The Bioscan 6(1) : 139-142, 2011
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

HIERARCHICAL CLUSTERING IN ECORACES OF TROPICAL TASAR SILKWORM, *ANTHERAEA MYLITTA* DRURY BASED ON QUANTITATIVE TRAITS

A. K. SRIVASTAVA*, P. K. KAR, M. K. SINHA, S. RAI AND B. C. PRASAD
Silkworm Breeding and Genetics Division,
Central Tasar Research and Training Institute,
Central Silk Board, Nagri, Ranchi - 835 303, Jharkhand
E-mail: aks_csb@rediffmail.com

KEY WORDS
Antheraea mylitta
Clustering
Quantitative traits
Tasar silkworm

Received on :
31.10.2010

Accepted on :
13.01.2011

***Corresponding author**

ABSTRACT

Tasar silkworm, *Antheraea mylitta* Drury is a commercially utilized sericigenous insect distributed over a wide forest range of Indian subcontinent. Varied topographical features, climatology, vegetation and edaphic factors in different regions have resulted in the diversity in the phenotypic, physio-genetic, behavioural and commercial characters of this silkworm. It is variability, which had led the taxonomists to the establishment of several species and sub-species of this insect. A detailed study was carried out to understand the wide variations and for the purpose, exploratory surveys were conducted in 10 states of India and 28 ecoraces were collected. Observations on regional ecology, reproductive behaviour and commercial attributes were made. Analysis indicated tremendous inter as well as intra-population variability between and within the ecoraces of *A. mylitta*. Based on multivariate analysis, 28 ecoraces were grouped in seven clusters. Observations reveal that there is no clear cut relationship with the genetic diversity and geographical origin of the ecoraces of *A. mylitta*. The populations of this insect species are declining alarmingly in their natural habitats due to forest destruction and rampant collection of wild cocoons for the cause of silk industry. Hence, adoption of conservation measures is the need of the hour.

INTRODUCTION

Antheraea mylitta Drury, tasar silkworm has a wide distribution both within the country and beyond it. In India the range of distribution of this species covers Assam, Himachal Pradesh, Sikkim, Meghalaya, Manipur, Nagaland, West Bengal, Orissa, Bihar, Jharkhand, Chhattisgarh, Madhya Pradesh, Karnataka, Maharashtra, Rajasathan, Tamilnadu, Pondicherry, Kerala, Uttar Pradesh, Jammu & Kashmir and Andhra Pradesh. It is represented in the continent by a great number of similar forms many of which were treated as distinct species though they are ecological populations of the same species (Singh and Srivastava, 1997). Since, *A. mylitta* is widely distributed over a wide range of Indian subcontinent of varied topography, climatic conditions, vegetation and soil conditions it exhibits diversity in the phenotypic, physio-genetic, behavioural and commercial characters (Sengupta and Sengupta, 1982; Sengupta, *et al.*, 1993; Singh and Srivastava, 1997; Thangavelu *et al.,* 2000; Srivastava, *et al.,* 2002 and 2003). Diversity in *A. mylitta* is the result of adaptation of a species to a variable eco factor and interaction of genetic constitution. The knowledge of genetic diversity in crop improvement is essential for higher yield and to gain hybrid vigour (Razdan *et al.,* 1994). For the purpose, studies with different plants and insects show the suitability of multivariate analysis in differentiating the populations for their genetic magnitude (Sinha, 1998). Crossing of more divergent parents is believed to increase the chances of obtaining hybrid vigour (Joshi and Dhawan, 1966; Anand and Murty, 1968; Murty and Arunachalam, 1966; Jain *et al.*, 1981). A number of silkworm breeders have also adopted D^2 statistics in order to measure genetic divergence in various genotypes of silkworm (Subba Rao *et al.,* 1989; Siddiqui *et al.,* 1992; Razdan *et al.,* 1994; Jolly *et al.,* 1989; Chatterjee and Datta, 1992 and Rajan *et al.,* 1997). Considering the potentiality, economic aspects of tasar silkworm, its scope of improvement and limited information available regarding genetic diversity of *A. mylitta*, the present study was undertaken with an objective of selection of right parents for hybridization programme in tasar silkworm.

