

CONSERVATION PACKAGE FOR MODAL ECORACE

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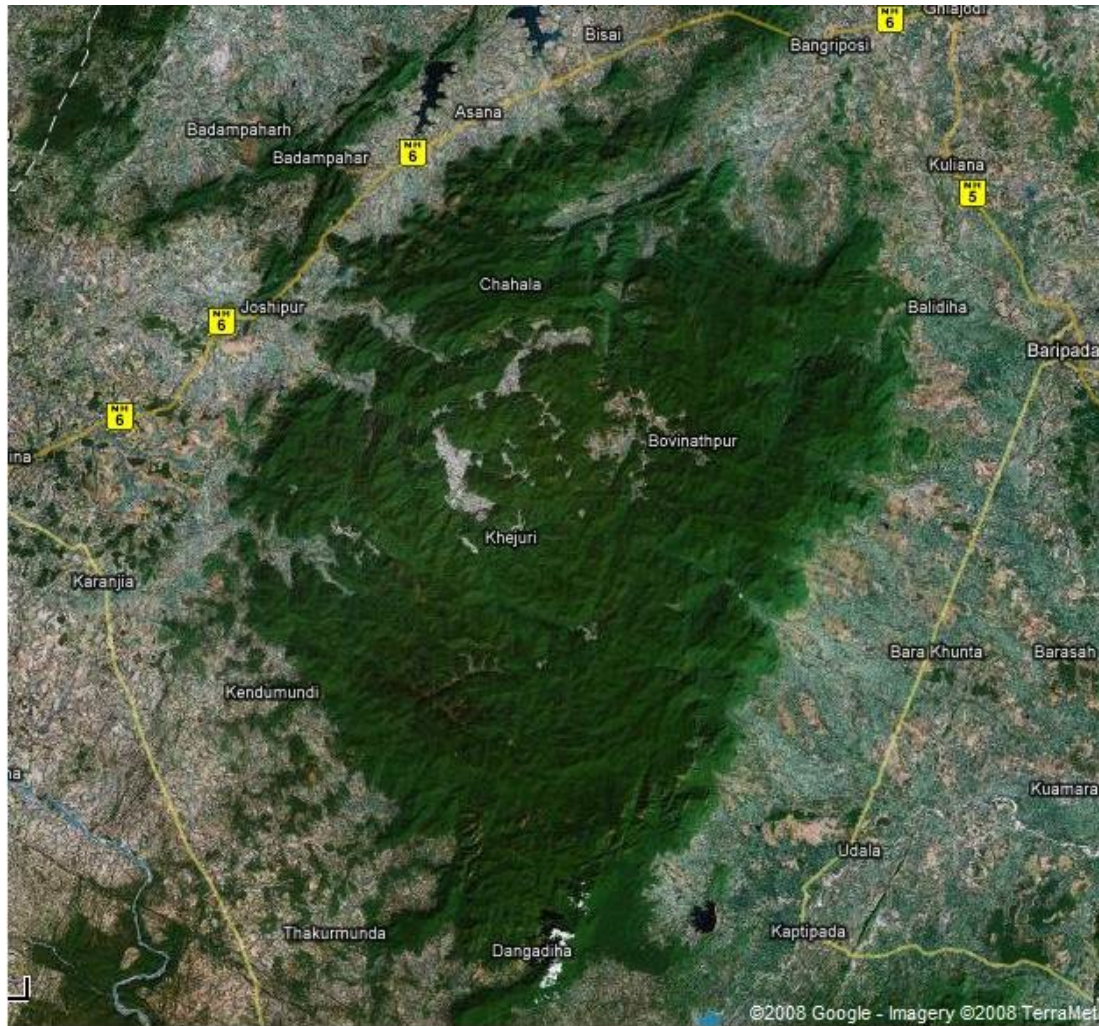
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Conserving biodiversity is about genetic variety, species, habitats and ecosystems. All are important, but it is often most appropriate, practical and effective to focus on species. With modern conservation awareness, there is a welcome and popular commitment to maintaining the diversity of species in the India. Nevertheless, over the last 50 years, we have witnessed the severe decline of many once widespread and familiar species, such as tropical Tasar silkworm *Antherea mylitta* D. Conservation is not just about avoiding extinctions, but about restoring or recovering species populations to secure levels and preventing other species from reaching such a perilous situation in the first place. Species, by their very nature, have specific ecological requirements. They may appear to share the same habitat with many others but each has a different, specific niche. It is what sets them apart, and makes them what they are. Habitat loss has historically been a factor in species decline. However, the way existing habitats are managed is also important. Restoring habitat and managing it correctly is not always enough to return species to areas from which they have been lost. India is a mega-biodiversity country, with great wealth of microbial, plant and animal species and as many as 4,00,000 of these are probably yet to be described. Unfortunately, we are thoughtlessly destroying varied species and ecosystem faster than nature can create new one. In the process, we are pushing the Earth from the state of biodiversity rich to 'biodiversity deficit'. Biological species alone are now vanishing faster than natural extinction, because of human actions like **expanding agriculture, developmental projects, human settlements, water diversions, steel plants, establishment of factories, power plants, forest fire and pollution. Now time is coming for nuclear plants.** Few years ago, Singhbhum Distt of Jharkhand alone was producing the 70 % global population of Tasar. But has the production has declined drastically because of mines and industries and ruthless destruction of forests. In addition, the earth's ecosystems are now being ripped at the rate of at least 50,000 species a year. At global level, there is realization that whatever biodiversity resources are now available in the wild should be protected. Creation of hybrid and improved varieties of species depends on their wild relative. Conservation of species cannot be done in isolation without protection of its habitat. Biodiversity conservation needs emphasis on generating employment of local people depending on forest resources. The people living in the area must be taken to believe that they are assured of their lively hood and sustenance, so that they will participate and support in conservation of biodiversity.

