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DIPTEROCARPS OF SOUTH ASIA

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CONTENTS

Page

ILLUSTRATIONS

Page

MAPS

PHOTOGRAPHS

Page

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CHAPTER I

INTRODUCTION

The geological history of dipterocarps has been traced hack to early tertiary or late mesozoic (Merril, 1923). The first fossil wood recognised as a diptcrocarp was from Java, and it was named ***Dipterocarpoxylon.*** A tertiary specimen reported by Holden from Burma was first credited as ***Dipterocarpoxy-****lon.* hut later its identity was established as ***Glutoxylon*** (Chowdhury, 1952). From mio Pliocene beds of Burma, three dipterocarp wood specimens have been unearthed. The first South Asian record of leaf fossils of the tertiary period was also from Burma (Edwards, 1923). Taking into account later findings from the Cuddalore sand-stones in South India and based on the fossil records collected from Bengal and Assam (India) and Burma, the following species have been determined.

Anisopteroxylon hengalensis – Ghosh and Kazmi (1958)
A. coromandelense – Novale (1963)
A. garoense Prakash and Tripathi (1970)
A. jawalamukhi – Ghosh and Ghosh (1958)
Dipterocarpoxylon arcotense – Awasthi **(MS)**
D. burmense – Prakash (1973)
D. chawdhurii – Ghosh (1956)
Dipterocarpoxylon kalaicharparense – Eyde (1963)
D. malavii – Ghosh and Ghosh, 1959
D. pondicherriense – Awasthi (1974)
D. tertiarum – Prakash (1973)
Dryohalanoxylon holdeni (Ramanujam) – Auasthi (MS)
D. indicum – Awasthi (1971)
Hopenium sp. – Awasthi **(MS)**
Shoreoxylon arcotense – Awasthi (1974)
S. hurmense – Prakash (1973)
S. deomaliense – Prakash and Awasthi (1971)
S. evidens – Eyde (1963)
S. indicum – Awasthi (1974)
S. krauseli – Ramanujam and Rama Rao (1967)
S. tipamense – Prakash and Awasthi (1970)

Evidence of fossil records from Burma and profusion of the same in Bangladesh, eastern India and southern India indicate that the dipterocarps were an important constituent of the ancient flora of the region. The first megafossil recovered from the extreme western part of India is a dipterocarp. It was collected from the pleiocene grey sandstone of Kutch (Ghosh and Ghosh, 1959). The pollen of dipterocarps has also been recorded from the eocene beds of Kutch. The unearthing of an ***Anisoptera*** from Jawalamukhi, Punjab, has given a clue about the north western limit of dipterocarps. Thus, the assumption of Merrill (1923) that the South Asian region had a far richer dipterocarp flora in the past, is fairly well founded.

It is generally believed that the centre of origin of dipterocarps was western Malaysia, where, about two-thirds of the dipterocarp species occur at present. From. western

Malaysia, it is presumed to have spread eastward to the Philippines, and northwards through Burma to eastern India. The migration froni here is supposed to have been south-wards to southern India and Sri Lanka. This speculation has been questioned as the South Indian fossils have a closer resemblance to Malaysian fossils rather than the fossils of eastern India (Ghosh and Ghosh, 1959). Lakhanpal (1974) is of the view that the dipterocarps originated in a mass of land at that time situated somewhere in the present Indian Ocean, from where, towards the beginning of the tertiary period, there were two main bifurcations of the ancestral group, one going westward to Africa and the other towards east into the Indo-Malayan region. While moving eastwards, it is presumed that there was another bifurcation, one to Malaysia and the other to South India and Sri Lanka. From western Malaysia it is supposed to have spread to eastern India through Burma. Thus, with a palaeontological record dating back to early tertiary or late mesozoic, the South Asian dipterocarps attained prominence even in the pre-historic period. *Shorea robusta* (sal), for example, was known even in early times as Ashwakana, Karsha, Sala and used for several purposes. The species has been mentioned in connection with the birth and 'parinirvan' of Buddha. Lumbini, Buddha s birth place, which was on the bank of the river Rohini, had sacred groves called 'Mangala Salavana'. It is also said that on the banks of the river Hiraniyavati, Budha had a bed prepared for himself in a sal grove, between two sal trees. Sukraniti, while describing the flora of the Himalayan region classified this dipterocarp as an important and valuable wood species. Kautilya in his 'Arthasstra' placed sal among the strongest timber yielding trees of the forests. Plant remains excavated from Pataliputra show that sal was used for the wooden palisade made in that historic city over 2000 years ago. From historic evidences, it is also known that sal was used in the performance of 'Ashwamedha' by ancient kings. The charcoal of sal has been recovered from the excavation of the Panchala kingdom, which is about 1000 years old. Although specific mention of other dipterocarps is not available in ancient records, it is believed that the wood of *Vutena* was used for a variety of purposes in South India.' The dipterocarps of South Asia, thus, have an ancient heritage and their importance has continued uninterrupted to the present day.

The family Dipterocarpaceae, since its inception by Blume in 1825, has had a chequered taxonomic history, with additions and deletions of taxa, and the process is still continuing. While Korthals described only 34 species in 1840/41, the enumeration of Brandis (1895) raised the number to 325 and the works of Ashton (1962, 1963) and Meijer (1963) have shown that the number has reached almost 600 (Gottwald and Parameswaran, 1966). Out of the total number of world species, South Asian dipterocarps account for about 16% only. It is in other regions like Malaysia and Borneo that the species profusion is more evident. The South Asian region has, however, played a significant role in the taxonomic history of the dipterocarps. It was from South Tipperah, Chittagong (Bangladesh) that Hamilton made the first scientific collection of some two winged fruits which formed the basis for the establishment of the genus *Depterocarpus* in 1805 by Gaertner (Parkinson, 1931). The earliest taxonomic diagnosis of several other dipterocarps are also founded on collections from South Asia.

