Madras Agric. J., 96 (7-12): 411-415, December 2009
https://doi.org/10.29321/MAJ.10.100523

Cocoon size Variables vis-a-vis Reeling Traits of Silkworm (*Bombyx mori* L.) Germplasm

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A study on the cocoon size variables and reeling traits was carried out with 101 bivoltine silkworm germplasm based on single cocoon reeling data with the objectives (i) to analyze the degree of correlation of cocoon length, width and L / W ratio on total filament length, non-broken filament length, (ii) to understand whether the shape of cocoons influences the reeling process, (iii) to find the cocoon shape uniformity among the accessions and (iv) to group the best accessions based on cocoon shape uniformity and longest filament length with less breakage during reeling cycle. The results revealed that 13 accessions (BBE-175, BBE-178, BBE-179, BBE-180, BBE-181, BBE-182, BBE-185, BBE-186, BBE-187, BBE-192, BBE-197, BBI-205 and BBE-270) showed more uniformity for cocoon shape, as its standard deviation and co-efficient of variation for cocoon length, width and L/W ratio were less than the overall mean values 1.886, 1.90 and 21.727; and 5.620, 9.990 and 12.360 respectively. These accessions also showed an average total filament length more than 1000 meters and less breakage during reeling cycles, indicating the superiority in filament strength. Correlation analysis showed that cocoon length, width and L/W ratio do not have statistically significant positive or negative correlation with total filament length or non-broken filament length. These 13 silkworm germplasm have elongated and oval cocoon shape and this study suggests that cocoon shape (especially oval or elongated) should be given more importance in breeding plan than considering the cocoon size (i.e., cocoon length, width).

Key words: Bombyx mori, Silkworm germplasm, Cocoon shape

Studies made on the variability in quantitative traits of mulberry silkworm Bombyx mori L. (Chatterjee et al., 1993; Lie, 1996; Rao et al., 1997) indicate that the shape of the cocoon influences silk reelability (Mano, 1994 and Nakada, 1994). Variations in cocoon shape of parental silkworm breeds have been studied by Hiraishi (1912); Nakada (1989, 1991, 1992 a & b; 1993) ; Nakada et al. (1991) ; Katsuki and Nagasawa (1917). The relationship of cocoon shape to the linear measurement of larval body is also reported. Cocoon spinning process also has direct relationship with size and shape of cocoons that influence the reeling process (Miura et al.1995; 1997). Cocoon shape uniformity influences the reeling process (Mano, 1994) and the cocoon shape uniformity has direct relation with reeling process using semi-automated and automated reeling machines. In the present study, evaluation of cocoon shape uniformity using cocoon shape variables such as cocoon length, cocoon width and cocoon length-width ratio and correlation of these cocoon shape variables with total reelable filament length and non-broken filament length were carried out with 101 bivoltine silkworm germplasm. Based on the results obtained, the degree of correlation between cocoon shape variables with total filament length and breakage were analysed and the germplasm accessions with more uniformity in cocoon shape, high filament length and less breakage were grouped and listed.

Materials and Methods

A total of 101 bivoltine silkworm germplasm accessions, which are being currently maintained at CSGRC, Hosur were taken for the present study. Cocoon shape variables *viz.*, length and width of cocoon were recorded using electronic Vernier calipers from a sample of 50 cocoons per accession. Based on the cocoon length and width length-width ratios were worked out for individual accessions. Reeling parameters such as total filament length, numbers of breaks during reeling process were recorded using automatic epprovette for each accession with a sample size of 50 cocoons /accession. Using the number of breaks during reeling cycle, non-broken filament length was computed and the data were statistically analysed using INDOSTAT® software package. Cocoon shape variation was determined by uniformity test on the basis of standard deviation as suggested by Mano (1994). Based on the analysis of variance, standard deviation and co-efficient of variation were estimated

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for each accession to determine cocoon shape uniformity. Correlation was worked out between average cocoon length, cocoon width and length-width ratio with filament length and non-broken filament length. Germplasm accessions with less co-efficient of variation and standard deviations within the population were grouped.

Results and Discussion

Results showed significant variability among the 101 accessions for cocoon length, cocoon width, cocoon length-width ratio, total filament length and non-broken filament length (Table-1).

Correlation of cocoon length, cocoon width and cocoon length-width ratio with total filament length indicated no significant relationship values amongst them. Thus the results indicate that the cocoon length and cocoon width do not have any significant positive or negative correlation with total filament length and non-broken filament length (Table-2), which predisposes the fact that cocoon length and width are not the contributing factors for filament length and breakage of filament during reeling process.

