, C. Basha, K., Ibrahim, H, Nagaraju, H. & Chandrashekhariah 2006. Evaluation of genetic potential of the polyvoltine silkworm (*Bombyx mori* L.) germplasm and identification of breeding programme. J. Zhejiang Univ. Sci., 7: 215-220.
Rao, P. S., Singh, R., Kalpana, G. V., Naik, V. N., Basavaraja, H. K., Rama Swamy, G. N. & Datta, R. K. 2001. Evaluation and Identification of Promising Bivolitine Hybrids of Silkworm, *Bombyx mori* L., for Tropics.Int. J. Indust. Entomol., 3 (1): 31-35.
Singh, R. & Gangopadhyay, **D.** 2013. Identification of bivoltine breeds and hybrids of the mulberry silkworm, *Bombyx mori* L. Mun. Ent. Zool., 8 (1): 203-207.
Singh, R. & Nirupama , **R.** 2012. Short listing of breeds and hybrids of the silkworm, *Bombyx mori* L. Mun. Ent. Zool., 7 (2): 978-982.

Table 1. Performance of bivoltine breeding lines of the silkworm, *Bombyx mori* L.

Breeds	Fecundity (no)	Hatching (%)	Pupation rate (%)	Yield/10,000 larvae (kg)	Cocoon wt (g)	Cocoon shell wt (g)	Cocoon shell (%)	Filament length (m)	Reelability (%)	Raw silk (%)	Neatness (p)
DNB_1	517	96.28	91.33	15.500	1.759	0.373	21.22	870	80.6	15.70	92
DNB_2	644	93.69	85.07	13.260	1.706	0.341	20.01	796	81.1	13.96	90
DNB_3	558	93.07	85.33	13.253	1.590	0.315	19.79	805	76.6	14.30	91
DNB_4	588	92.41	82.60	12.580	1.573	0.317	20.13	846	75.7	15.27	87
DNB_6	612	76.36	82.00	15.627	1.973	0.380	19.26	835	82.7	13.98	91
DNB_7	540	47.44	83.20	14.680	1.860	0.341	18.32	771	83.5	13.71	91
Max	644	96.28	91.33	15.627	1.973	0.380	21.22	870	83.5	15.70	92
Min	517	47.44	82.00	12.580	1.573	0.315	18.32	771	75.7	13.71	87
Mean	577	83.21	84.92	14.150	1.744	0.345	19.79	821	80.0	14.49	90
SD	47.25	18.92	3.41	1.290	0.160	0.030	0.96	36.34	3.2	0.81	1.75

Table 2. Subordinate index value of bivoltine breeding lines of the silkworm, *Bombyx mori* L.

Breeds	Fecundity	Hatching	Pupation rate	Yield/10,000 larvae	Cocoon wt	Cocoon shell wt	Cocoon shell	Filament length	Reelability	Raw silk	Neatness	Cumulative subordinate index value
DNB_1	0.00	1.00	1.00	0.96	0.47	0.89	1.00	1.00	0.63	1.00	1.00	8.94
DNB_2	1.00	0.95	0.33	0.22	0.33	0.40	0.58	0.25	0.69	0.13	0.60	5.48
DNB_3	0.32	0.93	0.36	0.22	0.04	0.00	0.51	0.34	0.12	0.30	0.80	3.94
DNB_4	0.56	0.92	0.06	0.00	0.00	0.03	0.62	0.76	0.00	0.78	0.00	3.74
DNB_6	0.75	0.59	0.00	1.00	1.00	1.00	0.32	0.65	0.90	0.14	0.80	7.14
DNB_7	0.18	0.00	0.13	0.69	0.72	0.40	0.00	0.00	1.00	0.00	0.80	3.92

Table 3. Performance of bivoltine hybrids of the silkworm, *Bombyx mori* L.

