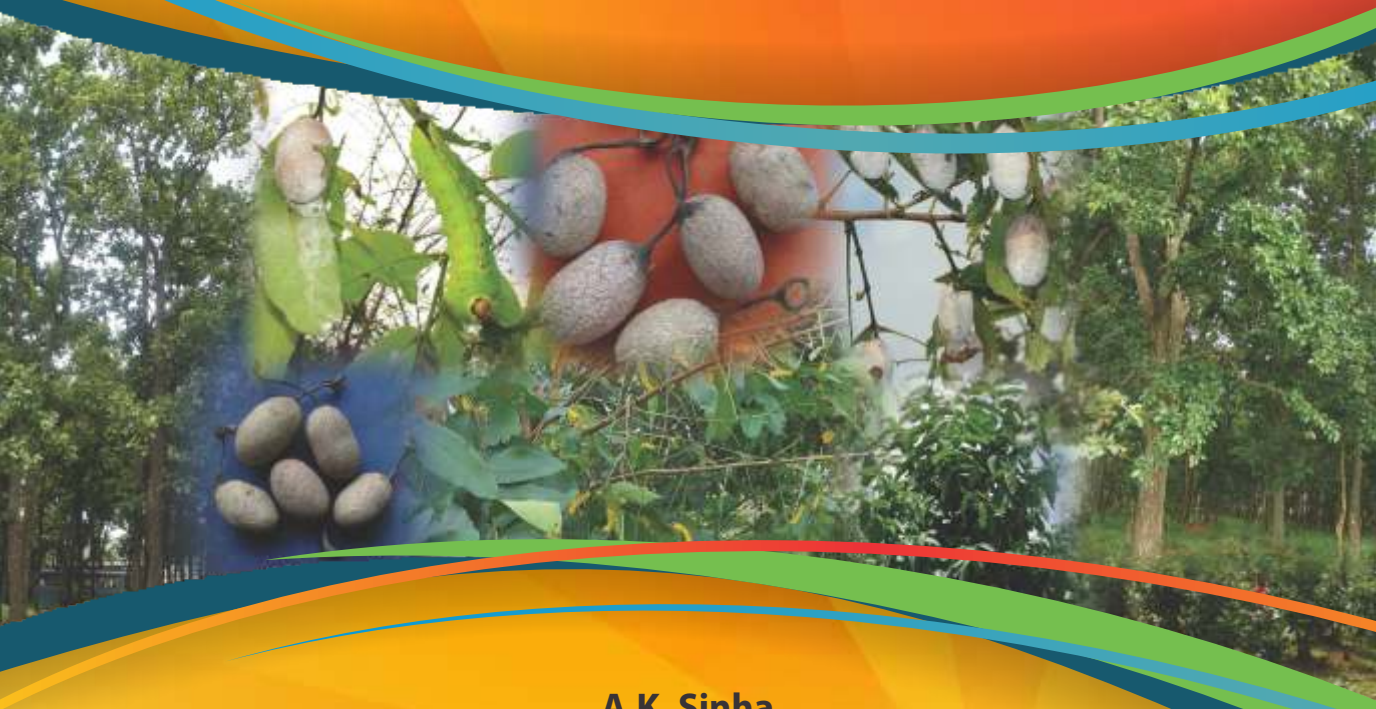
Handbook on

CONSERVATION AND MAINTENANCE OF TASAR SILKWORM ECORACES



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PREFACE

Tropical tasar silk production is a forest based agro-industry. It holds great promise for the rural populace, especially for tribal people in providing their livelihood. The biological interaction between the tropical tasar silkworm, Antheraea mylitta Drury and its food plants integrates an ideal ecosystem, uniquely suited as an industry to the economy and social structure of rural populace because of its very low investment and high employment potential. A. mylitta is a polyphagous insect feeding on a number of food plants primarily on Terminalia arjuna, T. tomentosa and Shorea robusta and secondarily on the species of Lagerstroemia, Ziziphus, Syzigium, Tectona, Bauhinia, Anogeissus, etc. It is well adapted to different areas ranging from 24–16° latitude and 79–88° longitude. Tropical tasar flora and fauna are abundantly distributed in the peninsular forests of Central India bordered by major rivers viz., Ganges in the north, Godavari in the south, Mahanadi in the east and Wainganga in the west. However, the range of distribution of the species covers Himachal Pradesh, Sikkim, Assam, Meghalaya, West Bengal, Odisha, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu and Pondicherry. Besides, discrete populations have also been reported from Jammu and Kashmir, Dadar and Nagar Haveli, Manipur, Nagaland, Uttar Pradesh and Kerala.

Critical analysis with regard to distribution of Antheraea mylitta reveals that once upon a time the species was available throughout the Indian peninsula. However, due to geographical isolation, the populations have adapted themselves to a particular ecological niche and are referred as 'Ecoraces'. These ecoraces vary in geography, topography, ecology, food plant flora and frequency of life cycle in latitudinal and altitudinal gradients. They exhibit diversity in phenotypic, behavioural, physio-genetic and commercial characters. These variations are genetic treasure, thus the conservation, maintenance and protection of the ecoraces are most important for their qualitative and quantitative improvement as a whole. However, the destruction of natural habitats of tasar silkworm due to deforestation, pollution, over-collection of naturally grown cocoons and overexploitation of floral and faunal wealth of Vanya silk has threatened the existence of many wild ecoraces of tropical tasar silkworm, Antheraea mylitta. This has called an urgent need for natural proliferation and conservation of these precious ecoraces.

The technology models have been developed involving specific packages of practices for natural proliferation and conservation of some of the economically important ecoraces of tropical tasar silkworm. This handbook highlights information of various aspects of ecoraces and details of technology models for their natural proliferation and conservation.

A.K. Sinha
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1. INTRODUCTION

1.1 Biodiversity

The history of origin and the process of evolution have led to the diversity of life forms. The increase in environmental awareness over the last few decades has underlined the need to enhance our understanding of the ways in which human race and biodiversity interact. It is surprising that till 1992, the subject of Biodiversity was never given the attention that it deserved, both at the national and the international level. It was only in June 1992, at the United Nations Conference on Environment and Development (UNCED) that the issue of Biological Diversity was taken up as a priority area for action for conservation and sustainable use. However, preparations for a Convention on Biological Diversity (CBD) were initiated by the Governing Council of the United Nations Environment Programme (UNEP) in 1987 through the establishment of an Ad-hoc Working Group of Experts on Biological Diversity, which met in 1988. The Ad-hoc Working Group was followed in 1991 by an Inter-Governmental Negotiating Committee for devising a Convention on Biological Diversity.

The agreed text of the CBD was adopted by 101 governments in Nairobi in May 1992 and was signed by 159 governments and the European Union at the UNCED held in Rio de Janeiro in June 1992. The Convention finally entered into force on December 29, 1993, which has since then been signed by 184 countries. India became a signatory to the Convention by signing it on June 5, 1992. The main objectives of the CBD include conservation of Biological Diversity, sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilisation of genetic resources by means of:

- Appropriate access to genetic resources;
- Appropriate transfer of relevant technologies, and
- Appropriate funding.

These pivotal issues were firmly set on the agenda of each signatory country and led to the need of a close analysis of all the issues raised by the provisions of the Convention and a search for ways in which they can be implemented effectively. A report titled “Status of Biodiversity in India” was prepared in 1997 and submitted in 1998. The Biological Diversity Act, 2002 was passed on December 11, 2002 and it received the assent of the President on February 5, 2003.

1.2 India's Biodiversity Profile and Status

India has a rich and varied heritage of biodiversity, encompassing a wide spectrum of habitats, from tropical rainforests to alpine vegetation and from semi-arid vegetation to coastal wetlands. India figured with two hotspots - the Western Ghats and the Eastern Himalayas - out of

25 biodiversity hotspots identified by Myers (1988). In addition, India has 26 recognized endemic centres that are home to nearly one third of all the flowering plants identified and described to date. Of the 1.7 million of the world's described biota, India contributes 7.3% of the global fauna. Among flowering plants, India accounts for 7% of the 250,000 flowering plants so far described in the world. India is one of the 12 centres of origin of cultivated plants. There are 167 cultivated species and 273 wild relatives of crop plants.

The endemism of Indian Biodiversity is high. About 33% of the country's recorded flora (49,219 plant species) are endemic to the country and are concentrated mainly in North-East India, the Western Ghats, North-West Himalayas and the Andaman and Nicobar Islands. In animals, the endemism among mammals and birds is relatively low (6 to 9%). However, the amphibians and reptiles are, respectively, nearly 62 and 50% endemic to India, and the majority of them are found in the Western Ghats.