The Similipal forest (Map-I) in Mayurbhanj district of Orissa state, representing the totality of plants, animals (including humans), and microorganisms, as an interconnected, interrelated, and interdependent system, is notified as a Biosphere Reserve in 1994. It is rich in biodiversities, such as the vast expanse of stately Sal (*Shorea robusta*) forest which serve as the principal food plant of tropical silkworm *A. mylitta* and its ecorace Modal, which produces the heaviest cocoon

among all the sericigenous lepidopteron of world. It is a hill studded ecosystem with varied topography, soil & climate; innumerable crests & valleys, cascading waterfalls, bewildering panorama of mammoth canopy bloomed in green veils and compact block of virgin, moist-dry deciduous & semi-evergreen forests with myriads of flora



Map 1. Satellite Map of Simlipal Biosphere

and fauna of diverse genetic resources (Dey, D, *et al.*, 2010). Modal is reported as univoltine in its natural habitat, but study is required to know the facts of this wild insect, as evidences are there that Modal race is multiplying in nature round the year. It behaves bi- or tri-voltine out of its natural habitat with higher temperature and longer photoperiod. In plains of Mayurbhanj district, Modal is commercially cultivated such cultivated generation is called Bogai. Modal contributed to the major cocoon production of Mayurbhanj district of Orissa up to 1965 (Table 1. showing production of Modal). Afterwards, with the introduction of ecoraces like Daba and Sukinda, production of wild cocoons showed a sharp decline from 10.81 millions in 1980 to 0.5 million in 2003. So, it is the high time to conserve and maintain the biodiversities of Modal and to enrich its population in its natural habitat. As such, Govt. of Orissa in collaboration with the Central Silk Board, Govt. of India has launched a five-year project (2000-2005) on Modal Ecorace Conservation in Simlipal Biosphere Reserve.

Table 1 Collection position of wild Tasar Cocoons in Orissa (in million numbers).

Year	Quantity
1960	23.46
1965	18.98
1970	15.74
1975	13.00
1980	10.81
1985	9.44
1990	1.61
1995	1.4
2003	0.5
2004	0.7
2005	0.8
2006	0.7
2007	0.9
2008	0.9
2009	1.0
2010	0.8

