Pattern of Silk Yield and Silk Filament Quality in Ecoraces and F1 Hybrids of Indian Tropical Tasar Silkworm, *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) in Relation to Crop Seasons


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**Abstract:** The evaluation of silk traits among the assorted ecoraces (Daba, Jata and Raily) of Indian tropical tasar silkworm, *Antheraea mylitta* Drury and their F1 hybrids during commercial crop rearing season have revealed clear variation between them and as well with the parental ecoraces of seed crop season. The parental ecoraces and F1 hybrids have recorded improvement in shell weight and length of silk filament during commercial crop season, while the silk yield was improved only in Jata ecorace (+21.1%) over same parent of seed crop season among the parents; and in Daba x Jata (+94.5%) and Jata x Daba (+82.6%) hybrid combinations over mid parent values among F1 hybrids. The silk filament denier has also shown improvement in all the parental ecoraces during the commercial crop rearing season over their respective parents of seed crop season. However, the filament denier of Raily x Daba hybrid combination has recorded negative (-10.5%), while the other three F1 hybrids have shown improvement in filament denier over mid parent value. The study infers that the economic performance of parental ecoraces and F1 hybrid combinations was superior during commercial crop rearing season due to positive interaction with the prevailed favourable environment to optimize their phenotypic expression. The superior performance of parental and hybrid genotypes of tropical tasar silkworm of commercial crop season has contributed for higher silk yield and lengthier but high denier silk filament. Hence, the rearing of additional commercial silkworm seed of parental ecoraces and F1 hybrid combinations during commercial crop season can result to superior phenotypes of parental as well as the F1 hybrid genotypes with improved silk yields and enhanced crop returns to sustain tropical tasariculture.

**Key words:** *Antheraea mylitta* D · Daba · Economic traits · Ecorace · F1 hybrids · Jata · Raily

**INTRODUCTION**

The available genetic variation of economically important wild and domesticated silk insects needs exploitation through silk associated traits for commercial advantage by applying the suitable breeding procedure [1-7]. The commercial success of tropical tasariculture depends on cocoon and silk yields for better crop returns, which depends on phenotypic expression of tasar cocoon form [8-11]. Though, the overall productivity in tasariculture is a collective impact of fecundity, hatching, effective rate of rearing (ERR), cocoon and shell weight and silk ratio; the most important is the genotype and environment interaction, which is a critical for tropical economic insect ecotypes of *Antheraea mylitta* to improve their commercial traits [1, 4, 5, 8, 12-15]. The gene is an endogenic factor and to play a major role, while the environment is exogenic factor and will influence the expressivity of gene to produce a phenotype based on the environment [10, 16-19]. The genetic interaction through hybridization not only provides heterobeltiosis but also contributes for silk quality due to genetic diversity of the
parental races involved in the breeding [10, 13, 20]. The fecundity, cocoon weight and shell weight showed higher co-heritability and significant correlations with the silk yield [4, 8, 13, 21]. The extent of hybrid vigor in silk related traits found varying under different temperatures [10, 18]. The variation in temperature, nutrient availability, feeding duration and larval crowding along with environmental stimuli influence the body plasticity [2, 22]. The silkworm hybrids have recorded better reeling performance over pure races [13, 23] and the correlation was positive among shell weight and filament length but negative between filament thickness and length [22, 24]. The lack of high yielding inherent breeds in tasar silkworm requires utilizing relevant variety for hybridization to improve the commercial traits. The combining of yield potential and survival consistency for best possible productivity through hybridization as well as the genotype environment interaction as the crop rearing seasons with three diverse ecoraces like Daba from Jharkhand, Jata from Orissa and Raily from Chhattisgarh is the aim of present study.