In India, as in many tropical regions of the world, deforestation and forest degradation continue due to various factors such as extension of cultivation, grazing, extraction of forest products, hydroelectric projects and commercial plantations. Because of these activities, for example, in the Western Ghats, nearly 40% of the natural vegetation has disappeared during the last 8 decades (Menon and Bawa, 1997). In north-east, central and eastern India, shifting cultivation is a major reason for forest degradation and loss. According to one estimate, about 6.4 million hectares are affected by shifting cultivation. Deforestation leads to several changes in the landscape. The degradation and fragmentation of forests, which generally precede deforestation, considerably affect the biodiversity. Several species with narrow distribution patterns become extinct and several rare and endemic species become endangered or threatened. According to the IUCN, 2000 Red List Data, India contains nearly 3% of the world's total number of threatened species. These include 86 species of mammals, 70 birds, 25 reptiles and 3 amphibians. Among plants, 19 are extinct, 44 critically endangered, 113 endangered and 87 vulnerable.

2. SERI-BIODIVERSITY

Seri-biodiversity refers the variability in sericigenous or silk producing insects and their host plants (Srivastav and Thangavelu 2005). Non-mulberry silk moths are wild or semi-domesticated "charismatic fauna" which produce lustrous silk and exhibit a great range of variation in life history from egg to adult with characteristically different physiological, morphological and feeding parameters. Fairly good numbers of references are on record about seri-biodiversity and their potential as a source of natural silk in Indian subcontinent. According to the classification, Saturniidae is the largest family of Bombycoidea, containing about 1861 species in 162 genera and 9 subfamilies. This family includes some of the largest and most spectacular species of Lepidoptera which are univoltine to multivoltine depending upon the climatic conditions and are distributed in both temperate and tropical regions. According to an estimate, Saturniidae comprises of about 1200-1500 species all over the world; of which the Indian sub-continent, extending from Himalayas to Sri Lanka, may possess over 50 species. (Arora and Gupta 1979; Jolly et al. 1975; Nassig et al. 1996; Srivastav and Thangavelu 2005; Thangavelu et al. 2000).

2.1 Tasar Silkworm Biodiversity

Tropical tasar silk production is a forest and agro-based industry and it holds great promise for the rural and tribal people as a subsidiary occupation. The biological interaction between primary product (tasar food plants) and consumer (the silkworm, *Antheraea mylitta* Drury) integrates an ideal ecosystem, uniquely suited as an industry to the economy and social structure of rural populace because of its very low investment and high employment potential. Tropical tasar flora and fauna are abundantly distributed in the peninsular forests of Central India bordered by major rivers viz., Ganges in the north, Godavari in the south, Mahanadi in the east and Wainganga in the west.

Tropical tasar silkworm, *Antheraea mylitta* has a wide distribution range both within the country and beyond it. It is a polyphagous insect feeding on a number of food plants primarily on *Terminalia arjuna, T. tomentosa* and *Shorea robusta* and secondarily on the species of *Lagerstroemia, Ziziphus, Syzigium, Tectona, Bauhinia, Anogeissus, etc*. In India, range of distribution of the species covers Himachal Pradesh, Sikkim, Assam, Meghalaya, West Bengal, Odisha, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Tamil Nadu and Pondicherry. Besides, discrete populations have also been reported from Jammu and Kashmir, Dadar and Nagar Haveli, Manipur, Nagaland, Uttar Pradesh and Kerala. Moreover, available literature reveal that they are distributed in Pakistan, Bangladesh, South China, Nepal and Sri Lanka.

2.2 Taxonomic Review of *Antheraea mylitta*

Evidences show that Antheraea mylitta was bred in Europe during the beginning of nineteenth century, while typical *A. mylitta* occurs only in the Asiatic continent. It is represented by a number of similar forms, many of which are treated as distinct species, though they are merely local races *viz., A. fasciata* Moore, *A. pulchra* Moore and *A. ochripicata* Moore. Due to its variable appearance, it was described under a number of synonyms (Cotes, 1889; Cotes and Swinhoe, 1889) viz., Tussur = *A. mylitta* (Hübner Walker Moore Aurvillius Wardle, Rondot & Co.) = *Phalaena* (*Attacus*) *mylitta* (Blunch) = *Bombyx mylitta* (Fabr. & Oliv) = *Phalaena paphia* (Cramera Roxburg.) = *A. paphia* (Moore and Beavan) = *Saturnia mylitta* (Westwood) = *Saturnia paphia* (Helfer) (Helfer, 1937). Besides the above which have long been admitted as identical, Hutton (1865) described *A. nebulosa* as a distinct form from that met in Chhotanagpur and Central India. A closely identical or allied form is also found in Ceylon and named as A. cingalesa. Besides, *A. sivalica* and *A. patterna* have been reported as synonyms of *A. paphia* (Hampson, 1892). According to Crotch (1956), *A. paphia* is extremely difficult to distinguish from *A. mylitta*, while Seitz (1933) referred that *A. paphia* is an extremely variable insect. Though records show the existence of two species *viz., A. paphia* and *A. mylitta* in Central India, it is difficult to distinguish these two species due to intangible breeding in nature for centuries (Jolly *et al.*, 1974).

Schüssler (1933) catalogued three sub-species of *A. paphia viz., A. paphia paphia* (Linn.), *A. paphia mylitta* Drury and *A. paphia cingalesa* Moore. *A. Paphia mylitta* is distinguishable as a geographical race from *A. paphia paphia*, as also admitted by Seitz (1933), who remarked that "*A. mylitta*" is quite similar to "*A. paphia*". Studies of Arora and Gupta (1979) on the specimens collected from South India and Sri Lanka further reveal their resemblance to the specimens collected from other parts of India as far as general colouration is concerned. These observations clearly indicate a great degree of variation in colour, which Lefroy (1909) assigned to hybridization in the species. These variations are, however, insufficient to distinguish one population of an area from that of another area. Hence, it is appropriate that the species referred as *A. paphia* should not be differentiated into hitherto known sub-species. Based on new morphological aspects namely presence or absence of supra-spiracular stripe in mature larvae, Nassig (1991) attempted to reclassify the genus *Antheraea* Hübner into three sub-genera. *A. mylitta* falling under third sub-genus: *Antheraea* (*Antheraea* Hübner, 1819) and this group (*paphia/frithi* group) were only defined by weak or supposedly plasiomorphic characters. Jolly *et al*. (1974) stated that the cocoons of *A. paphia* and *A. mylitta* imported to Europe often yield a series of aberrations and transitions. Thus, they expressed doubt about the value of forms and justification of the names.

2.3 Race Concept in *Antheraea mylitta*

Critical analysis with regard to distribution of *Antheraea mylitta* reveals that once upon a time the species was available throughout the Indian peninsula and with gradual depletion of forest cover due to increasing agricultural use of land and urbanization, habitat lost its continuity and resulted in geographic isolation. This geographic isolation allowed the populations to continue separately for generations to attain an equilibrium in its phenotypic, genotypic and life history traits. The differences in the characteristics identified with particular ecological niche led to consider them as separate units within the same species and invited many nomenclatures like race, ecorace, eco-population, ecotype, *etc*. Geographically isolated populations which have adapted themselves to a particular ecological niche are referred as '*Ecoraces*'. These ecoraces vary in geography, topography, ecology, food plant flora and frequency of life cycle in latitudinal and altitudinal gradients. They exhibit diversity in phenotypic, behavioural, physio-genetic and commercial characters. Recent studies on ecoraces have revealed variability in DNA (genetic) level also. These variations are genetic treasure, thus the conservation, maintenance and protection of ecoraces are most important for their qualitative and quantitative improvement as a whole.

Various terms have been used for intraspecific categories of a species. Turesson (1922) defines ecotype as "*the product arising as a result of the genotypical response of an ecospecies to a particular habitat*" and ecospecies is proposed for the "*Linnaean species from an ecological view point*". But several objections were raised later on. As habitats do vary continuously and as ecotypes are produced by the selective forces of habitat factors, discontinuous ecotypes should be impossible by definition. When ecotype concept is presented, there is an unexpressed assumption that phenotype responds to the environment as a unit. However, several authors prove that different phenotypic characters may respond independently to various components of the environments and delimitation of ecotype may depend on the choice of the characters. Populations that are particularly conspicuously adapted to a local habitat are often referred to as "Ecological Races". Hence, without entering into terminology conflicts, the race concept should be adopted and races should be identified not adhering to only single or few loci but considering the gene pool of the local populations as a whole.

