Trends in

Applied Sciences Research

ISSN 1819-3579

Academic Journals Inc.

www.academicjournals.com

Trends in Applied Sciences Research 6 (1): 81-88, 2011
ISSN 1819-3579 / DOI: 10.3923/tasr.2011.81.88

Impact of Trait Selection in Optimizing the Egg and Silk Yields of Daba Ecorace of Tropical Tasar Silkworm, *Antheraea mylitta* Drury for Seed and Commercial Crop Seasons

R. Manohar Reddy
Central Tasar Research and Training Institute, Central Silk Board, Ministry of Textiles, Government of India, P.O. Piskanagri, RANCHI-835 303, Jharkhand, India

ABSTRACT

Vanya silk production in Daba ecorace of *Antheraea mylitta* Drury (Lepidoptera: Saturniidae) often ends up with tentative yields and the present study aimed to optimize its seed (egg) and silk productivity through varied parental combine based on their commercial traits for optimal sustenance. The prospects of varied parental combinations were assessed through consecutive rearing seasons (RS_1 = July/Aug, 06; RS_2 = Sept/Dec, 06; RS_3 = July/Aug, 07; RS_4 = Sept/ Dec, 07; RS_5 = July/Aug, 08) to optimize the commercial trait output. The high pupal weight female and high shell weight male combination (C_4) has recorded gain in fecundity (+8.6%), shell weight (+22.2%), silk ratio (+13.9%) and silk yield (+12.1%) with minor reduction in egg hatching (-2.4%) and cocoon yield (-6.6%) over the randomly mated parental combination (control-C_1), when data of five successive rearing seasons were pooled. The high shell weight parental combination (C_3) has recorded higher gain in shell weight (+12.7%) and silk ratio (+9.8%), marginal progression in fecundity (+1.2%) and regression in egg hatching (-7.8%), cocoon yield (-24.1%) and silk yield (-17.8%) when compared to control. The high pupal weight parental combination (C2) has exhibited maximum gain in fecundity (+12.2%) and loss in hatching (-19.6%), cocoon yield (-35.5%), shell weight (-12.7%), silk ratio (-10.6%) and silk yields (-45.4%) in comparison to control. The parental combinations have expressed dissimilar performance in individual rearing seasons and average of five successive seasons, though they originated from same parental stock. The study suggested that same ecorace can have different parental combinations based on magnitude of commercial traits with associated crop rearing seasons and these can be utilized for evolving breeds of commercial worth with higher fecundity and shell weight to supplement the commercially important vanya silk yield.

Key words: *Antheraea mylitta*, commercial trait, crop season, daba ecorace, vanya silk

INTRODUCTION

The tasar silk is produced by *Antheraea mylitta* Drury, a wild tropical sericigenous insect (Lepidoptera: Saturniidae) available in central India having its distribution (11-31°N latitude and 72-96°E longitude), touching the Himalayan range in North, Kerala in South, Rajasthan in West and Nagaland in East. The polyphagous insect feeds primarily on *Terminalia tomentosa* (Asan), *Terminalia arjuna* (Arjun) and *Shorea robusta* (Sal) in addition to several secondary and tertiary food plants (Suryanarayana *et al.*, 2005).

