RECIPROCAL EFFECT IN HYBRIDS BETWEEN UNIVOLTINE AND MULTIVOLTINE BREEDS OF THE SILKWORM, *BOMBYX MORI* L.

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ABSTRACT: Reciprocal effects were studied in F_1 hybrids involving three indigenous multivoltine silkworm breeds and one tropical univoltine race. Superiority of straight crosses between univoltine and multivoltine breeds has been shown for cocoon yield /10,000 larvae by number and weight, cocoon weight, cocoon shell weight and cocoon yield/100 dfls whereas, reciprocal crosses of univoltine × multivoltine were found superior only for fecundity and cocoon shell percentage. Among the hybrids, Barpat × PM was adjudicated as the best hybrid exhibiting maximum average evaluation index values of 60.30 and >50 index values for all the economic characters except ERR by number and ranked first followed by Nistari × Barpat (50.76) and Sarupat × Barpat (49.44) which were ranked second and third exhibiting >50 evaluation index values for six and five characters respectively.

KEY WORDS: *Bombyx mori* L., multivoltine and univoltine breeds, reciprocal effect, straight and reciprocal hybrids.

In India, maximum silk production is from multivoltine × bivoltine hybrids but their reciprocal crosses *i.e.,* bivoltine × multivoltine are not practiced due to known genetic reasons (Nagatomo, 1942; Nakada, 1970; 1972; Benchamin et al., 1988; Tazima, 1988). Studies on reciprocal effects in the mulberry silkworm have been carried out by several workers (Petkov et al., 1977; Murakami and Ohtsuki, 1989; Chattopadhyay et al., 1996; Rajanna and Puttaraju, 1998; Mal Reddy et al., 2003). The reciprocal differences are caused primarily by sex linkage and maternal effects (Durrant, 1965; Crusio, 1987). Singh et al. (2006) have studied reciprocal effect in multivoltine, multivoltine × bivoline and bivoltine hybrids. No information is available on reciprocal effect in hybrids involving indigenous multivoltine and univoltine silkworm breeds. Hence, the present study was undertaken to know the effect of reciprocal crossing in hybrids between multivoltine and univoltine breeds of the silkworm, *Bombyx mori* L.

MATERIAL AND METHODS

Three indigenous multivoltine race *viz.,* Pure Mysore, Sarupat and Nistari and one tropical univoltine race Barpat were utilized in the present study. Three multivoltine × univoltine hybrids *viz.,* PM × Barpat, Sarupat × Barpat and Nistari × Barpat and their reciprocals were tested. Rearing was conducted with three replications in each hybrid where 250 larvae were retained after 3^{rd} moult. Data were recorded for ten characters namely, fecundity, hatching percentage, weight of ten larvae, yield / 10,000 larvae by number and weight, cocoon weight, cocoon shell weight, cocoon shell percentage cocoon yield/100 dfls and filament length.

Evaluation of the hybrids has been carried out through multiple traits evaluation index method of Mano et al. (1993). Evaluation Index (E. I.) for different characters was calculated using the following formula:

$$E.\ I. = A - B / C \times 10 + 50$$

Where,

A = value obtained for a particular hybrid combination.
B = mean value of particular trait of all the hybrid combinations.
C = standard deviation of particular trait of all the hybrid combinations.
10 = standard unit.
50 = fixed value.

RESULTS

Performance of F_1 hybrids between univoltine and multivoltine breeds and their reciprocals is given in Table 1. Cocoons of straight and reciprocal crosses have been depicted in Plate I. Character-wise results are briefly mentioned below.

Fecundity: Among the six hybrids, maximum fecundity (536) was observed in Barpat × PM followed by Nistari × Barpat (498) and Barpat × Sarupat (497).

Hatching percentage: Hatching percentage was recorded maximum 96.33 % in Barpat × PM followed by PM × Barpat and Barpat × Nistari (95.66 %).

Weight of 10 larvae: Weight of ten larvae was found maximum in Barpat × PM (33.50 g) followed by PM × Barpat and Barpat × Nistari (32.43 g).