3. TASAR SILKWORM ECORACES

Exploratory surveys conducted by Central Tasar Research and Training Institute (CTR&TI), Ranchi, Jharkhand from the year 1965 till date in 17 States and one Union Territory *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 Dadar Nagar & Haveli revealed the availability of so far 44 ecoraces/biotypes/morpho variants of *Antheraea mylitta* in different eco-niches of the country (Table 1). Of which, nine distinct ecoraces are economically important. These ecoraces breed better and maintain their physical and genetic characters in their natural habitat, the forests. Daba and Sukinda ecoraces are more or less semi-domesticated and have wider adaptability, thus presently their conservation does not require much attention. However, no wonder, the existence of other important wild ecoraces like Raily, Modal, Laria, Sarihan, Modia, Andhra Local and Bhandara is threatened as their natural habitat is depleting due to regular deforestation.

Distribution of the ecoraces in relation to the forest type indicates that the races are restricted mainly in the tropical moist deciduous forest area with average rainfall between 1200-2000 mm and the tropical dry deciduous forest zone with average rainfall up to 1000 mm. Major economically important ecoraces are distributed in Central India within 18-24° N and 80-88° E, whereas occurrence has been observed within 16-32°N and 72-96°E. Voltinism pattern in *A. mylitta* is observed to be in the categories of a) uni-bi-trivoltine, b) bivoltine and c) trivoltine, and so far, no ecorace collected or reared has shown only univoltinism. Since voltinism is governed by the year cycle of day length and temperature, only a part of the collected population behaves as univoltine. Humidity helps in triggering moth emergence and avoiding pupal mortality due to desiccation. Coupling variability exists in wild ecoraces, especially collected from *Shorea robusta*.

Table 1 : Distribution of ecoraces of *Antheraea mylitta*

#	Ecorace	Collection site	Predominant Food Plants
1.	Daba	West Singhbum (Jharkhand)	*Terminalia arjuna, T. tomentosa*
2.	Sarihan	Santhal Paragana (Jharkhand)	*Terminalia arjuna, T. tomentosa*
3.	Munga	Santal Paragana (Jharkhand)	*Shorea robusta*
4.	Modia	Dhanbad (Jharkhand)	*Shorea robusta*
5.	Laria	Peterbar, Hazaribagh (Jharkhand)	*Shorea robusta*
6.	Lodhma	Ranchi (Jharkhand)	*Shorea robusta*
7.	Palma	Ranchi (Jharkhand)	*Shorea robusta*
8.	Japla	Palamau (Jharkhand)	*Ziziphus jujuba*
9.	Kowa	Palamau (Jharkhand)	*Shorea robusta*

#	Ecorace	Collection site	Predominant Food Plants
10.	Barharwa	Simdega (Jharkhand)	*Shorea robusta*
11.	Modal	Keonjhar (Odisha)	*Shorea robusta*
12.	Nalia	Sundergarh (Odisha)	*Shorea robusta*
13.	Sukinda	Sundergarh (Odisha)	*Terminalia arjuna, T. tomentosa*
14.	Baodh	Phulbani (Odisha)	*Terminalia arjuna, T. tomentosa*
15.	Simlipal	Simlipal (Odisha)	*Shorea robusta*
16.	Omarkote	Kalahandi (Odisha)	*Shorea robusta*
17.	Sulky	Khairpali (Odisha), Beramkela (Chhattisgarh)	*Shorea robusta, Anogeissus latifolia*
18.	Raily	Bastar (Chhattisgarh)	*Shorea robusta*
19.	Kurudh	Kurudh (Madhya Pradesh)	*Terminalia tomentosa*
20.	Multai	Multai (Madhya Pradesh)	*Terminalia arjuna, T. tomentosa*
21.	Mandalla	Mandala (Madhya Pradesh)	*Shorea robusta*
22.	Jhabua	Jhabua (Madhya Pradesh)	*Shorea robusta*
23.	Bhopalpatnam	Bhopalpatnam (Madhya Pradesh)	*Shorea robusta*
24.	Piprai	Piprai (Madhya Pradesh)	*Shorea robusta*
25.	Seoni	Seoni (Madhya Pradesh)	*Lagerstroemia parviflora*
26.	Janghbhir	Bastar (Chhattisgarh)	*Shorea robusta*
27.	Korbi	Korba (Chhattisgarh)	*Shorea robusta, Terminalia* spp.
28.	Tira	Purulia (West Bengal)	*Lagerstroemia parviflora*
29.	Bankura	Bankura (West Bengal)	*Lagerstroemia parviflora*
30.	Dadar & Nagar Haveli	Dadar & Nagar Haveli (UT)	*Terminalia crenulata*
31.	Shiwalika	Batote (J&K), Palampur (Himachal Pradesh)	*Ziziphus jujuba*
32.	Bhandara	Bhandara (Maharashtra)	*Terminalia arjuna, T. tomentosa*
33.	Andhra Local	Adilabad, Karimnagar (Andhra Pradesh)	*Terminalia arjuna, T. tomentosa*
34.	Monga	Deoria (Uttar Pradesh)	*Terminalia arjuna, T. tomentosa, Ziziphus jujuba*
35.	Mirzapur	Mirzapur (Uttar Pradesh)	*Ziziphus jujuba*
36.	Sultanpur	Sultanpur (Uttar Pradesh)	*Terminalia arjuna, T. tomentosa*
37.	Tesera	Sahabad (Rajasthan)	*Ziziphus jujuba*
38.	Nowgong	Nowgong (Assam)	*Ziziphus jujuba*
39.	NE1, 95	Boko (Assam)	*Ziziphus jujuba, Careya arborea*
40.	NE2, 95	Mendipathar, Resubelpara (Meghalaya)	*Ziziphus jujuba, Careya arborea*
41.	Jiribam	Jiribam (Manipur)	*Ziziphus jujuba*
42.	NG, 94	Dimapur (Nagaland)	*Ziziphus jujuba*
43.	KE 02	Moorkanparamba (Kerala)	*Anacardium occidentale*
44.	Belgaum	Belgaum (Karnataka)	*Hardwickia binata*

Regional ecology along with distribution, phenotypic, commercial and physio-genetic characters of economically important ecoraces are given in detail.

3.1 ECORACE - DABA

Regional Ecology

Distribution	:	Jhinkpani, Chaibasa (West Singhbhum, Jharkhand)
Forest Type	:	Tropical Moist Deciduous
Nature of the forest	:	Mixed forest with *Terminalia tomentosa* (Asan), *T. arjuna* (Arjun) & *Shorea robusta* (Sal) [Fig. 1]
Soil Type	:	Red loamy

Geographical Coordinates

Latitude	:	22.12^0 N
Longitude	:	86.23^0 E
Altitude	:	209 MASL
Av. Max. Temperature	:	$28.90\ ^0$C
Av. Min. Temperature	:	$18.40\ ^0$C
Annual Precipitation	:	1095 mm
Predominant Food plant	:	*Terminalia tomentosa* (Asan)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Light grey [Fig. 8]
Shape	:	Oval
Length (cm)	:	4.8 – 5.7
Breadth (cm)	:	3.3 – 3.7
Peduncle Length (cm)	:	3.5 – 6.8
Cocoons weight (g)		
Male	:	8.45 – 13.50
Female	:	7.45 – 16.21
Shell weight (g)		
Male	:	1.13 – 2.62
Female	:	0.95 – 2.92

Physio-genetic Characters

Diapause period (months)	:	6 -7
Voltinism	:	Bivoltine / Trivoltine
Breeding period	:	June - November

3.2 ECORACE – SUKINDA

Regional Ecology

Distribution	:	Sukindagarh and Sundergarh (Odisha)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	Mix forest of *Terminalia* species with dominance of *T. tomentosa* (Asan) [Fig. 2]
Soil type	:	Red loamy

Geographical Coordinates

Latitude	:	21.00^0 N
Longitude	:	86.00^0 E
Altitude	:	209 MASL
Av. Max Temperature	:	$31.45\ ^0$C
Av. Mini Temperature	:	$20.60\ ^0$C
Annual Precipitation	:	1096 mm
Predominant Food plant	:	*Terminalia tomentosa* (Asan)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Yellow [Fig. 9]
Shape	:	Oval
Length (cm)	:	4.5-4.9
Breadth (cm)	:	2.8-3.1
Peduncle Length (cm)	:	3.2-6.5
Cocoons weight (g)		
Male	:	9.08-12.38
Female	:	9.38-12.76
Shell weight (g)		
Male	:	0.97-2.21
Female	:	1.05-2.48

Physio-genetic characters

Diapause period (months)	:	4
Voltinism	:	Trivoltine
Breeding period	:	June – February

3.3 ECORACE - RALLY

Regional Ecology

Distribution	:	Bastar (Chhattisgarh)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	Sal (*Shorea robusta*) dominant forest
Soil type	:	Sandy red

