CHAPTER-I

INTRODUCTION

Of all things you wear, your expression is the most important.

Janet Lane
1.0 INTRODUCTION

This thesis envisages some reproductive aspects of the Indian tropical tasar silkworms *Antheraea paphia* Linn. and *Antheraea mylitta* Drury, the systematic position of which goes as follows:

- **Division** : Animal Kingdom
- **Sub-division** : Invertebrata
- **Phylum** : Arthropods
- **Class** : Insecta
- **Super class** : Pterygota (Metabola)
- **Sub-class** : Holometabola
- **Division** : Endopterygota
- **Order** : Lepidoptera
- **Sub order** : Ditrysian
- **Super family** : Bombycoidea
- **Family** : Saturniidae
- **Tribe** : Saturnini
- **Genus** : *Antheraea* Hubner
- **Species** : 1. *paphia* Linnaeus  
  2. *mylitta* Drury

1.1 SILK - *Sūmmūm bōhium* OF THE SAGA

1.1.1 Basics of the bounteous term

The term ‘silk’ triggers in the memory of a layman a fine, soft, smooth, shiny, elegant, lustrous and sophisticated fabric. For a poet it is the same adjectives for a ‘feeling’ instead of a ‘fabric’ and in this introduction chapter same feeling has been expressed at few locations for silk and silkworm.

Basically, silk is a thin, fine fibre spun by an insect commonly called the silkworm at a definite period in its life cycle to form a protective shell to skip over the unfavourable environmental conditions. The life cycle of the silkworm consists of four
stages namely egg, larva or caterpillar, pupa and the moth. The pupal stage is the dormant stage demanding protection. Thus, at the end of larval period the caterpillar spins a protective fort of silk fibre called the cocoon inside which the caterpillar now transformed into a pupa rests. At the onset of favourable conditions the pupa emerges as the adult form of silkmoth by piercing through the cocoon. The moths mate to lay eggs and thereby complete the life cycle.

Though silk spinning caterpillar is called as silkworm, Nayak et al. (1988) preferred to recommend the term 'silk insect' or 'silkmoth' as silkworm is not a 'worm' but an insect and more specifically a 'moth'. However considering the universal use of the term 'silkworm' the same is also retained in this work.

The principal varieties of silk found in India are Mulberry, Tasar, Muga and Eri. All varieties of silk other than mulberry silk are called as non-mulberry silk. A brief comment on the biodiversity among silk and sericigenous fauna is given elsewhere.

Silk is called under different names in different languages, a few important ones are stated below:

<table>
<thead>
<tr>
<th>Language</th>
<th>Term</th>
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</thead>
<tbody>
<tr>
<td>Anglo saxon</td>
<td>seole</td>
</tr>
<tr>
<td>Burmese</td>
<td>tsa</td>
</tr>
<tr>
<td>Chinese</td>
<td>tsi (silkworm)</td>
</tr>
<tr>
<td>English</td>
<td>silk</td>
</tr>
<tr>
<td>French</td>
<td>soie</td>
</tr>
<tr>
<td>German</td>
<td>seiden</td>
</tr>
<tr>
<td>Greek</td>
<td>ser</td>
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<tr>
<td>Icelandic</td>
<td>silke</td>
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<tr>
<td>Latin</td>
<td>sericum</td>
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<tr>
<td>Russian</td>
<td>sheiolk</td>
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<tr>
<td>Sanskrit</td>
<td>patta</td>
</tr>
<tr>
<td>Hindi</td>
<td>resham</td>
</tr>
<tr>
<td>Oriya (of Orissa)</td>
<td>patto or resham (mulberry silk)</td>
</tr>
<tr>
<td></td>
<td>matha (tasar silk)</td>
</tr>
</tbody>
</table>
1.1.2 Structure

The cocoon shell is formed by the silk filament extruded from a pair of silk gland of the caterpillar. The silk filament is composed of two types of proteins called fibroin (72 to 81%) and sericin (19 to 28%). Microscopic examination shows the inner fibroin as two smooth and transparent cylinders of fairly uniform thickness under the covering of sericin layer. The brins or filaments are fibrillous in structure consisting of a number of minute fibrils. The thickness of each fibril is less than one micron. The fibrils run parallel to the axis of the fibre.

The length as well as the thickness of the silk filament varies with the type of the silk as shown below. The thickness or size of the filament is measured in deniers (d) which is weight in grams of 9000 m of filament.

\[
d = \frac{\text{weight in gm of silk filament}}{\text{length of silk filament in metres}} \times 9000
\]

The denier of different types of silk filaments are given below:

<table>
<thead>
<tr>
<th>Variety</th>
<th>Filament length</th>
<th>Denier</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mulberry</td>
<td>900-1400 m</td>
<td>2 to 3</td>
</tr>
<tr>
<td>Tasar</td>
<td>800 - 1400 m</td>
<td>8 to 13</td>
</tr>
<tr>
<td>Muga</td>
<td>500 - 800 m</td>
<td>5.5</td>
</tr>
<tr>
<td>Eri</td>
<td>500 - 800 m</td>
<td>2.2 to 2.5</td>
</tr>
</tbody>
</table>

1.1.3 Properties

Silk has surpassed all the textile fibres for its exquisite properties trailed below:

i. **Elegancy**

Raw silk is shiny, soft and lustrous. It comes in several shades.
ii. **Density**

The density of raw silk is 1.33. It is not constant and varies in different types/races. About 65% of the volume of silk is solid and rest 35% vacuoles.

iii. **Specific gravity**

Raw silk has a specific gravity of 1.30 - 1.37 whereas in degummed silk it is 1.25.

iv. **Hygroscopic nature**

Silk is highly hygroscopic and readily absorbs moisture to as much as 30% of its weight. The polypeptide chains of the fibroin may hydrolize in boiling water or in steam.

v. **Tensile strength**

Silk has considerable tensile strength with a breaking load of nearly 5000 kg per cm² or as much as 3 to 5 gm per denier. It has an elongation of about 20 to 25% of its original length before breaking. Excess moisture increases the weight and elasticity of silk but decreases its breaking strength. Tenacity varies in different varieties of silk and also in different layers of the same cocoon. Degummed bave has greater tenacity than raw bave.

vi. **Scroop**

The sibilant rustle of silk fabric is due to this property. Silk fibre when squeezed or pressed emit a crackling sound. This is however an acquired property and not an inherent one.

vii. **Photosensitivity**

Denaturation of sericin is observed in cocoons exposed to sunlight for a long period which impairs reelability and tensile strength.

viii. **Effect of ultraviolet light**

Silk fabrics are readily damaged by sun light. Silk tends to weaken by ultraviolet light. Six hours of exposure to ultraviolet light makes silk loss as much as 50% of its strength.
ix. **Thermosensitivity**
Silk cannot withstand high temperatures. It disintegrates at above 170°C.