In spite of wider distribution of the species over diverse ecological niche as 44 ecoraces (Suryanarayana and Srivastava, 2005), only few are applied commercially and the need is to exploit other prospective races (Hansda *et al.*, 2008; Ojha *et al.*, 2009). The bivoltine tasar insect has two annual lifecycles, the first being the seed crop (July-August) with shorter larval span yielding non-diapausing cocoons with thin shell and simultaneous moth emergence followed by egg laying, while the subsequent commercial crop (September-December) is with longer larval span yielding cocoons with thicker shell undergo prolonged pupal diapause of 6-7 months (Suryanarayana and Srivastava, 2005). The potential phenotypic expression of a genotype desires suitable environment (Srivastava *et al.*, 2004; Mulder and Bijma, 2005) and the environment being exogenic factor, it influences the expressivity of gene by generating different phenotypes under different environments (Jong and Bijma, 2002; Zhao *et al.*, 2007; Kumar *et al.*, 2008). The variations in climate, nutrient status, feeding duration and larval crowd along with environmental stimuli will influence the insect body size (Davidowitz *et al.*, 2004; Miller, 2005; He and Wang, 2006). The varied mating systems can balance desired traits in selected race combination and target of such stock continuation is for high egg recovery and silk yields (Nakada, 1992; Yamaguchi, 2001; Nagaraju, 2002; Reddy *et al.*, 2009b). The race maintenance, selection methods, crossing techniques, understanding of ecological requirements during insect's life cycle have great influence on trait expression during current and successive progenies (Moghaddam *et al.*, 2005; Rajnarain *et al.*, 2008; Reddy *et al.*, 2009c). The approach of breeding with specific parents is a tool for genetic improvement towards fecundity, shell weight and total silk yield in tropical tasar silkworm (Reddy *et al.*, 2009a). The parental selection as per commercial requirement lead to explicit individuals in their progeny and different mating systems can balance the traits in selected line for higher silk productivity and quality (Benchamin, 2002; Reddy *et al.*, 2009d). The selection of bigger females improves silkworm fecundity and parents with higher shell will contribute better shell weight and silk ratios (Yadav *et al.*, 2001; Calvo and Molina, 2005; Chandrasekhar and Basavaraja, 2008; Reddy *et al.*, 2008). However, the lack of information on impact of rearing of different parental combinations under varied rearing seasons on the versatility and expression of commercial traits in semi-domesticated Daba ecorace made to choose the present study.

MATERIALS AND METHODS

Collection and segregation of parental seed cocoons: The cocoons of tropical tasar Daba ecorace of *Antheraea mylitta* Drury used for study were obtained during May, 2006 from stabilized stocks of Central Tasar Research and Training Institute (CTR and TI), Ranchi. Sex wise assessment and assortment of cocoons were done based on high pupal weight and high shell weight groups. After making the groups based on high pupal and shell weight (above average), regrouping was done for mating of specified parents (males and females). The groups are: C_2: females and males having high pupal weight, C_3: females and males having high shell weight, C_4: females with high pupal weight and males with high shell weight and C_1: control parents where no sorting and grouping was made.

Preservation of seed cocoons and preparation of Dfls: The seed cocoons selected under parental combinations were maintained separately in tasar grainage house following integrated package of tasar seed cocoon preservation. The Disease free layings (Dfls) were prepared separately under each group following integrated package of tasar seed production. The cocoon stocks of subsequent progenies of these four combinations (C_1 to C_4) were maintained separately following selection over average performance and prepared Dfls during the five successive rearing seasons (RS_2 to RS_5) Sep/Dec, 06, Jul/Aug, 07, Sep/Dec, 07 and Jul/Aug, 08 to continue the cocoon stocks.

Rearing of different parental combinations: The Dfls prepared under four different parental combinations were reared following integrated tasar silkworm rearing package with Complete Randomized Block Design (CRBD) for five generations during Jul/Aug, 06 (RS_1), Sep/ Dec, 06 (RS_2), Jul/Aug, 07 (RS_3), Sep/ Dec, 07 (RS_4) and Jul/Aug, 08 (RS_5). The cocoons thus, produced were utilized to continue their progenies successively from rearing season RS_1 in Jul/Aug, 06 to RS_5 in Jul/Aug, 08, of-course inducing above average selection pressure in each subsequent generation. Three replications have been maintained in each parental combination (C_1 to C_4) considering larvae of one Dfl as one replication during all rearing seasons (RS_1 to RS_5) and the observations were recorded for fecundity, egg hatching, cocoon yield, single shell weight, silk ratio percentage and absolute silk yield. The data recorded on different commercial parameters in the study were subjected to statistical analysis.

