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Studies on the biodiversity of tasar ecoraces *Antheraea mylitta* Drury

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Abstract
Tasar silk is produced from the tasar silkworms (Insecta: Lepidoptera: Saturniidae) which has many ecoraces principally controlled by prevailing environmental conditions. The tasar silkworms are cultivated *ex-situ* in natural forests, however, some attempts have been made for its semi- domestication. Tasar culture is a traditional livelihood for lakhs of tribal population in our country. The present study depicts the variation in the different stages of tasar silkworm *Antheraea mylitta* Drury which is distributed in the form of ecoraces in varied geographical areas. From the studies it is observed that rich biological diversity of *Antheraea mylitta* Drury mainly is due to its wide range of distribution, climatic factors, and food plants etc., which have led to variations in their ethology and physiology.

Keywords: *Antheraea mylitta* Drury, environmental conditions, geographic distribution, variation, diversity, climatic factors

Introduction
Antheraea mylitta Drury, is a wild sericigenous insect, widely distributed from West Bengal in the East to Karnataka, in the South with its natural inhabitation in the forest areas of Andhra Pradesh, Bihar, Madhya Pradesh, Maharashtra, Orissa and Telangana. It is a polyphagous insect feeding on a number of food plants primarily on *Terminalia arjuna* and *T. tomentosa*, *Shorea robusta* and secondarily on *Ziziphus*, *Tectona*, *Bauhinia*, *Lagerstroemia*, etc (Table 1). Indian tasar occurs mostly in the tract of Ganges (North), Godavari (South), Orissa (South-East) and Narmada (East).

Exploratory surveys conducted by Central Tasar Research and Training Institute, Ranchi (Jharkhand) from the year 1965 till date in 17 states *viz*., Himachal Pradesh, Nagaland, Assam, Meghalaya, West Bengal, Orissa, Jharkhand, Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Telangana, Maharashtra, Uttar Pradesh, Manipur, Jammu & Kashmir, Rajasthan, Karnataka, Kerala and one Union territory Dadar Nagar and Haveli reveals that there are 44 ecoraces/biotypes/morpho variants of *Antheraea mylitta* Drury [1-3].

Observations indicated that range of distribution of *Antheraea mylitta* Drury is almost between 12–31°N latitude 72–96°E longitude. This wide range of variation in its genotype, further inter-breeding among different ecoraces in nature over centuries has led to high degree of heterozygosity in natural population of *Antheraea mylitta* Drury [4]. This species is endemic and distributed in different geographical regions of India in the form of different ecological races [5]. It shows variation in phenotypic traits such as fecundity, voltinism, cocoon weight, and also in its host plant preference [6].

The performance of parental ecoraces and their hybrids clearly indicate the role of their origin and genetic diversity [7-9] on commercial out-put. The higher number of fertilized eggs, highest silk yield in Daba race proves its commercial superiority and economic viability in spite of lower shell weight. The species of *Antheraea mylitta* Drury with wide distribution, encounter diverse biological niche and on adaptation forms in to ecoraces [10, 11]. Most of the phenotypic variations are highly influenced by temperature, relative humidity and rainfall [12].

In the present investigation, tasar populations of *Antheraea mylitta* were collected from various parts of the country. A detailed study on their environmental conditions, behavior pattern was studied. Though Daba and Sukinda are available in many parts of tasar producing states as robust cocoons, Bhandara, Raily, Modal and Andhra local ecoraces are found in limited numbers exclusive areas of natural environs, bestowing their respective unique features, *viz.*, Andhra local, an exclusive ecorace of Warangal region has hard and compact cocoons with high reelability but low yield, Modal of Orissa is the bulkiest of all cocoons, a

highest silk yielder producing coarse and heavy filament. However, Bhandara of Nagpur produces a distinctive silk fibre and Raily is bestowed with better shell weight, longer filament length but low egg fertility and lesser silk yield making commercially less beneficial. These cocoons are not readily accessible in the forest region and found to be gradually decreasing in number, which is the primary concern to take up the present work.