MATERIALS AND METHODS

Three parental ecoraces Daba, Jata and Raily of Antheraea mylitta Drury were initially reared in a randomized block design with three replications each during the seed crop rearing season (July-August) for three successive years (2007 to 2009), raised the non hibernating seed cocoon stocks and kept in the grainage house following integrated package of seed cocoons preservation and conducted grainage for seed production [25]. The fresh moths emerged during September month of respective year were used to produce disease free layings (Dfls) of F1 hybrids viz; Jata x Daba, Raily x Daba and their reciprocals in addition to pure layings of parents through selfing. Three parental ecoraces along with four F1 hybrids in total seven (7) were reared simultaneously in a randomized block design with three replications each during commercial crop season (September-November) of three years (2007 to 2009) on the economic plantation of Terminalia tomentosa (W&A) at field laboratory of Central Tasar Research and Training Institute, Ranchi, Jharkhand, India following integrated package of tasar silkworm rearing [26]. The larvae of one disease free laying (Dfl) of parents as well as F1 hybrids were considered as one replication during rearing for recording the observations. The single shell weight was calculated with equal number of random samples and the silk yield was calculated multiplying the average single shell weight with the number of cocoons harvested per Dfl. The silk related technological characters like length and denier of silk filament were studied on single cocoon basis in parents and F1 hybrids at post cocoon technology division of the Institute. The data recorded on different parameters in the study were subjected to statistical analysis.

RESULTS

The analysis of variance (ANOVA) in respect of shell weight, silk yield, silk filament length and filament denier among parents of seed crop, parents of commercial crop and F1 hybrids of commercial crop seasons (Table 1) revealed significant variance, except for shell weight among the controls i.e. the parents of seed crop rearing season and for filament denier in controls versus treatments. However, the ANOVA among the seven treatments i.e. the three parents and four F1 hybrid combinations of commercial crop season has shown significant variance for all the silk associated traits studied.

The Performance levels of shell weight, silk yield, filament length and filament denier in respect of parents of seed crop, parents of commercial crop and F1 hybrids of commercial crop seasons (Table 2) indicates the deviation. The performance improvement was recorded in parental ecoraces, Daba (T1), Jata (T2) and Raily (T3) during

<p>| Table 1: ANOVA for silk associated economic traits among parents of seed and commercial crops and F1 hybrids of commercial crop seasons |</p>
<table>
<thead>
<tr>
<th>Particulars</th>
<th>Source</th>
<th>Mean sum of squares</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replicates</td>
<td>DF</td>
<td>Shell weight (g)</td>
</tr>
<tr>
<td>Control</td>
<td>2</td>
<td>0.02</td>
</tr>
<tr>
<td>Treatments</td>
<td>6</td>
<td>2.54 **</td>
</tr>
<tr>
<td>Control versus Treatments</td>
<td>1</td>
<td>1.6 **</td>
</tr>
<tr>
<td>Error (A)</td>
<td>18</td>
<td>0.05</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Mean values: Silk yield (g), Filament length (m), Filament denier (d)

***-significant at 0.1% **- significant at 1% NS-non significant
Table 2: Performance levels of silk associated economic traits of parents of seed and commercial crops and F₁ hybrids of commercial crop seasons (values represent mean, ±SE, + or - percent change over parents of seed crop and values in parenthesis are the mid parent heterosis over parents of seed crop)

<table>
<thead>
<tr>
<th>Race/ F₁ hybrid</th>
<th>Shell weight (g)</th>
<th>Silk yield (g)</th>
<th>Filament length (m)</th>
<th>Filament denier (d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daba (C)</td>
<td>1.43 ±0.07</td>
<td>96.2 ±9.3</td>
<td>799 ±86</td>
<td>10.61 ±0.17</td>
</tr>
<tr>
<td>Jata (C)</td>
<td>1.63 ±0.12</td>
<td>70.7 ±3.0</td>
<td>1016 ±79</td>
<td>12.59 ±0.36</td>
</tr>
<tr>
<td>Raily (C)</td>
<td>1.75 ±0.07</td>
<td>39.3 ±3.2</td>
<td>1157 ±83</td>
<td>13.65 ±0.39</td>
</tr>
<tr>
<td>Daba (T₁)</td>
<td>1.70 ±0.02±18.9</td>
<td>95.6 ±6.5</td>
<td>880 ±10.1</td>
<td>11.04 ±0.34</td>
</tr>
<tr>
<td>Jata (T₁)</td>
<td>1.82 ±0.12±11.6</td>
<td>85.6 ±5.3</td>
<td>1249 ±89.2</td>
<td>12.64 ±0.30</td>
</tr>
<tr>
<td>Raily (T₁)</td>
<td>2.11 ±0.09±20.6</td>
<td>36.7 ±5.6</td>
<td>1257 ±56.6</td>
<td>13.85 ±0.46</td>
</tr>
<tr>
<td>Daba x Jata (T₂)</td>
<td>2.21±0.18(+44.4)</td>
<td>162.2 ±10.4</td>
<td>1790 ±129.6</td>
<td>11.98 ±0.25</td>
</tr>
<tr>
<td>Jata x Daba (T₂)</td>
<td>2.09±0.14(+36.6)</td>
<td>152.3 ±9.9</td>
<td>1744 ±92.3</td>
<td>12.32 ±0.17</td>
</tr>
<tr>
<td>Daba x Raily (T₂)</td>
<td>2.45±0.20(+54.1)</td>
<td>44.9 ±2.8</td>
<td>1109 ±19(13.4)</td>
<td>12.18 ±0.49</td>
</tr>
<tr>
<td>Raily x Daba (T₂)</td>
<td>2.47±0.12(+55.3)</td>
<td>35.0 ±3.0</td>
<td>1546 ±40(58.1)</td>
<td>10.86 ±0.40</td>
</tr>
</tbody>
</table>