Geographical Coordinates

Latitude	:	19.05^0 N
Longitude	:	82.05^0 E
Altitude	:	670 MASL
Av. Max Temperature	:	$31.50\ ^0$C
Av. Mini Temperature	:	$18.60\ ^0$C
Annual Precipitation	:	1275.62 mm
Predominant Food plant	:	*Shorea robusta* (Sal)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Blackish grey (Fig. 10)
Shape	:	Oval
Length (cm)	:	5.0-5.3
Breadth (cm)	:	3.2-3.4
Peduncle Length (cm)	:	2.5-3.8
Cocoons weight (g)		
Male	:	7.00-12.89
Female	:	11.16-18.58
Shell weight (g)		
Male	:	1.18-2.96
Female	:	1.11-3.44

Physio-genetic characters

Diapause period (months)	:	4 -10
Voltinism	:	Uni / Bi / Trivoltine
Breeding period	:	June - December

3.4 ECORACE – MODAL

Regional Ecology

Distribution	:	Keonjhar, Mayurbhanj, Simlipal (Odisha)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	Mixed forest with *Shorea robusta* (Sal) dominance
Soil type	:	Red loamy

Geographical Coordinates

Latitude	:	21.40^0 N
Longitude	:	86.40^0 E
Altitude	:	423 MASL
Av. Max Temperature	:	$30.40\ ^0$C
Av. Mini Temperature	:	$20.30\ ^0$C
Annual Precipitation	:	1218.20 mm
Predominant Food plant	:	*Shorea robusta* (Sal)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Copper grey (Fig. 11)
Shape	:	Oval
Length (cm)	:	5.8-6.4
Breadth (cm)	:	4.5-5.4
Peduncle Length (cm)	:	4.3-5.5
Cocoons weight (g)		
Male	:	09.60-16.54
Female	:	12.59-20.10
Shell weight (g)		
Male	:	2.25-3.82
Female	:	2.30- 3.92

Physio-genetic characters

Diapause period (months)	:	4 -10
Voltinism	:	Uni / Bi / Trivoltine
Breeding period	:	June - December

3.5 ECORACE - LARIA

Regional Ecology

Distribution	:	Gola, Dadu Bandh and Peterbar (Hazaribagh, Jharkhand)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	*Shorea robusta* (Sal)
Soil type	:	Red loamy

Geographical Coordinates

Latitude	:	23.04^0 N
Longitude	:	85.40^0 E
Altitude	:	613 MASL
Av. Max Temperature	:	28-40 ^{0}C
Av. Mini Temperature	:	17.66 ^{0}C
Annual Precipitation	:	1100.10 mm
Predominant Food plant	:	*Shorea robusta* (Sal)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Blackish grey (Fig. 12)
Shape	:	Oval
Length (cm)	:	4.5 –5.0
Breadth (cm)	:	2.8 – 3.1
Peduncle Length (cm)	:	4.5 – 7.2
Cocoons weight (g)		
Male	:	5.26 – 10.18
Female	:	6.05 – 10.09
Shell weight (g)		
Male	:	1.03 – 2.45
Female	:	0.91 – 2.26

Physio-genetic Characters

Diapause period (months)	:	4 -10
Voltinism	:	Uni / Bi / Trivoltine
Breeding period	:	June - December

3.6 ECORACE – SARIHAN

Regional Ecology

Distribution	:	Santhal Pargana (Jharkhand)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	Mixed forest with *Terminalia tomentosa* (Asan), *T. arjuna* (Arjun) & *Shorea robusta* (Sal)
Soil type	:	Red loamy
Geographical Coordinates		
Latitude	:	24.30^0 N
Longitude	:	87.00^0 E
Altitude	:	140 MASL
Av. Max Temperature	:	30.08 ^{0}C
Av. Mini Temperature	:	18.50 ^{0}C
Annual Precipitation	:	1100.20 mm
Predominant Food plant	:	*Terminalia arjuna* (Arjun) & *T. tomentosa* (Asan)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Grey (Fig. 13)
Shape	:	Oval
Length (cm)	:	4.8 – 6.2
Breadth (cm)	:	3.3 – 4.5
Peduncle Length (cm)	:	2.4 – 3.8
Cocoons weight (g)		
Male	:	10.49 – 15.60
Female	:	15.22 – 20.45
Shell weight (g)		
Male	:	2.23 – 3.58
Female	:	2.60 – 4.21

Physio-genetic characters

Diapause period (months)	:	4
Voltinism	:	Trivoltine
Breeding period	:	June - December

3.7 ECORACE – MODIA

Regional Ecology

Distribution	:	Hatgamharia, Jaintgarh, Sagarketta, Jhinkpani, Chaibasa (West Singhbhum, Jharkhand)
Forest type	:	Tropical Moist Deciduous
Nature of the forest	:	Mixed forest with *Terminalia tomentosa* (Asan), *T. arjuna* (Arjun) & *Shorea robusta* (Sal)
Soil type	:	Red loamy

Geographical Coordinates

Latitude	:	22.13^0 N
Longitude	:	86.23^0 E
Altitude	:	209 MASL
Av. Max Temperature	:	30-08 ^{0}C
Av. Mini Temperature	:	18.50 ^{0}C
Annual Precipitation	:	1100.20 mm
Predominant Food plant	:	*Shorea robusta*

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Grey (Fig. 14)
Shape	:	Oval
Length (cm)	:	4.8 – 6.2
Breadth (cm)	:	3.3 – 4.5
Peduncle Length (cm)	:	2.4 – 3.8
Cocoons weight (g)		
Male	:	10.49 – 15.60
Female	:	15.22 – 20.45
Shell weight (g)		
Male	:	2.23 – 3.58
Female	:	2.60 – 4.21

Physio-genetic Characters

Diapause period (months)	:	7
Voltinism	:	Bivoltine
Breeding period	:	June - November

3.8 ECORACE - ANDHRA LOCAL

Regional Ecology

Distribution	:	Adilabad, Karimnagar (Andhra Pradesh)
Forest type	:	Tropical Dry Deciduous
Nature of the forest	:	Mixed forest with dominance of *Terminalia tomentosa* (Asan)
Soil type	:	Black clayey

Geographical Coordinates

Latitude	:	19.40^0 N
Longitude	:	79.18^0 E
Altitude	:	170 MASL
Av. Max Temperature	:	$31.52\ ^0$C
Av. Mini Temperature	:	$21.80\ ^0$C
Annual Precipitation	:	925.25 mm
Predominant Food plant	:	*Terminalia tomentosa* (Asan)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Whitish grey (Fig. 15)
Shape	:	Oval
Length (cm)	:	3.0-3.2
Breadth (cm)	:	2.2-2.5
Peduncle Length (cm)	:	2.6- 4.9
Cocoons weight (g)		
Male	:	4.21-6.30
Female	:	6.75-10.11
Shell weight (g)		
Male	:	0.63-0.98
Female	:	0.86-1.42

Physio-genetic characters

Diapause period (months)	:	4
Voltinism	:	Trivoltine
Breeding period	:	June - December

3.9 ECORACE – BHANDARA

Regional Ecology

Distribution	:	Bhandara, Gadchiroli (Maharashtra)
Forest type	:	Tropical Dry Deciduous
Nature of the forest	:	Mixed forest with dominance of *Terminalia tomentosa* (Asan)
Soil type	:	Black clayey

Geographical Coordinates

Latitude	:	21.09^{0} N
Longitude	:	79.42^{0} E
Altitude	:	311 MASL
Av. Max Temperature	:	$34.50\ ^{0}$C
Av. Mini Temperature	:	$20.80\ ^{0}$C
Annual Precipitation	:	939.40 mm
Predominant Food plant	:	*Terminalia tomentosa* (Asan)

Cocoons Characters - Phenotypic and Commercial

Predominant colour	:	Grey (Fig. 16)
Shape	:	Oval
Length (cm)	:	3.8-4.1
Breadth (cm)	:	2.4-2.5
Peduncle Length (cm)	:	2.6-5.9
Cocoons weight (g)		
Male	:	4.99-6.70
Female	:	7.23-9.98
Shell weight (g)		
Male	:	0.63-0.98
Female	:	0.86-0.98

Physio-genetic characters

Diapause period (months)	:	5
Voltinism	:	Trivoltine
Breeding period	:	June - December

