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Application of Parents by Selection for Basic and Commercial Seed Efficiency in Tropical Tasar Silkworm, *Antheraea mylitta* Drury (Lepidoptera: Saturniidae)

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Abstract: The growing requirement of seed (eggs) of tasar silkworm, *Antheraea mylitta* Drury, needs parental application by selection for strategic maintenance of its basic seed and to achieve optimal productivity in commercial seed. The varied lines of basic seed of Daba ecorace maintained on the basis of parental pupal and shell weights for five successive seasons [Jul/Aug '06 (S1), Sep/Nov '06 (S2), Jul/Aug '07 (S3), Sep/Nov '07 (S4) and Jul/Aug '08 (S5)], shown superior performance averages in egg fecundity (286 no) by high pupal line (L2); shell weight (1.42 g) by high shell line (L3); egg fecundity (277 no), shell weight (1.54 g) and silk yield (76.1 g) by high pupal and high shell line (L4) over the control line (L1). These lines of basic seed help in improving and balancing the needy commercial traits for a specific season or region. The mid pupal weight group (MPW) of males (6.50 to 7.50 g), females (9.00 to10.00 g), their combinations and vice versa of Daba ecorace have shown enhanced moth coupling (8.7 and 5.2 %), fecundity (4.9 and 15.2 %), egg fertility (3.5 and 3.1 %) and egg hatching (23.8 and 24.8 %) respectively over the control i.e. random mated group. The correlation among male and female pupal weights and their combination indicates the suitability of moths from mid to low weights in males and from mid to high in females for optimal commercial seed productivity. The study infers that, the maintenance of varied parental lines based on pupal and shell weight in basic seed and suitable combinations of male and female moths in commercial seed helps in enhancing the seed efficiency of commercially exploited tropical tasar ecorace, Daba.

Key words: *Antheraea mylitta* · Seed efficiency · Parents by selection · Basic and commercial seed

INTRODUCTION

Tropical tasarculture is the rearing of wild silkworms of *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) for production of tasar (Vanya) silk and it provides livelihood to rural tribals in India. Over generations, the insect species have adapted to different tropical forest environments and formed as 44 ecoraces with phenotypic variations [1]. They feed mainly on *Shorea robusta* (Sal), *Terminalia arjuna* (Arjun) and *Terminalia tomentosa* (Asan), besides many other secondary and tertiary food plants. Among the ecoraces, Daba and Sukinda along with a little of Jata are semi domesticated and commercially applied for rearings [2]. The basic and commercial seed activities of tasarculture need optimization to enhance returns to growers, rural employment and raw silk productivity. The selection of parental races should be precise as per commercial requirement and traits of productivity [3,4,5] and the parental application with specific traits lead to explicit individuals in their progeny [6]. The different mating systems can balance the traits in selected line for higher cocoon yield and silk quality [7,8], the selection of bigger females improves silkworm fecundity [9-12] and parents with higher shell will contribute better shell weight and silk ratios [13]. The repeated and unplanned multiplication of breed leads to poor yield and the proper maintenance of basic stock can retain the parental characters essential for further multiplication [8,14,15]. During the race maintenance, the methods of selection, crossing techniques and ecological requirements are to be maintained because of their crucial impact on seed quality and viability [7,8,14,15,16]. The males of different breeds can influence the egg laying performance in *Bombyx mori* L [17,18] and the age of moths alters the fecundity and egg fertility in *Antheraea mylitta* D [19].

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The male derived factors control egg fecundity and fertility besides the activity of copulation in insects [20]. The better rearing conditions, environment and nutrition during larval period will produce bigger females, leads to higher fecundity [3, 21,22] and the males on first mating can transfer sufficient spermatic fluid yielding higher fecundity and better hatching [17]. The release of sperm along with fecundity enhancing substances (FES) influence egg quality [23] and mating duration has impact on egg hatching [24]. The optimization of vigor in an ecorace through strategic maintenance of its basic seed applying parents by selection and to enhance the efficiency of males and females by correlating pupal weights and combinations for viable commercial seed in tropical tasarculture has prompted to take up the present study.

