SELECTION OF POLYVOLTINE BREEDS AND POLYVOLTINE × BIVOLTINE HYBRIDS OF THE SILKWORM, *BOMBYX MORI* L.

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ABSTRACT: Selection of polyvoltine breeds and polyvoltine × bivoltine hybrids of the silkworm, *Bombyx mori* L. was carried out utilizing subordinate function indices method of Gower (1971). Out of six polyvoltine breeds, AGL_5 ranked first exhibiting maximum cumulative subordinate function indices value of 10.95 for eleven characters followed by AGL_3 which exhibited higher cumulative subordinate function indices value of 7.45 whereas among thirty polyvoltine × bivoltine hybrids, $AGL_5 \times CSR_2$ ranked first exhibiting maximum cumulative subordinate function indices values of 10.40 followed by $AGL_3 \times CSR_2$ exhibiting cumulative subordinate function indices values of 9.70. Seven polyvoltine × bivoltine hybrids *viz*., $AGL_2 \times CSR_{12}$, $AGL_4 \times CSR_2$, $AGL_2 \times CSR_4$, $AGL_3 \times CSR_3$, $AGL_2 \times CSR_2$, $AGL_5 \times CSR_{12}$ and $AGL_1 \times CSR_2$ were also found promising which exhibited cumulative subordinate function indices values of 7.47, 7.44, 7.43, 7.30, 7.29, 7.27 and 7.15, respectively. Importance of application of subordinate function indices method for the identification of silkworm breeds and hybrids has been discussed.

KEY WORDS: *Bombyx mori,* performance, polyvoltine × bivoltine hybrids, silkworm breed, subordinate function indices.

Silkworm breeds and hybrids are judged on the basis of cumulative effect of several economic characters (Narayanaswamy et al., 2002). In the mulberry silkworm, *Bombyx* mori L., subordinate function index method of Gower (1971) has been employed for the identification of promising silkworm hybrids (Ramesh Babu et al., 2002; Rao et al., 2001, 2004, 2006; Lakshmi & Chandrashekharaiah, 2007; Nirupama et al., 2008). In the present study, an attempt has been made to identify promising polyvoltine breeds developed utilizing androgenesis coupled with conventional breeding techniques and polyvoltine × bivoltine hybrids through subordinate function index method.

MATERIALS AND METHODS

In the present study, six polyvoltine breeds *viz*., AGL_1, AGL_2, AGL3, AGL_4, AGL_5 and Pure Mysore (PM) and thirty polyvoltine × bivoltine hybrids were prepared utilizing five bivoltine breeds *viz*., CSR_2, CSR_3, CSR_4, CSR_{12} and NB_4D_2. Three replications were reared in each hybrid and 250 larvae were retained after IIIrd moult. The performance of polyvoltine 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

Data presented in Table 1 showed variation for various characters among the different polyvoltine breeds. Two breeds AGL_5 and AGL_3 recorded higher values for all the eleven characters. Subordinate function index values in polyvoltine breeds for eleven characters are given in Table 2. AGL_5 and AGL_3 showed their superiority by exhibiting cumulative subordinate function index value of 10.95 and 7.45 respectively. Mean rearing performance of thirty polyvoltine × bivoltine hybrids is given in Table 3. Two hybrids namely, AGL_3 × CSR_2 and AGL_5 × CSR_2 exhibited higher performance for most of the economic characters. It was interesting to note that ten out of thirty hybrids recorded significant increase for three characters namely, cocoon shell weight, cocoon shell percentage and neatness. As per the subordinate function index method, AGL_5 × CSR_2 exhibited maximum cumulative index value (10.40) followed by AGL_3 × CSR_2 (9.70)). In addition, seven polyvoltine × bivoltine hybrids *viz*., AGL_2 × CSR_{12}, AGL_4 × CSR_2, AGL_2 × CSR_4, AGL_3 × CSR_3, AGL_2 × CSR_2, AGL_5 × CSR_{12} and AGL_1 × CSR_2 were also found promising which exhibited cumulative subordinate function indices values of 7.47, 7.44, 7.43, 7.30, 7.29, 7.27 and 7.15, respectively.