NATURAL HABITATS AND HOST PLANTS OF TROPICAL TASAR SILKWORM ECORACES

Fig 1 : Mixed forest with *Terminalia tomentosa, T. arujuna* & *Shorea robusta*

Fig 2 : Mix forest of Terminalia species with dominance of *T. tomentosa*

Fig 3 : Forest with *Terminalia tomentosa*

Fig 4 : Forest with *Shorea robusta*

Fig 5 : *Terminalia arjuna* plant

Fig 6 : *Terminalia tomentosa* plant

Fig 7 : Coppice *Shorea robusta* plants

COCOONS OF COMMERCIALLY EXPLOITED TROPICAL TASAR SILKWORM ECORACES

Fig 8 : Daba cocoons

Fig 9 : Sukinda cocoons

COCOONS OF ECONOMICALLY IMPORTANT TROPICAL TASAR SILKWORM ECORACES

Fig 10 : Raily cocoons

Fig 11 : Modal cocoons

Fig 12 : Laria cocoons

Fig 13 : Sarihan cocoons

Fig 14 : Modia cocoons

Fig 15 : Andhra Local cocoons

Fig 16 : Bhandara cocoons

4. ECORACE CONSERVATION

During last few decades, the advancement in agriculture, industrialization and urbanization has depleted the forest coverage which resulted in the erosion of biodiversity. Tasar culture being traditional practice in the concentrated tribal belts in different States plays a pivotal role in providing livelihood to tribal populace who are dependent on biodiversity utilization for their sustenance. However, the destruction of natural habitats of silkworm due to deforestation, introduction of pervasive agro-technology at the cost of indigenous germplasm, over-collection of naturally produced cocoons, overexploitation of floral and faunal wealth of Vanya silk by rapacious traders and pollution has threatened the existence of many wild ecoraces of tropical tasar silkworm, *Antheraea mylitta*. A few decades back nature grown cocoons of tasar ecoraces contributed substantially to the total tasar silk production in India but it declined alarmingly in last one or two decades. This is due to anthropogenic stress which has resulted in shrinkage of habitat of *A. mylitta*, consequently affecting the proliferation of this insect and gradually declining population size to the extent of their extinction.

4.1 Need for Ecorace Conservation

a) Socio-technical analysis:

Introduction of Daba and Sukinda ecoraces during 70s affected the population structure of wild ecoraces adversely in different States as well as in the country. Thus, an alarming trend of decline was observed in population of Modal in Odisha, Raily in Chhattisgarh, Laria, Sarihan and Modia in Jharkhand, Andhra Local in Andhra Pradesh and Bhandara in Maharashtra. The reason for such decline may be examined by the fact that when high yielding variety ecoraces with bumper harvest were introduced, the tribal rearers were tempted and preferred them. It called for lesser effort when compared to rigorous drill needed in cultivating/rearing wild ecoraces. This weakened their attachment towards the wild ecoraces and their host plants. Slowly forest trees fell for one pretext or other, their age-old defence towards forest ecosystem succumbed to the pressure of changing time and the deforestation disturbed the biodiversity of many silkworm ecoraces including tasar. Cultivated variety ecoraces which played a major role in such devastation however could not retain their vigour. There was a regular qualitative and quantitative decline that made the rearers turn away from tasar culture. Since tasar culture and forestry are inseparable, it is impossible to uplift tasar sector by any mean that overlooks forestry. Along with preservation of host environment, application of modern knowledge of conservation genetics will be helpful in making conservation plan.

b) Socio-economic analysis:

Tribals generally collect wild tasar cocoons during their search for minor forest produce while roaming in the forest. Cocoons so collected are exchanged for rice, salt or kerosene. Grocer sells to Mahajan and then cocoons are smuggled to neighbouring States where more demands and better price are available. Thus, tasar cocoons drain out from the forest cover over the years without interference.

The nature grown cocoons of wild silkworm ecoraces declined alarmingly due to the following reasons:

- Large scale collection of cocoons from their ecological niches without giving any heed towards natural breeding process for self-perpetuation.
- Over-exploitation and destruction of natural habitats of different ecoraces leading to the shrinkage of forest area occupied by silkworm host plants due to denudation of forest to meet the fuel, forage and timber demand.
- Environmental stress changes the climate/environment/forest ecosystem.
- Human interference for industrial and housing areas with increasing human population.
- Least involvement of masses in protecting biodiversity due to lack of awareness, and
- Lack of conservation strategies for the wild ecoraces.

To sum up these causes, it could be said that massive depletion of tasar forest flora along with rampant collection of nature grown cocoons calls for urgent attention to conserve these precious silkworm ecoraces from the threat of extinction by way of ban on irrational collection and marketing of nature grown cocoons of ecoraces by the tribals with the following objectives:

1. To protect and maintain essential tasar host plants in the forest ecosystem.
2. To preserve the existing wild ecoraces and their population in natural habitat.
3. To ensure sustainable utilization of the ecoraces and ecosystem.

4.2 Conservation Strategies

Since the natural distribution is threatened and ecological disturbance is ever ending; hence, most vital component for the sustainable use and economic importance of the wild silkmoths diversity is its conservation. To salvage the rapidly narrowing genetic base of economically important tasar silkworm ecoraces, following conservation strategies have been outlined.

- Careful conservation of selected areas of ecosystem to preserve the desired genetic resource of tasar silkworm.

- Prevention of genetic erosion by prohibiting further exploitation of the ecoraces and its variants.
- Study of population structure, behaviour, ecology and dynamics of ecoraces in their natural habitat.
- Collection and updating of biodiversity data.

As short and long term measures, the following strategies can be adopted to conserve the precious genetic resources of Vanya silkworms.

I Short term measures:

- The deteriorating trend of breeding population can be arrested by introduction of additional breeding material of the wild tasar silkworms in identified protected area of natural habitats for allow them to breed and multiply free from interference.
- Time instituted programme can be earmarked to allow the collection of cocoons in a cyclic manner from protected area.
- Regular surveillance is necessary to check pests and diseases in forest ecosystem.
- Motivation, training and sensitization of members of local community on conservation of floral and faunal diversity of Vanya silkworm.

ii) Long Term Measures

- Population structure, behaviour ecology and population dynamics of Vanya silkmoths are required to be studied in detail in their natural habitats.
- Comprehensive gene pool with well-coordinated programme for collection, evaluation and conservation of genetic resource are the need of the hour, for which in-situ and ex-situ conservation methodology are to be adopted.
- State-wise establishment of Biotic Resource Inventory and Biodiversity data updating are required for monitoring biodiversity erosion.
- Identification of rare, vulnerable, endangered and extinct wild silkmoths is necessary for adopting suitable conservation strategies.
- Biotic salvage operation for forest ecosystem and threatened population are to be carried out.
- The forest loving tribals can be made to understand how food plants and nature grown Vanya silk cocoons can vouch a better livelihood for them.
- Establishment of environmental education centres in Vanya silk growing states.

5. TECHNOLOGY PACKAGE FOR ECORACE CONVERVATION

Naturally grown cocoons move out from inside of forest without replenishment. Since multiplication rate of ecoraces is very low, the population dwindles down. To overcome these problems, the conservation plan was developed by the CTR&TI, Ranchi for proliferation of wild ecoraces in their ecological niches which is dealt herewith for immediate remedial measures for wild ecorace conservation.

5.1 Introduction of breeding material *in-situ*

By introduction of additional breeding materials *in-situ* condition, the deteriorating trend of breeding population can be checked. For this purpose, a forest patch is selected and divided into three different zones for natural proliferation of the ecoraces in their own ecological niches:

i) **Core zone:** Core zone acts as virgin zone wherein silk moths are allowed to reproduce *suo moto* in nature and should never be allowed to collect, except for research purposes. This zone serves as a gene pool reservoir for ecorace and is allowed to multiply amidst utter silence and serenity.

ii) **Buffer zone:** This is the middle zone which acts as the buffer zone from where ecoraces are allowed to move to their natural habitat (core zone) as well as peripheral zone of the forest patch.

iii) **Peripheral zone:** Outer or peripheral zone of the forest patch comprises of all village forests/reserve forests where rearing of silkworms is conducted and rearers are allowed to collect wild cocoons. During the process of infusion of ecorace for conservation, wild ecoraces pose problems at their different stages of culture in captivity. Two major constraints pertaining to seed cocoon preservation and seed preparation are discussed below.

1. The collected seed cocoons of the same ecorace preserved under captivity show great loss due to irregular and unseasonal emergence *inter alia* pupal mortality.

2. Natural coupling is very less which by and large reduces recovery rate of fertile eggs.

I. Grainage Technology:

To overcome the above problems, a package has been developed for seed cocoon preservation and seed preparation. The package deals with the selection and preservation of seed cocoons, which is more or less same as per grainage of semi-domestic ecoraces - Daba and Sukinda.

Selection of seed cocoons: For seed preparation purpose, well formed, compact and healthy cocoons should be selected. Flimsy cocoons, uzi & yellow fly infected and dead cocoons should be discarded during the collection stage itself. The seed cocoons are selected on visual and feel basis. Seed cocoons should not be selected on the basis of their size as male cocoons are smaller than female. Proper cocoon selection reduces preservation loss by 30-40% when compared to unselected ones. In addition, there is gain in seed production due to increase of 15-20% in fecundity.