MATERIALS AND METHODS

Nature grown cocoons of tropical tasar silkworm were collected from a number of places and considered as representative samples of different ecoraces from the geographically and ecologically diverse areas of Assam, Jharkhand, Orissa, Chhattisgarh, Manipur, Andhra Pradesh, West Bengal, Maharastra, Karnataka and Uttar Pradesh. Collected cocoons were preserved and maintained at Central Tasar Research and Training Institute, Nagri, Ranchi. The cocoon samples collected were the *Terminalia* fed Sarihan, Munga, Jarai, Nega, Daba, and *Shorea* fed Laria, Jedai, Modia, Barharwa, Palma and Mungia ecoraces from Jharkhand; *Terminalia* fed Nowgaon from Assam; *Zizyphus* fed Jiribam from Manipur; *Terminalia* fed Belgaum from Karnataka; *Shorea* fed Raily-G, Raily-N, Raily-K from Chhattisgarh; *Terminalia* fed

Bhandara from Maharashtra; *Terminalia* fed Andhra from Andhra Pradesh; *Terminalia* fed Mirzapur and Moonga from Uttar Pradesh; *Lagerstroemia* fed Tira from West Bengal and *Terminalia* fed Bogai, Patjharia, Sukly, and Sukinda, *Shorea* fed Modal and Nalia from Orissa.

These ecoraces were reared by following randomized block design with five replications in each. Rearing was conducted in both the crops July-August and October-November on Arjun (*Terminalia arjuna*) plants having row to row and plant to plant distance of 8´x8´. Nine yield contributing traits viz. fecundity, number of worms hatched, larval weight, number of cocoons harvested, female cocoon weight, and shell weight, male cocoon weight and shell weight besides absolute silk yield were evaluated.

The genetic divergence of the ecoraces was analysed through the technique of measuring distance as proposed by Mahalanobis (1936). Mahalanobis distance takes into account the covariance among the variables in calculating distances. With this measure, the problems of scale and correlation inherent in the Euclidean distance are no longer an issue. Mahalanobis distance stretches the sphere of distribution of mean values to correct the respective scales of the different variables, and to account for correlation among variables. Thus it generates a mean cluster value for each cluster. Contribution of individual character towards total divergence was worked out and clusters were made. The significance of D^2 values was tested against the table value of F for p and $[n_1-n_2-(p-1)]$ degrees of freedom, where p is the total number of characters included in the study. If the calculated value of D^2 is higher than table value of F it is considered significant and *vice versa*.

RESULTS AND DISCUSSION

Wide range of phenotypic variation was observed in nature grown cocoons of collected ecoraces like cocoon colour, size, peduncle length, cocoon weight and shell weight within and between ecoraces. It is observed that male cocoons were found to be always higher in silk ratio than the female cocoons. Apart from the mean values, range and co-efficient of variation of these attributes were computed for better understanding of the differences between the collected ecoraces (Table not shown). From the observations, it is clear that among the *Terminalia* based ecoraces higher co-efficient of variation was recorded for female and male shell weights of Sukly and Andhra, whereas for both females and males cocoon weight, highest co-efficient of variation was registered for Belgaum (24.70% for male and 18.80% for females) followed by Jarai (21.15% for males and 17.58% for females). These observations indicated high intra-population variability of the ecoarces.

Perusal of Table 1 reveals that, out of 28 ecoraces, nine fall in cluster I, eight, in cluster II, seven in cluster III, whereas single ecorace each represented in cluster IV, V, VI and VII. The pattern thus reveals that there is no apparent relationship between genetic diversity and the geographical origin of the ecoraces. However, it has clearly put the two commercially exploited ecoraces Daba and Sukinda in cluster III.