MATERIALS AND METHODS

Seed Cocoon Selection, Basic Seed Preparation and Silkworm Rearing: The stabilized cocoon stocks of Daba ecorace obtained from reserve pool of Central Tasar Research and Training Institute, Ranchi were used for the study. The cocoons were assessed for pupal weights, shell weights and pupal sexing to segregate high pupal weight and high shell weight groups with both sexes; while the other as high pupal female and high shell male group in addition to a mixed group of cocoons without any selection. The disease free layings (Dfls) of varied lines **(L1 to L4)** have been prepared by crossing parents by selection, based on pupal and shell weights with high pupal female x high pupal male as **L2** (PxP), high shell female x high shell male as **L3** (SxS) and high pupal female x high shell male as **L4** (PxS) along with random female x random male, the control as **L1**. The Dfls prepared under four lines **(L1 to L4)** of Daba ecorace were reared successively for five seasons (generations) during Jul/Aug ’06 **(S1)**, Sep/Nov ’06 **(S2)**, Jul/Aug ’07 **(S3)**, Sep/Nov ’07 **(S4)** and Jul/Aug ’08 **(S5)** and the cocoons produced under four varied lines of each generation were utilized to continue their progenies. During the course of stock maintenance the parental cocoons were considered based on better fecundity and egg hatching percentage, period of larval spinning, uniform shape and color of cocoons, shell weight and higher silk yields in addition to pupal and shell weights for different lines. Three replications have been maintained for each line **(L1 to L4)** considering larvae of one Dfl as one replication during all rearing seasons **(S1 to S5)** and observations were recorded for fecundity (no), egg hatching (%), shell weight (g) and silk yield (g). The data recorded on different parameters in the study with three replications each of varied lines over seasons were subjected to statistical analysis.

Male and Female Pupal Combination and Commercial Seed Preparation: The seed cocoons of Daba ecorace obtained from reserve pool of Central Tasar Research and Training Institute, Ranchi were cut open and male and female pupae were separated. Based on weight, each sex has made into three groups as low pupal weight (LPW), mid pupal weight (MPW) and high pupal weight (HPW). In one set of experiment the females of mid pupal weight (MPW) were mated separately with males of three varied groups i.e. LPW, MPW, HPW and random (no selection) mating group as control, while in other set of experiment the males of mid pupal weight (MPW) were used for mating separately with females of three varied groups i.e. LPW, MPW, HPW and random mating group as control, to study correlation between the reproductive performance and male/ female pupal weights / combinations. The freshly emerged males and females of different pupal weight groups were coupled at 8.00 AM using separate cocoon cages. Combination wise coupling percentages were recorded, allowed mating for 8 hours i.e. up to 4.00 PM and the decoupled female moths kept individually in paper boxes for oviposition. Eggs of each female moth were collected after 72 hours, recorded fecundity and incubated under optimal conditions (25±1°C temperature and 85±5% relative humidity) till hatching. The egg hatching was recorded for first three days to calculate hatching percentage and the eggs were allowed to hatch till last to know the number of fertilized eggs and fertility percentage. The study conducted during both grainage seasons for two years and data on different parameters with six replications of each group were subjected to statistical analysis.

RESULTS

Study on Varied Lines of Basic Seed: The performance levels of Daba ecorace in commercial traits under different lines versus seasons and seasons versus lines (Table 1) indicate their significance at 5% level as against their respective controls of **L1 x S1** to **L4 x S1.** The maximum improvement has been recorded in fecundity (286 to 309 no) of high pupal line, **L2**, while the high pupal and high shell line, **L4** has recorded better fecundity (273 to 294 no) and egg hatching (64.2 to 73.7 %) along with highest shell weight (1.4 to 1.9 g) and silk yield (60.6 to 110 g).

Table 1: Performance of parental lines on seed and silk traits of Daba ecorace over seasons (values represent mean and ± SE)