In order to preserve the natural biodiversity present among these populations, attempts are being made to understand the genetic structure of each population. However, no systematic studies were made to generate substantial information on the genetic diversity of these populations so as to develop appropriate strategy for its conservation at the natural habitat. The present study is focused on the genetic diversity of seven commercial populations of *Antheraea mylitta* Drury in selected parts of India based on physical features, climatic conditions and cocoon characteristics.

Material and Methods

For the present study, the natural habitats of the seven ecoraces of Tasar Silkworm, *Antheraea mylitta* Drury, were explored in their natural habitats and the geographical parameters were recorded.

The ecological aspects of the seven ecoraces of tasar silkworm, *Antheraea mylitta* Drury were observed in their natural habitats and recorded [13]. The ecoraces Daba TV, Sukinda, Bhandara and Andhra local which were collected from the forest areas were grown under an optimum temperature of 26-30 °C and a relative humidity of 70-80% in the Tasar Plantation at Kakatiya University, Warangal.

The optimum temperature and relative humidity for the tasar silkworm rearing are 25-30 °C and 60-70% respectively. In the present study, the temperature and relative humidity were recorded with the help of lab thermometer and hygrometer respectively. The average of lowest and highest values taken and noted them instar-wise.

To study the ethological aspects of Andhra local, Daba TV/BV, Sukinda and Bhandara ecoraces, the worms during different stages of life history till cocoon formation were observed in the rearing site developed by Department of Zoology, Kakatiya University, Warangal. Such observations were made during first, second and third crops and the behaviour during feeding, moulting, ecdysis, defecation and cocoon spinning, emergence pattern, etc., have been recorded.

For the present study, the economically important ecoraces of Tasar silkworm, *viz.*, Daba, Sukinda, Raily, Modal, Bhandara, and Andhra local were collected from their natural habitat and were maintained in the germplasm bank of Kakatiya University, Warangal.