Preservation of seed cocoon garlands: Selected seed cocoons are tied together, irrespective of sexes, with gunny thread (sutli) in the form of garlands each consisting of 50 cocoons.

Seed cocoon preservation devices: To avoid unseasonal moth emergence and pupal mortality, the seed cocoons are preserved in different devices/structures erected under natural environment.

1. **Host tree device:** A patch of host trees in the forest is selected and trees are pollarded to the level of 5-6' height from the ground level. Pollarded trees are cleared from pests and predators and optimum aseptic conditions are maintained in the surrounding areas. Seed cocoons garlands are hanged on the branches of host trees maintaining proper spacing in between the garlands. The trees are covered with cotton net of the desired size as per their canopy and requirements. To avoid pupal mortality, a temporary shade of paddy/wild grasses is made around the trees.

2. **Pagoda device:** Pagoda is made under the host trees using indigenous materials such as wooden poles and paddy straws (Figs. 17 & 18). The size of the structure may vary as per the quantity of seed cocoons. Seed cocoon garlands are preserved in hanging position inside the Pagoda. All sides of Pagoda are covered with a cotton net to protect cocoons from the attack of pests and predators.

   Precautions: Preservation site should be devoid of water stagnation. Cotton net may be removed during the morning hours to allow cool breeze flow through the cocoons without obstacle.

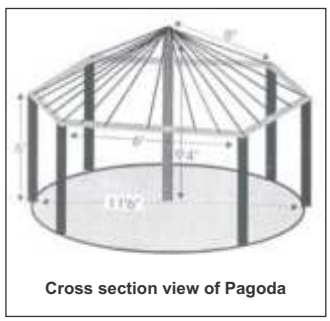

Fig. 17 : Schematic diagram of Pagoda device

Fig. 18 : Pagoda cfor seed cocoon preservation

II. Grainage Operations:

It has been experienced that mating efficiency and egg laying process of wild ecoraces are mainly influenced through intrinsic and microclimatic factors of the area. As such, the grainage operations are conducted inside the Pagoda under natural environment, maintaining suggested hygienic conditions.

III. Natural Proliferation:

Following methodology is employed for natural proliferation of wild ecoraces in peripheral zone.

1) **Release of seed cocoons:** Seed cocoons are hanged on host trees, just prior to regular emergence.

2) **Moth release:** During peak period of emergence, male and female moths are released in the selected area.

3) **Gravid moth release:** The male and female moths are allowed for mating inside net and gravid moths released in the selected area every day in the evening.

4) **Release of eggs in leaf cups:** The disease free layings (dfl) prepared from the cocoons preserved under host tree or Pagoda devices in the base camp of peripheral zone should be used for release. Eggs of single dfl is placed in a Sal leaf cup and tied to the plant in such a way so that rain water does not enter into the leaf cup.

5) **Release of Chawki worms:** Chawki worms are reared up to 03 days on Sal leaves and subsequently released in natural habitat.

All the natural regeneration methods as discussed above are effective in ecorace conservation and rejuvenation; however, there are some merits and demerits. The release of seed cocoons and moths give lower seed production due to synchronization barrier in emergence. The release of Chawki worms enhances natural population but it cannot be practiced in large scale release programme. This method is more suitable in sampling and multiplication of ecorace in ex-situ. Among all, the leaf cup method is more suitable, as it is observed that the production of nature grown cocoons is increased considerably on adoption of conservation measures through release of eggs in leaf cups.

5.2 Periodic cordoning off forest for natural multiplication

After field release of cocoons, moths, eggs and Chawki worms in identified forest patch, the area should be cordoned off and a time bound collection of cocoons should be allowed in peripheral and buffer zone in a cyclic manner.

5.3 Periodic checks on conserved ecorace

Every year, within the conservation programme and using suitable sampling methods, the supervision is to be made for control of diseases, pests and predators attack.

5.4 Exploration of new pockets

New eco-pockets are to be explored in remote forest areas to serve as alternate conservation area. This will pave the way for collection and closing schedule alternately for the benefits of tribals who partially depend on the income from the collected nature grown cocoons.

5.5 Impact of technology Package

The present technology helps in arresting declining trend of Raily and Modal ecoraces of *Antheraea mylitta*. According to an estimate, the Raily cocoon production has increased from 21.50 lakh in 1990-91 to 2044.41 lakh in 2013-14. Similar efforts may also be made for other wild ecoraces of tropical tasar silkworm.

5.6 *Ex-situ* maintenance

Ecorace populations which are endangered and their conservation under *in-situ* condition is not possible, the only way to conserve the original population is through *ex-situ* maintenance.

a) Exploration and collection:

i) Random sampling of cocoons of ecoraces from their ecological pockets.

ii) Recording of meteorological data.

iii) Studying quantitative characters of existing genetic resources collected from the nature.

iv) Recording of important ethological parameters during and after diapause.

v) Maintenance and acclimatization of ecoraces under ex-situ condition.

vi) Generation-wise recording of biological, commercial and technological characters of ecoraces.

vii) Evaluation of ecoraces based on biological and commercial parameters.

b) Maintenance:

Efforts are being made to acclimatize the collected ecoraces at CTR&TI, Ranchi and each of the ecoraces after morphological descriptions as per descriptor are being evaluated for the following parameters:

Biological: Emergence pattern, emergence span, coupling behaviour, fecundity, hatching (%), larval weight (g.), larval span (days), effective rate of rearing (%), yield per dfl & cocooning (%).

Commercial: Cocoon weight (g), shell weight (g), silk ratio (%), filament length, denier, reelability (%), recovery (%), tenacity, yield per 1000 cocoons and absolute silk yield (g/dfl).

6. ECORACE CONSERVATION MODELS

For natural proliferation and conservation of some of the economically important tasar silkworm ecoraces, the technology models have been developed by the CTR&TI, Ranchi & its Regional Research Stations. These conservation models are given hereunder.

6.1 MODEL FOR CONSERVATION OF RAILY ECORACE

Raily ecorace of tropical tasar silkworm, *Antheraea mylitta* is an endemic ecorace of Bastar region of Chhattisgarh. It is a unique sericigenous wild ecorace found in nature in dense tropical moist deciduous forests abundantly on *Shorea robusta* (Sal) in forest ranges of Bastar in Chhattisgarh. It also feeds on *Terminalia tomentosa* (Asan), *T. arjuna* (Arjun) and *Anogeissus latifolia* (Axle wood or Dhawra).

The following package of practices has been developed to conserve the ecorace Raily utilizing vast Sal flora available in Bastar region of Chhattisgarh.

1. Identification of potential eco-niches
2. Augmentation of seed through Pagoda Device
3. Methods of Natural Regeneration
4. Ideal release period for different seasons
5. Module for different field releasing methods
6. Calendar (work plan) for rearing of Raily

i) Identification of potential eco-niches:

Through bio-prospecting, suitable eco-niches (forest ranges) for ecorace Raily have been identified in its core areas. These include Antagarh, Narayanpur, Dhaurai, Chotey Donger, Dantewada, Tongpal, Farasgaon, Makdi, Kondagaon, Mardapal, Bhanpuri, Bakawand, Tokapal, Barsur, Geedam, Darbha, Kanger, Nangoor and Keshkal. The same has been suggested to the State Govt. of Chhattisgarh to have a plan for restoration of deteriorated/ disturbed ecological niches.

ii) Augmentation of seed through Pagoda Device:

The innovation of a Pagoda device for *in-situ* seed cocoon preservation and grainage operation has ensured a viable, efficient and effective seed production of wild Raily ecorace for conservation (Figs. 17 & 18).

iii) Methods of Natural Regeneration:

Five methods are suggested for natural regeneration (field releasing) of ecorace Raily. These are 1. Release of seed cocoons, 2. Release of moths, 3. Release of gravid moths, 4. Release of eggs in Sal leaf cups and 5. Release of Chawki worms in the place of conservation. It was established that all the five methods contributed in enhancing the natural population of Raily with variable rates of productivity. The cocoons produced by these release methods exhibited similar commercial characters as of nature grown cocoons. As regard to cost-benefit ratio, conservation methods 1 & 2 are operationally and technically more feasible but economically unfeasible; however, methods 3 & 4 are feasible on all counts (Fig. 19).

iv) Ideal release period for different seasons:

In order to derive ideal releasing period, phase rearing of Raily ecorace was conducted at an interval of 10 days over a period of five years involving ten crops. Based on the survival probability and economic traits, it was identified that second fortnight of June for 1st crop season and first fortnight of October for 2nd crop season were ideal release periods to realise maximum Raily cocoons production in the eco-niches.

v) Module for different field releasing methods

A module has been prepared incorporating all the activities involved in the release of Raily ecorace in Bastar forest (Table 3).

vi) Calendar (work plan) for rearing of Raily

A calendar has been prepared for carrying out different activities for rearing of tasar silkworm under in-situ and ex-situ conditions (Table 4).