	Factors	Fecundity (no)	Hatching (%)	Shell weight (g)	Silk yield (g)
Lines	L1x S1 to	255 ±4.1	58.3 ±1.7	1.0 ±0.0	50.0 ±3.0
VS	L4 x S1(C)				
Seasons	L1 x S2	250 ±7.4	68.6 ±1.1	1.5 ±0.0	73.5 ±5.2
	L1 x S3	253 ±12.0	68.4 ±0.9	1.2 ±0.03	65.9 ±6.1
	L1 x S4	260 ±2.0	71.2 ±1.2	1.5 ±0.03	81.9 ±4.8
Lines	L1 x S5	257 ±4.0	73.4 ±1.3	1.1 ±0.03	68.2 ±3.5
L1 = Control: Parents	Average	255	68.0	1.26	67.9
randomly mated	L2 x S2	286 ±5.0	54.3 ±2.4	1.2 ±0.03	23.0 ±0.6
L2 = High pupal female	L2 x S3	309 ±10.0	50.6 ±1.7	1.1 ±0.06	32.8 ±1.1
x high pupal male	L2 x S4	295 ±6.4	54.5 ±1.1	1.1 ±0.1	34.6 ±0.9
L3 = High shell female	L2 x S5	287 ±8.2	55.7 ±2.0	1.1 ±0.1	45.3 ±0.2
x high shell male	Average	286	54.7	1.10	37.1
L4 = High pupal female	L3 x S2	257 ±5.5	59.8 ±1.2	1.6 ±0.0	37.7 ±4.9
x high shell male	L3 x S3	262 ±9.4	61.7 ±3.9	1.4 ±0.03	55.8 ±4.9
Seasons	L3 x S4	256 ±5.9	65.1 ±0.7	1.6 ±0.07	57.2 ±3.8
S1 = July/Aug' 06	L3 x S5	261 ±3.7	68.8 ±0.9	1.5 ±0.06	78.4 ±4.5
S2 = Sept/Nov' 06	Average	258	62.7	1.42	55.8
S3 = July/Aug' 07	L4 x S2	278 ±5.8	65.6 ±2.3	1.9 ±0.06	67.8 ±10.0
S4 = Sept/Nov' 07	L4 x S3	273 ±4.3	64.2 ±1.1	1.5 ±0.06	60.6 ±2.0
S5 = July/Aug' 08	L4 x S4	283 ±4.0	70.4 ±1.2	1.9 ±0.09	110.0 ±5.1
	L4 x S5	294 ±4.0	73.7 ±2.6	1.4 ±0.07	91.8 ±7.2
	Average	277	66.4	1.54	76.1
	CD at 5%	20.7	4.9	0.15	13.0

Table 2: Performance of varied pupal groups of males and females of Daba ecorace(values represent mean, ± SE and % change over random group)

Race	Pupal group	Pupal weight (g)	Coupling (%)	Fecundity (nos)	Fertility (%)	Hatching (%)
Daba male	Random	No selection	77.2 ±3.4	244 ±12.9	92.93 ±0.8	69.4 ±1.8
Daba male	Low weight	5.70 - 6.45	73.9 ±3.3(-04.3)	243 ±7.4(-0.40)	90.93 ±1.2(-02.1)	68.6 ±3.0(-01.2)
Daba male	Mid weight	6.50 - 7.50	83.9 ±3.3(+08.7)	256 ±7.8(+04.9)	96.22 ±0.5(+03.5)	85.9 ±2.6(+23.8)
Daba male	High weight	7.75 - 8.45	41.1 ±8.6(-46.8)	208 ±9.7(-14.7)	81.42 ±2.1(-12.4)	64.6 ±4.2(-06.9)
		CD at 5%	15.8	24.6	4.3	9.0
Daba female	Random	No selection	77.2 ±3.4	244 ±12.9	92.93 ±0.8	69.4 ±1.8
Daba female	Low weight	7.50 - 8.80	46.7 ±6.1(-39.5)	141 ±7.8(-42.2)	79.54 ±2.1(-14.4)	60.7 ±1.7(-12.5)
Daba female	Mid weight	9.00 - 10.00	81.2 ±6.8(+05.2)	281 ±7.5(+15.2)	95.80 ±1.1(+03.1)	86.6 ±2.9(+24.8)
Daba female	High weight	10.50 -11.40	57.2 ±6.5(-25.9)	220 ±4.0(-09.8)	87.68 ±1.5(-05.6)	69.2 ±1.9(-0.30)
		CD at 5%	17.3	27.0	4.9	7.3

The performance of high shell line, **L3** was moderate, though it out do line **L2** in egg hatching (59.8 to 68.8 %), shell weight (1.4 to 1.6 g) and silk yield (37.7 to 78.4 g), it was less in fecundity. However, the performances of **L2** and **L3** are inferior to line **L4** in all traits, except for fecundity of line **L2**. The impact of different seasons on egg and cocoon traits of Daba ecorace indicate the improvement in fifth season **(S5)** over first season **(S1)**, except for egg hatching (55.7 %) and silk yield (45.3 g) of L2. The improvements of cocoon characters were better in seasons of commercial crop **(S2 and S4)** over the seasons of seed crop **(S3 and S5)** as well as over the first season **(S1)**.