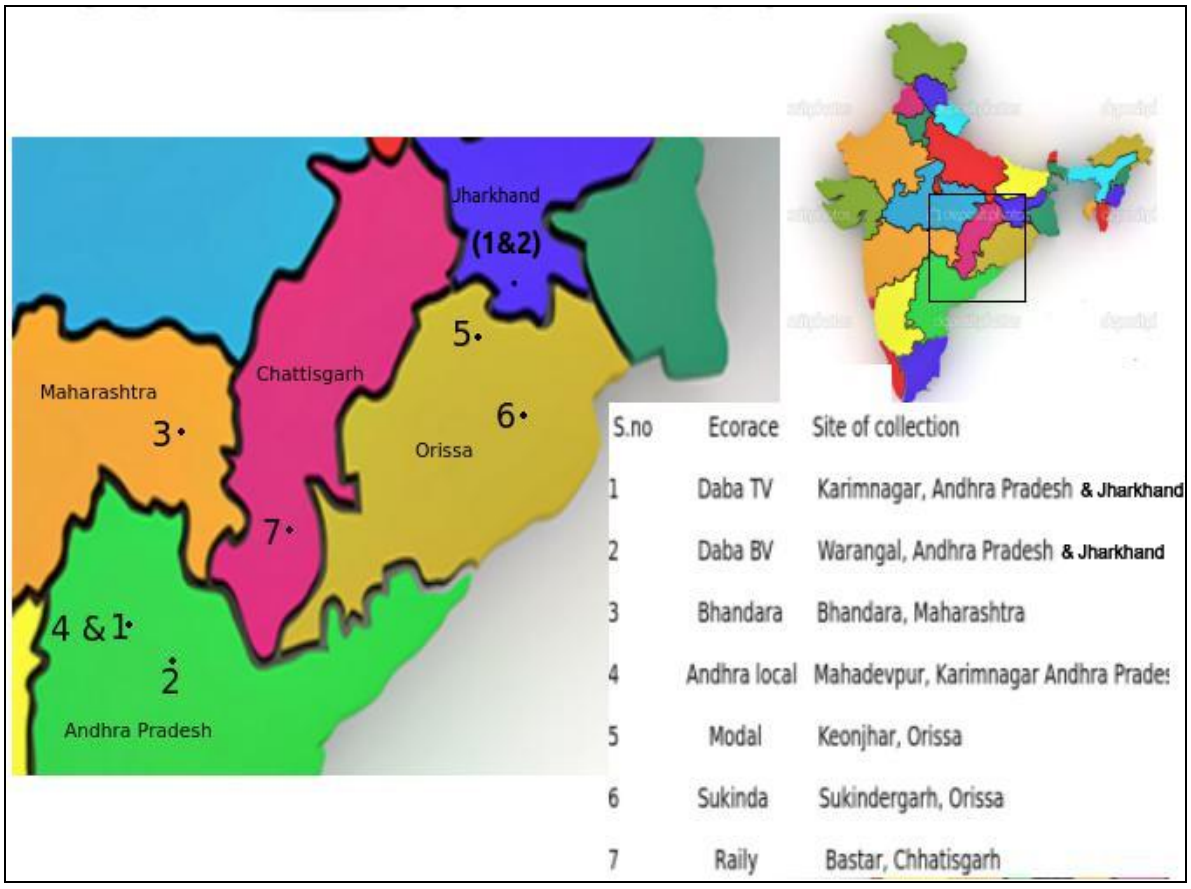

Fig 1: The rearing sites of ecoraces of Tasar Silkworm, *Antheraea mylitta* Drury.

Collection of Tasar Samples from Selected Parts of the Country

Collection of wild cocoons of Daba TV/BV and Andhra local ecoraces from distant ecopockets of Andhra Pradesh were collected by exploring the natural habitats (Fig. 1). The ecoraces like modal, sukinda, raily and bhandara were collected from Keonjhar (Orissa), Sukindergarh (Orissa), Bastar (Chhattisgarh) and Bhandara, (Maharashtra) respectively (Fig. 2). The details of the natural conditions which include temperature, rainfall and soil conditions were recorded (Table 2).

Rearing method

The rearing of Tasar ecoraces was done by taking proper measures of disinfection to prevent outbreak of diseases and any attack by predators in fields. The quality of cocoons depends upon the selection of rearing site and food plants, optimum temperature and relative humidity, brushing, removal of dead and diseased worms, supervision and maintenance of larvae and other rearing operations like pruning, weeding out, watering etc., If any of these operations are infective, it seriously affects the yield.

Fig 2: Collection of *Antheraea mylitta* Drury, Daba TV cocoons at A Mahadevpur, Telangana and B. Bhandara (Maharastra).

Rearing Of Tasar Silkworm

The rearing of the tasar silkworm, *Antheraea mylitta* Drury (Andhra local, Bhandara, Daba TV/BV, Sukinda) ecoraces were reared on the *Terminalia* plantation raised at Kakatiya University campus and the larval span, moth colour, voltinism, etc., were observed. During rearing, environmental fluctuations were seen, which sometimes involved unfavourable conditions like rain, storm or hail. As the larvae were also attacked by pests and predators, usage of net for their prevention was ensured. Temperature and relative humidity were measured regularly (Fig 3).