It was observed that 13 accessions viz., BBE 0175, BBE-0178, BBE-0179, BBE-0180, BBE-0181,

Table 1. Variability in cocoon length, cocoon width, l/w ratio, filament length and non-broken filament length of silkworm (*Bombyx mori* L.) germplasm

Sl. No.	Accession No.	Race	Cocoon Length (mm)	Cocoon Width (mm)	Cocoon L/W Ratio	Filament Length (m)	Non broken Filament Length (m)
1	BBE-0171	A25	33.120	19.620	1.688	1096.850	914.750
2	BBI-0172	Boropolu (Jammu)	34.180	20.110	1.700	1060.150	928.200
3	BBE-0173	CC (SL)	34.660	21.050	1.647	920.900	837.200
4	BBE-0174	Feng Shong	33.840	18.470	1.832	835.150	700.450
5	BBE-0175	Hong zhou (G)	31.230	19.770	1.580	1023.450	846.400
6	BBE-0176	Hong zhou (R)	32.520	20.550	1.582	896.650	666.400
7	BBE-0177	JPN5 x B25	36.910	18.090	2.040	991.650	941.900
8	BBE-0178	JPN5 x NK25	34.400	18.060	1.905	1020.700	887.300
9	BBE-0179	JPN6 x A26	33.410	20.890	1.599	1047.200	879.050
10	BBE-0180	JPN6 x B25	34.050	17.530	1.942	1052.110	911.050
11	BBE-0181	JPN12D	35.410	19.710	1.797	1086.700	934.050
12	BBE-0182	CSGRC-12	33.950	18.260	1.859	1061.900	970.100
13	BBE-0183	CSGRC-1	34.870	20.520	1.699	960.950	917.700
14	BBE-0184	CSGRC-2	33.320	20.430	1.631	1046.950	909.600
15	BBE-0185	CSGRC-3	32.640	15.670	2.083	1046.500	909.300
16	BBE-0186	CSGRC-4	34.250	19.030	1.800	1054.250	881.150
17	BBE-0187	CSGRC-5	33.850	18.660	1.814	1022.300	893.000
18	BBE-0188	CSGRC-6	36.560	17.940	2.038	1042.350	776.250
19	BBE-0189	Zebra Yellow	37.790	17.850	2.117	727.550	582.300
20	BBE-0190	36 PC	32.210	17.910	1.798	525.125	477.386
21	BBE-0191	39 P	36.500	19.960	1.829	703.431	633.088
22	BBE-0192	44 B M	34.110	17.280	1.974	1005.338	837.781
23	BBE-0193	44 F (M)	33.900	16.790	2.019	743.988	437.640
24	BBE-0194	644	35.020	17.560	1.994	668.000	401.050
25	BBE-0195	6p	32.140	20.670	1.555	981.963	818.302
26	BBE-0196	7042	31.190	19.580	1.593	901.063	901.063
29	BBE-0199	Auz-4	37.050	17.580	2.108	712.075	647.341
30	BBE-0200	Auz-5	32.090	16.310	1.968	744.940	622.550
31	BBE-0201	C124	34.190	21.950	1.558	961.083	524.227
32	BBE-0202	C124 (SL)	36.100	20.780	1.737	804.538	731.398
33	BBI-0203	CC1 (SL)	31.330	21.380	1.465	608.181	547.363
34	BBI-0204	CCS	33.740	21.890	1.541	996.813	906.193
35	BBI-0205	CDC2	35.480	20.860	1.701	1028.510	881.580
36	BBE-0206	CN X C140	33.180	21.220	1.564	989.275	706.625
37	BBI-0207	CPP1	33.420	16.990	1.967	927.913	773.260
38	BBI-0208	DD3	35.780	16.910	2.116	436.788	272.992
39	BBE-0209	Daizo	32.930	15.060	2.187	1021.713	851.427
40	BBE-0210	Dong 306	34.430	20.580	1.673	628.100	338.900
41	BBE-0211	European (P)	35.260	19.040	1.852	934.300	934.300
42	BBE-0212	European (M)	36.460	19.610	1.859	828.038	752.761
43	BBE-0213	FCC2 (P)	34.320	19.560	1.755	796.463	724.057
44	BBE-0214	FU247	32.320	20.960	1.542	922.638	768.865