x. **Electrical property**
Silk is a poor conductor of electricity and a good insulator for which it is used in electric apparatus and atomic appliances.

xi. **Sensitivity to water**
Water decreases the strength of silk to about 20% but the same is regained upon drying. The fibre swells but does not dissolve when steeped in warm water.

xii. **Sensitivity to acids**
Though moderately resistant to organic acids, the polypeptide chain of the silk fibre breaks down in the presence of strong acids. Dilute inorganic acids have no action on silk fibre. Concentrated acids like sulphuric acid makes the fibre contract in length and hence used in creping of silk fabric. But prolonged treatment makes the fibre brittle.

xiii. **Reaction to alkalis**
Silk is immune to dilute alkalis. However the lustre of the fibre is somewhat dulled. Silk dissolves in strong hot alkalis.

xiv. **Response to metallic salts**
Silk is treated with stannic chloride for the process of silk weighting to improve draping properties of the fabric.

xv. **Action of oxidizing agents**
Oxidizing agents react destructively with the silk fibre.

xvi. **Sensitivity to dye stuffs**
Silk absorbs both basic and acid dyes at a low temperature readily due to its greater affinity for dye than any other textile fibre.

1.1.4 **Importance**
Silk appears to elude time since ages unaffected retaining its glory, admiration and importance. It has been highly valued through aeons. It is sacred, royal,
The Hindus of India wear silk fabrics during worship, matrimony and other sacred festive occasions. Throughout the globe it is regarded as an expensive, sophisticated delicate and proud possession. In the past it served the clothing of Kings and Monarchs. The real importance of silk in the present context lies in its multifarious use in the modern civilization.

The most common use of silk is in the textiles industry. It is woven into expensive fabrics for dress materials, rugs, tapestries, flags, furnishings, accessories, hankys, socks, under garments and home decorations. It is used in tennis rackets, fly fishing lines, parachutes, tyres for racing cycles, operation sutures, electric and atomic appliances (Hyde, 1984), rattles, necklaces, purses and artifacts (Peigler, 1993), milling and chemical industry, telephone and wireless receivers, type writer ribbons, musical instruments, gifts, fashion soaps, lipsticks, skin care, toiletries, drinks, health tonic, medicine, sun care, breads and biscuits, biocontrol etc. (Nayak, 1996). Indeed its multifarious use is a revolution in itself.

1.1.5 Sericulture

The term sericulture probably has originated from the Greek words Ser and kultur meaning 'silk' and 'cultivation' respectively. Thus, briefly stating the word sericulture denotes to cultivation of silk. But silk cannot be cultivated as such and is prepared by the caterpillar in the form of a cocoon as already stated. Hence basically, sericulture is the art and science of cultivation or rearing of silkworm to obtain silk. Broadly speaking, sericulture involves all aspects leading to the production of silk. This includes preparation of eggs, rearing of caterpillar till they spin cocoons, production of yarn from the cocoons and its subsequent utilization etc. With the advancement of science and technology in this field, sericulture covered more and more directions hitherto unnoticed. This includes multidimensional basic as well as applied research on silkworm and sericulture.

1.2 ORIGIN OF THE TEXTILE-QUEEN

Silk with its subtle charm fascinating mankind since time immemorial. The swift stream of time swept the human civilization from caves to sky-scrapers.
Empires, dynasty and kingdoms burst and mingled into nothingness like water bubbles in its infinite march. But amazingly since its origin silk has retained its glaze and glory.

The origin of silk remains obscure and remains to be traced authentically. The presently available scientific knowledge is insufficient to scale the bottom of the past life of silk. Indian scholars believe that sericulture was practised in the foot hills of sub-Himalayas and that, the culture of silk originated somewhere in the areas flanking the great Indian rivers Ganga and Brahmaputra. The Aryans discovered the silkworm in sub-Himalayan region and Semetics in Western Himalayas beyond Kashmir (Mukherjee, 1919). Thus sericulture is as old as the Indian ancient culture. References of silk has been traced in Vedas - the most revered holy scriptures of the Hindus and the oldest known literature of human civilization. References were also made in the famous Indian epics, Ramayan and Mahabharat (Nanavaty, 1963). In Mahabharat silk is mentioned as the great luxury item brought in the court of Pandavas after conquest of the world (Van Buttern, 1975). The exact time when the events depicted in Ramayan and Mahabharat took place could not be traced till date. It is roughly estimated to be 8000BC and 4500BC respectively. But it might have occurred much earlier to that. Dwellings of Lord Ram of the epic Ramayan (viz. Dandakaranya, Dhanushkoti etc.) and Pandavas of the epic Mahabharat (viz. Mahendragiri, Mahabalipuram etc.) during their exile are at present worshipped as temples. Radioactive dating may help in finding the exact date of these dwellings and consequently the exact date the events occurred.

Buddhist literature reveals use of silk lace by women folk in dressing their hairs. In Brahmo Jala Sutra detail mention was there about Sikha bandhanam i.e. hair dressing. Here different styles of hair dressing were described. One among these is Bandhan which prescribes tying of the dense, long hairs with a silk lace. Thus it is evident that silk was used in India during the period of Lord Budha.

Though in the old Testament Ezekiel spoke of silk, Western historians believe China as the place of origin of silk. The bank of river Hwango Ho in Shantung province was mentioned as the place of origin of silk by Confucius.
In China there is a beautiful legend which goes like this. Long ago the then emperor of China married to a fourteen years young girl named Xi-ling-tsi. But the empress always remain depressed. The emperor got very much worried after all efforts by the court physicians were exhausted. One evening when the queen was sitting silently under the shade of a mulberry tree in the royal garden, a glistening white object fell from the tree into the hot tea pot near her. Curiously the princess took out the object which was nothing but a silk cocoon. Due to the dip in the hot tea the cocoon softened and the empress could unwind the fine, shining silk fibre. So dearly fascinated by its texture she wondered how a fabric from such a sleek thread would look like. This laid the foundation stone of sericulture in China. Devoted and dedicated to this work the queen forgot her depression and recovered totally. The thrilled emperor extended full patronage to the cultivation of silk due to which his sweetheart was completely cured. Till date the Chinese worship Xi-ling-tsi as the "Goddess of silk". In China silkworm is called as ‘tsi’. The event is estimated to have occurred around 2640 BC.

Mulate (1994) presented the myth of origin of silk in China and India which stand in confirmation of the above narrations. Though the western historian believe that silk was brought to India from China through the famous "Silk Road" via Khotan in 140 BC, Charseley (1982) in his book "Culture and Sericulture" contended that wild silks (viz. Tasar, Muga and Eri) are produced in India for a long time and these wild silks are certainly indigenous to India as there was no 'specific' mention ever made in Indian epics of mulberry silk. Thus the discussions definitely points out that India cultivated some kind of wild silk independent of China from ancient times (Nanavaty, 1965).