Adoption of the above conservation model on large scale by the State Govt. of Chhattisgarh has resulted in attaining an enormous enhancement in the production of Raily cocoons from 21.50 lakhs in the base year of 1990-91 to 20.44 crore in 2013-14 (Table 2).

Table 2 : Trend of Raily cocoon production after initiation of conservation programme.

Year	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02
Cocoon production (in Lakh)	21.50	30.00	70.00	198.75	260.03	230.25	145.00	565.00	453.00	480.00	496.00	570.42
Year	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14
Cocoon production (in Lakh)	382.72	828.79	758.16	378.86	506.05	586.74	400.00	510.00	870.08	1636.27	1999.77	2044.41

Table 3 : Module for different field releasing methods of Rally ecorace in Baster forest

#	Nature of activity	Crop Season	Release of seed cocoons	Release of moths	Release of gravid moths	Release of layings in Sal leaf cups	Release of Chawki worms
1	Selection of releasing site or area	I & II	Nature grown core area	Nature grown core area	Core/Peripheral area	Core/Peripheral area	Core/Peripheral area
2	Schedule of Site Selection	I	2nd fortnight of May	2nd fortnight of May	2nd fortnight of May	2nd fortnight of May	2nd fortnight of May
3	Procurement of Seed Cocoons	I II	March* 15th Aug. to 15th Sept.**	March* 15th Aug. to 15th Sept.**	March* 15th Aug. to 15th Sept.**	March* 15th Aug. to 15th Sept.**	March* 15th Aug. to 15th Sept.**
4	Preservation of seed cocoons	I II	March to May --	March to May --	March to May --	March to May --	March to May --
5	Method of cocoon preservation & conducting grainage operations	I II	*In-situ*	*In-situ*	*In-situ*	*In-situ*	*In-situ*
6	Sorting of seed cocoons and preparation of garlands	I II	20th - 30th May 25th - 31st Aug.	20th - 30th May 25th - 31st Aug.	20th - 30th May 25th - 31st Aug.	20th - 30th May 25th - 31st Aug.	20th - 30th May 25th - 31st Aug.
7	Release of seed cocoons	I II	1st to 7th June 1st - 7th Sept.	1st to 7th June 1st - 7th Sept.	1st to 7th June 1st - 7th Sept.	1st to 7th June 1st - 7th Sept.	1st to 7th June 1st - 7th Sept.
8	Method/mode of releasing seed cocoons	I & II	Bush Method (1)	Bush Method (1)	Bush Method (1)	Bush Method (1)	Bush Method (1)
9	Regular emergence	I II	-- --	10th June -10th July 1st -30th Sept.(2)	10th June -10th July 1st -30th Sept.(2)	10th June -10th July 1st -30th Sept.(2)	10th June -10th July 1st -30th Sept.(2)
10	Time of releasing of moths	I & II	--	5.00 AM to 6.00 AM	--	--	--
11	Mating operation	I & II	--	*In-situ* under nylon net (3)	*In-situ* under nylon net(3)	*In-situ* under nylon net (3)	*In-situ* under nylon net (3)
12	Time of decoupling	I & II	--	4.00 PM	4.00 PM	4.00 PM	4.00 PM
13	Release of gravid moths	I & II	--	--	5.00 AM to 6.00 AM	--	--
14	Collection of layings	I & II	--	--	--	Earthen Cups	Earthen Cups
15	Method/mode of releasing layings	I & II	--	--	--	Place single laying in a Sal leaf cup	--
16	Time of release of layings	I & II	--	--	--	Early Morning / Evening	--
17	Method of Chawki rearing	I & II	--	--	--	--	Bottle method on Sal twigs
18	Duration of Chawki rearing	I & II	--	--	--	--	72 hours
19	Release of Chawki worms	I & II	--	--	--	--	Transfer the twigs early morning into outdoor
20	Packing the pierced cocoons	I II	11th - 15th July 10th - 15th Oct.	11th - 15th July 10th - 15th Oct.	11th - 15th July 10th - 15th Oct.	11th - 15th July 10th - 15th Oct.	-- 10 - 15th Oct.
21	Normal period of natural regeneration	I II	19th Jun-19 Aug. 10th Sep-10th Nov.	19th Jun-19th Aug. 10th Sep-10th Nov.	19th Jun-19th Aug. 10th Sep-10th Nov.	19th Jun-19th Aug. 10th Sep-10th Nov.	19th Jun-19th Aug. 10th Sep-10th Nov.
22	Collection of cocoons	I II	August - September November - March	August - September November - March	August - September November - March	August - September November - March	August - September November - March

Note : *Diapausing, **Non-Diapausing, (1) hanging cocoons on the Sal bushes, (2) varies with the period of collection, (3) Pagoda device may be incorporated.

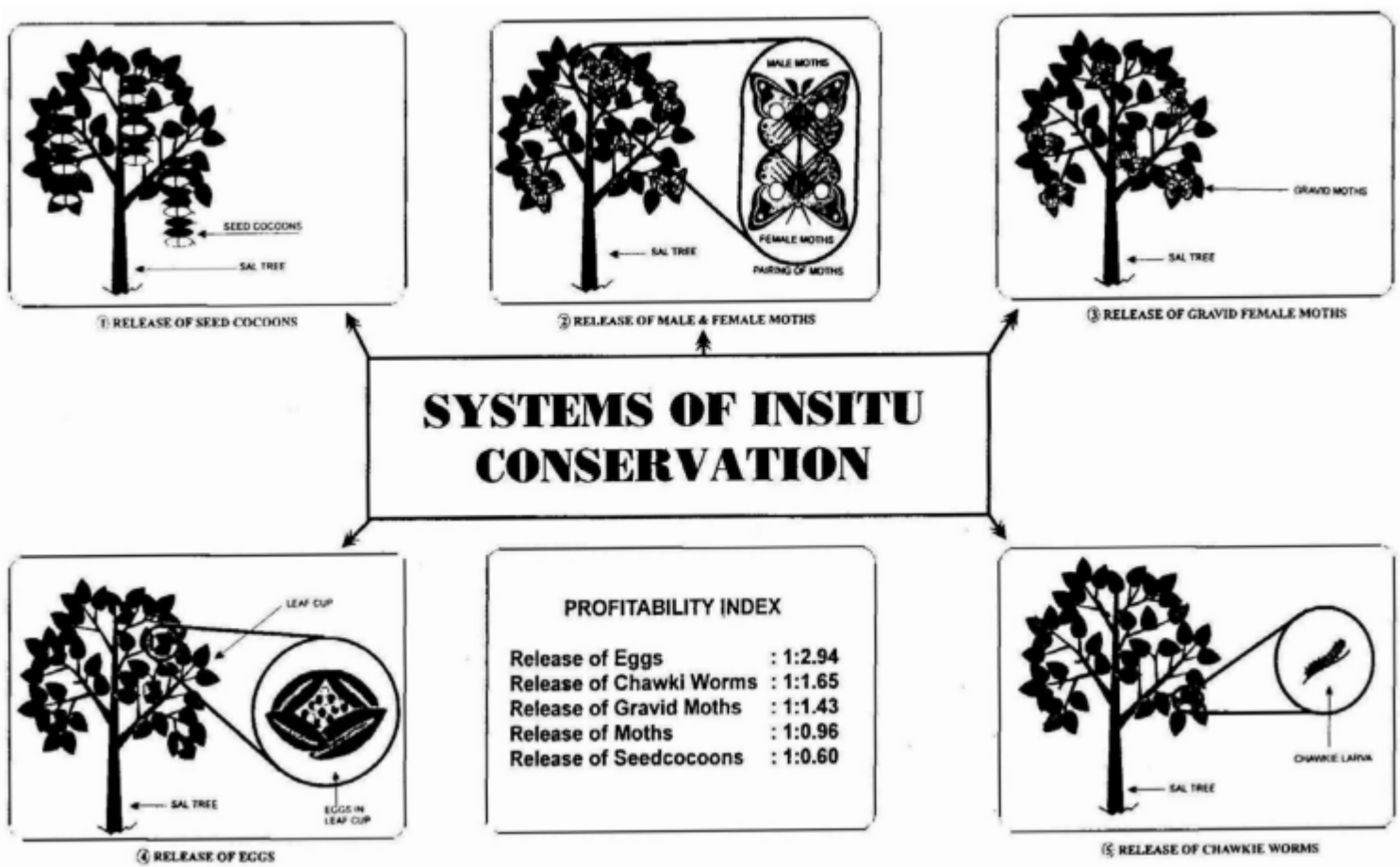

Fig. 19 : Efficacy of different release methods on natural regeneration of Raily

Table 4 : Calendar (work plan) for rearing of Raily ecorace of tropical tasar silkworm, *Antheraea mylitta*