NATURAL HABITAT OF MODAL ECORACE

The ecorace Modal is endemic to tropical forest of Simlipal Biosphere of Mayurbhanj and Keonjhar over a forest of 2750 sq. kms of which core forest area is 845.70 sq. km and buffer area is 904.30 sq. kms. It is also reported in some pockets of Dhenkanal Distt. of Orissa. The total forest in Orissa is 5.48 million h of which 0.89 million h is in the Tasar belt. The total forest area under *Shorea robusta* (SAL) is 0.77million h and under *Terminalia tomentosa* is 0.12 million h. The area under Sal (*Shorea robusta*) is commercially exploited for Tasar cocoon production and only Modal, the wild ecorace, is maintained in nature on this forest. The highest point of Simlipal Biosphere is Khairiburu and is above 1165.6 MASL. The maximum temperature touches around 42°C during summer and -3°C in winter. Average temperature fluctuates between 20.5°C and 28.3°C. Average rainfall is around 2000 mm. Modal ecorace is situated in between 21.32°N to 22.91°N Latitude and 86.35°E to 86.50°E longitude in Mayurbhanj Dist. of North Orissa with compact block of virgin, moist-dry deciduous and semi-evergreen forests in an altitude ranging up to 1182 meters above MSL.

Similipal Biosphere has a rich variety of plants. In addition to many tree species, climbers and Orchids of attractive shapes and sizes are seen. A total of 1076 sps. of plants including 87 orchids have been identified. Simlipal has a rich variety of animals. A list of 42 species of mammals, 231 species of birds and 29 species of reptiles have been prepared (Tripathy and Patro, 1997). In the middle buffer zone and peripheral zone, tribes are leaving. After becoming the forest reserve, Govt. of Orissa tried to shift the tribes and prepared rehabilitation centre but some of the NGO has lodged a case in Supreme Court in favour of Tribes against the Government of Orissa.

DEMARCATIION OF SIMLIPAL BIOSPHERE:

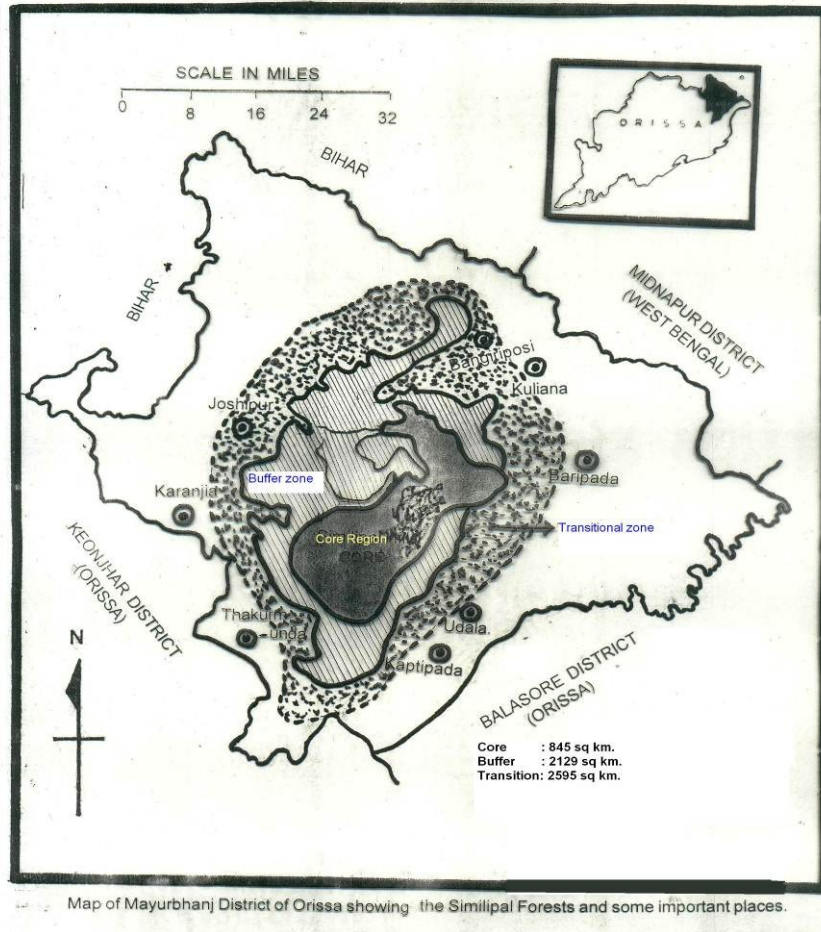
Entire Simlipal, genetic diversity as one of the factor, has been gazetted as a Biosphere Reserve in 1994. The Simlipal Biosphere Reserve is the conglomeration of a National Park, a Project Tiger and a Sanctuary and divided into three zones viz., **i) Central Core zone** (with 845.70 sq km area where no human activity is permitted and gazetted as a National Park under the provisions of wild life protection act), **ii) Middle Buffer zone** (with 1904.30 sq km of area is gazette as a Sanctuary and restricted for conservation, research, environmental education & training, tourism and recreation) and **iii) Peripheral zone** (with 77.07 sq km of area is restricted to research and can be utilised as sustainable resource (Nayak *et al*, 1998).