The dipterocarps of this region have throughout been associated with the splendour of tropical forests. Most of the species, other than *Shorea robusta* were not utilised for a long time and they remained undisturbed in their sequestered domain in remote regions. But their ***size*** and form let them down and it was not for long that they could continue undisturbed. With humble beginnings, they grew in importance and towards the end of first World War, they established themselves as a source of useful timber. When it was found that in addition to their unmatched cylindrical form and bole size, they were eminently suited for 'peeling', a new dimension was added to their usefulness.

With the development of plywood industry in the region, their seclusion was broken, their complicated hut fragile ecosystem massively disturbed and in several areas in Bangladesh and India their very existence has been threatened. In less than 150 years, plant formations with the dominance of dipterocarps have either heen replaced or transformed irretrievably. In the beginning, due to lack of knowledge of regeneration potential and later, due to the mixed reasons of imperfect understanding of suitable regeneration procedures and considerations of economics of return, attempts to propagate them were comparatively few, except in respect of *Shorea robusta*. The result is that, apart from some fortunate exceptions, the dipterocarp forests have been either degraded or replaced.

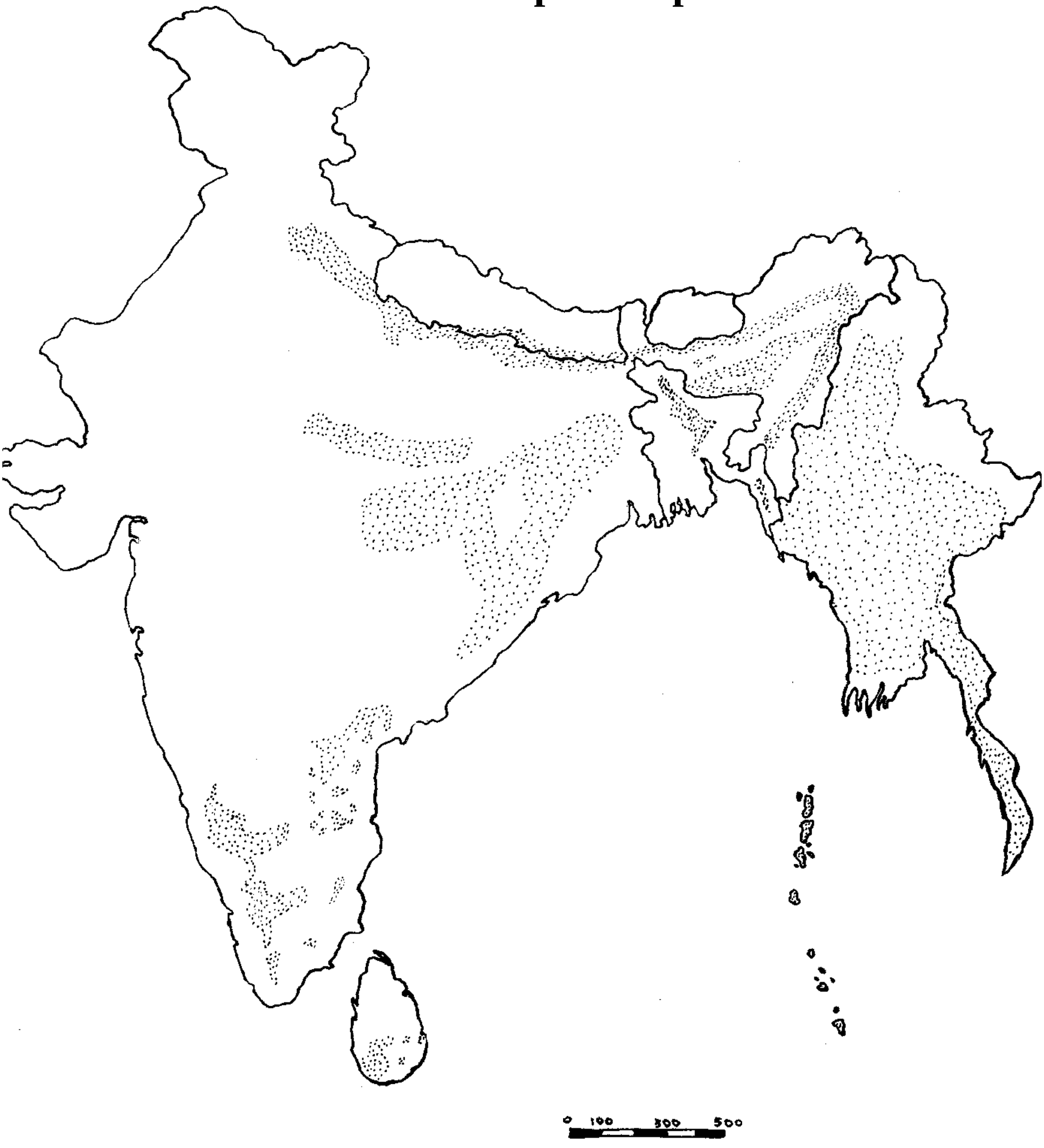
It is against this background that the importance of collating information relating to various aspects like Botany, Silviculture and Utilisation of this interesting plant group has to be considered. After an overview of the dipterocarps of the region, details pertaining to Taxonomy, Distribution, Ecology, Silviculture, Wood, Non Wood Products and Uses are dealt with species wise. Pests and diseases are treated separately.