RESULTS

Analysis of variance: The ANOVA for commercial traits under different parental combinations, varied successive rearing seasons and parental combinations versus rearing seasons of Daba ecorace (Table 1) indicate their levels of significance. The variance among four different parental combinations (C_1 to C_4) and varied successive rearing seasons (RS_1 to RS_5) has shown significance at 0.1% level except for fecundity among rearing seasons which recorded non-significant. The variance in parental combinations versus rearing seasons has also shown significance at 0.1% level in respect of egg hatching, cocoon yield, shell weight, silk ratio and silk yield, while the fecundity found significant at 5% level.

Comparison of different parental combinations: The performance of different parental combinations over five successive rearing seasons and their average performance as against their respective controls, C_1 x RS_1 to C_4 x RS_1 (Table 2) show clear variations in respect of egg and cocoon related traits. The optimal trait expression has been recorded in fecundity of high pupal combination (C_2) with an average of 286 eggs over five successive rearing generations, ranging between 286 and 309 eggs during different rearing seasons. A specific trend was also noticed in uniformity of shell weight under different rearing seasons. The high pupal and high shell combination, C_4 has recorded better average fecundity next to C_2, with an average of 277 eggs (ranging between 273 and 294) while the average egg hatching was 66.4% (ranging between 64.2

Table 1: ANOVA for egg and silk traits of Daba ecorace under varied parental combinations (C_1 to C_4) and crop rearing seasons (RS_1 to RS_5)

		Mean sum of squares					
SOV	df	Fecundity (No.)	Hatching (%)	Cocoon yield (No.)	Shell weight (g)	Silk ratio (%)	Silk yield (g)
Particulars							
Replicates	2	119	28	22	0.03	1.2	46
Combinations (C)	3	3658***	530***	1062***	0.54***	39***	4282***
Rearing Seasons (RS)	4	327 NS	165***	988***	0.68***	28***	1394***
Combinations (C) VS Rearing Seasons (RS)	12	288*	38***	131***	0.05***	3.9***	601***
Error	38	157	8.6	31	0.01	0.56	62
Total	59	372	52	168	0.09	5.1	476

*Significant at 5%; ***Significant at 0.1%; NS: Non significant

Table 2: Performance of varied parental combinations (C_1 to C_4) of Daba ecorace under crop rearing seasons (RS_1 to RS_5)

Factors	Fecundity (No.)	Hatching (%)	Cocoon yield (No.)	Shell weight (g)	Silk ratio (%)	Silk yield (g)
Combinations vs. Rearing seasons						
$C_1 \times RS_1$ to $C_4 \times RS_1$	255±4.1	58.3±1.7	49.3±2.9	1.0±0.01	10.8±0.1	50.0±3.0
$C_1 \times RS_2$	250±7.4	68.6±1.1	49.0±3.5	1.5±0.01	13.5±0.3	73.5±5.2
$C_1 \times RS_3$	253±12	68.4±0.9	53.3±5.9	1.2±0.03	11.7±0.3	65.9±6.1
$C_1 \times RS_4$	260±2.0	71.2±1.2	53.3±2.0	1.5±0.03	13.7±0.4	81.9±4.8
$C_1 \times RS_5$	257±4.0	73.4±1.3	58.6±4.3	1.1±0.03	11.2±0.5	68.2±3.5
Ave. (C_1)	255	68.0	52.7	1.26	12.2	67.9
$C_2 \times RS_2$	286±5.0	54.3±2.4	18.0±1.0	1.2±0.03	12.1±0.4	23.0±0.6
$C_2 \times RS_3$	309±10	50.6±1.7	30.6±1.2	1.1±0.06	10.0±0.2	32.8±1.1
$C_2 \times RS_4$	295±6.4	54.5±1.1	30.6±2.6	1.1±0.1	10.8±0.8	34.6±0.9
$C_2 \times RS_5$	287±8.2	55.7±2.0	41.6±3.3	1.1±0.1	10.6±0.7	45.3±0.2
Ave. (C_2)	286 (+12.2)	54.7 (-19.6)	34.0 (-35.5)	1.10 (-12.7)	10.9 (-10.6)	37.1 (-45.4)
$C_3 \times RS_2$	257±5.5	59.8±1.2	23.3±2.8	1.6±0.01	14.7±0.2	37.7±4.9
$C_3 \times RS_3$	262±9.4	61.7±3.9	40.0±4.0	1.4±0.03	13.1±0.3	55.8±4.9
$C_3 \times RS_4$	256±5.9	65.1±0.7	34.6±1.2	1.6±0.07	14.8±0.4	57.2±3.8
$C_3 \times RS_5$	261±3.7	68.8±0.9	53.0±1.5	1.5±0.06	13.8±0.3	78.4±4.5
Ave. (C_3)	258 (+01.2)	62.7 (-07.8)	40.0 (-24.1)	1.42 (+12.7)	13.4 (+09.8)	55.8 (-17.8)
$C_4 \times RS_2$	278±5.8	65.6±2.3	31.0±3.5	1.9±0.06	13.4±0.3	67.8±10
$C_4 \times RS_3$	273±4.3	64.2±1.1	47.3±5.8	1.5±0.06	17.7±0.7	60.6±2.0
$C_4 \times RS_4$	283±4.0	70.4±1.2	56.3±4.5	1.9±0.09	14.0±0.8	110±5.1
$C_4 \times RS_5$	294±4.0	73.7±2.6	62.3±2.0	1.4±0.07	13.4±0.3	91.8±7.2
Ave. (C_4)	277 (+08.6)	66.4 (-02.4)	49.2 (-06.6)	1.54 (+22.2)	13.9 (+13.9)	76.1 (+12.1)
CD at 5%	20.7	4.9	9.2	0.15	1.2	13.0