I. Central virgin/core zone: Comprises from Chahala in the west to Barhepani, Nawana, Nigirda, Bhajam, Lulug in east of the N-E direction as shown Map1. It is densely populated with pre-dominantly Sal population. The tribal of this area collect wild cocoons from this area and smuggle out.

II. Middle Buffer Zone is an irregular band of forest around the core zone. It shelters Guruguria and Tulsibani on the west, Talabandha and Joranda on the north, Pithabata on east and Notto and Khandabarai on south.

III Outer border/peripheral Zone is the stretch of forest encircling middle buffer zone until it turns into a plain land. On the north and north – west, it terminates with NH 6. On the west - south east, it encircles a band that starts from Jashipur, Singoda on the west, moving downwards to south Kendumundi, Kendujuani and Mohuldiha, then to Thakurmunda and moves eastward to Sarat, Kaptipada through Udalato, Mudrajodi, Bhuasuni, Shyamsundarpur and through Baincha to Bangriposi of North joining NH 5-NH 6 junction completing the circle.

SIMILIPAL BIOSPHERE RESERVE ABODE OF MODAL



BIO-DIVERSITIES OF MODAL:

Variability, in general, can be at different level. This is described in brief in the Table 2.

Table 2. Types, importance and quality distribution of variability

Level	Importance of Variability	Importance of Quantity and Distribution
Genes	adaptive variability for production and resilience to environmental change, pathogens, and so on	local resistance and resilience
Populations	different populations retain local adaptation	local provisioning and regulating services, food, fresh water
Species	the ultimate reservoir of adaptive variability, representing option values	community and ecosystem interactions are enabled through the co-occurrence of species
Ecosystems	different ecosystems deliver a diversity of roles	the quantity and quality of service delivery depend on distribution and location

Modal is a *Shorea* based ecorace of tropical Tasar silkworm *Antheraea mylitta* Drury, is exclusively wild, multiplies *sou moto* in nature, univoltine, totally disease free, produces the heaviest cocoon with highest silk content among all the sericigenous lepidopteron of world and contributes 19 % raw silk production of India. There is great variation in the genotypes of Modal in the varied ecological conditions of Similipal forest. Further, interbreeding among different ecotypes in nature over centuries has resulted high degree of heterozygosity in its natural population. Modal ecorace is characterized by fecundity eggs/laying up to 390 in number; larvae are polyphagous but prefer Sal leaves before feeding on other leaves, highly variable in morphological features, clothed with numerous setae on whole body and of varied colour patterns viz., brownish-yellow, green, leafy-green and deep-green; cocoons of large, oval, up to 7.31 cm in length, 5.38 cm in diameter and 20 cc (male) - 50 cc (female) in volume and of varying colours; peduncle of cocoon strong and stout with one ring; pupae of robust and almost spherical shape with brunt sienna body colour, cocoon shells of thick and compact type; higher shell weight (males up to 16.7 gm and females up to 21.5 gm), silk content of 2.375 kg of reeled yarn from 1000 cocoons & silk ratio percentages of 25.68; filament length of a single cocoon up to 1600 meters in length; coarse and heavier with average denier of 12; moths either brick red or brown in colour in males and polymorphic in colour viz., yellow, pink, sepia, etc., in females; moths emergence & coupling percentages of 86 & 12, respectively.