MONTH	SET I (First Crop)		SET II (Second crop)	
	Chawki Garden	Natural Plantation	Chawki Garden	Natural Plantation
January	Natural defoliation			
February	Sprouting by 15th February; 1st foliar spray by 3rd week of February with 0.09% Rogor			
March	2nd foliar spray of 0.09% Rogor after 15 days of 1st spray			
April	3rd foliar spray of 0.09% Rogor after 15 days of 2nd spray			
May	Defoliation: 15-20 May; Sprouting: 24-29 May; 1st foliar spray of 0.09% Rogor after sprouting			
June	Application of NPK (Pit dose) on onset of monsoon; Foliar spray of 1.5% urea; Plucking of apical leaves; **4th week:** Incubation, Hatching & Brushing		Application of NPK (Pit dose) on onset of monsoon; Foliar spray of 1.5% urea	
July	Chawki rearing: I - III stages up to 15th July)	Late age rearing (IV (IV - V stages) : 2nd fortnight	--	--
August	--	Spinning: 2nd week; Harvesting: 3rd & 4th week	Defoliation: 1st week; Foliar spray of 0.9% Rogor after sprouting (10th August); Application of NPK (Pit dose) 15th August; Foliar spray of 1.5% urea by 20th August; Dressing of plants cleaning, weeding, *etc.*	
September	--	--	Second fortnight: Incubation, Hatching, Brushing & Chawki rearing (I-III stage)	--
October	--	--	--	Late age rearing (IV & V stage)
November	--	--	--	-Spinning -Harvesting of cocoons (Third week)
December	Application of FYM			

6.2 MODEL FOR CONSERVATION OF MODAL ECORACE

Modal ecorace of tropical tasar silkworm, *Antheraea mylitta* is found in Simlipal Biosphere Reserve in Mayurbhanj district of Odisha State. The quantitative cocoon traits as well as fecundity of Modal are at par with Raily ecorace. However, the life cycle strategies of Modal ecorace differ to a great extent even both feed mainly on *Shorea robusta*. Modal ecorace shows excellent behavioural as well as quantitative traits under in-situ conditions than the captivity. The ecorace is not amenable for human handling and loses its racial quantitative and qualitative characters on human interference besides exhibiting low survival. Modal cocoons collected in August are used by farmers to raise commercial crop (Bogai) because after Bogai crop it is difficult to maintain its life cycle. Hence, the emphasis is given for *in-situ* conservation of Modal ecorace.

The following package of practices has been recommended for conservation of Modal ecorace by utilizing Sal flora.

1. Identification of potential ecopockets
2. Identification of seasons for collection and preservation of seed cocoons
3. Augmentation of seed through Pagoda device in the base camp.
4. Identification of different release methods (cocoon hanging, release of gravid moth, placing eggs in leaf cup for hatching on to the trees without human interference).
5. Estimation of population through fresh litter search method
6. Encouraging the out breeding by allowing outside males to mate the females in the Pagoda.
7. Calendar for rearing Modal (Bogai crop) and Nalia (also available in peripheral zone of Simlipal Biosphere Reserve)

Under Modal Ecorace Conservation Project (MECP) implanted by the Dept. of Textiles, Govt. of Odisha, the package of practices as mentioned above is followed which resulted in enormous increase in the production of Modal cocoons (Table 5). The conservation camps are conducted in the places covering core, buffer and peripheral areas. Presently, Tasar Rearers Cooperative Societies (TRCSs) are assigned with the task of conservation of Modal ecorace under Modal Ecorace Conservation Project.

Table 5 : Estimate of Modal cocoon production in Mayurbhanj since 1998-99 (includes the crop Bogai also)

Phase	Year	Total Cocoon Collection (in lakh) (Modal + Bogai)
Before the Project	1998-99	30.60
	1999-00	21.72
	2000-01	21.42
During 1st Phase of the Project (MECP)	2001-02	57.49
	2002-03	34.27
	2003-04	75.04
	2004-05	69.55
	2005-06	69.44
During 2nd Phase of the Project (MECP)	2006-07	38.05
	2007-08	72.13
	2008-09	82.24
During 3rd Phase of the Project (MECP)	2009-10	119.76
	2010-11	173.21
	2011-12	153.21
	2012-13	140.5
	2013-14	74.5
During 4th Phase of the Project (MECP)	2014-15	35.5
	2015-16	175.8

N.B. Production during 2002-03 was affected due to cyclone, similarly there was severe impact on wild Modal populations during 2013-14 & 2013-14 due to the cyclone "Phailin"

6.3 MODEL FOR CONSERVATION OF LARIA ECORACE

Laria is one of the important ecoraces of tropical tasar silkworm, *A. mylitta* distributed in various parts of Jharkhand State. The ecorace is notable for its small sized and robust cocoons with low denier (8-9) compared to Daba (10-12). The characteristic voltinism of Laria is uni, bi and tri but major population behaves as bivoltine. The farmers utilize Laria mostly for second crop as third crop is unstable and breeding behaviour during first crop in nature is not studied. In order to make Laria crop successful and remunerative, a suitable rearing schedule and package of practices has been developed for conservation of Laria ecorace utilizing vast Sal flora available in Jharkhand State.

I. Methodology for Conservation of Laria ecorace

For introducing additional breeding materials *in-situ* condition, a patch of Sal forest is selected as conservation site. Conservation rearing net made up of nylon polyamide (Size: 50' x 50' x 25'; Code: 210 D/213/25 mm) provided with interlocking polypropylene rope on all sides is utilized to cover 25 to 30 Sal plants at the identified conservation site.

Wild cocoons of Laria are collected as breeding material. Good cocoons are sorted to prepare the garlands. The garlands are hanged inside the net cover. Apart from hanging the seed cocoons as breeding materials, eggs in leaf cups and gravid female moths in Chullus (egg laying and transferring device) made of local wild Kans grass (*Saccharum spontaneum*) are also hanged inside and outside the net cover. To overcome the menace of predators such as rats, squirrels, etc., open cellars made of iron mesh and bamboos can be erected inside the net cover at conservation site.

Laria seed cocoons hanged in Sal forest under nylon net

Iron mesh cellar for protection of Laria seed cocoons from predator menace

Benefits of the technology

1. *In-situ* grainage technology for Laria ecorace has been standardized through which Laria dfls can be produced in the ratio of 5:1 which was not possible earlier in captive (*ex-situ*) conditions.
2. In the natural conditions under net cover, pairing was observed 80 - 88% during June - July and 88 - 91 % during August - September.

II. Recommended Technology Package for Proliferation of Laria ecorace

Besides *in-situ*, *ex-situ* grainage technology for Laria ecorace has also been standardized through which Laria dfls can be produced. For *in-situ* conservation and *ex-situ* proliferation, successful brushing period for Laria is found to be during third to fourth week of September.

During Rainy season, Laria should be allowed to proliferate in natural pockets, as *ex-situ* rearing is not much successful during this period. Thus, emphasis must be given for conservation of Laria in natural ecopockets in the forests of Jharkhand. A detailed package has been recommended for the efficient utilization of vast Sal flora and also to make Laria cocoon productivity more remunerative.

1. Grainage behaviour studies indicate that untimely (erratic) emergence of Laria takes place during April to May resulting in loss of biological material. Due to high temperature, even the dfls cannot be utilized. On the other hand, life cycle continues in forest ecopocket, therefore summer preservation of Laria cocoons should be discouraged.

2. Collection of Laria cocoons should not be encouraged before the completion of rainy season, as most of the biological material would not serve the purpose due to unfavourable conditions.

3. During June-July, the natural proliferation and continuation of life cycle of Laria should be allowed *in-situ* without human interference.

4. For preservation and grainage to produce dfls, Laria cocoons should be collected after rainy season *i.e.*, during August. During autumn season, the dfls can be utilized for rearing on Sal coppice plants.

5. The brushing must be scheduled during 3rd to 4th week of September for the better survivability and productivity of Laria on Sal.

6. Emphasis should be given for conservation of Laria in natural ecopockets in the forests of Jharkhand with minimum densities of other primary and secondary host plants, as it is difficult to conserve Laria in isolated coppice plantation.

By adopting a systematic well planned and coordinated multiplication programme of wild ecoraces (i.e., *in-situ* conservation) with the help of technical expertise and organizational stability, the conservation as well as its sustainable utilization can be achieved and simultaneously this could create the avenues for employment generation to poor forest dwellers.

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