Combinations, C_1: Control: Parents mated randomly, C_2: High pupal female×high pupal male, C_3: High shell female×high shell male C_4: High pupal female×high shell male, Rearing Seasons, RS_1: July/Aug, 06, RS_2: Sept/Dec, 06, RS_3: July/Aug, 07, RS_4: Sept/Dec, 07 and RS_5: July/Aug. 08. Values are Mean±SE, average and % change over control

and 73.7). The 73.7 % of egg hatching at fifth rearing generation recorded in C_4 was the highest among all the parental combinations and crop rearing seasons. However, the shell weight average of 1.54 g (ranging between 1.4 and 1.9), silk ratio percentage average of 13.9 (ranging between 13.4 and 17.7) and silk yield average of 76.1 g (ranging between 60.6 and 110) are the highest recorded among all parental combinations. The performance of high shell combination, C_3 was moderate, though it could out-do the C_2 combination in egg hatching average of 62.7% (ranging between 59.8 and 68.8), shell weight of 1.42 g (ranging between 1.4 and1.6 g) and silk yield of 55.8 g (ranging between 37.7 and 78.4), it has shown less in average fecundity with 258 eggs (ranging between 256 and 262). Though, the control (C_1) has recorded better cocoon yield average (52.7 no.) over C_4, C_3 and C_2 respectively, the highest cocoon yield of 62.3 no. has been recorded by C_4 at fifth rearing generation. The performances of C_2 and C_3 parental combinations are inferior to C_4 in all traits, except for fecundity of C_2. The impact of five different and successive rearing seasons on egg, cocoon yield and silk traits of Daba ecorace indicates optimal yield in fifth Rearing Season (RS_5) than the first season (RS_1), except for egg hatching (55.7 %) and silk yield (45.3 g) of C_2. The expression of cocoon related characters were found better in rearing seasons of commercial crop (RS_2 and RS_4) over the rearing seasons of seed crop (RS_3 and RS_5) as well as over the first Rearing Season (RS_1).

DISCUSSION

The tropical tasar silkworm, *Antheraea mylitta,* with pupal diapause, limited annual life cycles and rearings in outdoor need coherent application of parental variation available among or within the ecorace, to augment seed (egg) and silk production competency. The inadequacy of race option in general and for a rearing season or region in specific is the main constraint in utilizing the potential of tasarculture and the critical need is to exploit appropriate breed options (Hansda *et al*., 2008; Ojha *et al*., 2009). In view of very limited applicable tasar ecoraces, the maintenance of vigor in existing choice is one of the essential requisites to attain possible productivity and commercial sustenance (Rajnarain *et al*., 2008; Reddy *et al*., 2009c). The continuation of same parental stock through generations with repeated and traditional crossing system leads to inbreeding depression and to regain the race potential, application of parental recombination is essential (Yamaguchi, 2001; Benchamin, 2002; Chandrasekhar and Basavaraja, 2008; Reddy *et al*., 2009b). Further, the selection of parents must be based on phenotypic traits of productive and commercial value, besides their better heritability and season compatibility for commercial advantage.