The perusal of the intra and inter cluster values (Table 2) reveals small differences among the intra-cluster values of clusters I, II and III. Inter-cluster values range between 4.151 and 12.7, the highest being between clusters III and V (12.7), followed by V-VII (11.292). An examination of the means of these clusters (Table 3) reveals that ecoraces of the third cluster are rich in fecundity (282), Average larval weight (38.471g), female cocoon weight (16.161g), female shell weight (2.45g), male cocoon weight (12.017g), male shell weight (2.166g) and absolute silk yield (225.243g/dfl) followed by ecoraces of cluster-VI in respect of larval weight (37.82g), female cocoon weight (15.262g) and male shell weight (2.126g).

Table 1: Distribution and parentage origin of 28 ecoraces of different clusters

Clusters	N.eco-races	ecoraces included in each cluster	Parentage / distribution
I	9	Munga	Santhal Pargana (Jharkhand)
		Jarai	Santhal Pargana (Jharkhand)
		Nega	Santhal Pargana (Jharkhand)
		Nowgaon	Nowgaon (Assam)
		Patjharia	Singbhum (Jharkhand)
		Sarihan	Santhal Pargana (Jharkhand)
		Mirzapur	Mirzapur (Uttar Pradesh)
		Moonga	Deoria (Uttar Pradesh)
		Bogai	Keonjhar, Mayurbhanj (Orissa)
II	8	Laria	Peterbar (Jharkhand)
		Andhra	Adilabad (Andhra Pradesh)
		Nalia	Sundergarh (Orissa)
		Jedai	Santhal Pargana (Jharkhand)
		Tira	Purulia (West Bengal)
		Modia	Dhanbad (Jharkhand)
		Mungia	Santhal Pargana (Jharkhand)
		Jiribam	Jiribam (Manipur)
III	7	Raily-G	Geedam (Chhattisgarh)
		Palma	Ranchi (Jharkhand)
		Sukly	Sundergarh (Orissa)
		Raily-K	Keskal (Chhattisgarh)
		Daba	Singhbhum (Jharkhand)
		Sukinda	Sukindagarh (Orissa)
		Raily-N	Nangoor (Chhattisgarh)
IV	1	Bhandara	Bhandara (Maharashtra)
V	1	Belgaum	Belgaum (Karnataka)
VI	1	Modal	Mayurbhanj (Orissa)
VII	1	Barharwa	Gola (Jharkhand)

Comparisons of *Shorea* based ecoraces and *Terminalia* based ecoraces for commercial attributes (cocoon weight, shell weight and silk ratio) indicated that majority of the ecoraces collected from the *S. robusta* plants had more silk contents when compared with that of *Terminalia* based ecoraces. Co-efficient of variation of economic attributes for almost all the ecoraces were higher when compared with those of *Terminalia* based.

From the foregoing observations, it could be said that substantial variation is present both within and among ecoraces of *A. mylitta*. Earlier studies (Jolly *et al.,* 1968; Sengupta and Sengupta, 1982; Sengupta *et al.,* 1993; Singh and Srivastava, 1997) had attributed a strong directional selection over centuries for particular characters. From the results obtained in the present investigation, it is also evident that selection is the major force operating in this insect although it is difficult to address the exact mechanism of selection. Wade (1983) has suggested that one of the most common causes of spatial

Table 2: Average inter and intra–cluster distances based on D^2 analysis of nine characters

Cluster	I	II	III	IV	V	VI	VII
I	3.440	6.597	9.578	6.680	5.893	8.836	7.053
II	6.597	3.641	7.318	4.930	9.513	5.160	5.729
III	9.578	7.318	3.316	4.957	12.700	5.750	5.398
IV	6.680	4.930	4.957	0.000	9.404	5.245	4.151
V	5.893	9.513	12.700	9.404	0.000	10.732	11.292
VI	8.836	5.160	5.750	5.245	10.732	0.000	7.378
VII	7.053	5.729	5.398	4.151	11.292	7.375	0.000