The drawings are hased on selected representative specimens from the herbaria of Botanical Survey of India, Forest Research Institute, Dehra Dun and Peradeniya Botanical Gardens, Sri Lanka, published illustrations or fresh specimens collected for the purpose. For botanical descriptions, authentic published works were consulted. Although considerable attention has been paid to verify the validity of scientific names and distributional details, there are doubts about some of the Burmese dipterocarps. Although *Dipterocarpus indicus* Bedd. has been reduced to ***D.*** *turbinatus* Gaertn. f., they are treated separately because of significant morphological differences. For similar reasons the taxonomic identity of *Balanocarpus erosa* Bedd. is tentatively maintained.

The ecological and silviculturil details have been collected mostly from ledger files of forest departments, working plans and field studies. The vegetational studies of Champion (1936), Andrews (1961), Hundley (1961), Champion and Seth (1968), Stainton (1972) and Sommer (1976) were also of considerable value to determine the ecological features of the dipterocarps of the region. As floristics are the ultimate indices of edaphic and climatological inter-actions, efforts have been made to describe the compositional characteristics of representative. areas in which the dipterocarp species are constituents. The detailed investigations of Pearson and Brown (1932) and Chowdhury and Ghosh (1958) have been freely made use of for the description of wood. Supplemental information has been drawn from Metcalfe and Chalk (1950), Gottwald and Parameswaran (1966) and direct observations.

Thus, an attempt has been made to bring together alailahle informations on all important aspects of the dipterocarpaceous taxa of the region to serve as a basis for further investigations.

South Asian Dipterocarps Distribution



CHAPTER **I1**

DIPTEROCARPS **OF** SOUTH ASIA – **AN** OVERVIEW

Dipterocalps constitute an extremely important element in the productive forests of the South Asian region. Adapting themselves to a variety of ecological conditions, forming pure stands of particular species or growing in associations with several other genera and species, they have a remarkably wide coverage from sea level to about 1800m in the hills.

The species ***Shorea*** *robusta* alone accounts for about 13 million hectares in Bangladesh, India and Nepal. The extent of distribution of the dipterocarps shown in the map is based on the putative taxonomic diagnosis according to which there are 10 genera and 99 species in the region.

Country-wise Distribution **of** South Asian Dipterocarps

Sl. No.	Genus	No. of species in South Asia	Distribution				
			Bangladesh	Burma	India	Nepal	Sri Lanka
1	*Anisoptera*	*3*	1	*3*	1	–	–
2	*Balanocarpus*	1	–	–	1	–	–
3	*Cotylelobium*	**2**	–	–	–	–	2
4	*Dipterocarpus*	19	5	12	11	–	4
5	*Hopea*	18	1	6	10	–	4
6	*Parashorea*	2	–	2	–	–	–
7	*Shorea*	27	1	10	4	1	15
8	*Stemonoporus*	15	–	–	–	–	15
9	*Vateria*	3	–	–	2	-	1
in	*Vatica*	9	1	6	2	-	*3*
	Total	*99*	9	**39**	31	1	44

Anisoptera, with three species is highly restricted in the evergreen forests of Bangladesh, Burma and India. While ***A.*** *scaphula* is found in all the three countries, *A. curtisii* and ***A.*** *oblonga* are confined to Burma. Most of the species of *Balanocarpus* have been reduced to *Hopea* but the taxonomic status of the only species of this region, *B. eroiza* is yet to be determined. It is of highly restricted occurrence and localised to semi-evergreen forest of South India. Both the species of *Cotylelobium* are endemic to Sri Lanka and found in the highland and lowland evergreen forests. *Dipterocarpus* has a fairly wide distributiowin-all the countries of the region except Nepal. Most of the species are in the evergreen forests, a few straying into the moist and dry deciduous zones. All the four species in Sri Lanka are endemic. Out of the remaining 15 species, *D. alatus,*, ***D.*** *costatus, D. gracilis, D. tuberculatus* and *D. turbinatus* are found in Bangladesh, Burma and India. *D. grandiflorus, D. kerrii* and ***D.*** *macrocarpus* are in Burma and India. While *D. bourdilloni,* ***D.*** *indicus,* and *D. mannii* are confined to India, ***D.*** *baudii, D. dyeri* and *D. obtusifolius* are found only in Burma. One more species *D. paniculatus* has been reported to occur in Burma (Hundley and Chit KOKO, 1961), but authentic information is wanting. In the genus *Hopea,* 4 species are endemic to Sri Lanka. *Hopea odorata* has a comparatively wide distribution in Bangladesh, Burma and India, *Hopea* ***helferi*** is found mostly in Burma and occasionally seen in restricted localities of Andaman Islands (India). 8 species (most of which are endemic) are confined to India and 4 to Burma. Both the species of *Parasphorea* are confined to Burma, *Parashorea stellata* being found in both evergreen and semi evergreen forests. *Parashorea buchananii* has been reported from highly restricted localities in this country (Fischer, 1926; Hundley and Chit KO KO, 1961). *Shorea* has the largest number of species and the widest distribution in the region. 15 species are endemic to Sri Lanka. S. ***ardentea,*** S. *farinosa, S. gratissima,* **S.** *obtusa, S. siamensis* and **S.** *sericeiflora* are found in Burma. Two more species S. *griffithii* and *S. symingtonia* have also been reported to occur in Burma (Hundley and Chit KO KO, 1961) but authentic information is lacking. S. *assamica* and *S. roxburghiz* are found both in Burma and India, the former occupying large tracts in the evergreen forests of eastern India. ***S.*** *thumbuggaia* **is** locdised to dry deciduous forests of South India. It is only S. *robusta* which extends over a very large area in a variety of moist deciduous forests in Bangladesh, India and Nepal. Out of **3** species of *Vaterza, V. copallifera* is endemic to Sri Lanka. It however bears a very close resemblance to *V. macrocarpa* which is endemic to India. More detailed studies are therefore necessary to establish the authenticity of the lone Sri Lanka species. *V. indica* is a South Indian species found in the evergreen forests. This genus is not represented in the dipterocarp rich Burmese region. Two species of *Vatica* are endemic to Sri Lanka and *Vatica chinensis* is found both in South India and Sri Lanka. ***V.*** *lanceaefolza* is found in Burma and India and it has been reported to occur in restricted localities in Bangladesh. Five more species have been reported to occur in Burma but authentic information about *Vatica astrotricha. V. dyerz, V. griffithiz* and *V. scaphula* (listed by Hundley and Chit KOKO, 1961) is lacking.