Study on Different Mating Combinations: The results on reproductive performances of low, mid and high pupal weight groups of males against mid pupal weight group of females in Daba ecorace (Table 2) indicate positive improvement in mid pupal weight group of males over random mated group. Highest positive change in hatching

(+23.8 %) in addition to coupling (+8.7%) fecundity (+4.9 %) and fertility (+3.5 %) in mid weight group has been recorded over the random group. The performances are less in low group, while they were least in high pupal weight group of males over random group. The results on reproductive performances of low, mid and high pupal weight group of females against mid pupal weight group of males indicate positive improvement in mid pupal group of males over random mated group. Highest positive change in hatching (+24.8%), fecundity (+15.2%), coupling (5.2 %) and fertility (3.1 %) were recorded over random mated group. However, the performances are less in high group, while they recorded least in low pupal weight group of females over random group. The levels of performance among male pupal weight groups were found descending in the order from mid, random, low and high pupal groups, while the same was from mid, random, high and low pupal groups among female weight groups.

DISCUSSION

Parental Application by Selection for Higher Productivity: Selection is the process of deciding superior quality animals to become parents of next generation and is a basic tool for improving the genetic structure and productivity status of any stock [5,8]. Though, the simplest form of selection is only choosing of parents based on preferred phenotypic traits, the degree of improvement, however depends on variability among parents, extent of selection induction, heritability of trait; as the induced selection is only an additional force enhancing the natural selection [6,7]. The role of environment on genotype has found apparent [4,21], the productive potential of progeny needs to be attained with matching seasons [22] and specifically for the trait of commercial importance. Further, the selection of more traits reduces the expressiveness of phenotype on trait of economic importance. Unlike fully domesticated mulberry silkworm, *Bombyx mori*, the wild and semi-domesticated tropical tasar silkworm, *Antheraea mylitta,* with pupal diapause and outdoor rearings, needs coherent application of parental variation available among ecoraces or within the ecorace, to optimize the basic and commercial seed production efficiency.

Maintenance of Varied Basic Seed Stock Lines: The maintenance of basic seed and its timely replenishment with breeder's stock are fundamental in exploiting optimal vigor of a race and quality needs of commercial seed [7,8, 14,15,16]. The performance levels of tasar ecoraces are comparatively inferior under *ex-situ* (commercial rearings) than its *in-situ* (natural rearings) habitat [2] and however, on methodical continuation of Daba ecorace through varied lines **(L1 to L4)** over five successive seasons **(S1 to S5)**, shown positive progress (Table 1). The enhancement in fecundity from 257 to 309 eggs in **L2** indicates the role of high pupal parents in improving the trait of commercially important egg fecundity [6,9,12]. Further, different types of parental crossings among high shell parents and high pupal and high shell parents can balance the related commercial traits and leads to high egg recovery, higher cocoon shell, silk ratio and silk yields [7, 13,14,15]. This might be the reason in respect of lines, **L3** and **L4,** which could clearly augment shell weight and fecundity cum shell weights respectively and were contributed for better silk yield. The improvement in egg and cocoon related traits among varied lines **(L1 to L4)**, though all of them originate from same stock, clearly indicates the role of parents by selection in improving breed with desirable traits. The advantage of higher fecundity jointly with better hatching, as they together contributes more number of brushed larvae (hither to, a known problem in commercial tasarculture), which contributes for enhanced cocoon yield, in spite of initial instars' larval loss due to fluctuations of outdoor rearing environment. The improvement of silk yield (important commercial parameter) at **S5**, although it was seed crop season, could compete with commercial crop season at **S4**. This is one of the salient impacts of parents by selection and could happen with the involvement of other associated traits like fecundity, egg hatching and shell weights [5,8,13,14]. The least variation in control line **(L1)** compared to other lines **(L2, L3 and L4)** specify the role of parents by selection over continuous seasons in upgrading the breed for enhanced efficiency. The improvement in shell weight was minimum in line **L2**, reflecting same trend in total silk yield and was vice versa in line **L3**, where the total silk yield (78.4 g), improved over line **L2** in spite of un-changed fecundity (261). But in line **L4**, where the parents were mixed with high pupal and high shell weights, the improved fecundity, egg hatching and shell weights have contributed for silk yield (91.8 g). Though, the significant improvement of shell weight (1.9 g) of line, **L4** could enhance the silk yield at seasons **S4** (110 g) and **S5** (91.8 g), which might be also with additional influence of fecundity and hatching. This infers the importance of parents by selection in basic seed stock maintenance of Daba ecorace under varied lines either for genetic improvement or for balancing the desired traits of productivity and quality.