Modal exhibits different voltinism and seasonal polymorphism in an altitude gradient of 50-1000 meters above MSL characterized by varied environmental conditions. Its voltinism changes when reared out of its natural habitat and exhibits deterioration in its qualitative characters. It behaves univoltine in higher altitude (above 600 meters above MSL) with lower temperature, higher humidity, fewer hours of sunshine and shorter day length. This univoltine ecorace is the true Modal. However, it behaves bivoltine in medium altitude (600-300 meters above MSL) with medium temperature, higher humidity and medium hours of sunshine and day length. True Modal univoltine cocoons and characterized by a slender and short peduncle with one ring. Further, at lower altitude (below 300 meters above MSL) with occurrence of higher temperature & humidity and longer hours of sunshine & day length, the uni and bivoltine types behave tri-voltine. These tri-voltine cocoons are not grown in nature. The diapause cocoons of Modal are collected from their natural habitat, reared in lower elevations and this generation is known as Bogai. Rearers prefer rearing Bogai because it is totally disease resistant with lower larval mortality, higher cocoon & silk yield and guaranteed crop, and reelers prefer Bogai cocoons for its better reliability, evenness, tenacity and lustre of yarn with denier of 9. However, Bogai cocoons cannot be utilised as seed cocoons as most of them emerge during March-April. As such, Bogai cocoons are only used for commercial purpose and not for breeding. For taking up a Bogai crop, each time, the diapausing cocoons of Modal and Nalia are to be collected from nature for seed purpose.

The varying colours of Modal larvae reveal that green coloured larvae are wild and other coloured larvae are mutants. Similarly, the varying colours of cocoons exhibit black coloured cocoons with highest silk content more genetically superior than the cream coloured cocoons with comparatively lowest silk content. These differences within a population is believed to have been generated from the inter play

of selection forces and gene flow which in turn brought genetic variability in the populations.

BIODIVERSITY DETERIORATING FACTORS:

The diversified geographical, ecological and weather conditions of Similipal forest promote luxurious growth of Sal trees thereby a diverse gene pool of *Antheraea mylitta* Drury. However, in recent years, there is drastic degeneration of the natural habitat leading to the deterioration of its biodiversities, few factors are as follows:

1. Over exploitation of Modal cocoons from its natural habitat thereby reducing its natural population.

2. Collection of a greater portion of diapause cocoons by the nomadic tribal people living inside Similipal for their sustenance thus creating a gap in its genetical diversity.

3. Vulnerability of Modal to human interference as there are 63 villages in Core and Buffer zones with a total population of about 8,643 and 200 villages in Peripheral one with 65,791 populations live inside the Similipal forest.

4. Excessive deforestation to meet the manifold activities of the increasing population.

5. Transformation of denuded forest land into agricultural land or degrade forest.

6. Paucity of host plants for the existing population of Modal for breeding due to rampant deforestation of its natural habitat.

7. Human activities disrupting the evolutionary processes thereby effecting the organization of communities in the Biosphere Reserve, because changes in population density and the introduction of new species cause the extinction of other species.

8. Low population levels of other species cause the chance loss of genes important to the ongoing eco evolution of other interactions because of the intricate interdependencies among all organisms of the biosphere.

9. Specific man-made environmental problems viz., accelerated soil erosion through crop interfering, overgrazing & deforestation; the human impact on stream regimen and quality; the environmental impact of modern agricultural technologies through the increased use of fertilizers, pesticides & herbicides; the impoverishment of natural species directly or indirectly through human actions; and the environmental impact of urbanization.

CONSERVATION & MANAGEMENT OF MODAL & ITS HABITAT BIODIVERSITY:

It has been realized that conservation of biodiversity saves the future of human lives in the long run as it is not only the number and spread of the species, but the

presence of genes or characters for resistance to diseases and pathogens and a variety of environmental stresses reside in the wild species which in isolation Similipal ecosystem has taken million of years to evolve and stabilize. Once destroyed it is impossible to get these back a new. So, it is the high time to conserve and manage its biodiversities. A few conservation and management measures suggested are:

1. All types of non-forestry activities should be stopped in Core zone, as it is the Germplasm centre of different flora and fauna.
2. More numbers of forest officials/officers should be posted and they should be provided with best system of communication, ammunition and amenities for better management of the vast stretch of 2750 sq km area of the biosphere.
3. People living in Core and Buffer zones should be rehabilitated properly out side of the zones and engaged in alternative avocation for their sustenance.
4. The peripheral settlers can fend for their living by rational utilization of forest produces.
5. Artificial forests through social forestry scheme should be implemented in the available waste and denuded forestlands in the peripheral zone.
6. Intensive scientific and legal management of degraded forests, eviction of forestland already encroached upon & bringing back those lands under an effective tree cover should be taken up.
7. Due attention should be given to demarcation of fire protection lines, extensive soil conservation work to prevent soil erosion, management of water resources, regular monitoring of forest resources, more frequent updating of working plan maps & maintenance of data base by using remote sensing technology and prevention of further encroachment, overgrazing, illegal felling of trees, mining activities, hunting wild lives & cultural activities.
8. Eco development programme should be taken up for the people living within 10 km of the biosphere under the “Man and Biosphere Programme to reduce the dependence of people on biosphere for their livelihood
9. Priority should be given to conserve representative samples of ecosystem and provision of long-term conservation of genetic diversity in situ.
10. A strong political will combined with efficient administration and people’s cooperation is required for preserving the biosphere.
11. Modal rearing has to be promoted in Buffer zone for bi-directional migration of Modal population to Core and Peripheral zones.
12. Scientific approach should be initiated for continuance and enrichment of Modal as the ecorace is sensitive to human interference.
13. Impregnated female Modal moths after coupling should be released into the nature for enriching the population.

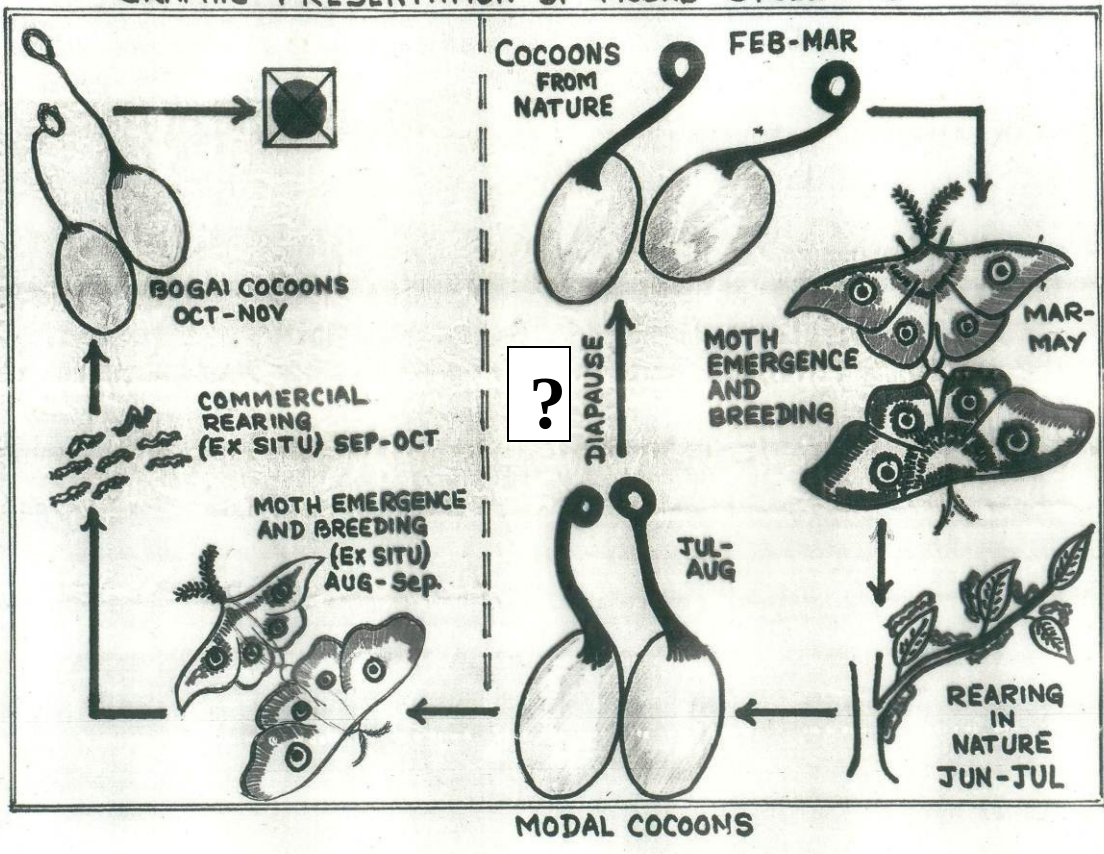
14. Over exploitation, smuggling and illegal transaction of wild cocoons should be completely checked through enforcement
15. Awareness programmes on trees from felling self-help conservation of wild Tasar, prevention of collecting, selling and smuggling of wild Tasar safe guarding the precious wealth of biosphere and generation of friendly atmosphere among tribes
16. Institutions should be involved to make a thorough study on status of biodiversity changes on socio-economic status, meteorological data, soil and water management, habitat utilization by wild animals, and distribution, ecological amplitude. physiological stress, pollination & germination compatibility and penology of threatened species.