Performance of different parental combinations: The continuation of rearing under different parental combinations (C_1 to C_4) of Daba ecorace over five successive crop rearing seasons (RS_1 to RS_5) has shown enhancement of commercial trait(s) like fecundity and shell weight in relation to the parents applied. The average fecundity of 286 eggs over five generations in high pupal combination (C_2) indicates the role of parents involved in enhancement of fecundity trait compared to 255 eggs in first generation. The higher fecundity and lower performance in other traits of C_2 in all generations, irrespective of rearing season, further supports the positive co-relation of pupal weight and fecundity traits are corroborating with earlier reports (Yadav *et al*., 2001; Calvo and Molina, 2005; Chandrasekhar and Basavaraja, 2008; Reddy *et al*., 2008). However, the decline in egg hatching, cocoon yield, shell weight and silk ratio of C_2 has resulted to low silk yield. The high shell combination (C_3) has inherited higher shell weight in successive generations with an average of 1.42 g compared to 1.00 g in first generation. The expression of shell weight trait has been consistent irrespective of the rearing season supports the role of selected parents in enhancement of associated trait as reported by Chandrasekhar and Basavaraja (2008) and Reddy *et al.* (2009a). But, this combination could surpass the control and C_2 in respect of shell weight and silk ratio, though improvement in fecundity was marginal and silk yield was low in comparison to the control. Interestingly, both the combinations (C_2 and C_3) have exhibited same trend of improvement in traits associated with parental selection with lesser impact on other commercially important traits, irrespective of the rearing seasons. This indicates the principal role of high pupal and high shell parents on the improved fecundity and shell weights respectively with no significant change in silk productivity over different rearing seasons, in spite of variations in rearing climate, feed quality and larval feeding duration.

Expression of fecundity and shell weight traits: However, the combination C_4, where the parents are of high pupal female and high shell male could express better average performance both in respect of fecundity and shell weight, which has contributed for higher silk yield, in spite of marginal reduction in egg hatching and cocoon yield. The trend of C_4 remains as like C_2 and C_3 in expression and increase in fecundity and shell weights all-through the generations and hence it has recorded highest silk yield. Though, the expression of all the traits are closely associated and influenced with rearing seasons in control (C_1), the selective parental combinations (C_2, C_3 and C_4) have clearly influenced the selected trait irrespective of the rearing season. But, the expression of shell weight has been influenced by the seasons in all the combinations except for C_2, where the selection stress was more on fecundity. Further, all the combinations have recorded less impact of rearing seasons in respect of fecundity and egg hatching whereas season influenced the shell weight and silk ratio significantly are in accordance with earlier reports (Zhao *et al*., 2007; Kumar *et al*., 2008; Reddy *et al*., 2009d). This might be due to the varied feeding duration of larva, climate and feed quality during seed and commercial rearing seasons and importantly due to diapause preparation of the silk insect to face severe winter followed by summer.

Performance variation during seed and commercial crops: The seed crop (July/August) cocoons with less silk content are utilized for seed production but, all the cocoons so generated may not be considered for seed either due to disease incidence or the quality requirement in seed cocoons for commercial grainage activity. The enhanced fecundity and hatching contributes for higher cocoon yields, while the higher shell weight and silk ratio leads to more silk yield and the combination of both can fetch better yields and returns. Since, the cocoon or silk yield are dependent on fecundity, egg hatching, shell weight and silk ratio and their interaction as reported by Jong and Bijma (2002), Srivastava *et al*. (2004) and Mulder and Bijma (2005) the selected parental combinations can serve to buffer the total silk yield. This is clear when we see the performance of C_4 at RS_5 (seed crop) showing better silk yield over other combinations except C_4 at RS_4 (commercial crop). From the above it becomes clear that the combination of assorted parents has resulted to yield enhancement in some of the commercial parameters (Davidowitz *et al*., 2004; Miller, 2005; He and Wang, 2006; Reddy *et al*., 2009b).