In Bangladesh, the dipterocarps are distributed in two distinct zones. In the northern zone, the principal component is *Shorea robusta.* Other dipterocarps are mostly confined to the southern zone. The Burmese dipterocarps are distributed almost all over the country ranging from Myitkyina in the north to Victoria Point in the south. Majority of the species are, however, found in the evergreen tracts of lower Burma, the genus *D+terocarpus* being mostly confined to the eastern slopes and southern end of Arakan Yoma, Pegu Yoma and Tenasserim. In India, *Shorea robusta* has its own zone of distrihution in North India. Other dipterocarps are essentially in three widely separated zones viz., north eastern zone, south western zone and the offshore island zone, Andaman and Nicobar islands. Nepal has only *Shorea robusta* which extends as a continuous stretch from west to east along the terai and foot hills. Sri Lanka has a very interesting pattern of dipterocarp distribution and in fact it constitutes one of the most compact units of distribution of the group in the world (Fax-worthy, 1946).

BOTANY

Taxonomy

The dipterocarps are typically tropical and the family consists exclusively of woody taxa attaining tree forms of varying sizes. It can be easily distinguished from its allied families Guttiferae and Theaceae by the enlarged persistent calyx, stipulate leaves and characteristic resin canals. The bark is of considerable diagnostic value in field identification. Whitmore (1962a, b, c) made a detailed investigation of the bark morphology of the family and recognized seven general types. The bark of South Asian dipterocarps may be smooth as in ***Bahnocarpus,*** most species of ***Dipterocarpus*** and ***Vatica;*** dippled as in some species of ***Shorea,*** fissured as in many species of ***Hopea*** and laminated as in ***Anisoptera.*** Leaves simple, alternate, with deciduous or persistent stiuples. Flowers in axillary or terminal racemes, spikes or panicles bracts usually minute or absent, rarely large and persistent. Calyx tube free and campanulate or very short and adnate to the base of the ovary. Petals connate at the base or free. Stamens 5, 10, 15 or many, connate or adnate to the petals, filaments short often dilated at the base, anthers 2 celled, connective extending into aprominent appendage. Ovary superior, rarely semi inferior, usually 3 celled, with 2 ovules in each, style with or without stylopodium, stigma minute or 3-6 lobed. Fruit usually one seeded, varying considerably in size and form; often with two or more wings.

The dipterocarpaceous fruits from which the family derived its name have considerable taxonomic significance. Moreover, they present a variety of morphological forms which are singularly striking. In view of the importance of fruits as a taxonomic aid detailed description has been given for most of the species.

The dipterocarps are known by several common names in different languages of the region. These names are invariably given and the abbreviations are expanded below.

Bangladesh			
	Beng.	–	Bengali
Burma			
	Bur.	–	Burmese
India			
	And.	–	Andamanese
	As.	–	Assamese.
	Beng.	–	Bengali
	Hind.	–	Hindi
	Kan.	–	Hindi
	Kan.	–	Kannada
	Mal.	–	Malayalam
	Mar.	–	Marathi
	Or.	–	Oriya
	Tam.	–	Tamil
	Tel.	–	Telugu
Nepal			
	Nepal	–	Nepali
Sri Lanka			
	Sinh.	–	Sinhalese
	Tam.	–	Tamil

Floral Anatomy

Not much work has been done on the floral anatomy of dipterocarps. Rao (1962) investigated the floral anatomy and development of the gametophytes of ***Hopea racophloea.*** The sepals are supplied by three traces, which arise from a common gap. Adjacent sepal laterals fuse, forming characteristic loops. Branches arise from these loops and enter the sepals which are thus strongly vascularised. There is a common petal-stamen bundle and a stamen fascicle bundle. Branches from these two bundles vascularise the ovary wall. The dorsal regions of the carpels are supplied by three traces which are seen distinctly on the outer side of each locule. The wall of the ovary is supplied by a number of small bundles arranged in a ring. The septa are incomplete at the top. The lateral position of floral organs is indicated by the occurrence of vestigial receptacular vascular tissue which is seen even after the ventral bundles are distinct. The dorsal bundles and some bundles in the ovary wall continue into the hollow style, fuse and finally fade out.