Methodology

Conservation can be in three steps:-

1. Survey and collection of natural cocoons from the mid-buffer zone, their selection and the study of morphological characters.
2. Seed preservation:-Selected seed cocoons should be garlanded and preserved in the Pagoda. Some cocoons may be scattered among small bushes covered by mosquito nets (preferably cotton). A carpet of stitched leaves may be placed on the floor bed. Female cocoons may be kept outside the net. The male and female cocoons ratio may 1:1 but, more female cocoons give better result as there is always a chance of migration of male moths from the jungle. Even if no males come from the jungle, available male moths satisfy the need due to their polygamous nature.
3. Copulation: Copulation takes place when emerged female moths are tossed into the net. Female moths after copulation lay eggs on bushes or leaf carpet. Such eggs are gently scraped and collected and disinfected. After disinfection, the eggs are kept in bamboo tray for incubation.
4. Just before one day of hatching, eggs are clipped into food plants through leaf cups. The trees selected for clipping should be at a good distance (200mtrs) from pagoda or base camp. Each big trees should not carry more than 3 leaf cups@ 20-30 eggs per cup.
5. A distance of 2 m May be maintained between the two leaf cups. Distance between the 2 clipped trees may be around 20 m depending upon the availability of food plants. The larvae are left undisturbed to live on their own. The larvae comfortably complete their life cycle; spin cocoons, boosting up wild tasar population.
6. At least 6 base came/pagoda is required to run closer to the core area of Similipal Biosphere.

GRAPHIC PRESENTATION OF MODAL CYCLE



Demographic studies of three identified potential eco-pockets: Gudgudia, Sarat and of Similipal Biosphere

Parameters	Gudgudia (623 MSL)	Sarat (523 MSL)	Lulung (78 MSL)
Soil Type	Sandy Loam	Red Laterite	Sandy Loam
Soil Reaction	Acidic	Acidic	Acidic
Organic Carbon (%)	0.27-1.18	0.05-0.77	0.22-0.77
Phosphorus (Kg/h)	0.06-6.20	0.40-1.60	1.20-3.40
Potash (Kg/h)	220-660	120-280	43-73
Forest Type	Semi-deciduous	Semi-deciduous	Semi-deciduous
Ann. Rainfall (mm)	2220	1930	1870
Min. Temp. (°C)	5-10	6-10	5-10
Max. Temp. (°C)	30-40	30-43	32-43
Humidity	67-100	60-100	38-100

Salient Features of Modal Ecorace:

- Modal cocoons showed clear colour polymorphism
- Blackish Grey Cocoons dominate the population (80 %)
- Colour of cocoons did not show marked effect on cocoon characters
- Occurrence of Male & Female cocoons was 60:40
- Volume of the cocoons ranges between 28.5-37.0 cc in Male and 35.0-40.0 in Female
- Cocoon Weight ranges between: Male: 11.7-13.5 & Female: 16.2-17.5 g
- Shell Weight ranges between: Male: 2.8-3.2 & Female: 3.4-3.7
- Silk Ratio ranges between: 19.5-25.9 %
- No significant character diversity occurs among eco-pockets