1.3 HISTORY OF THE "SLEEK señorita"

The oldest silk items were found in China. In the Hanzhou palacial and historical museum, silk items estimated to be 4500 years old are displayed (Hyde, 1984). Anthropological excavation of the Chou Tomb of Warring States and near Jiangling North of river Yangtze in Hubei province, China in 1982 uncovered skeletons holding rolls, preserved silk quilts and gowns which are calculated to be 2300 years old. Records speak that around that time sericulture in China was guarded as a secret and
anyone who violated the secrecy was doomed to death by torture. The chronicles of Chou-King (2200 BC) carries the earliest authentic record of silk (Nanavaty, 1965). Some scholars believe that the silk industry originated in the province of Chan-Tong. However the secrets of sericulture later seeped to other countries.

Around 1200 BC some Chinese immigrants started sericulture in Korea. During 300 BC empress Singu-Kongo conquered Korea and spread sericulture in Japan. It is only in the later part of nineteenth century Japan gave serious attention to develop her own sericulture. The silk treasure had helped in renaissance of war devastated Japanese economy during the post-war period.

Marco Polo brought silk from China to Venice travelling through the famous silk-road. By thirteenth century Italy was the silk centre of the west. From Italy the silk secret migrated to France where it got a boost in 1480 AD. French revolution almost destroyed the silk industry which is rejuvenated only recently.

In western literature, works of Aristotle (384-322 BC) carries the first mention of silkworm. In England and America sericulture was introduced in 1685 and 1522 AD respectively, but could not sustain.

Mulberry sericulture was believed to be brought to Khotan in Tibet clandestinely by a Chinese princess who got married to the king of Khotan. From Tibet the silk industry slipped to India and Persia. As already stated a portion of the 6000 miles long silk road was the only important connection between China and India for trade of silk. This road originatec from Xian now in Shaanxi province of China and bifurcated, one towards west to Mediterranean countries and the other southwards to India. The traders had to pass through a perilous and uncertain journey. Silk road began to decline in the seventeenth century when sea trade developed and the sea route proved to be safer than the risky journey by road.

India had a trade of silk with China in the Mauryan period during fourth to second century BC (Basham, 1961). During the reign of king Kanishka (56 BC) there was a flourishing trade of Indian silk with Rome and Greece.
By the fourth century AD sericulture was well established in India. In the court of king Harsha (606-648 AD) silk was highly admired. During medieval period sericulture was widely practised in India though foreign invasions interrupted the progress at times. The industry had a prosperous time during the Moghuls particularly during the reign of the famous Moghul king "Akbar the Great" who admired silk fabrics. Tipu Sultan developed sericulture in Mysore State in 1785 AD. Late nineteenth century witnessed dwindling of silk industry in India. The chief reasons were spread of diseases, decline in export to the buyer countries and stiff competition from China and Japan in the International market. The situation became so worse that India had to import silk to meet her own requirement. The silk industry revived for a short period during World War-I. It is during World War II when the boost got an important momentum, but due to entry of synthetic fibres like rayon the silk industry again shrunk.

In 1949 Central Silk Board was established on recommendations by the Silk Development Directorate (1945). Planned development of the industry was taken up. During the first three decades the development was slow yet steady. But remarkable progress was noticed after 1970 and India became the second largest silk producer in the world after China. This became possible due to systematic planning, co-ordination, funding and import of technical know-how from countries advanced in the field of sericulture.

1.4 STATUS OF THE “SHY signorina "

1.4.1 Geographical

A sericultural belt runs parallel to the tropic of Cancer. The temperate sericulture zone extends up to 50°N whereas the tropical zone stretches to 10°S latitude.

Most of the mulberry growing countries lie north of the equator except Brazil which lies on south of the equator (14° to 23°S). Countries with lower range of latitude i.e. 5° N-28°N such as India (except northern region), Sri Lanka, Brazil, Egypt, Thailand, South Vietnam, Indonesia and Myanmar came under low income group whereas countries which lie in the belt of high range of latitude i.e. 28°N to 55° N fall under high income group.
1.4.2 Industrial

At present over twenty-five countries produce silk in the world. Some of these are novice in the field and whereas some others practise this as an age old tradition. Demand for silk is fast increasing especially by developed countries. The rise in production as well as in the number of countries involved in it spells a bright future for the silk industry.

It is amazing to note that there has always been a shifting and transfer among the list of silk producing countries with respect to their position in silk production. The position of Japan and Korea in the past and at the present can be taken as an example. The silk industry in a country appear to dwindle once it reaches the top probably due to greater emphasis on industrialization by the country concerned. Sericulture seems to be an idle occupation for the developing countries. Sericulture contributes to the economy of the said countries making them developed. Once a country gets developed it would look after lucrative industries which would fetch her more riches wilting her silk resources due to the abandonment.

Sericulture can play a vital role in the economic upliftment of Third World Nations for the lucrative foreign exchange earnings. In comparison to other industries it needs a meagre investment while providing an assured income. A levelling of the per capita income is brought about by sericulture as generally the money flows from the rich buyers of silk goods to the poor silk growers. Engagement of idle family labour in sericulture helps alleviate poverty enhancing employment opportunities in densely populated poor countries. Sericulture being practised as a cottage industry checks urban migration balancing the population structure.

In India among cottage and village industries sericulture is the largest employer after handlooms. Considering that a large number of handloom weavers are engaged specifically in the weaving of silk fabrics, the overall employment in sericulture and silk industry becomes highest. Besides the end-products like the fabrics, the by-products of sericulture i.e. twigs, silkworm litter, pupae, rejected cocoons, yarn waste etc. are useful and provide income.
Sericulture in India is making great strides due to the strategic planning and implementation by the Government. India is at rank one in production of tropical tasar and muga silk in the world. It occupies second position in the production of temperate tasar and mulberry silk.

About ninety percent of the domestic market in India is saree viz. a seven metres long and one metre wide fabric preferred by Indian women. The rest ten percent constitute other garments. A steady growth in the exports of Indian silk goods has been recorded with a growth rate of over twenty-five percent per annum. Now Indian silk fabrics are known worldwide for their fine quality and cultural value with their unique fascinating handloom designs.

1.5 DIVERSITY AMONG THE DEXTROUS FAUNA

The world of natural silk comprises of mulberry, non-mulberry and other animal silks. Non-mulberry silk is universally known as forest silk or wild silk. It includes Tropical tasar, Temperate tasar, Eri, Muga, Anaphe, Fagara, Coan and other uncultivated silk species. Other animal silks are non-insect silks such as Mussel silk and Spider silk (Fig. 1.1). A brief description on the various types of natural silk is given below.