Table 3: Cluster means of nine characters based on D^2 analysis

Characters	Clusters						
	I	II	III	IV	V	VI	VII
Fecundity (no.)	203.86	185.32	282.23	261.4	174.400	194.600	275.400
Worms hatched (no.)	144.08	137.67	182.63	184	126.200	131.400	187.000
Avg. larval weight (g)	29.58	31.69	38.47	33.620	30.560	37.820	32.620
Cocoon harvested (no.)	73.73	71.65	97.74	101.600	67.200	88.000	87.600
Female cocoon weight (g)	10.48	13.6	16.16	13.950	8.490	15.262	13.282
Female shell weight (g)	1.45	2.33	2.45	2.258	1.112	2.518	2.206
Male cocoon weight (g)	9.38	11	12.02	10.488	6.960	11.102	12.012
Male shell weight (g)	1.22	1.95	2.17	1.976	0.918	2.126	2.024
Absolute silk yield (g/dfl)	99.48	154.08	225.24	216.997	67.908	202.378	185.107

structuring of insect populations is the discontinuous or patchy distribution of resources. Furthermore, individuals within the same patch are often more likely to interact and interbred with each other rather than with individuals in different patches. In *A. mylitta* also the spatial structuring has been observed in relation to food plant distribution and polyphagous nature of the species. It is thus also substantiated that disruptive selection is in operation in *A. mylitta* also to evolve the populations as per adaptation in different niches. The overall picture and evolutionary differentiation in *A. mylitta* thus indicates a very effective species/environment strategy due to which the species has been able to invade and adapted in different localized environments due to the evolution of distinct populations through spatial structuring and conspecific cueing in the form of ecoraces.

Genetic constitution of the population is controlled by the breeding behaviour of the individuals and the changes in breeding systems have accelerated the genetic differentiation in the natural populations (Srivastav *et al.*, 1992). It is notional that geographical diversity is reflected as genetic diversity. Analysis of 28 ecoraces has indicated considerable amount of genetic variability in the ecoraces under study based on the nine economic traits. Ecoraces collected from different geographical regions fall in seven distinct clusters. This pattern revealed that there is no relationship between geographical origin and genetic diversity. The results thus suggested that the selection of parents need not necessarily be based on geographical distance for crop improvement programmes. Results corroborate the observations of earlier authors (Murty and Arunachalam, 1966; Siddiqui *et al.*, 1992; Razdan *et al.*, 1994; Jolly *et al.*, 1989 and Rao *et al.*, 1981). Scanning of cluster means with regard to fecundity, larval weight, female cocoon weight, male cocoon weight and female and male shell weight are higher in cluster III, followed by cluster IV with regard to larval weight, female cocoon weight and male shell weight (Table 6). Further, it is interesting to note that commercially exploited ecoraces fall under cluster III, thereby establishing an appreciable degree of variability present in the ecoraces. Therefore it would be logical to include such ecoraces grouped in cluster III and IV for heterosis breeding. Fecundity followed by female cocoon weight, male cocoon weight and larval weight are the most important character that have contributed to the genetic divergence, hence, these traits should be given priority for improvement in the quantitative traits.

REFERENCES

Anand, I. J. and Murty, B. R. 1968. Genetic divergence and hybrid performance in linseed. *Indian J. Plant Breed.* **28:** 178-185.

Chatterjee, S. N. and Datta, R. K. 1992. Hierarchical clustering of fifty-four races and strains of the mulberry silkworm, *Bombyx mori* L. Significance of biochemical parameters. *Theo. App. Genet.* **85:** 394-402.

Jain, R. C. and Pandya, B. D. and Pande, K. 1981. Genetic divergence in chickpea. *Indian J. Genet.* **41:** 220-225.

Jolly, M. S., Chaturvedi, S. N. and Prasad, S. 1968. A survey of tasar crops in India. *Indian J. Seric.* **1:** 50-58.