Embryology

Embryological studies in the family are mainly confined to 5 Indian species. Apart from studies in polyembryony in *Shorea robusta* (Ghosh and Shahi, 1957) and few other members of the family (Maury, 1970), Rao has made a detailed study of gametogenesis and embryogeny of *Shorea roxburghii* (1953), *Vuteria indica* (1955a), *Shorea robusta* (1956b) and *Hopea wightiana* (1956a). He has also studied the gametogenesis of *Hopea racophloea* (1962).

Above studies have shown that the anther is tetrasporangiate and its wall development follows the dicotyledonous type. The endothecium does not develop fibrous thickenings. The middle layers are ephemeral. Dehiscence of the anther takes place by the disintegration of the wall layers. Tapetal cells are glandular and binucleate. The microspore tetrads are tetrahedral, isobilateral or decussate. Pollen grains are 2-celled at the time of shedding.

Ovule is anatropous, bitegmic and crassinucellar, micropyle being formed by the inner integument. The integuments of some dipterocarps have been studied by Corner (1976) and the following details are available.

		Outer intcgumcnt	Inner integument
1.	*Hopca odorato*	2-5 cells thick	4-5 cells thick
2.	*Shorea roxburghii*	5 cells thick	2-5 cells thick
3.	Vateria *indica*	5 cells thick	7 cells thick

The archesporial cell cuts off a primary parietal cell which forms about 5 layers of parietal tissue within the nucellar epidermis. Cytokinesis in the megaspore mother cell accompanies meiosis and the chalaza1 megaspore of a linear or T-shaped tetrad develops into a *Polygonurn* type of embryosac. The synergids are hooked, the polar nuclei fuse toward the centre of the embryosac and the 3 antipodal cells degenerate soon after fertilization.

Endosperm is nuclear, walls develop at the micropylar pole and the tissue becomes cellular throughout except in *Vateria* where it remains free nuclear. *Annona* type of rumination, due to localised ingrowths of the seed coat during development, occurs in *Shorea* (Periasamy, 1962).

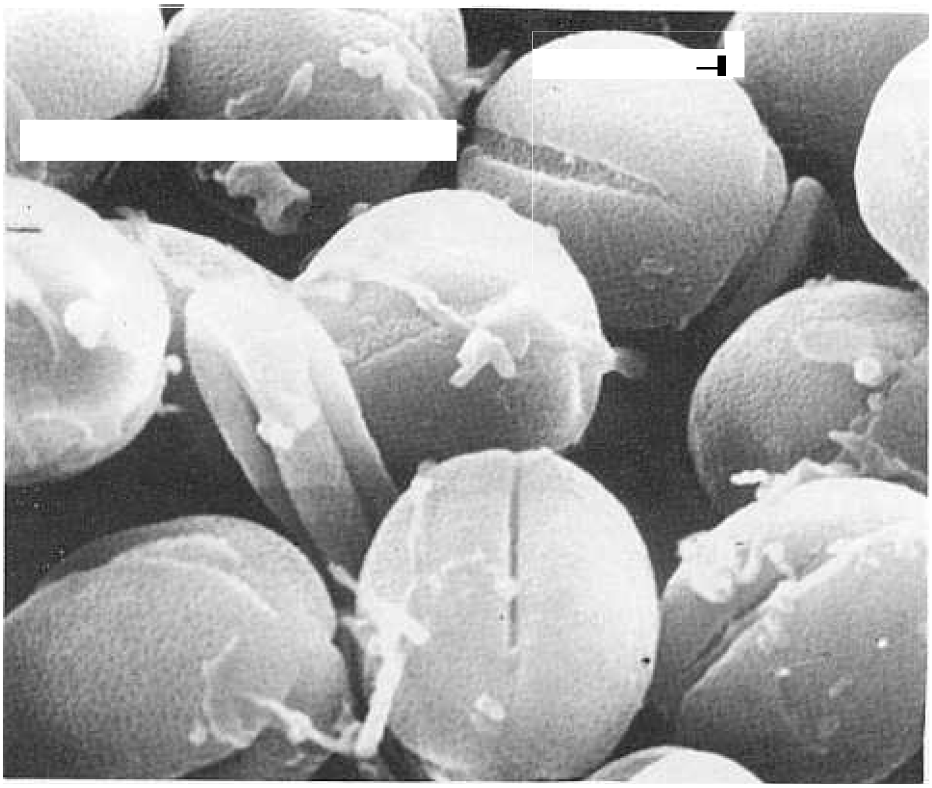
Embryogeny conforms to no definite type, since clevage planes are irregular after the inner transverse or oblique division, although in *Shorea robusta* there is resemblance to *Asterad* type.