DISCUSSION

Perusal of data revealed superiority of two hybrids AGL_3 × CSR_2 and AGL_5 × CSR_2 exhibiting significant increase in most of the characters over the control PM × CSR_2. No hybrid excelled in all the 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 polyvoltine silkworm breeds and polyvoltine × bivoltine hybrids. The results demonstrated the superiority of two breeds AGL_3 and AGL_5 among six breeds and two hybrids AGL_5 × CSR_2 and AGL_3 × CSR_2 which excelled among thirty hybrids. The hybrids exhibited high subordinate cumulative index values (10.40 and 9.70). In view of the results obtained, AGL_3 and AGL_5 can be further utilized in future breeding programmes for the development of outstanding polyvoltine breeds and two promising polyvoltine × bivoltine hybrids AGL_5 × CSR_2 and AGL_3 × CSR_2 may be recommended for commercial exploitation.

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Table 1. Mean rearing performance of polyvoltine silkworm breeds.

Breeds	Fecundity (no)	Hatching (%)	Pupation (%)	Yield/10,000 Larvae (wt) (kg)	Cocoon wt (g)	Cocoon shell wt (g)	Cocoon shell (%)	Filament length (m)	Reel ability (%)	Raw silk (%)	Neat ness (p)
AGL1	462	93.42	88.78	10.411	1.144	0.181	15.86	466	71	11.5	88
AGL2	414	94.42	90.00	10.266	1.189	0.193	16.20	465	71	12.1	87
AGL3	495	94.85	91.18	10.511	1.142	0.193	16.91	526	82	12.8	90
AGL4	423	95.10	89.22	10.488	1.164	0.188	16.18	492	74	12.2	87
AGL5	516	95.66	92.50	11.111	1.271	0.225	17.70	555	84	12.9	90
Mean	462	94.69	90.33	10.557	1.182	0.196	16.57	501	76	12.3	88
SD	44.36	0.84	1.52	0.32	0.05	0.02	0.74	39.2	5.91	0.57	1.34

Table 2. Subordinate function index values of polyvoltine silkworm breeds.

Breeds	Fecundity	Hatching (%)	Pupation (%)	Yield/10,000 Larvae (wt)	Cocoon wt	Cocoon shell wt	Cocoon shell (%)	Filament length	Reel ability (%)	Raw silk (%)	Neat ness (p)	Cumulative index values
AGL1	0.474	0.000	-0.001	0.172	0.887	0.008	-0.002	0.011	0.000	0.000	0.333	1.88
AGL2	-0.003	0.446	0.327	0.000	0.928	0.265	0.185	-0.004	0.026	0.436	0.000	2.61
AGL3	0.794	0.640	0.645	0.290	0.885	0.273	0.568	0.674	0.821	0.974	0.889	7.45
AGL4	0.092	0.749	0.117	0.263	0.905	0.167	0.174	0.304	0.256	0.513	0.000	3.54
AGL5	1.003	1.000	1.001	1.000	1.000	1.000	1.001	1.000	0.974	1.077	0.889	10.95