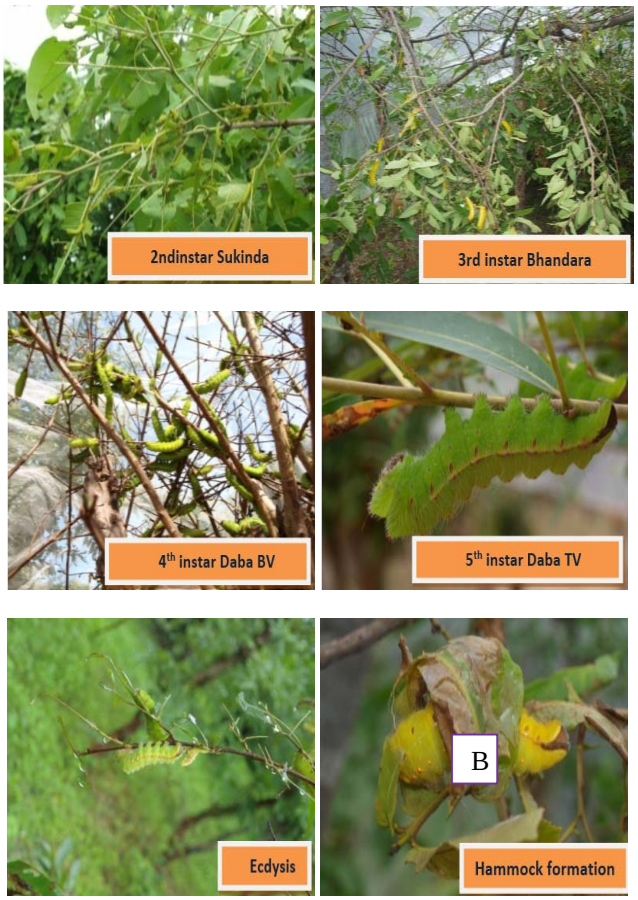

Fig 3. Various stages of tasar silkworm rearing on *Terminalia Arjuna* plantation at Kakatiya University, Warangal, Telangana, India.

Results

Table 1: Origin and characteristics of Tasar Silkworm, *Antheraea mylitta* Drury.

Sl. No	Ecorace	Site of collection	Food plant	Cocoon availability	Level of adaptability
1.	Andhra local	Mahadevpur Karimnagar (Telangana)	*Terminalia arjuna* and *T. tomentosa*	Forest collection	Wild
2.	Daba TV	Karimnagar (Telangana)	*Terminalia arjuna* and *T. tomentosa*	Silkworm rearing	Wider adaptability
3.	Daba BV	Warangal (Telangana)	*Terminalia arjuna* and *T. tomentosa*	Silkworm rearing	Wider adaptability
4.	Modal	Keonjhar (Orissa)	*Shorea robusta*	Forest collection	Wild
5.	Sukinda	Bhandara, Nagpur (Maharashtra)	*Terminalia arjuna* and *T. tomentosa*	Silkworm rearing	Wider adaptability
6.	Raily	Bastar (Chhattisgarh)	*Shorea robusta*	Forest collection	Wider adaptability
7.	Bhandara	Bhandara (Maharashtra)	*Terminalia arjuna* and *T. tomentosa*	Forest collection	Wild

Table 2: Natural habitat and ecological parameters of the ecoraces of Tasar Silkworm *Antheraea mylitta* Drury

Ecorace	Area of habitat	Geographical ordinates ^{0}N ^{0}E		Forest type	Soil type	Avg. max. Temp (ºC)	Avg. min. Temp. (ºC)	Annual preci. (mm)	Altitude (m)
Andhra Local	Adilabad (Telangana)	19.40	79.18	Tropical dry deciduous	Black clayey	31.52	21.80	925.25	265.5
Daba	Singhbhum (Jharkhand)	22.12	86.23	Tropical moist deciduous	Red loamy	28.90	18.40	1095.00	244
Bhandara	Bhandara (Maharashtra)	21.09	79.42	Tropical dry deciduous	Black clayey	34.50	20.80	939.40	288
Modal	Keonjhar (Orissa)	21.40	86.40	Tropical moist deciduous	Red loamy	30.40	20.30	1218.20	533
Sukinda	Sukindagarh (Orissa)	21.00	86.00	Tropical moist deciduous	Red loamy	31.45	20.60	1096.00	256
Raily	Bastar (Chhattisgarh)	19.05	82.05	Tropical moist deciduous	Sandy red	31.50	18.62	1275.62	554

Table 3: The Larval characteristics of Tasar Silkworm, *Antheraea mylitta* Drury.