Cocoons Characteristics collected from Sarat and Gudgudia areas

Place	Colour	Occurrence (%)	Sex	Occurrence (%)	Vol. (cc)	Coc. Lgt h. (cm)	Coc. Bdt h. (cm)	Ped. Lgt h. (cm)	Coc. Wt. (g)	Sh. Wt. (g)	SR (%)
Sarat	Grey	80	♂	62	31.00	5.16	3.38	5.20	15.57	3.45	22.158
			♀	38	39.50	5.54	3.70	5.44	17.75	3.67	20.676
	Yellow	20	♂	65	28.50	5.02	3.22	5.97	13.67	3.36	24.140
			♀	35	38.10	5.57	3.57	5.78	16.24	3.36	20.689
Gudgudia	Grey	83	♂	60	33.60	5.18	3.33	6.71	13.53	3.03	22.394
			♀	40	38.77	5.48	3.61	4.98	17.28	3.38	19.651
	Yellow	17	♂	63	33.40	5.15	3.34	5.31	13.34	2.87	21.514
			♀	37	40.85	5.50	3.53	4.17	17.36	3.38	19.470

In situ behaviour of Modal ecorace

Grainage Behaviour

Cocoons preserved	Moth Emergence %		Total Emergence	Couplings Obtained	Coupling Percentage	Dfls Recovered	Cocoon Dfl Ratio
	Male	Female					
8563	46.6	26	6211 (72.5 %)	1162	52.3	1156	7.4:1

Highlights:

- Modal grainage conducted in *in situ* conditions gives better result as compared with *ex situ* grainage
- Grainage in *ex situ* conditions showed very low rate of coupling (24 %) and was not successful
- Grainage started during march takes longer time (94 days) compared to August grainage
- Mechanical coupling was not successful

Rearing behaviour

Seasons of Rearing	Dfls Brushed	Avg. Fecundity	Hatching %	Larval Wt. (g)	No. of cocoons harvested	Cocoon:Dfl Ratio	SR %
September - October	702	248	76.9	34.290	8861	13.0	17.84
May - June	296	252	71.0	38.200	Rearing in nature (not assessable)		23.56 *

*247 cocoons were collected from area of brushing

Highlights:

- Rearing in *ex situ* condition is not successful
- *In situ* rearing during September-October produces inferior cocoons
- Natural rearing during May-June produced cocoons akin to the parent with higher SR %

Plant community Structure of eco-pockets and food plant preference

- Dominating food plant: Sal (*Shorea robusta*): (84.0 %)
- Next preferred food plant: Asan (*Terminalia tomentosa*): 19.0 %
- Insect plant Association: *S. robusta* : 97.0 %; *T. tomentosa*: 3.0 %

Conservation strategies MODAL ECORACE:

- **Seed:**
 1. Time of collection : February – March from Sal trees in natural forest after leaf fall; Long distance transportation to be avoided
 2. Area of collection : Transitional to buffer zones of Similipal Biosphere
 3. Cocoon characters : Cocoon colour – blackish grey
Cocoon stiffness – hard and tuff uniform cocoons

Cocoon size (minimum) – length: 5.0 cm;
breadth: 3.0 cm
peducle length: 4.3-6.5 cm
Peduncle ring – clear, round and thick ring:
diameter: 1.08-1.44 cm
Cocoon wt. (min.) – Female: 13.0 g; Male: 9.0 g
SR % (min.) – Female: 18.0 %; Male: 21.0 %

• **Cocoon preservation-cum-grainage:**

1. Place of preservation : In transitional to buffer zones of the biosphere
2. Grainage : Can also be done inside a grainage house, if available
3. Preservation : Hanging garland in nylon net/pagoda
4. Time of grainage : March - May
5. Oviposition : In earthen cups/nylon bags/bamboo baskets
6. Fecundity : Normally above 250 eggs per dfl (3 days oviposition)
7. Egg disinfection : No disinfection or surface sterilisation required. However to avoid fungal infection and remove muconium, light soap may be used

• **Rearing:**

1. Season of rearing : Preferably May – June; if climatic conditions are congenial, rearing can also be done in April
Rearing during August – September is not advisable due to pests, predators and diseases
2. Place of rearing : *In situ* rearing, preferably in transitional areas
3. Food Plant : Sal (*S. robusta*)
4. Method of brushing : Worm brushing on Sal trees of medium height in compact patches
5. Time of brushing : Early in morning and late in after noon
6. Method of rearing : Natural rearing with minimal of interference

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Cocoon preservation in Pagoda



Cocoon garlands in Pagoda



Coupling in Pagoda



Coupling inside Pagoda



Base Camp



Nylon net cocoon preservation



Clipping of eggs on Sal tree



Clipping of eggs on Sal tree