1.5.1 Mulberry silk

The mulberry silk represents the silk produced by the silkworm *Bombyx mori* Linn. The silkworm feeds exclusively on leaves of mulberry plant *Morus* sps. This silkworm is domesticated and reared indoors. Mulberry silk is the finest silk and constitutes about ninety percent of the total silk production in the world.

1.5.2 Non-mulberry silk

The non-mulberry silk is also called as 'Wild Silk' or 'Forest Silk' probably due to the outdoor rearing/occurrence of the silkworm in wild conditions of the forest. About five hundred sps. have been found involved in the production of non-mulberry silks, but only about eighty have been commercially exploited in Asia and Africa by the native tribals. The major varieties of non-mulberry silks are described below.
1.5.2.1 Tasar silk

Tasar is the chief non-mulberry silk variety. About ninety-five percent of the global production of non-mulberry silk is tasar.

The tasar (Tussor, Tusser, Tassar, Tussah or Tusah) silk is of two types- temperate and tropical. Out of the thirty-eight species of tasar silkworms the temperate tasar includes seven species namely *Antheraea roylei* Moore, *A. Pernyi* Guerin-Menville, *A. yamamai* Guerin - Menville, *A. polyphemus* Cramer, *A. goadmani* Druce, *A. montezuma* Salle and *A. hart* Moore. The specieswise distribution is India, S.China, Japan, United States, and N.China respectively. Temperate tasar is also called as Oak tasar as these species of silkworm feed exclusively on oak plants belonging to genus *Quercus* Linn.

Details of tropical tasar is described at length separately, as this thesis involves study of tropical tasar silkworm species.

1.5.2.2 Muga silk

The word ‘muga’ is derived from an ancient sanskrit word meaning ‘amber’ probably due to the colour of the silk. The silk is produced by the silkworm *Antheraea assamensis* Westwood restricted to the river valley of Brahmaputra in the state of Assam, India. The silkworms are reared outdoors on trees of *Machilus bombycina* King and *Litsaea polyantha* Juss. Muga silk is so highly valued that apart from its role in fabric production it is even substituted for gold in filigree works.

1.5.2.3 Eri silk

The eri (Endi, Aandi or Eranda) silk is produced by the species *Samia ricini* Boisduval (or *Philosamia ricini* B.) - the only fully domesticated non-mulberry silkworm. The wild form is *Samia cynthia* D. which have sixteen variants feeding principally on the leaves of *Ricinus communis* Linn. The eri silkworm is ubiquitous in distribution. Members of the genus are found in the palaeartic and Indo-Australian biogeographic regions. In India production of this lustrous and durable silk is restricted to several eastern states.
1.5.2.4 Anaphe silk

In the southern and central Africa the natives practise the cultivation of anaphe silk as a traditional craft. The important species which produce this silk are *A. infracta* Walsingham, *A. venata* Butler, *A. panda* Boisduval, *A. reticulata* Walker, *A. carteri* Walsingham, *A. moloneyi* Druce and *A. ambrizia* Butler feeding on food plants of genus *Sterculia, Zizyphus* etc. As a departure from the general pattern of formation of silk cocoons, these silkworms form the cocoons in community i.e. dozens of silkworms collectively spin a large nest like structure ensheathed by a thin layer of silk. The natives collect them from the forest and spin the fluff into raw silk which is used for light clothing material and for embroidery work with highly religious and cultural value.

1.5.2.5 Fagara silk

The caterpillar of g ant silk moth *Attacus atlas* Linn. and a few other related species viz. *A. crameri* Fldr., *A. standingeri* Roth., *A. edwardsi* While, *A. dohertyi* Roth. etc. inhabiting Indo-Australian biogeographic region, China and Sudan (Jolly et al., 1979) spin light brown cocoons from which fagara silk is obtained.

1.5.2.6 Coan silk

In ancient times coan silk was used in the manufacture of dresses for nobles of Rome. The silk is produced by the silkworms *Pachypasa otus* Drury and *Pachypasa lineosa* Vill. found in several Mediterranean countries. Important food plants of the silkworm belong to genus *Quercus, Cypressus* and *Juniperus*. Commercial exploitation of coan silk has long been abandoned.

1.5.2.7 Potential wild silk

Unlike the varieties discussed above there are several non-mulberry species which are not cultivated commercially and are found potentially in the wild form. Such wild forms are divided into four categories depending upon the country they inhabit viz. American, African, Chinese and Indian.

The American potential silk includes silkworms *Gloveria psidi* Salle, *Eucheria socialis* Westwood, *Malacosoma* sps., *Hyalophora* sps. etc. *Gonometapostica*
Walker and *G. ruforbrunea* Aurivillius are two important species producing African potential wild silk. A few species belonging to genus *Borocera, Argema, Antistathmoptera, Gonimbrasia, Athletes Bunaopsis, Imbrasia* and *Bunaea* also produce wild silk. These species are endangered due to over exploitation by the local communities as a food and thus included in a conservation programme (Raina, 1994). The Chinese potential silk includes silk produced by *Saturnia boisduvali* Eversman, *Rhodinia fugax* Butler and *Saturnia (= Eriogyna) pyretoorum* Westwood. Silkworms of genus *Actias, Rhodnia, Cricula, Caligula, Rinaca, Saturnia* and *Salassa* produce the Indian potential wild silk.

Most of the potential wild silkmoths are yet to be explored and needs detailed investigation.

1.5.3 Other animal silk

Some non-insect animals also produce silk *e.g.* the bivalve mussel belonging to Mollusca and the spider of Arachnida.

1.5.3.1 Mussel silk

The bivalve mollusc *Pinna squamosa* produce a strong filament for anchorage of its shell in the shallow waters of the seashore. This Mediterranean mussel is found along Italian and Dalmatian shores of Adriatic sea. Processing of the silk is restricted to Toronto and Italy (Jolly *et al.*, 1979).

1.5.3.2 Spider silk

The commercial production of the fine, soft yet strong and elastic spider silk comes from certain Madagascan species including *Nephila madagascarensis, Miranda aurentia* and *Epeira*. Though the spider silk is not used in textiles industry, its durability and resistance to extremes of temperature, humidity and oxidation make its use indispensable in making cross lines in various optical instruments to mark optical centre. The lines last long and often last for more than the life of the instruments themselves (Jolly *et al.*, 1979). In New Guinea webs of other species of *Nephila* were used to make fishing nets (Peigler, 1993).
1.6 TROPICAL TASAR SILK - THE "RAW BIO-GOLD"

The tasar silk occupies the supreme position among all varieties of silk next to mulberry. It even has some advantages which shall be discussed elaborately. Besides, it is important to discuss details of distribution, history, status etc. with special reference to the State of Orissa - a south eastern State of India, since the study site of this research is located in Mayurbhanj district of Orissa (Fig.1.4).