Cocoon yield / 10,000 larvae by number: Cocoon yield/10,000 larvae by number was observed maximum in Nistari × Barpat (9880) followed by PM × Barpat and Barpat × Nistari (9840).

Cocoon yield / 10,000 larvae by weight (kg): Variation was observed in cocoon yield / 10,000 larvae by weight. In hybrid Sarupat × Barpat, maximum cocoon yield / 10,000 larvae by weight (14.320 kg) was observed followed by Barpat × PM (14.027 kg) and Nistari × Barpat (13.280 kg).

Cocoon weight (g): Higher cocoon weight was observed in Sarupat × Barpat (1.455 g) followed by Barpat × PM (1.448 g) and Nistari × Barpat (1.409 g).

Cocoon shell weight (g): Cocoon shell weight was observed higher in Barpat × PM (0.227 g) followed by Nistari × Barpat (0.219 g) and Barpat × Nistari (0.213 g).

Cocoon shell percentage: Cocoon shell percentage was found higher in Barpat × Nistari (15.89 %) followed Barpat × PM (15.69 %) and Nistari × Barpat (15.56%) respectively.

Cocoon yield/100 dfls (kg): Cocoon yield/ 100 dfls was recorded higher in PM × Barpat (57.493 kg) followed by Sarupat × Barpat (57.280 kg) and Barpat × PM (56.106 kg) respectively.

Filament length (m): Longest filament length of 603 m was observed in Barpat × PM followed by Sarupat × Barpat (563 m) and Barpat × Sarupat (512 m) respectively.

Average Evaluation Index values: Among the six hybrids, Barpat × PM was adjudicated as the best hybrid exhibiting maximum average evaluation index value (60.30) and >50 index values for all the economic characters except ERR by number and ranked first followed by Nistari × Barpat (50.76) and Sarupat × Barpat (49.44) which were ranked second and third exhibiting >50 evaluation index values for six and five out of ten characters respectively.

DISCUSSION

Multivoltine hybrids are not economical for commercial exploitation as they possess less fecundity and moreover qualitative and quantitative characters are low both in straight and reciprocal crosses. Straight crosses of multivoltine × bivoltine hybrids are commonly used for commercial exploitation whereas the reciprocal crosses (bivoltine × multivoltine) are disadvantageous in terms of cocoon yield / 10,000 larvae by weight, cocoon weight, cocoon shell weight, cocoon shell percentage and filament length. Similar observations were reported by Tazima (1988) and Benchamin et al. (1988). Utilization of reciprocal crosses would be advantageous in increasing fecundity. The study is in agreement with that of Mal Reddy et al. (2003). In this study, possibility of utilizing multivoltine breeds with one tropical univoltine race "Barpat" has been explored. The striking feature of PM × Barpat and its reciprocal Barpat × PM is that there was no significant difference for most of the characters between straight and reciprocal cross. Less effect in the reciprocal cross may be due to diapausing nature of the eggs of the univoltine parent Barpat utilized. It is interesting to note that cocoon weight and cocoon shell weight in univoltine × multivoltine hybrids are low as compared to the straight cross except in Barpat × PM where they are higher than the straight cross. High or low cocoon weight may be due to the presence of sex linked maturity genes like late maturity genes (Lm) found in univoltine and early maturity genes (Lm^e) in multivoltine (Morohoshi, 1949). Univoltine breeds are assumed to possess dominant genes on Z chromosome. In the straight cross, both male and female F_1 progeny produce high quantitative characters whereas in the reciprocal cross, the genetic constitution of male favours to possess high quantitative characters as depicted in Figure 1.