Hybrids	Fecundity (no)	Hatching (%)	Pupation rate (%)	Yield/10,000 larvae (kg)	Cocoon wt (g)	Cocoon shell wt (g)	Cocoon shell (%)	Filament length (m)	Reelability (%)	Raw silk (%)	Neatness (p)
$DNB_1 \times CSR_2$	501	94.99	92.33	16.968	1.809	0.390	21.54	977	78.3	17.10	92
$DNB_1 \times CSR_4$	503	95.83	93.87	16.920	1.816	0.381	21.00	930	78.2	17.05	93
$DNB_1 \times CSR_{17}$	534	96.13	91.20	16.160	1.867	0.371	19.89	929	75.4	14.53	90
$DNB_1 \times NB_4D_2$	550	93.03	94.27	16.747	1.849	0.377	20.38	844	73.3	15.67	88
$DNB_2 \times CSR_2$	549	93.25	96.80	16.600	1.893	0.368	19.44	836	75.5	14.56	88
$DNB_2 \times CSR_4$	563	96.15	92.40	15.747	1.789	0.346	19.36	954	80.4	14.45	92
$DNB_2 \times CSR_{17}$	532	95.88	85.33	14.547	1.854	0.360	19.43	891	81.3	14.52	91
$DNB_2 \times NB_4D_2$	485	94.45	90.27	14.747	1.715	0.342	19.92	834	79.3	14.56	87
$DNB_3 \times CSR_2$	472	94.47	93.20	17.107	1.902	0.363	19.07	867	84.4	14.51	91
$DNB_3 \times CSR_4$	488	94.57	86.00	13.413	1.551	0.306	19.73	754	80.0	14.63	89
$DNB_3 \times CSR_{17}$	470	94.78	83.87	15.307	1.962	0.383	19.52	864	74.5	14.28	89
$DNB_3 \times NB_4D_2$	471	93.83	86.67	14.320	1.723	0.320	18.56	776	72.9	13.33	92
$DNB_4 \times CSR_2$	409	95.27	89.20	15.520	1.841	0.367	19.92	870	84.2	14.64	88
$DNB_4 \times CSR_4$	457	97.11	94.80	16.427	1.837	0.372	20.24	925	75.7	16.23	91
$DNB_4 \times CSR_{17}$	524	94.91	84.80	14.760	1.863	0.372	19.98	866	82.0	15.75	92
$DNB_4 \times NB_4D_2$	557	95.24	91.80	15.307	1.817	0.351	19.29	913	81.8	14.61	91
$DNB_5 \times CSR_2$	555	95.60	98.80	17.227	1.883	0.379	20.11	963	84.9	15.32	91
$DNB_5 \times CSR_4$	592	96.06	85.20	14.400	1.665	0.318	19.13	826	82.1	14.51	92
$DNB_6 \times CSR_{17}$	626	95.87	87.60	14.533	1.686	0.338	20.04	906	72.9	15.10	88
$DNB_6 \times NB_4D_2$	630	95.24	95.60	15.840	1.652	0.323	19.54	779	73.4	14.66	90
$DNB_7 \times CSR_2$	539	97.32	97.73	16.627	1.827	0.359	19.65	928	86.1	15.63	90
$DNB_7 \times CSR_4$	519	95.40	83.20	12.920	1.693	0.332	19.62	778	79.7	14.42	91
$DNB_7 \times CSR_{17}$	501	90.00	82.00	14.453	1.913	0.382	19.97	871	76.7	14.55	88
$DNB_7 \times NB_4D_2$	562	95.52	90.00	15.667	1.833	0.347	18.94	925	72.7	14.12	87
$CSR_2 \times CSR_4$	550	95.56	90.27	16.640	1.912	0.380	19.88	932	75.3	15.43	92
Max	630	97.32	98.80	17.227	1.962	0.390	21.54	977	86.1	17.10	93
Min	409	90.00	82.00	12.920	1.551	0.306	18.56	754	72.7	13.33	87
Mean	526	95.06	90.29	15.556	1.806	0.357	19.77	878	78.4	14.97	90
SD	51.67	1.46	4.78	1.190	0.100	0.020	0.63	62.53	4.2	0.88	1.81

Table 4. Subordinate index value of bivoltine hybrids of the silkworm, *Bombyx mori* L.