Ecorace	Diapause period (months)	Voltinism	Average fecundity	Predominant female moth colour	Avg. larval weight (g)	Avg. Larval span (days)	Predominant cocoon color
Andhra Local	4	Trivoltine	176	Brown	25	42	Creamish /yellow
Daba	6-7	Bi/ Trivoltine	250	Yellow	42	31	Grey
Bhandara	5	Trivoltine	200	Brown	30	35	Blackish grey
Modal	4- 10	Uni /Bi/ Trivoltine	275	Grey	45	32	Yellow
Sukinda	4	Trivoltine	240	Yellow/Grey	35	36	Blackish grey
Raily	4 - 10	Uni /Bi/ Trivoltine	290	Grey	45	32	Blackish grey/ yellow/ creamish

The diapause period of the tasar silkworm, *Antheraea mylitta* Drury, was ranging from4-5, 5-7 and 10 months for bivoltine, trivoltine and univoltine respectively, in the seven ecoraces studied. The moth colour was also observed to be brown, yellow or grey predominantly. The average Fecundity oftasar silkworm, *Antheraea mylitta* Drury, Andhra local, Daba TV, Bhandara, Modal, Sukinda, Raily ecoraces were 176, 250, 200, 275, 240 and 290, respectively. The average larval weight (g) of tasar silkworm, *Antheraea mylitta Drury*, Andhra local, Daba TV, Bhandara, Modal, Sukinda, Raily ecoraces were 25, 42, 30, 45, 35 and 45, respectively. The average Larval spanoftasar silkworm, *Antheraea mylitta*, Andhra local, Daba TV, Bhandara, Modal, Sukinda, Raily ecoraces were 42, 31, 35, 32, 36 and 32, respectively (Table3).

Discussion

Tropical tasar silkworm, *Antheraea mylitta* Drury is a commercial variety, which exists in various forms as 44 ecological populations or ecoraces in different geographical niches of our country depend on food plants and environmental conditions. In the present study out of the seven ecoraces studied, except Andhra local and Bhandara, which are predominantly found in dry tropical forest area, all other ecoraces grow in moist deciduous forest areas of red loamy and black clayey regions within maximum temperature range of 30-34 °C and a minimum of 18-21 °C, the annual precipitation ranging from 925-939 mm in dry deciduous and 1000-1275mm in moist tropical deciduous forest areas[13]. The voltinism (uni/bi/tri) in *Antheraea mylitta* Drury is regulated by environmental factors like temperature, relative humidity, day length and rainfall. Some have reported that voltinism pattern is found to be stable for a particular zone can change in different environmental conditions (Kar, 2000). Humidity also plays an important role in growth of the larvae, triggering the moth emergence and preventing pupal desiccation.

The present study depicts the variation in the different stages of tasar silkworm *Antheraea mylitta* Drury which is distributed in the form of ecoraces in varied geographical areas. From the studies it is observed that rich biological diversity of *Antheraea mylitta* is mainly due to its wide range of distribution, climatic factors, and food plants etc., which have led to variations in their ethology, physiology and commercial traits. The area occupied by the Tasar silkworm, *Antheraea mylitta* is highly diversified geographically as such the population from diverse sources has not evolved uniformly. The range of distribution is also so large that this had an opportunity for geographic variation. Inter – and intra – populational variability is very much prominently seen.

Antheraea mylitta Drury, a lepidopteran insect of the Saturniidae family produces tasar silk of commercial importance. This species is endemic and distributed in different geographical regions of India in the form of ecological races (Table 2). They show variation in their phenotypic traits such as fecundity, voltinism, cocoon weight, silk ratio and also in their host plant preference [6]. To understand the genetic closeness and also for the identification of the wild silkworm *Antheraea mylitta* Drury ecoraces, usage of RFLP markers was reported by Mahendran *et al*., in 2006. The subsequent phylogenetic analysis revealed that their relationships were found to be consistent with a neighbourhood structure of randomly mating population and the geographically closely situated populations tend to be genetically more similar.