Productivity and Quality of Commercial Seed: The levels of reproductive performance of silk insect vary with extraneous climatic factors in addition to physiological status of the parents involved [17,19]. The correlation between the sizes of parental cocoons, pupae, moths, etc. and reproduction of economic insects is of vital importance for their commercial viability [10,12,18]. The significant performance variations on egg related commercial traits among different pupal groups of males versus mid pupal group of females and vice versa in Daba ecorace (Tables 2) indicate the importance and impact of parents by selection on commercial seed efficiency. The quantity and quality are fundamentally important even for economics of commercial tasar seed production and use of right parents and combinations can optimize tasar seed production. In spite of availability of better female component, the optimal reproductive success can be attained with the combination of appropriate male counterpart. The fertility, a vital character of egg hatching, depends on potency of male in transferring sperms along with secretions of accessory glands [17,18,23]. Likewise, the optimal reproductive success of better male component depends on the availability of healthy and better sized female counterpart to yield more of fertile eggs [9,10,12]. The optimal fecundity and fertility is possible only with proper mating combination of parents from mid to low pupal weight groups in males and mid to high in females [18,20,24], which helps in attaining productivity, quality and sustainability of commercial tasar seed. The changes in the environment also play a vital role on the reproductive competence of silk insect during its emergence, pairing and egg laying. The seed production activity during first grainage which occur during summer months (May/ June) with irregular climate (temperature of 25 to 37°C and RH% of 35 to 75%), needs management of abiotic factors to improve the productivity and quality levels of commercial tasar seed.

Utilisation of Génotype X Environnent Interaction: Phenotype is the combined produce of genotype and environment [3,4,22]. The tasarculture being an outdoor practice and management of rearing environment is not under control, it will be more valid to choose an ecorace which performs better in foreseen seasons. Environmental conditions have a great influence on efficiency of parents by selection, so do the selection that take an advantage of season's distinctiveness [10,11,21]. In commercial crop season (Sep-Nov: with temperature of 17-27°C and RH of 60-80%), selection of quantitative traits like silk yield and filament length should be emphasized as the prevailed climatic conditions are congenial, in addition to better feed and longer larval feeding duration [3,21]. But, during the seed crop season (Jul-Aug: with temperature of 23-35°C and RH of 45-75%), the weather fluctuates as like feed quality, additionally with sporadic rainfall, the priority should be on fecundity and egg hatching to provide additional population to compensate young age larval loss [16]. The better performance of parental lines under commercial crop season (favourable conditions) indicates better compatibility of genotype with environment. However, the tasarculture need separate breed or line options for different crop seasons due to their rearings over different seasons and varied behavior of non-diapause and diapause destined generations. The cocoons of seed crop with thin shell and low silk, the cocoons of commercial crop with thick shell and high silk denotes their defined role towards seed and silk productivity with appropriate exchanges among genotype and environment prevailed during respective seasons.

CONCLUSION

The need based application of parents and combinations by selection, suits combating irregular reproductive behaviour and inadequacy in basic and commercial seed of tasarculture. The varied lines of basic seed help either in improving or balancing the needy commercial traits for a specific season or region. The correlation among male and female pupal weights and their combination indicates the suitability of moths from mid to low weights in males and from mid to high in females for optimal commercial seed productivity. The study infers that, the maintenance of varied parental lines based on pupal and shell weight in basic seed and suitable combinations of male and female moths in commercial seed helps in enhancing the seed efficiency of commercially exploited tropical tasar ecorace, Daba.

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