Hybrids	Fecundity	Hatching	Pupation rate	Yield/10,000 larvae	Cocoon wt	Cocoon shell wt	Cocoon shell	Filament length	Reelability	Raw silk	Neatness	Cumulative subordinate index value
$DNB_1 \times CSR_2$	0.42	0.68	0.61	0.94	0.63	1.00	1.00	1.00	0.42	1.00	0.83	8.53
$DNB_1 \times CSR_4$	0.43	0.80	0.71	0.93	0.64	0.89	0.82	0.79	0.41	0.99	1.00	8.40
$DNB_1 \times CSR_{17}$	0.57	0.84	0.55	0.75	0.77	0.77	0.45	0.78	0.20	0.32	0.50	6.50
$DNB_1 \times NB_4D_2$	0.64	0.41	0.73	0.89	0.73	0.85	0.61	0.40	0.04	0.62	0.17	6.09
$DNB_2 \times CSR_2$	0.63	0.44	0.88	0.85	0.83	0.74	0.30	0.37	0.21	0.33	0.17	5.75
$DNB_2 \times CSR_4$	0.70	0.84	0.62	0.66	0.58	0.48	0.27	0.90	0.57	0.30	0.83	6.74
$DNB_2 \times CSR_{17}$	0.56	0.80	0.20	0.38	0.74	0.64	0.29	0.61	0.64	0.32	0.67	5.85
$DNB_2 \times NB_4D_2$	0.34	0.61	0.49	0.42	0.40	0.43	0.46	0.36	0.49	0.33	0.00	4.33
$DNB_3 \times CSR_2$	0.29	0.61	0.67	0.97	0.85	0.68	0.17	0.51	0.87	0.31	0.67	6.60
$DNB_3 \times CSR_4$	0.36	0.62	0.24	0.11	0.00	0.00	0.39	0.00	0.54	0.34	0.33	2.95
$DNB_3 \times CSR_{17}$	0.28	0.65	0.11	0.55	1.00	0.92	0.32	0.49	0.13	0.25	0.33	5.05
$DNB_3 \times NB_4D_2$	0.28	0.52	0.28	0.33	0.42	0.17	0.00	0.10	0.01	0.00	0.83	2.94
$DNB_4 \times CSR_2$	0.00	0.72	0.43	0.60	0.71	0.73	0.46	0.52	0.86	0.35	0.17	5.53
$DNB_4 \times CSR_4$	0.22	0.97	0.76	0.81	0.70	0.79	0.56	0.77	0.22	0.77	0.67	7.24
$DNB_4 \times CSR_{17}$	0.52	0.67	0.17	0.43	0.76	0.79	0.48	0.50	0.69	0.64	0.83	6.48
$DNB_4 \times NB_4D_2$	0.67	0.72	0.58	0.55	0.65	0.54	0.24	0.71	0.68	0.34	0.67	6.35
$DNB_5 \times CSR_2$	0.66	0.77	1.00	1.00	0.81	0.87	0.52	0.94	0.91	0.53	0.67	8.66
$DNB_5 \times CSR_4$	0.83	0.83	0.19	0.34	0.28	0.14	0.19	0.32	0.70	0.31	0.83	4.97
$DNB_6 \times CSR_{17}$	0.98	0.80	0.33	0.37	0.33	0.38	0.50	0.68	0.01	0.47	0.17	5.03
$DNB_6 \times NB_4D_2$	1.00	0.72	0.81	0.68	0.25	0.20	0.33	0.11	0.05	0.35	0.50	5.00
$DNB_7 \times CSR_2$	0.59	1.00	0.94	0.86	0.67	0.63	0.37	0.78	1.00	0.61	0.50	7.94
$DNB_7 \times CSR_4$	0.50	0.74	0.07	0.00	0.35	0.31	0.36	0.11	0.52	0.29	0.67	3.90
$DNB_7 \times CSR_{17}$	0.42	0.00	0.00	0.36	0.88	0.90	0.47	0.52	0.30	0.32	0.17	4.34
$DNB_7 \times NB_4D_2$	0.69	0.75	0.48	0.64	0.69	0.49	0.13	0.77	0.00	0.21	0.00	4.84
$CSR_2 \times CSR_4$	0.64	0.76	0.49	0.86	0.88	0.88	0.44	0.80	0.19	0.56	0.83	7.34