Table 1- Continued

Sl. No.	Accession No.	Race	Cocoon Length (mm)	Cocoon Width (mm)	Cocoon L/W Ratio	Filament Length (m)	Non broken Filament Length (m)
45	BBI-0215	G	33.190	21.240	1.563	866.713	787.920
46	BBE-0216	HO (SL)	34.760	18.430	1.886	968.813	807.344
47	BBE-0217	HU 204	28.450	20.440	1.392	665.458	285.196
48	BBE-0218	HUA1 X A2	33.100	21.450	1.543	1019.514	398.940
49	BBE-0219	I-1	28.740	18.580	1.547	976.238	887.489
50	BBE-0220	I-15	29.610	14.990	1.975	820.963	746.330
51	BBE-0221	JB1 (M)	36.290	17.550	2.068	1009.175	840.979
52	BBE-0222	JC2M	33.730	15.970	2.112	915.913	832.648
53	BBE-0223	JC2P	29.690	20.260	1.465	809.713	578.366
54	BBE-0224	JZH (MO)	33.610	19.480	1.725	732.200	563.231
55	BBE-0225	JZH (PO)	31.990	20.350	1.572	619.800	403.890
56	BBE-0226	M2	32.760	18.890	1.734	632.400	351.333
57	BBE-0227	M56	32.240	16.010	2.014	755.409	639.192
58	BBE-0228	M78	32.880	21.980	1.496	1000.950	909.955
59	BBE-0229	M910	35.210	15.810	2.227	718.500	496.710
60	BBE-0230	N140 (SL)	36.320	19.720	1.842	1159.125	965.938
61	BBE-0231	N4	33.430	16.420	2.036	751.750	502.110
62	BBE-0232	NB1	34.690	22.360	1.551	729.790	666.110
63	BBE-0233	NB2	30.710	21.040	1.460	927.136	637.406
64	BBI-0234	NB2A	33.460	21.210	1.578	614.860	489.330
65	BBI-0235	NB2C2	33.310	19.030	1.750	863.722	863.722
66	BBE-0236	NB3	33.080	23.060	1.435	961.625	801.354
67	BBI-0237	NB4D2 (SL)	31.110	16.210	1.919	931.200	620.800
68	BBE-0238	NBH (PO)	30.770	20.900	1.472	1076.875	846.116
69	BBI-0239	NCD	36.260	19.440	1.865	937.238	852.034
70	BBE-0240	NJ1 (SL)	34.600	18.160	1.905	941.375	251.033
71	BBE-0241	NJ3	35.470	17.140	2.069	938.463	938.463
72	BBE-0242	NN6D	35.140	19.940	1.762	1002.738	835.615
73	BBI-0243	PBL1	32.870	19.340	1.700	738.875	604.534
74	BBE-0244	SC1 (SL)	33.800	19.020	1.777	786.013	604.625
75	BBE-0245	SH2	32.420	21.920	1.479	754.113	754.113
76	BBE-0246	SPC2	31.640	20.930	1.512	965.563	877.784
77	BBE-0247	SPJ2	36.120	18.010	2.006	580.000	457.030
78	BBI-0248	SS (OP)	32.600	21.800	1.495	1004.839	879.234
79	BBI-0249	TC1	31.230	21.460	1.455	1057.688	881.406
80	BBE-0250	Ud	35.550	18.010	1.974	863.410	511.220
81	BBE-0251	Var-3	34.780	19.890	1.749	650.950	650.950
82	BBE-0252	Wr	33.150	19.680	1.684	1005.663	838.052
83	BBI-0253	BL1	33.690	22.120	1.523	661.000	398.210
84	BBI-0254	CC1	32.820	21.440	1.531	659.396	494.547
85	BBI-0255	CP1B	33.160	21.960	1.510	716.213	651.102
88	BBI-0258	P5	34.330	19.660	1.746	809.175	577.982
89	BBI-0259	PLF	34.300	23.160	1.481	542.088	492.807
90	BBE-0265	CJ3P	33.900	20.330	1.667	1037.588	864.660
91	BBE-0266	J2P	31.900	17.790	1.793	8.563	529.100
92	BBE-0267	14M	36.110	17.290	2.088	1102.781	802.020
93	BBE-0268	J1M	34.380	17.410	1.975	1060.071	570.810
94	BBE-0269	J2HMC	35.070	18.490	1.897	934.425	622.950
95	BBE-0270	J2M	34.760	17.860	1.946	1092.600	993.270
96	BBI-0271	JA1	37.060	17.470	2.121	1084.922	619.960
97	BBE-0272	G146	32.390	18.750	1.727	845.016	614.560
98	BBI-0273	NB1	28.530	21.150	1.349	942.125	652.240
99	BBI-0275	690	34.180	20.090	1.701	1118.411	460.520
100	BBI-0276	990	32.850	20.640	1.592	897.075	747.560
101	BBI-0277	890	32.670	20.600	1.586	879.525	879.525
		Mean	33.580	19.308	1.739	871.491	701.841
		SD	1.886	1.911	2.172	187.267	193.377
		CV	5.62	9.900	1.236	21.488	27.5528