Orissa is known for the world famous pilgrim centre Puri - the holy abode of the Hindu deity Lord Jagannath. The famous car-festival which is organised here once a year has spread far and wide and celebrated with much fanfare even in big cities of the West like Los Angles, California, New York, San Francisco etc.

The State of Orissa face the sea 'Bay of Bengal' on its east. It is locked on its other three sides by the States of West Bengal, Bihar, Madhya Pradesh and Andhra Pradesh. Orissa is situated between 82°41' to 87°11' East longitude and 18°21' to 22°34' North latitude with tropical climatic conditions. The State receives its rain fall from South-East monsoon during June - September every year. The state has a vast forest wealth except the coastal plains.

1.6.1 Distribution

The tropical tasar fauna is distributed in the Indo-Australian biogeographic region and in the palaearctic region (Fig.1.2). The specieswise distribution is shown in Table 1.1.

In India a distinct belt of dense humid tropical forest between 16°- 24° latitude and 80°-88° longitude sprawling over the central and southern plateau is the homeland of tropical tasar. Indian districts with vast occurrence of tropical tasar are Singhbhum, Hazaribagh, Dhanbad, Palamu and Santal Paragana in Bihar State; Bastar, Bilaspur, Raigarh, Sarguja and Jagdalpur in Madhya Pradesh; Mayurbhanj, Keonjihar, Sundargarh and Sambalpur in Orissa; Purulia and Bankura in West Bengal; Bhandara in Maharashtra; Adilabad and Warangal in Andhra Pradesh; and Belgaon in the State of Karnataka (Fig.1.3). In addition tropical tasar is also found in a few other States along with Andaman and Nicobar islands of the country where commercial exploitation is wanting.
In Orissa in addition to the districts already stated tasar culture also exist in the district of Cuttack, Dhenkanal, Koraput, Ganjam, Bolangir and Phulbani or Boudh-Khondmal (Fig.1.4).

1.6.2 Origin and History

The word 'tasar' seems to have originated from the sanskrit word trasara (shuttle). The origin of tasar remains obscure and is believed to have taken place aeons ago in India. Considering the mention of silk fabrics in the age-old scriptures and assuming that the domestication of mulberry silkworm as not possible at that time, it is presumed that wild silk preferably tasar silk was produced long ago and silk fabrics were adorned by the legendary characters of ancient India.

In Orissa evidences from archaeological studies including lithographic recordings, palm leaf inscriptions (Shi, 1908), remnants of ancient structures etc. along with the culture, tradition and festivals observed by the present inhabitants recalling the glorious past vindicates the fact that Orissa had a fabulous wild silk trade long ago (Parischa, 1995).

In the literature of Orissa, there were ample mention about the Sadhabsi.e. a community of sailor cum traders of the coastal plains who in ancient and medieval period dared to sail overseas for trade. The sadhabsi were famous for their courage in facing the rashful sea with their indigenous ships. Tasar fabrics especially tasar sarees occupied an important position among the trade items. Mention is also there about the importance and preference people of the buyer country (at present South East Asian countries) gave to the tasar silk items of Orissa. Resurrecting the buried past people of Orissa celebrate a festival called 'Boita bandano' meaning 'ship-worship', on the full moon day of kartik month (i.e. November as per English calendar). In the dawn hours of the day, worship of ships is symbolised by carrying small model ships made of white cork, colour papers or pieces of bark of banana plant along with beetle leaves, beetle nuts, fruits, flowers, turmeric, vermilion and sandal paste, incense sticks, ghee lit lamp, camphor etc.
The activities of sadhabs came to a standstill due to several reasons. The major ones are natural calamities, weakness in administration, sea pirates, competition with foreign traders, coastal erosion etc. (Behera, 1994).

1.6.3 Past and present status of management of tasar culture

The tradition of tasar cultivation is a time honoured skill of the hill folk and aboriginals of the country like Ho, Oran, Santhal, Munda, Khadia, Budha, Telege, Koya who have been rearing tasar for centuries.

In India records on organisation of tasar culture in the past with respect to States other than Orissa is almost lacking. In Orissa tasar culture was first organized by the princely state of Mayurbhanj. Adi Bhanj (640 AD), the first ruler of Mayurbhanj patronized tasar culture in the vicinity of the State capital Khiching. Through out Bhanj dynasty (640 - 1947 AD) tasar culture received royal patronage. Tasar culture reached its peak during the reign of Krishna Bhanj (1630 - 1660 AD) and Trivikram Bhanj (1660 - 1680 AD). The glory of tasar fabrics of Mayurbhanj spread all over India and abroad (Pande, 1944). Basing on the reports of Clavel (1676) on the prospects of tasar trade, East India Company (1630 - 1930 AD) signed an agreement to establish monopoly over the trade. Due to its negative and restrictive trade practices tasar culture declined slowly and almost decayed in the early decade of twentieth century. Pratap Chandra Bhanj (1920) the then ruler tried to revive tasar culture by making a survey and taking many developmental and administrative steps (Pande, 1944). In 1930, credit cooperative societies were organised to render financial assistance to the poor and needy rearer offering them a reasonable price for the tasar cocoons. A central tasar depot was established. Due to these developmental efforts annual turnover of tasar trade was increased three and half folds within five years (Pande, 1944). The cocoon market dissolved during World War-II. The post-war period saw a gain in the momentum in tasar trade with penetration of middlemen called Mahajans exploiting the illiterate tasar rearers. This subsequently led to a pathetic situation during the post independence period.

During the second Five Year Plan (1956-57 to 1960-61) tasar rearers co-operative societies were organised in the districts of Mayurbhanj and Keonjhar by the
Government of Orissa. In 1962 State Tasar and Silk Co-operative Society Ltd., came into being which gained monopoly over tasar cocoon trade in Orissa. Though the Central Silk Board was setup in 1949, it was basically looking after the mulberry sericulture. To improve tasar culture in the country, Central Tasar Research and Training Institute (CTR&TI) was set up in Ranchi in the state of Bihar by the Government of India. To overcome various problems and to make tasar culture economically viable the CTR&TI is carrying out research on propagation and plantation of tasar food plants, improvement of silkworm strains, seed organisation and seed production, improvement of rearing condition, reeling of tasar silk etc. Since the progress on the desired lines is checked by various hurdles CTR&TI is highlighting on issues like concept of chawki rearing, block plantation, concept of seed farmers, seed grainage, introduction of three crops for increased productivity, exploitation of hybrid vigour etc. The production of tropical tasar silk in the country has gone up to 6.5 metric tonnes at present from 1.2 metric tonnes in 1950. The growth rate is not at all satisfactory when compared to the mulberry sector. The tasar rearers of the country are presently utilizing only five percent of the existing food plants. Steps are on for systematic utilization of the rich forest wealth.