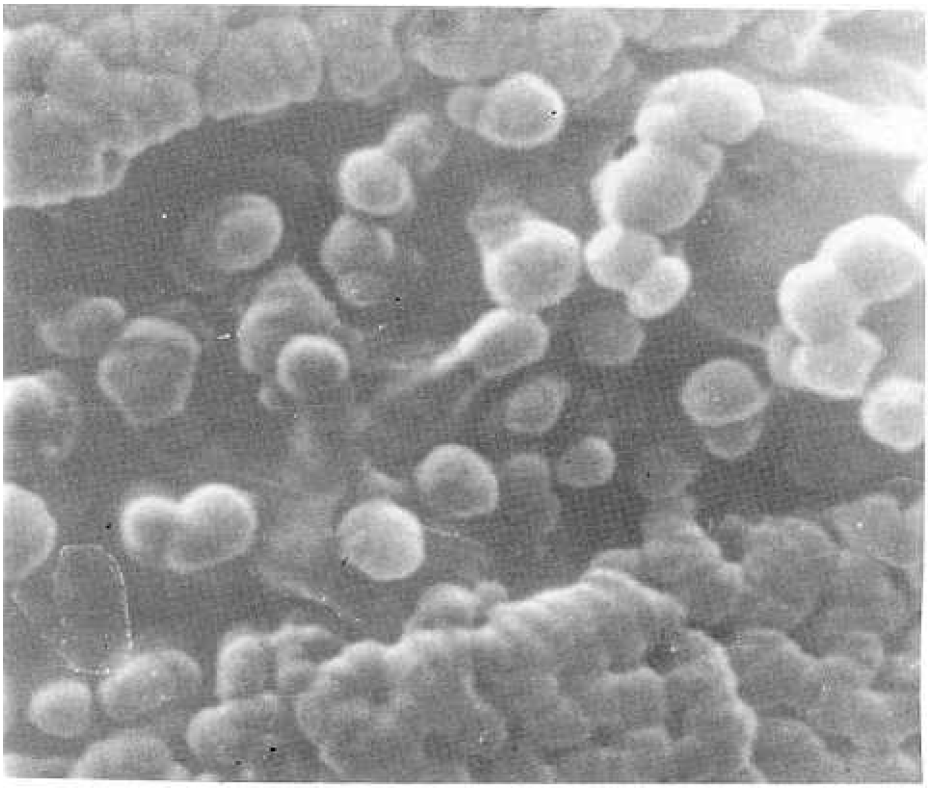
The seed coats in many genera get completely crushed at maturity and show little differentiation except in *Dipterocarpus* and *Vatica*. The cortical vascular bundles, the complexity of the pedicel and the tegmic as well as testa bundles in some species of *Dipterocarpus* suggest a more primitive origin than other families of Malvales, Tiliales or Euphorbiales (Corner, 1976).

Cytology

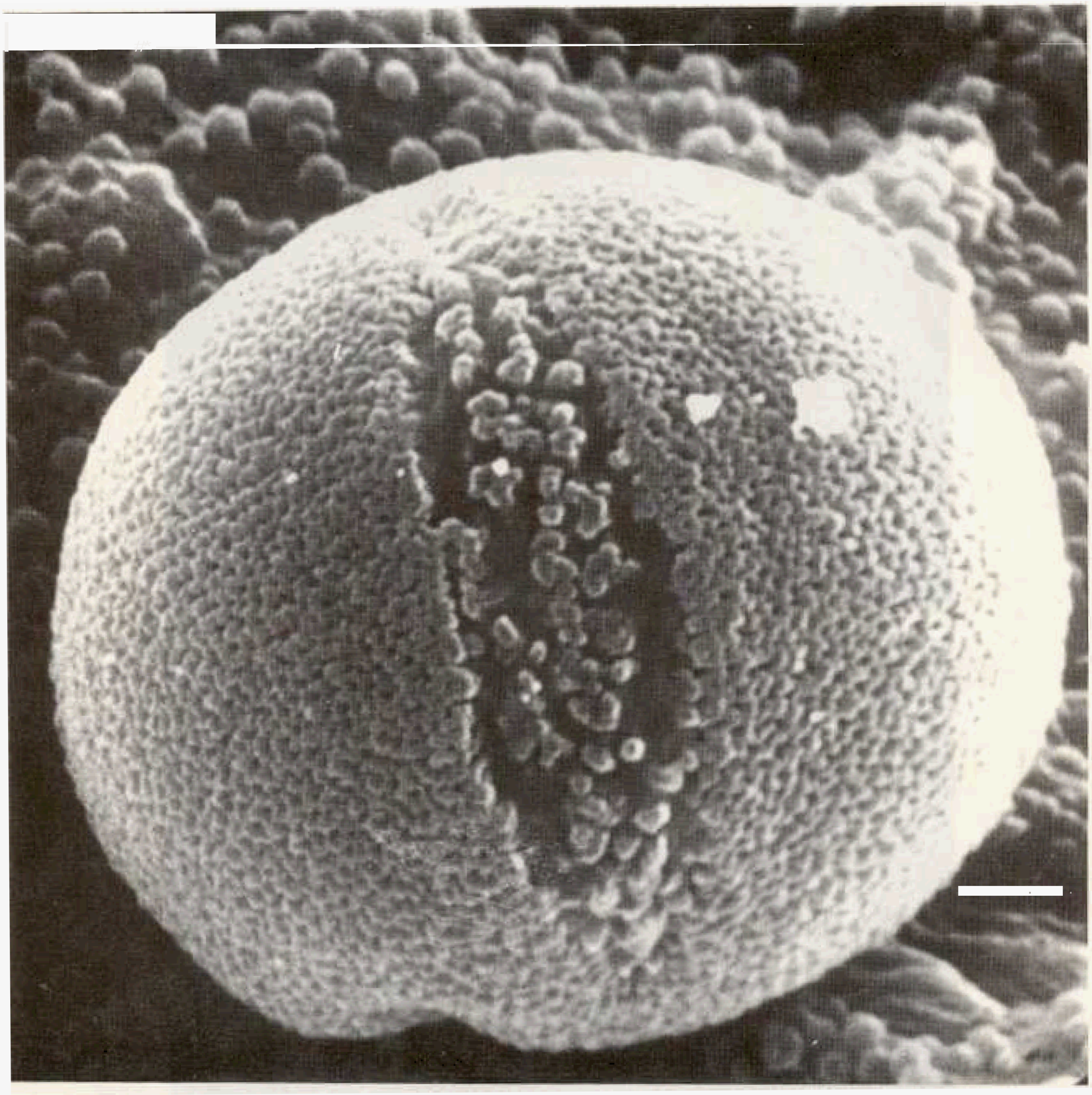
Cytological studies are limited to a few species of the region. According to Roy and Jha (1965), cytologically the family is a dibasic one and 2 distinct basic chromosome numbers are observed, i.e., 2n = 22 and n = 11 as in *Dipterocarpus alatus* and 2n = 14 and n = 7 as in *Shorea robusta*, S. *roxburghii* and *Hopea odorate*. It is significant that Desch (1941) as a result of his studies on wood anatomy concluded that Dipterocarpeae tribe is more primitive than Shorea. The statement is substantiated by the present finding that Dipterocarpeae has the basic number 11 and Shoreae has 7. The present cytological findings clearly indicate the phylogenetic relationship of Dipterocarpaceae with the Magnoliales—Myrtales line – a relationship drawn on morphological and taxonomic grounds by Hutchinson.