Role of environmental conditions of rearing seasons: Miller (2005), Chandrasekhar and Basavaraja (2008) and Reddy *et al*. (2009b) have reported that the environmental conditions of different rearing seasons also have its influence on expression of parental combinations. The environmental role can be explained through the cocoons with thin shell and low silk yield observed during seed crop (July/August) and thick shell and high silk during commercial crop (September/December) seasons, which also signifies their role in seed production and silk production. Hence, for the commercial crop season (Sep-Dec: with temperature of 17-27°C and RH of 60-80%), selection of quantitative traits like shell weight, silk ratio and silk yield should be emphasized so as to achieve longer filament, while during seed crop season (Jul-Aug: with temperature of 23-35°C and RH of 45-75%), the priority should be on fecundity and egg hatching to achieve higher cocoon yield to support the planned commercial seed production. The tested parental combinations have shown their contribution for both seed and commercial crop rearing seasons by expressing increase in fecundity and shell weights and to finally enlarge the silk yield.

CONCLUSION

The different parental combinations (C_1 to C_4) have recorded varied performance in fecundity, egg hatching, cocoon yield, shell weight, silk ratio and silk yield traits over the individual rearing seasons (RS_1 to RS_5) and average of five successive rearing seasons, but for their beginning from same parental stock. The study infers the obvious role of parental selection and combination over successive rearing seasons in improving the commercial traits of Daba ecorace. The study suggests that same ecorace can have different parental combinations based on magnitude of commercial traits with associated crop rearing seasons and these can be utilized for evolving breeds of commercial worth with higher fecundity and shell weight to supplement the commercially important vanya silk yield.

ACKNOWLEDGMENT

The author is thankful to the Director, Central Tasar Research and Training Institute, Central Silk Board, Ranchi for providing facilities while making this article.

REFERENCES

Benchamin, K.V., 2002. Strategies for improvement of silkworm seed quality. Indian Silk., 41: 5-8.

Calvo, D. and J.M. Molina, 2005. Fecundity-body size relationship and other reproductive aspects of *Streblote panda* (Lepidoptera: Lasiocampidae). Ann. Entomol. Soc. Am., 98: 191-196.

Chandrasekhar, K. and H.K. Basavaraja, 2008. Changes in qualitative and quantitative characters in bivoltine silkworm breeds of *Bombyx mori* L. under different selection methods. Indian J. Seric., 47: 175-182.

Davidowitz, G., L.J.D. Amico and H.F. Nijhout, 2004. The effects of environmental variation on a mechanism that controls insect body size. Evol. Ecol. Res., 6: 49-62.

Hansda, G., R.M. Reddy, M.K. Sinha, N.G. Ojha and N.B.V. Prakash, 2008. *Ex situ* stabilization and utility prospects of *Jata* ecorace of tropical tasar silkworm *Antheraea mylitta* drury. Int. J. Indus. Entomol., 17: 169-172.

He, X.Z. and Q. Wang, 2006. Asymmetric size effect of sexes on reproductive fittness in an aphid parasitoid *Aphidius ervi* (Hymenoptera: Aphidiidae). Biol. Control, 36: 293-298.

Jong, D.G. and P. Bijma, 2002. Selection and phenotypic plasticity in evolutionary biology and animal breeding. Livest. Prod. Sci., 78: 195-214.

Kumar, N.S., H.K. Basavaraja, P.G. Joge, G.V. Kalpana and N. Malreddy, 2008. Heterosis studies on hybrids of cocoon color sex-limited breed of the silkworm, *Bombyx mori* L. under different environments of temperature. J. Entomol. Res. Soc., 10: 1-12.

Miller, W.E., 2005. Extrensic effects on fecundity-maternal weight relations in capital-breeding Lepidoptera. J. Lepidop. Soc., 59: 143-160.