BBE-0182, BBE-0185, BBE-0186, BBE-0187, BBE-0197, BBE-0205 and BBE-0270 showed more uniformity in cocoon shape as the standard deviation and co-efficient of variation were less than the overall mean values 1.88 and 8.00 respectively (Table-3). These accessions also showed the total filament length more than 1000 meters with SD and CV being 164.320 and 18.62 respectively. In all the accessions the average non-broken filament length was more than 825 metres with SD and CR being 193.545 and 27.46 respectively indicating less breakage during the total reeling process. Observations made on these 13 accessions showed that except BBE-0205 all the other accessions have elongated cocoon shape with faint constriction indicating the superiority of the elongated cocoon shape for getting filament with less breakage during reeling process.

Table 2. Correlation matrix of cocoon size variables with filament length and non- broken filament length in silkworm (*Bombyx mori* L.) germplasm

Parameter	Cocoon Length	Cocoon Width	Length Width Ratio	Filament Length	Non-broken Filament Length
Cocoon Length	1.00000	-0.16973	0.58115	0.05350	0.07314
Cocoon Width	-	-	0.89617	0.00283	0.05973
Length Width Ratio	-	-	-	0.01338	-0.02327
Filament Length	-	-	-	-	.073855
Non-broken Filament length	-	-	-	-	-

Table 3. Statistics of best-ranked silkworm (*Bombyx mori* L.) germplasm accessions for uniformity in cocoon shape and filament characters

Accession No.	Cocoon Length (mm)			Cocoon width (mm)			Length-width Ratio			Average	Average
	Mean	SD	CV%	Mean	SD	CV%	Mean	SD	CV%	Filament Len(m)	NBF (m)
BBE-0175	31.23	1.590	5.090	19.77	0.726	3.672	157.967	9.145	5.785	1023.54	846.40
BBE-0178	34.40	1.664	4.836	18.06	1.047	5.800	190.476	12.699	6.650	1020.70	887.30
BBE-0179	33.41	1.498	4.484	20.89	0.861	4.123	159.933	4.906	3.067	1047.20	879.05
BBE-0180	34.05	1.682	4.942	17.53	1.088	6.211	194.238	15.412	7.905	1052.11	911.05
BBE-0181	35.41	1.516	4.280	19.71	0.883	4.484	179.655	10.062	5.592	1086.70	934.05
BBE-0182	33.95	1.489	4.386	18.26	0.779	4.267	185.926	11.148	5.986	1061.90	970.10
BBE-0185	32.64	1.550	4.749	15.67	0.742	4.739	208.296	9.861	4.730	1046.50	909.30
BBE-0186	34.25	1.462	4.270	19.03	0.763	4.011	179.979	8.387	4.655	1054.25	881.15
BBE-0187	33.85	1.417	4.187	18.66	0.786	4.215	181.404	9.955	5.480	1022.30	893.00
BBE-0192	34.11	1.260	3.694	17.28	0.958	5.549	197.396	9.994	5.053	1005.33	837.78
BBE-0197	33.40	1.435	4.297	19.04	1.077	5.658	175.420	10.583	6.018	1173.61	1043.21
BBI- 0205	35.48	1.643	4.632	20.86	1.026	4.921	170.086	9.402	5.519	1028.51	881.58
BBE-0270	34.76	1.548	4.455	17.86	0.905	5.076	194.625	7.429	3.814	1092.60	993.27

Conclusion

It is evident from the results obtained that cocoon shape exerts more influence on filament breakage during reeling process and cocoon size variables like cocoon length and width do not contribute significantly for total filament length and non-broken filament length. Since mode of inheritance of cocoon shape in silkworm and the number of genes controlling the expression of cocoon shape and size have been established by Hirabayashi (1982) and Gamo et al. (1985),the present study corroborate the earlier findings that cocoon shape along with those quantitative traits governing silk productivity needs to be given more emphasis for identifying or selecting suitable parents for breeding and evaluation programme to produce uniform shaped cocoons with desired filament characteristics.

Acknowledgements

Authors thank Shri.R.Pugalendi, Technical Assistant for single cocoon reeling analysis and Shri.S.Sekar, Computer Programer for statistical analysis.

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Received: February 04, 2009; Revised: October 28, 2009; Accepted: November 10, 2009