Jolly, M. S., Datta, R. K., Noamani, M. K. R., Iyengar, M. N. S., Nagaraj, C. S., Basvaraj, H. K., Kshama, G. and Rammohan Rao, P. 1989. Studies on genetic divergence in mulberry silkworm, *Bombyx mori* L. *Sericologia* **29:** 545-553.

Joshi, A. B. and Dhawan, N. L. 1966. Genetic improvement of yield with special reference to self-fertilising crops. *Indian J. Genet. Plant Breed.* **264:** 101-113.

Mahalanobis, P. C. 1936. On the generalized distance in statistics. *Proc. Nat. Acad. Sci., India* **2:** 49-55.

Murty, B. R. and Arunachalam, V. 1966. The nature of genetic divergence in relation to breeding system in crop plants. *Indian J. Genet.* **26A:** 188-198.

Rajan, M. V., Chaturvedi, N. K. and Sarkar, A. 1997. Multivariate analysis as an aid to genotype selection for breeding in mulberry. *Indian J. Seric.* **36:** 111-115.

Rao, A. V., Prasad, A. S. R., Saikrishna, T., Seshun, D. V. and Srinivasan, T. E. 1981. Genetic divergence among some brown plant hopper resistant rice varieties. *Indian J. Genet. Plant Breed.* **41:** 179-185.

Razdan, J. L., Siddiqui, A. A., Bahal, R. K. and Mukherjee, P. 1994. Identification of region specific silkworm (*Bombyx mori* L.) hybrids. *Sericologia.* **34:** 641-648.

Sengupta, A. K. and Sengupta, K. 1982. Ecoraces of tasar and their potentialities. Base paper 6: *Workshop on Tasar Culture and Silk Industry*, CTR&TI, Ranchi. pp. 1-14.

Sengupta, A. K., Sinha, A. K. and Sengupta, K. 1993. Genetic reserves of *Antheraea mylitta* Drury. *Indian Silk.* **32:** 39-46.

Siddiqui, A. A., Chatterjee, S. N., Goel, A. K. and Sengupta, A. K. 1992. Genetic divergence in the tasar silkworm, *Antheraea mylitta* D. *Sericologia.* **32:** 425-431.

Sinha, B. R. R. P. 1998. Survey of genetic resources and study on the genetic divergence in *Antheraea mylitta* Drury. Ph.D. Thesis, Ranchi University, Ranchi, India.

Singh, B. M. K. and Srivastava, A. K. 1997. Ecoraces of *Antheraea mylitta* Drury and exploitation strategy through hybridization. Base paper 6: *Current Technology Seminar on Non-Mulberry Sericulture, CTR&TI, Ranchi*, India. pp. 1-39.

Srivastav, P. K., Siddiqui, A. A. and Goel, A. K. 1992. Genetic diversity in half-sib seedlings of *Terminalia arjuna* Bedd. *Sericologia.* **32:** 469-475.

Srivastava, A. K., Sinha, A. K. and Sinha, B. R. R. P. 2002. Present status of tropical tasar silkworm germplasm management, *Proceedings of Workshop on Germplasm Management and Utilization*, CSGRC, Hosur. pp. 116-122.

Srivastava, A. K., Sinha, A. K. and Sinha, B. R. R. P. 2003. *Descriptor of topical tasar silkworm, Antheraea mylitta Drury (Lepidoptera: Saturniidae),* CTR&TI, Ranchi, India.

Subba Rao, G., Das, S. K., Das, N. K. and Nandi, S. 1989. Genetic divergence in bivoltine silkworm, *Bombyx mori. Indian J. Agric. Sci.* **59:** 761-765.

Thangavelu, K., Srivastav, P. K. and Srivastava, A. K. 2000. Management of tropical tasar silkworm and host plant germplasm, *National Workshop on Management of Sericultural Germplasm for Posterity*, CSGRC, Hosur. pp. 72-90.

Wade, M. J. 1983. The effects of genotypic interactions on evolution in structural populations, *Frontiers of Genetics* IV. Oxford and IBH Publishing Co. New Delhi, India. pp. 283-290.