1.6.4 Importance

Tasar culture is an agro-based industry of immense economic importance particularly for social development in a developing country like India. It offers all those benefits discussed at 1.4.2. In addition, it also has some unique advantages as described below.

Tasar culture holds great promise for forestry as a supplementary activity. On one hand it can help arrest forest destruction and on the other hand it permits conservation and gainful utilization of this vast natural wealth which is dwindling at an alarming rate. Due to conservation of forests, soil erosion, drought, floods and untimely rain can be checked. Thus tasar culture helps the nature in ecological balancing.

Tasar silk is chiefly used in the production of garments. Indian tasar fabrics are sold in over twenty countries including United States, Canada, Germany,
France, Sweden etc. The famous fashion columnist, Evelyn Livingstone of Chicago Tribune paid high tributes to tasar as a textile marvel. It can be rightly said that tasar fabrics occupied a safe niche in the textile ecosystem.

Certain aborigins use tasar silkworm as food. The pupa is used as medicine and aphrodisiac by tribals. The by-products of tasar culture are equally important as of those stated at 1.4.2.

1.6.5 Diversity

The tropical tasar includes thirty species of the genus *Antheraea* as shown in Table 1.1 alongwith their place of occurrence. This exclude the eight *Antheraea* species already discussed, seven under temperate tasar silk and one as Muga silk. The species of *Antheraea* are so similar that they are constantly mistaken for one another. Out of all the species and nearly forty forms/variants/aberrants/races many are yet to be assessed for their commercial value. For the development of tasar industry Australian and Asian continents deserve concentrated attention.

Out of the thirty tropical tasar species *A. paphia* and *A. mylitta* are cultivated largely in India due to their economic value. *A. paphia* is extremely variable insect and is quite common. It is distributed from India and Sri Lanka to S. China. Due to variation of colour this species has been assigned such a great number of names that it is very difficult to separate the forms. Many authors even connect *A. paphia* with *A. mylitta*.

*A. mylitta* is widely distributed in India. Though typical *mylitta* occurs only on the Asiatic continent it is represented in islands by a great number of very similar forms, many of which were treated as distinct species, though they are merely local races. *A. mylitta* was bred in Europe during the beginning of nineteenth century. The cocoons of *A. paphia* and *A. mylitta* imported to Europe often yielded series of such aberrations and transitions that the value of the forms and justification of the names were rather doubtful (Jolly *et al.*, 1974).

Considering the controversy it is necessary to give a detailed comment on the issue.
Linnaeus (1758) was the first to designate tasar silkworm as *Phalena bombyx paphia*. Hübner erected *Antheraea* to include *paphia* of Linnaeus. Cotes and Swinhoe (1889) stated that a large number of synonyms exist for *A. paphia*. Blanch named the tasar species as *Attacus mylitta* whereas Febr. and Oliv. called it *Bombyx mylitta*. It was named as *Phaloena paphia* by Cramer and Roxburg, and as *Saturnia mylitta* by Westwood whereas Helfer named it as *Saturnia paphia*. Schüssler (1933) divided *A. paphia* into three subspecies viz. *A. paphia paphia* Linn., *A. paphia mylitta* Drury, *A. paphia cingalesa* Moore. According to Croth (1956) *A. paphia* is extremely difficult to distinguish from *A. mylitta* and further stated that the two species had been inextricably mixed due to intangible breeding in nature for centuries. Seitz (1933) refers that *A. paphia* is an extremely variable insect. According to him the post median line in *paphia* moths exhibit a clear outside white and inside red line. Arora and Gupta (1974, 1979) stated that since *A. mylitta* is only a semidomesticated race, it is not distinguishable as a geographic race from *A. paphia* though they exhibit a great degree of variation in colour and further suggested that *A. paphia* Linn. should not be further differentiated into hitherto known subspecies. *A. mylitta* has been given the status of a species though it resembles morphologically with the wild species *A. paphia* to a large extent. But due to wide variation in habit, habitat, colour and most important of all in economic traits, it is preferred to retain the name *A. mylitta* Drury to the cultivated species (Jolly et al., 1974, 1979; Jolly, 1985) and *A. paphia* Linn. to the wild species (Panda, 1962, 1972; Rath, 1989; Nayak, 1994). The Common Wealth Institute of Entomology, London has also identified the wild tropical tasar species as *A. paphia* Linn.

Occurrence of large number of ecoraces of the tasar fauna in India has been reported (Nanavaty, 1965; Jolly, 1967, 1968; Jolly et al., 1968, 1974; Choudhury 1969; Krishnamurti and Chadha, 1972). Twentyfour ecoraces of *A. mylitta* has been identified by Jolly et al. (1979) with wide variation in ecological and economic traits.

In Orissa, Jolly et al. (1974) identified five ecoraces of *A. mylitta* viz. Sukinda, Daba, Bogai, Nalia and Modal. Panda (1972) and Rath (1991) identified two ecoraces of *A. paphia* namely Nalia and Modal. Alam (1991) identified six ecoraces of *A. mylitta* named Modal, Nalia, Bogai, Omarkote, Boudh and Sukinda. Thus it seems
that the position of ecoraces in the State of Orissa is mingled up, confusing and overlapping. Nayak (1994) deciphered that Modal, Nalia and Bogai ecoraces belong to \textit{A. paphia} whereas Sukinda and Daba ecoraces belong to \textit{A. mylitta}.

1.6.6 Life cycle

The life history of \textit{A. paphia} and \textit{A. mylitta} resemble each other closely. A generalized description of the life cycle is given below with specific mention of differences if any between them at any particular point.

The life cycle constitutes of four stages viz. egg, larva, pupa and adult (Fig.1.5). Variation is noticed in the period of completion of these stages. The life cycle may be completed within 30 to 60 days depending upon the ecorace and season of rearing (Panda, 1959; Jolly et al., 1979).

Eggs are laid in clusters by adult female moths after mating with the male. The eggs are brownish and oval, each measuring about 3 x 2.5 mm and weighing about 10 mg. The eggs of \textit{paphia} moths are whiter and heavier. Number of eggs per moth \textit{i.e.} fecundity is about two hundred in \textit{A. mylitta} and as much as three hundred fifty in \textit{A. paphia} (Dash and Nayak, 1990a). After about one week of the day of oviposition \textit{i.e.} laying of eggs, the eggs hatch. Minute larva sneeks out of the egg shell (Plate 1.1). The larva is dull brownish yellow in colour measuring about 7 x 1 mm in size and weighing 8 mg. The larval stage is the only feeding stage in the life cycle. The larva is polyphagous and feeds on a variety of food plants. The three primary food plants being \textit{Shorea robusta}, \textit{Terminalia alata} (= tomentosa) and \textit{Terminalia arjuna}. While \textit{A. paphia} prefers the former \textit{A. mylitta} is reared on the latter two. There are a number of secondary food plants such as \textit{Ziziphus jujuba}, \textit{Lagerstroemia parviflora}, \textit{Anogeissus latifolia} etc. The food plants are abundant in the vast, dense and humid tropical forests.