From the cytological investigations, it is evident that polyploidy has not played any role in speciation in this family. In the absence of polyploidy, the sources of varia-

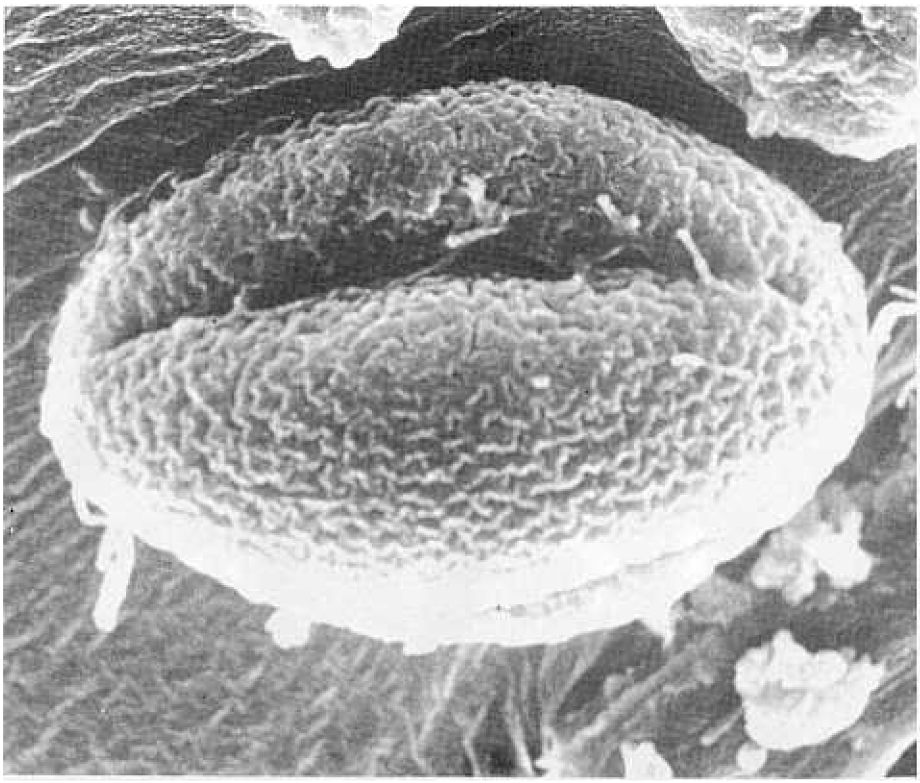


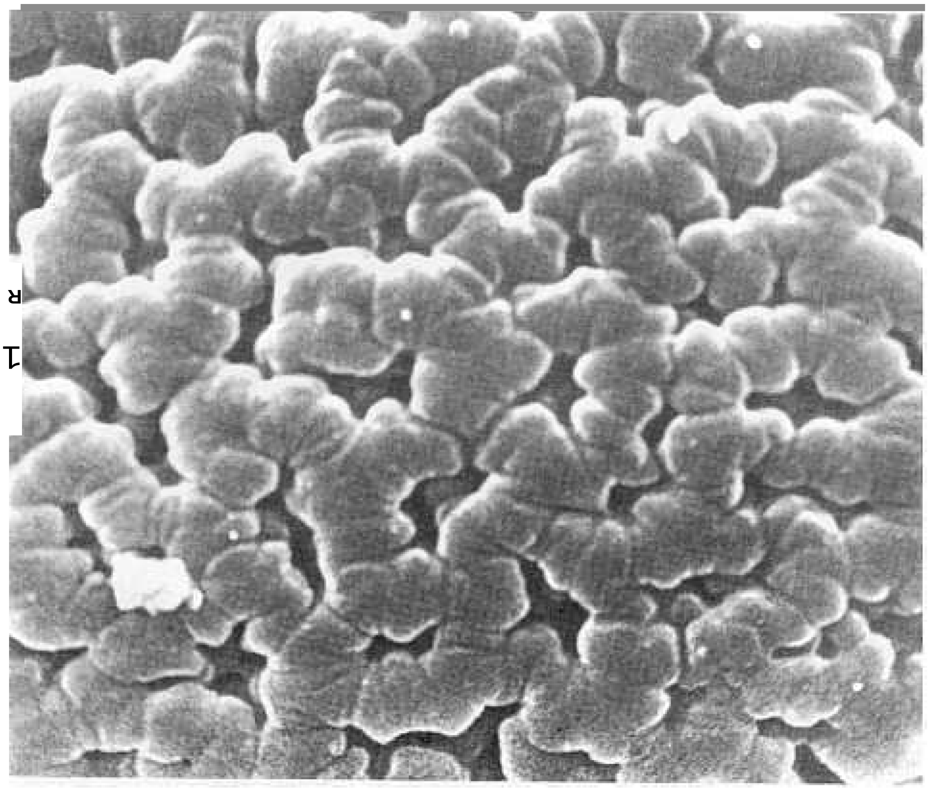


1. *Shorea* zeylanica spherical, ticolpate Pollen grains within their apertoral membrane supporting sculptured alements.
2. *Shorea affinis* sculptured elements on Colpus.