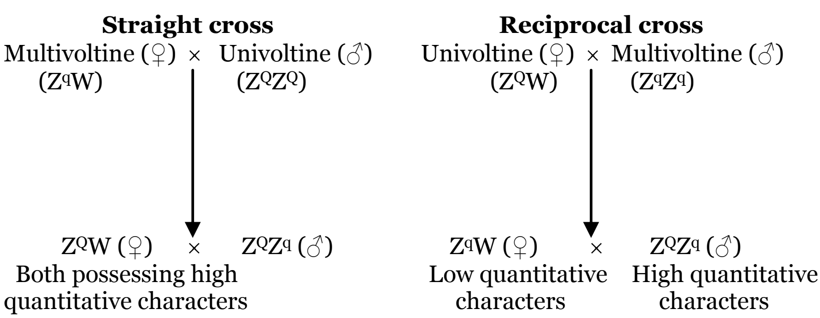

Figure 1. Genetic constitution of straight and reciprocal crosses between univoltine and multivoltine breeds.

In this study, high cocoon yield / 10,000 larvae, cocoon weight and cocoon shell weight were observed in straight crosses. In the reciprocal crosses, the quantitative characters are low in terms of cocoon yield, cocoon weight and cocoon shell weight except the hybrids involving PM and Barpat. Low quantitative characters in reciprocal cross of multivoltine and univoltine breed may be due to recombination of sex-linked genes (Nagatomo, 1942; Murakami and Ohtsuki, 1989; Mal Reddy et al., 2003).

In the present study, reciprocal effects were pronounced in the hybrids involving silkworm breeds with different voltinism and straight crosses between univoltine and multivoltine silkworm breeds exhibited their superiority for several economic characters like cocoon yield, cocoon weight and cocoon shell weight. PM × Barpat and its reciprocal Barpat × PM may be recommended for large scale exploitation in the field as the quantitative characters are on par in straight as well as in the reciprocal cross.

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Table 1. Performance of straight and reciprocal crosses between univoltine and multivoltine breeds of the silkworm, *Bombyx mori* L..

Hybrid	Fecundity	Hatching (%)	Weight of 10 larvae (g)	Yield / 10,000 larvae		Cocoon weight (g)	Cocoon shell weight (g)	Cocoon shell (%)	Cocoon yield/100 dfls (kg)	Filament length (m)	Average Evaluation Index
				By No.	By Wt. (kg)						
PM × Barpat	487 (46.08)	95.36 (56.02)	32.43 (42.66)	9733 (58.10)	14.373 (44.06)	1.434 (44.85)	0.209 (46.00)	14.57 (37.67)	57.493 (60.56)	443 (37.79)	47.38 (V)
Barpat × PM	536 (67.39)	96.33 (62.67)	33.50 (66.44)	9547 (45.19)	14.027 (59.85)	1.448 (59.28)	0.227 (64.00)	15.69 (57.67)	56.106 (55.64)	603 (64.91)	60.30 (I)
Sarupat × Barpat	468 (37.82)	92.35 (35.41)	33.04 (56.22)	9346 (36.34)	14.320 (64.73)	1.455 (60.28)	0.212 (49.00)	14.57 (36.67)	57.280 (59.80)	563 (58.13)	49.44 (III)
Barpat × Sarupat	497 (50.43)	93.52 (43.42)	32.37 (41.33)	9480 (42.24)	12.827 (39.85)	1.289 36.57)	0.197 (34.00)	15.31 (50.89)	50.773 (36.73)	512 (49.49)	42.49 (VI)
Nistari × Barpat	498 (50.87)	93.97 (46.50)	32.73 (50.66)	9880 (59.86)	13.280 (47.40)	1.409 (53.71)	0.219 (56.00)	15.56 (55.36)	53.120 (45.05)	469 (42.20)	50.76 (II)
Barpat × Nistari	487 (46.08)	95.36 (56.02)	32.43 (42.66)	9840 (58.10)	13.080 (44.06)	1.347 (44.85)	0.213 (44.85)	15.83 (60.17)	52.320 (42.21)	498 (47.11)	48.61 (IV)

Values in parentheses indicate evaluation index value.

1 2

3 4

5 6

Plate I. Photographs of hybrid cocoons between univoltine and multivoltine silkworm breeds: 1. PM × Barpat 2. Barpat × PM 3. Sarupat × Barpat 4. Barpat × Sarupat 5. Nistari × Barpat and 6. Barpat × Nistari.