The larva while voraciously feeding on the leaves of the food plant passes through five stages after moulting for four times \textit{i.e.} tetramoulter. During mouln the larva rests without feeding. After each moul the larva sheds its old skin \textit{i.e.} ecdysis; the size and weight of its body increases. The fully matured larva is about 13
x 2.1 cm in size and weighs about 50 gms (Jolly et al., 1974, 1979). Thus, during the larval period a considerable increase in the body size and a tremendous gain in the body weight occurs. The final stage larva of A. paphia is larger in size, heavier in weight and robust in appearance.

The fully matured larva (Plate 1.2) has a hypognathous head, three segmented thorax and ten segmented abdomen. The mouth parts are of biting and chewing type. The thorax is provided with three pairs of thoracic legs one pair on each segment and four pairs of tubercles on the second thoracic segment. The abdominal segments are provided with four pairs of abdominal legs on third to sixth abdominal segments and one pair of anal claspers on the tenth segment which carries the anal flap. About four types of body tubercles are found on the abdominal segments. Minute white hairs are distributed all over the larval body. White pointed and long body setae are found at the base of dorsal tubercles of first to eighth abdominal segments. Besides, shining spots occur laterally on the second to seventh abdominal segments.

The duration of the larval stage varies seasonally and also according to the ecorace. It is longer in A. paphia. The total larval life span may vary from thirty to sixty days (Singh, 1962; Jolly et al., 1974, 1979). At the end of the larval stage the larva stops feeding and starts secreting silk from its silk glands which are modified labial glands. The liquid silk after coming in contact with air hardens into a filament (Plate 1.3). The larva spins a cocoon with this silk filament around its own body and metamorphoses inside this cocoon shell into a pupa (Plate 1.4). The female larva spins larger cocoon than the male. In case of A. paphia the pupa is slightly larger in size and heavier in weight than A. mylitta. The cocoons are also harder with high silk content in case of A. paphia. The silk cocoon is a hard shell with a peduncle for grip. The peduncle length is about three times in Nalia ecorace of A. paphia than that of other ecoraces of A. paphia as well as A. mylitta. Besides, the peduncle in Nalia ecorace has two to three loops whereas only one loop is seen in the peduncle of other ecoraces.

The pupa inside the cocoon is of obtect adectious type with appendages firmly fixed to the body. The body segmentation is clear. The mandibles are reduced.
The pair of forewing is folded ventrally almost hiding the hind wings. The pupa in the life cycle represents the dormant diapausing stage. The period of dormancy differs among different ecoraces, depending, upon the voltinism. Voltinism is the number of times the life cycle is repeated in a year i.e. the number of generations per year. The silkworm may be uni, bi- or tri-voltine depending upon repetition of life cycle once, twice or thrice a year respectively. In case of univoltine silkworm ecoraces viz. Modal of *A. paphia* diapause prolong for about ten months from September to June. In case of bivoltine ecoraces viz. Nalia of *A. paphia* and Daba of *A. mylitta* the period of diapause is November to June. In case of trivoltine ecorace viz. Sukinda of *A. mylitta* the period of diapause being January to June. Thus at the onset of monsoon diapause is terminated in all the ecoraces. It can be seen that the diapause stage enables the silkworm to skip over extreme climatic conditions viz. cold winter (Nov.-Feb.) and hot summer (Mar.-May).

Before emergence the transformation of pupa to moth takes place inside the cocoon. The moth emerges by piercing through the cocoon shell. The moths show distinct sexual dimorphism. The mandibles and labial palpi are poorly developed. Two pairs of wings are present. The genitalia are well developed. The moths of *A. paphia* are wild in appearance, more active and are darker. The post median line in wings of *A. paphia* exhibits a clear outside white and inside red line.

After emergence the moths of opposite sex mate. Copulation continues for some hours (Plate 1.5). After separation the female moth lay eggs completing the life cycle (Plate 1.6).

1.6.7 Tasar culture

The cultivation of tasar silk is known as tasar culture. It includes propagation of food plants, preparation of eggs, rearing of caterpillar till they spin cocoons, preservation of seed cocoons in grainage for procurement of eggs and processing of cocoons to silk yarn.

The silkworm *A. mylitta* is semidomesticated. The eggs are collected from grainage and are allowed to hatch. After hatching the minute larvae are allowed
to crawl over small branches and are transferred to *adapahi* viz. a small patch of land with tasar food plants. The larvae are transferred from leaf-exhausted plant to fresh plant during rearing till they spin cocoons. The cocoons so obtained may either be used to obtain silk or for preparation of eggs depending upon the qualitative and quantitative characters. The healthy good quality cocoons which can be used for the preparation of eggs are called seed cocoons and are hanged in garlands inside grainage house. Here the moths emerge from the cocoons, copulate and lay eggs. The eggs are distributed for rearing of another crop. Cocoons other than seed cocoons are reeled for silk yarn which is carried to textile sector for fabric production.

In case of *A. paphia* the culture is different as it is a wild form and avoid domestication. The seed cocoons of this species are collected from deep forest. The cocoons can be located by tracing the faecal matters fallen under trees (*Shorea robusta*). After collection these seed cocoons are tied by means of rope and kept in a thatched house in or near forest for emergence. The male moths emerge early and some of them flee to far away places for nuptial. The female moths are taken in a twig and hung up outside safely. The males from the forest reach and copulate the female moth. The female moths are also coupled by the few males that did not migrate to forest. After copulation for a good many hours the females are separated which then starts laying the eggs. The eggs are placed in cups made up of leaves among the food plants in the forest. The freshly hatched larvae crawl over and starts feeding. The larvae grows naturally and finally spin the cocoons which are later plucked by the rearer.

1.6.8 Present production status of tasar culture in Orissa

Orissa has a vast natural forest wealth. At present, out of the total 5.48 million ha of tropical forest tasar food plants occupy 1.78 million ha. A total of 3004 active tasar rearing patches are found in 23641 ha of forest land having about 4.65 million food plants. It is estimated that 3.73 million food plants have been lost over a period of 25 years due to land encroachment, soil erosion, utilisation for fire wood, medicinal and other economic avocations in addition to natural death, calamities etc. It is calculated that the rate of depletion of plants was about 1.83 times higher than that of replenishment (Nayak, 1996).
In Orissa, one hundred million tasar cocoons of both *A. paphia* and *A. mylitta* have been produced annually. The collection potential sharply decreased over the years. Collection potential of *A. paphia* cocoons decreased from 24.26 million in 1935 to 1.48 million in 1995. Similarly the collection figures in *A. mylitta* stands at 28.67 million in 1995 from 40.52 million cocoons in 1970 (Nayak, 1996).