Moghaddam, S.H.H., N.E. Jomeh, S.Z. Mirhosseini and M.R. Gholamy, 2005. Genetic improvement of some traits in 4 strains of silkworm, *Bombyx mori* L. Int. J. Ind. Entomol., 10: 95-99.

Mulder, H.A. and P. Bijma, 2005. Effects of genotype x environment interaction on genetic gain in breeding programs. J. Anim. Sci., 83: 49-61.

Nagaraju, J., 2002. Application of genetic principles for improving silk production. Curr. Sci., 83: 409-414.

Nakada, T., 1992. Sequence of some cocoon traits in the progeny tests after crossing between wild and domesticated silkworms. Wild Silkmoths, 91: 98-104.

Ojha, N.G., R.M. Reddy, G. Hansda, M.K. Sinha, N. Suryanarayana and N.B.V. Prakash, 2009. Status and potential of Jata, a new race of Indian tropical tasar silkworm (*Antheraea mylitta* Drury). Acad. J. Entomol., 2: 80-84.

Rajnarain., S.S. Rath, G.S. Singh, M.K. Singh and N. Suryanarayana, 2008. Strategy for race maintenance in tropical tasar. Indian J. Seric., 47: 234-238.

Reddy, R., N. Suryanarayana and N.B.V. Prakash, 2008. Heterosis potential in selective parental F1 hybrids of divergent geographic ecoraces of tropical tasar silkworm, *Antheraea mylitta* D (Lepidoptera: Saturniidae). Acad. J. Entomol., 1: 32-35.

Reddy, R., G. Hansda, N.G. Ojha and N. Suryanarayana, 2009a. Heterobeltiosis in F1 hybrids of wild and domesticated ecoraces of tropical tasar silkworm *Antheraea mylitta* drury. Sericologia, 49: 189-200.

Reddy, R., M.K. Sinha, G. Hansda and N.B.V. Prakash, 2009b. Application of parents by selection for basic and commercial seed efficiency in tropical tasar silkworm, *Antheraea mylitta* drury (Lepidoptera: Saturniidae). Acad. J. Entomol., 2: 56-61.

Reddy, R., N. Suryanarayana, N.G. Ojha, G. Hansda, S. Rai and N.B.V. Prakash, 2009c. Basic seed stock maintenance and multiplication in Indian tropical tasar silkworm *Antheraea mylitta* Drury: A strategic approach. Int. J. Ind. Entomol., 18: 69-75.

Reddy, R., N. Suryanarayana, M.K. Sinha, N.S. Gahlot, G. Hansda, N.G. Ojha and N.B.V. Prakash, 2009d. Silk filament progression with backcross breeding generations in tropical tasar silkworm, *Antheraea mylitta* D. Int. J. Ind. Entomol., 19: 187-192.

Srivastava, A.K., A.H. Naqvi, A.K. Sinha, S.R. Vishwakarma and G.C. Roy, 2004. Genotype and environment interaction in *Antheraea mylitta* drury and its implications. Pers. Cytol. Genet., 11: 219-224.

Suryanarayana, N. and A.K. Srivastava, 2005. Monograph on Tropical Tasar Silkworm. Central Tasar Research and Training Institute, Ranchi, India, pp: 1-87.

Suryanarayana, N., R. Kumar and Gargi, 2005. Monograph on Indian Tropical Tasar Silkworm Food Plants. Central Tasar Research and Training Institute, Ranchi, India, pp: 1-9.

Yadav, G.S., B.M.K. Singh, B.R.R.P. Sinha and K. Thangavelu, 2001. Studies on association between moth weight and potential fecundity of ecorace Bhandara of tasar silk moth (*Antheraea paphia* Linn.). Bull. Ind. Acad. Seric., 5: 59-67.

Yamaguchi, A., 2001. Future directions of bivoltine silkworm breeding in India. Indian Silk, 39: 26-28.

Zhao, Y., K. Chen and S. He, 2007. Key principles for breeding spring and autumn silkworm varieties: From our experience of breeding 873 x 874. J. Environ. Sci., 5: 57-61.