As is evident from the present investigation (Table 2), the tasar silkworm, *Antheraea mylitta* is found to be distributed in a diverse geographic areas of varied eco-climatic conditions like temperature, humidity, photoperiod, rainfall; edaphic factors like soil, texture; geographic coordinates like latitude and longitude and forest resources of food plants etc., leading to changes in phenotypic, physiological, ethological, adaptational, economic traits and ultimately genetic variations in populations.

The rich biological diversity of *Antherea mylitta* is largely due to its wide range of distribution and foraging of silkworm on a variety of food plants. Its wide range of distribution the species has encountered diverse geo climatic conditions like annual Precipitation, temperature, day length, plant succession. The factors like latitude, longitude etc., of distinct areas lead to marked differences expressing wide variations in phenotypic, physiological, behavioural, commercial and technological traits. Various populations thus, isolated geographically over centuries have adapted to a particular ecological niche and referred to as ecological races13.

Though Daba and Sukinda are available in many parts of tasar producing states as robust cocoons, Bhandara, Raily, Modal and Andhra local ecoraces are found in limited numbers exclusive areas of natural environs, bestowing their respective unique features, *viz.*, Andhra local, an exclusive ecorace of Warangal region has hard and compact cocoons with high reelability but low yield, Modal of Orissa is the bulkiest of all cocoons, a highest silk yielder producing coarse and heavy filament. However, Bhandara of Nagpur produces a distinctive silk fibre and Raily is bestowed with better shell weight, longer filament length but a low egg fertility and lesser silk yield making commercially less beneficial.

Among these ecoraces, modal and raily feed on *Shorea robusta*, while all other feed primarily on *Terminalia arjuna* and *T. tomentosa*. The rich biological diversity of *Antherea mylitta* is attributed to its wide range of distribution and foraging of silkworm on a variety of food plants. From the present data it is observed that except Andhra local, the ecoraces primarily feeding on *Terminalia arjuna* have greater cocoon weight and shell weight than those feeding on *S. robusta*. It is also corroborated by recent studies that post-cocoon parameters showed significant positive relationship with leaf constituents like crude protein, chlorophyll, nitrogen,

phosphorus, potassium, calcium, magnesium and sulphur [14]. The role of minerals and ions like K^+ and Mg^{2+} in the hemolymph of the larvae reflects the levels of these elements in the plant tissues [15]. The phytochemical analysis of *Terminalia arjuna* revealed the presence of as proteins, carbohydrates, phenols, tannins, flavonoids, saponins, glycosides, steroids, terpenoids and alkaloids [16] (and also calcium, Aluminium, Magnesium, silica, zinc and copper [17,18], while that of *Shorea robusta* has revealed a low concentration of proteins in its plant extracts [19].

From the studies on biodiversity of Tasar silkworm it is abundantly clear that rich biological diversity of *Antheraea mylitta* Drury is mainly due to its wide range of distribution, climatic factors, and food plants etc., which lead to variations in their ethology, physiology and commercial traits. The area occupied by the Tasar silkworm, *Antheraea mylitta* is highly diversified geographically as such the population from diverse sources has not evolved uniformly. Earlier reports have revealed that decreasing genetic diversity increases the extinction risk of populations due to a decline in fitness of individuals, which has been endorsed by many authors [20-23]. Genetic diversity is inversely proportional to isolation and that it is directly correlated with population size. The genetic diversity of populations responds to environmental heterogeneity *via* alterations in the relative strengths of the four opposing genetic forces: mutation, migration, selection, and genetic drift. The balance and cumulative history of these forces determines actual levels of genetic diversity at any one time [24]. The main reasons for extinction of Andhra local ecorace may be its dwindling population size, which is consequential to physiological attributes and environmental adaptation.

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