commercial crop season in all the parameters except for silk yield of T₁ and T₂ over their respective parents of seed crop rearing season. The F₁ hybrid, Daba x Jata (T₂) and its reciprocal Jata x Daba (T₁) have recorded mid parent heterosis over the parents of seed crop in all the silk associated traits and better heterosis was recorded in T₂. The Daba x Raily (T₂) F₁ hybrid and its reciprocal Raily x Daba (T₁) have recorded positive mid parent heterosis over the parents of seed crop in shell weight and filament length and negative in silk yield, while the filament denier was marginally positive in T₂ and noticeably negative in T₁. However, the performance of all the F₁ hybrids in respect of shell weight, silk yield and silk filament length traits are superior over the parents of both seed and commercial crop rearing seasons except for the filament denier, which was marginally reduced over one of the parents in Jata based hybrids (T₁ & T₂), while it was reduced over both the parents in Raily based hybrids (T₁ & T₂).

**DISCUSSION**

The significant variance among the parents of seed crop season (controls), parents and F₁ hybrids of commercial crop season (treatments - T₁ to T₂) specify the existence of genetic divergence among the parental tasar ecocores. Further, their varied phenotypic performances when reared under different rearing environments i.e. seed (July-August) and commercial (September-November) crop seasons indicate the impact of rearing environment on their economic performance. The significance variation was high among the treatments i.e. treatments T₁ to T₂; in spite the fact that the treatments includes both parents as well as F₁ hybrids and however, the rearing crop season and rearing environments were identical, which indicates the role of genotype and environment (G x E) interaction on the phenotypic expression of a genotype with change in the environment [1, 8, 10, 11, 13, 18, 19]. Yet, the existence of variance among treatments (T₁ to T₂), though they reared only under commercial rearing season (September-November) and the higher performance of F₁ hybrids (T₁ to T₂) over the parents (T₁ to T₂) also indicates the clear mid parent heterosis in the silk associated economic traits [8, 10, 14, 18, 23].

The performance levels of parental ecocores clearly indicate their distinctiveness in respect of silk associated traits as like their origin from different ecozones of the country and existence of genetic diversity among them [3, 5, 7, 10, 14, 23]. The higher total silk yield with lower filament denier in spite of lesser shell weight in Daba parental ecocore proves its commercial superiority and economic viability and might be the reason for its popular commercial practice in almost all the tasar practicing areas of the country. In contrary, the other two wild ecocores, Jata and Raily in spite of having better shell weight and longer filament length, their low silk yield and non domestication made them not suitable for exploitation through commercial rearings, but for the actuality that they are substantially contributing for country’s tasar raw silk production from the nature grown wild cocoons collected by the local tribal farmers. To evaluate the performance of these diverse tasar ecocores away from their ecozones (ex-situ) under two different crop rearing seasons and also to mix the advantage characters of both domesticated and wild ecocores for heterosis [1, 4, 5, 7, 13, 14] in silk related economic traits at F₁ level, the three assorted tasar ecocores (Daba, Jata and Raily) of *A. mylitta* have been selected.