From 1960, eggs of *A. paphia* were supplied by Govt. of Orissa through four Tasar Seed Stations which became defunct in 1971, leaving the art of *A. paphia* culture in the hands of unauthorised and non-technical persons. In case of *A. mylitta* though the production of eggs increased from 652 kg. in 1970 to 1210 kg in 1995 (Nayak, 1996), the cocoon production has decreased contrastingly as cited above due to several reasons mentioned elsewhere.

Out of the 37954 registered tasar rearer families in Orissa, only 21.66% are left as active rearers at present. On an average 20.76% of the annual income of a tasar rearer household is contributed by tasar culture. The average household size of a rearer is 7 persons per family (Nayak, 1996). Since family labour is abundant and since chance to work as a wage labour outside is uncertain, tasar culture seem to be a rewarding opportunity to utilize the idle family labour with maximum return.

In Orissa, tasar cocoons are purchased from the rearers by sixty three numbers of Tasar Rearer Co-operative Societies (TRCS) covering 2293 tasar growing villages. At present 57.09% of the villages numbering to 1309 are found to be defunct (Nayak, 1996) leading to the diminishing of activities of most of the TRCS.

Irrespective of crop potentiality the tasar rearers in Orissa follow a pattern of rearing suitable to their need leading to a decreased trend in cocoon production. On an average a rearer produces 3162 cocoons per rearing of 400 gms of silkworm eggs *i.e.* 200 Dfls reflecting an ERR of only 10%. The average daily income per rearer is rupees 21.5 which is less than the Govt. prescribed labour wage of Rs 25 per day (Nayak, 1996). The reason for such a poor income and low ERR% may be attributed to the lack of technical know-how and natural calamities.
Though various organisations under the Govt., non-Govt. and corporate sectors are involved in tasar culture throughout the State, tasar development is not getting any momentum due to lack of expertise, technical monitoring and evaluation of productivity of the schemes and projects meant for the development of tasar culture.

It is observed that during the last 25 years, tasar culture has lost 42.41% of tasar cocoon production, 41.36% of tasar rearing patches, 63.13% of tasar rearing area, 44.51% of tasar food plants, 78.34% of rearers and 57.09% of tasar growing villages (Nayak, 1996). Immediate steps need to be taken to protect the existing plantation, replenishment through new plantation, introduction of proper technical know how in disease free egg production, hygienic rearing and quality cocoon production providing an excellent scope for sustained all round economic growth of the state, her forest wealth and her tribe.
Table 1.1  Global distribution of tropical tasar species

<table>
<thead>
<tr>
<th>Sl No.</th>
<th>Name of the species</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Antheraea andaman Mr.</td>
<td>Andaman (India)</td>
</tr>
<tr>
<td>2.</td>
<td>Antheraea biflitonesis Mr.</td>
<td>Mr. Indonesia</td>
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<tr>
<td>3.</td>
<td>Antheraea brunnea Eecke</td>
<td>Sumatra</td>
</tr>
<tr>
<td>4.</td>
<td>Antheraea coryphone coryphone Weym.</td>
<td>Celebes</td>
</tr>
<tr>
<td>5.</td>
<td>Antheraea crompta R &amp; J</td>
<td>Assam (India)</td>
</tr>
<tr>
<td>6.</td>
<td>Antheraea delegata Swh.</td>
<td>Singapore</td>
</tr>
<tr>
<td>7.</td>
<td>Antheraea eucalypti Scott</td>
<td>Australia</td>
</tr>
<tr>
<td>8.</td>
<td>Antheraea fiekei Weym.</td>
<td>N. Cebes</td>
</tr>
<tr>
<td>9.</td>
<td>Antheraea frithii Mr.</td>
<td>Himalayas (India)</td>
</tr>
<tr>
<td>10.</td>
<td>Antheraea gephyra Niep</td>
<td>N. Borneo</td>
</tr>
<tr>
<td>11.</td>
<td>Antheraea heiferi Mr.</td>
<td>Himalayas (India)</td>
</tr>
<tr>
<td>12.</td>
<td>Antheraea imperator Wts.</td>
<td>Java</td>
</tr>
<tr>
<td>13.</td>
<td>Antheraea janna Stoll</td>
<td>Java, Borneo</td>
</tr>
<tr>
<td>14.</td>
<td>Antheraea knyvetti Hmp.s</td>
<td>Sikkim (India)</td>
</tr>
<tr>
<td>15.</td>
<td>Antheraea larissa Wv</td>
<td>Java</td>
</tr>
<tr>
<td>16.</td>
<td>Antheraea larissoides Bouv.</td>
<td>Tonkin</td>
</tr>
<tr>
<td>17.</td>
<td>Antheraea mylila Drury</td>
<td>Europe, India</td>
</tr>
<tr>
<td>18.</td>
<td>Antheraea mylittoides Bouv.</td>
<td>Java</td>
</tr>
<tr>
<td>19.</td>
<td>Antheraea paphia Linn.</td>
<td>India, Sri Lanka, S. China</td>
</tr>
<tr>
<td>20.</td>
<td>Antheraea pasteurii Bouv.</td>
<td>Java</td>
</tr>
<tr>
<td>21.</td>
<td>Antheraea pratti Bouv.</td>
<td>Sumatra</td>
</tr>
<tr>
<td>22.</td>
<td>Antheraea prelarissa Bouv.</td>
<td>Java</td>
</tr>
<tr>
<td>25.</td>
<td>Antheraea ridleii Mr.</td>
<td>N. Borneo</td>
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<td>26.</td>
<td>Antheraea rumphi Fldr.</td>
<td>Amboina</td>
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<td>27.</td>
<td>Antheraea sciron Ww.</td>
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<td>29.</td>
<td>Antheraea sivalika Mr.</td>
<td>N. India</td>
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<tr>
<td>30.</td>
<td>Antheraea surakarta Mr.</td>
<td>Java</td>
</tr>
</tbody>
</table>
Fig. 1.1 The silk clock.
Fig.1.2 Global distribution of tropical tasar.

I. Flora
II. Fauna
Fig.1.3 Distribution of tropical tasar in India.
Fig. 1.4 Distribution of tropical tasar in Orissa.
Fig. 1.5 Life cycle of tropical tasar silkworm.
Plate 1.1  Eggs and hatchlings of tropical tasar.

Plate 1.2  Fully matured larva of tropical tasar.
Plate 1.3  Onset of spinning process.

Plate 1.4  Formation of tasar cocoon.
Plate 1.5  Pairing between tasar silkworms.

Plate 1.6  Oviposition.
(Wings of the moth cut saving injury to show the abdominal portion).