Table 3. Mean rearing performance of polyvoltine × bivoltine hybrids

Hybrids	Fecundity (no)	Hatching (%)	Pupation (%)	Yield/10,000 Larvae (wt) (kg)	Cocoon wt (g)	Cocoon shell wt (g)	Cocoon shell (%)	Filament length (m)	Reel ability (%)	Raw silk (%)	Neat ness (p)
$AGL_1 \times CSR_2$	506	94.00	95.20	17.421	1.866	0.371	19.88	811	79	14.9	90
$AGL_1 \times CSR_3$	413	94.67	95.73	17.421	1.729	0.354	20.50	752	79	14.7	89
$AGL_1 \times CSR_4$	422	96.61	95.87	16.275	1.744	0.333	19.07	813	78	14.4	90
$AGL_1 \times CSR_{12}$	417	96.88	97.20	16.490	1.664	0.335	20.11	688	72	14.9	88
$AGL_1 \times NB_4D_2$	418	96.89	96.27	16.307	1.712	0.338	19.74	817	83	14.7	90
$AGL_2 \times CSR_2$	487	95.34	97.73	16.137	1.782	0.369	20.70	781	78	14.6	89
$AGL_2 \times CSR_3$	460	96.64	97.73	17.038	1.755	0.354	20.15	727	79	14.6	90
$AGL_2 \times CSR_4$	484	96.30	94.80	16.841	1.756	0.359	20.46	814	81	14.5	90
$AGL_2 \times CSR_{12}$	473	94.57	97.33	16.966	1.775	0.377	21.22	808	79	15.1	90
$AGL_2 \times NB_4D_2$	435	94.55	97.73	16.602	1.722	0.330	19.16	777	75	13.4	88
$AGL_3 \times CSR_2$	493	96.21	96.60	18.322	1.928	0.412	21.38	870	82	16.2	91
$AGL_3 \times CSR_3$	490	95.44	97.47	16.862	1.764	0.364	20.62	766	79	15.4	88
$AGL_3 \times CSR_4$	505	95.58	94.33	16.605	1.751	0.356	20.34	739	74	15.1	86
$AGL_3 \times CSR_{12}$	513	94.62	97.47	16.472	1.703	0.340	19.99	737	76	14.7	85
$AGL_3 \times NB_4D_2$	468	95.50	93.87	15.363	1.655	0.319	19.28	772	79	13.9	88
$AGL_4 \times CSR_2$	427	96.87	97.60	16.982	1.782	0.365	20.50	808	80	14.3	90
$AGL_4 \times CSR_3$	465	95.49	96.13	16.054	1.694	0.334	19.73	794	80	13.9	86
$AGL_4 \times CSR_4$	450	94.96	94.53	16.165	1.734	0.333	19.22	772	80	13.4	86
$AGL_4 \times CSR_{12}$	440	96.05	95.20	15.455	1.643	0.326	19.85	739	76	14.5	88
$AGL_4 \times NB_4D_2$	424	96.14	95.60	15.611	1.659	0.314	18.95	727	76	13.2	86
$AGL_5 \times CSR_2$	499	96.00	97.20	19.692	2.041	0.438	21.44	885	84	15.5	91
$AGL_5 \times CSR_3$	431	95.82	96.13	16.439	1.713	0.353	20.59	762	76	14.3	88
$AGL_5 \times CSR_4$	416	95.35	93.60	15.348	1.669	0.316	18.92	786	78	13.9	90
$AGL_5 \times CSR_{12}$	431	95.49	96.27	16.599	1.749	0.367	21.01	786	80	15.7	90
$AGL_5 \times NB_4D_2$	438	96.20	96.00	16.350	1.707	0.328	19.21	766	80	14.3	89
$PM \times CSR_2$	422	94.53	97.60	16.917	1.762	0.336	19.05	778	81	13.7	87
$PM \times CSR_3$	423	94.70	97.33	15.605	1.611	0.312	19.39	749	76	13.9	86
$PM \times CSR_4$	397	94.05	88.13	14.766	1.636	0.297	18.18	736	75	13.3	87
$PM \times CSR_{12}$	366	92.92	90.40	13.242	1.626	0.286	17.61	592	76	12.8	85
$PM \times NB_4D_2$	409	94.18	95.61	13.690	1.544	0.281	18.22	654	77	12.8	86
Mean	448	95.42	2.31	16.302	1.729	0.343	19.82	767	78	14.4	88
SD	37.29	0.99	97.73	1.20	0.10	0.03	0.96	57.35	2.77	0.84	1.73