The tropical tasar ecocores with bivoltinism show different cocoon performances over seed crop (July-August) and commercial crop (September-November) seasons due to environmental variations and quality of food plant leaf [2, 7, 10, 13, 22], which can alter the larval duration and diapause and non-diapause predestined compatibilities. The said reasons contribute for the cocoon phenotype with thin cocoon shell of non
diapausing character during seed crop season and with thicker cocoon shell of diapausing character during commercial crop season. These describe the role of environment in exhibiting the phenotypic characters of a genotype and hence the comparison has been made among the parents of both crop seasons along with $F_1$ hybrids of commercial crop season. This is to also assess the impact of crop seasons on phenotypic expression in relation to the silk associated traits and the extent of difference among parents and hybrids to identify the impact of heterosis on the silk associated economically important traits. The improvement in shell weight, filament length and denier in parents of commercial crop season i.e. $T_1$ to $T_1$ over their respective parents of seed crop season and also silk yield in $T_2$ (Jata race) indicate the impact of crop seasons on the phenotypic expression of the ecoraces [5, 7, 14, 18], which might also be a cumulative or interrelated impact among the silk associated traits [4, 11, 13, 19]. However, the silk yield in respect of $T_1$ (Daba) and $T_1$ (Raily) reduced marginally in commercial crop season in spite of improvement in all other three silk associated traits might be due to low effective rate of rearing (ERR) and cocoon yields, vulnerability to diseases and racial characteristic performance with the crop seasons. The high filament denier recorded in the parents and $F_1$ hybrids of commercial crop season over seed crop season indicates the impact of crop season as well as heterosis on most important silk associated trait, which decides the silk filament commercial quality. This might also be due to the predestined diapausing compatibility of the parental and hybrid cocoon genotype generation, as both the cocoons (Parents and hybrids) of commercial crop will undergo diapause after commercial crop season. However, the silk yield, filament length and filament denier are the commercially important traits in terms of productivity and quality; they rarely exist together as they are related inversely. Hence, the better silk yield or the lengthier silk filament even with high denier and moderate length in silk filament with low denier are advantageous over the existing ecorace options, which can contribute for the comparatively better sustenance of tropical tasariculture.

While comparing the impact of mid parent heterosis in respect of silk associated traits in $F_1$ hybrids, the $T_i$ i.e. Daba x Jata and $T_i$ i.e. Jata x Daba have shown improvement in all traits, (though it was not desirable in silk filament denier) indicating the combined role of hybridization and crop season on the phenotypic expression of silk traits with prominent jump in silk yield and silk filament length [8, 13, 23, 24, 27]. The higher performance of $T_i$ (Daba x Jata) over the parents of both crop seasons in all the traits except for filament denier indicate the positive mid parent heterosis and genotype environment relation during the commercial crop season on silk associated economic traits [3, 4, 5, 7, 21, 27] as the hybrid has been compared with its parental ecoraces reared under same crop season. The increase in filament denier of these two hybrids was found lesser than their respective parents of corresponding crop season. The overall performance of $F_1$ hybrid, Jata x Daba ($T_{1i}$) was next to Daba x Jata ($T_{2i}$) combination with marginal decrease in shell weight, silk yield and filament length and increase in filament thickness and however, it could surpass its parents of both crop seasons. The $F_1$ hybrid, Daba x Raily ($T_{1i}$) and its reciprocal, Raily x Daba ($T_{2i}$) have shown better performances during commercial crop season over the parents of both crop seasons in addition to positive heterosis in shell weight, filament length with filament of finer denier among all the hybrids by $T_{1i}$, were next to $T_{2i}$ and $T_{1i}$ and most importantly were negative in very important silk associated trait, the silk yield even on its parents of corresponding commercial crop rearing season.

CONCLUSION

The study reveals that the performance of parental ecoraces and $F_1$ hybrids was superior during commercial crop rearing season due to positive interaction with the environment of crop season to attain better cocoon phenotype. The improved performance of parental and hybrid genotypes of tropical tasar silkworm during commercial crop season has given higher silk yield and lengthier silk filament with high denier. Hence, the rearing of additional tasar silkworm seed both of parental ecoraces and $F_1$ hybrid combinations during commercial crop rearing season can enhance the silk yield and crop returns to sustain Indian tropical tasariculture.

REFERENCES