Table 4. Sub-ordinate function index values of polyvoltine × bivoltine hybrids

Hybrids	Fecundity	Hatching (%)	Pupation Rate	Yield/10,000 wt.	Cocoon wt	Cocoon shell wt	Cocoon shell (%)	Filament length	Reel ability (%)	Raw silk (%)	Neat ness (p)	Cumulative index values
$AGL_1 \times CSR_2$	0.950	0.272	0.736	0.648	0.648	0.573	0.594	0.749	0.583	0.618	0.778	7.15
$AGL_1 \times CSR_3$	0.317	0.441	0.792	0.470	0.372	0.467	0.754	0.547	0.556	0.559	0.667	5.94
$AGL_1 \times CSR_4$	0.383	0.929	0.806	0.504	0.402	0.329	0.382	0.755	0.500	0.461	0.833	6.28
$AGL_1 \times CSR_{12}$	0.347	0.997	0.945	0.475	0.242	0.342	0.652	0.329	0.028	0.627	0.556	5.54
$AGL_1 \times NB_4D_2$	0.356	1.000	0.848	0.449	0.339	0.363	0.556	0.768	0.889	0.559	0.778	6.90
$AGL_2 \times CSR_2$	0.825	0.610	1.000	0.589	0.480	0.561	0.807	0.644	0.528	0.529	0.722	7.29
$AGL_2 \times CSR_3$	0.639	0.938	1.000	0.558	0.425	0.463	0.663	0.462	0.583	0.539	0.778	7.05
$AGL_2 \times CSR_4$	0.800	0.851	0.695	0.495	0.427	0.499	0.744	0.759	0.778	0.490	0.889	7.43
$AGL_2 \times CSR_{12}$	0.728	0.415	0.959	0.577	0.464	0.609	0.944	0.737	0.583	0.676	0.778	7.47
$AGL_2 \times NB_4D_2$	0.469	0.411	1.000	0.521	0.359	0.312	0.405	0.633	0.278	0.167	0.444	5.00
$AGL_3 \times CSR_2$	0.864	0.828	0.882	0.788	0.773	0.837	0.985	0.950	0.861	0.990	0.944	9.70
$AGL_3 \times CSR_3$	0.846	0.636	0.973	0.561	0.443	0.527	0.785	0.594	0.611	0.765	0.556	7.30
$AGL_3 \times CSR_4$	0.946	0.670	0.646	0.521	0.416	0.478	0.712	0.501	0.139	0.667	0.222	5.92
$AGL_3 \times CSR_{12}$	1.002	0.427	0.973	0.501	0.319	0.378	0.621	0.494	0.333	0.569	0.000	5.62
$AGL_3 \times NB_4D_2$	0.694	0.651	0.598	0.329	0.223	0.242	0.436	0.615	0.611	0.314	0.500	5.21
$AGL_4 \times CSR_2$	0.415	0.995	0.986	0.580	0.480	0.537	0.754	0.737	0.667	0.451	0.833	7.44
$AGL_4 \times CSR_3$	0.676	0.648	0.834	0.436	0.302	0.340	0.554	0.688	0.667	0.314	0.222	5.68
$AGL_4 \times CSR_4$	0.571	0.514	0.667	0.453	0.383	0.333	0.420	0.613	0.639	0.186	0.167	4.95
$AGL_4 \times CSR_{12}$	0.503	0.789	0.736	0.343	0.199	0.287	0.584	0.502	0.333	0.510	0.444	5.23
$AGL_4 \times NB_4D_2$	0.392	0.811	0.778	0.367	0.232	0.212	0.350	0.461	0.306	0.108	0.222	4.24
$AGL_5 \times CSR_2$	0.907	0.776	0.945	1.000	1.001	0.998	1.000	0.999	1.028	0.804	0.944	10.40
$AGL_5 \times CSR_3$	0.444	0.730	0.834	0.496	0.340	0.456	0.778	0.580	0.306	0.451	0.444	5.86
$AGL_5 \times CSR_4$	0.342	0.612	0.570	0.327	0.251	0.221	0.341	0.661	0.528	0.324	0.833	5.01
$AGL_5 \times CSR_{12}$	0.444	0.648	0.848	0.520	0.412	0.550	0.887	0.663	0.667	0.853	0.778	7.27
$AGL_5 \times NB_4D_2$	0.490	0.826	0.820	0.482	0.328	0.299	0.419	0.594	0.639	0.441	0.667	6.00
$PM \times CSR_2$	0.383	0.406	0.986	0.570	0.439	0.348	0.376	0.635	0.722	0.275	0.333	5.47
$PM \times CSR_3$	0.390	0.449	0.959	0.366	0.134	0.200	0.465	0.537	0.306	0.314	0.167	4.29
$PM \times CSR_4$	0.209	0.284	0.334	0.236	0.184	0.104	0.149	0.490	0.222	0.137	0.333	2.68
$PM \times CSR_{12}$	0.002	0.001	0.000	0.000	0.166	0.034	-0.001	0.001	0.306	-0.010	0.056	0.55
$PM \times NB_4D_2$	0.295	0.318	0.236	0.069	0.001	0.002	0.159	0.210	0.417	0.000	0.167	1.87