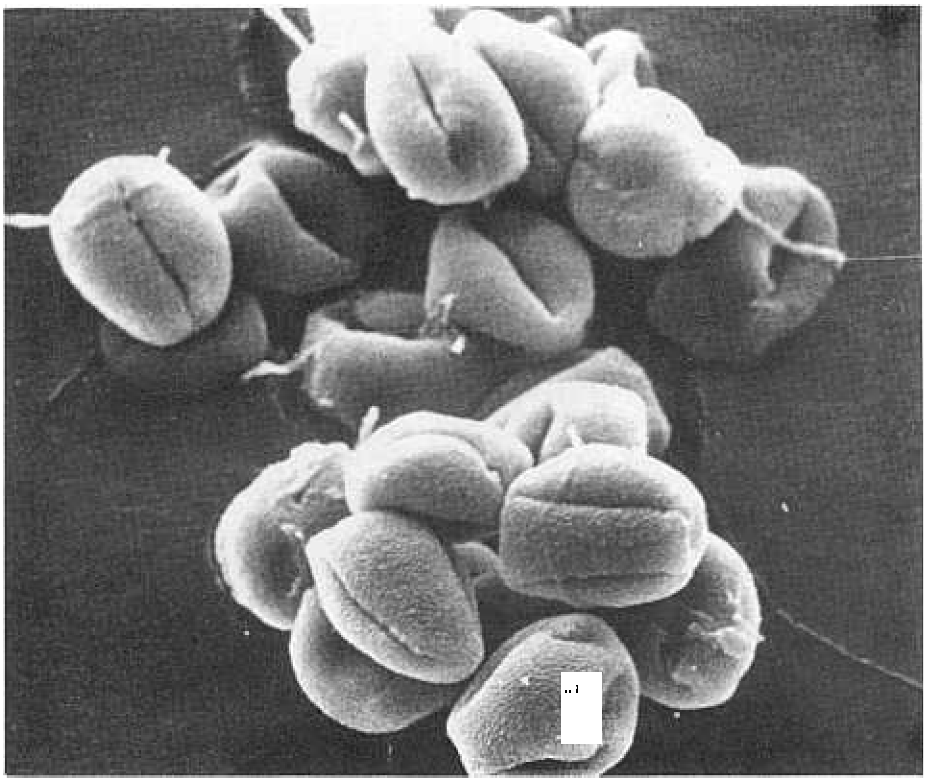


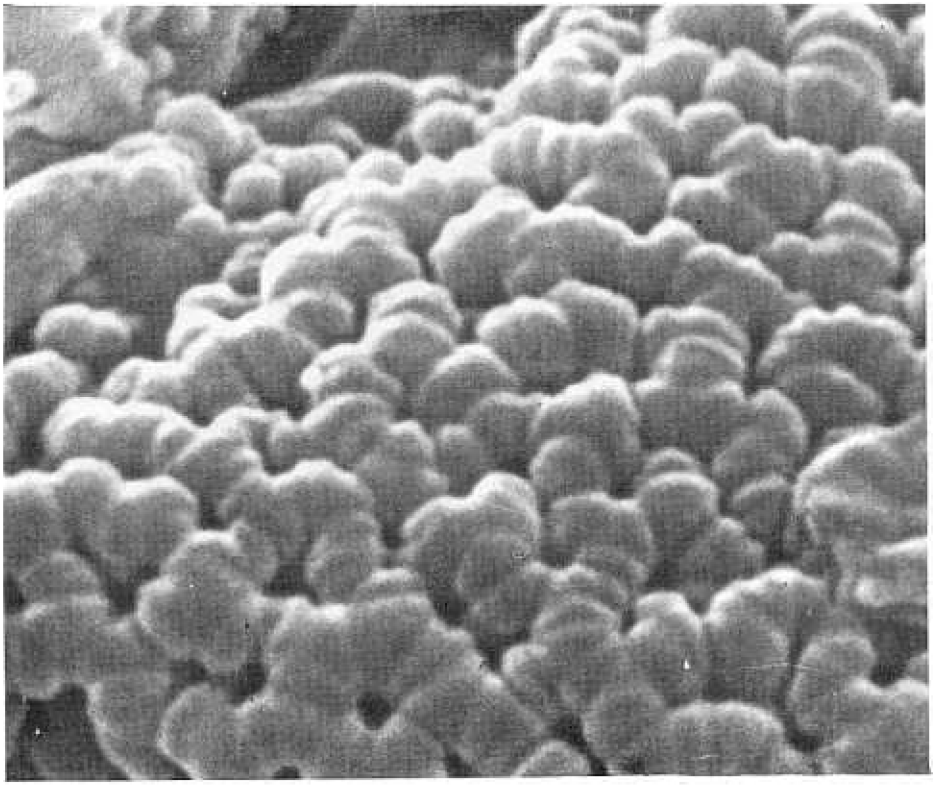
Shorea affinis **whole pollen** grain **partly adpressed by the pressure of the scanning microscope, elements of the Colpus.**



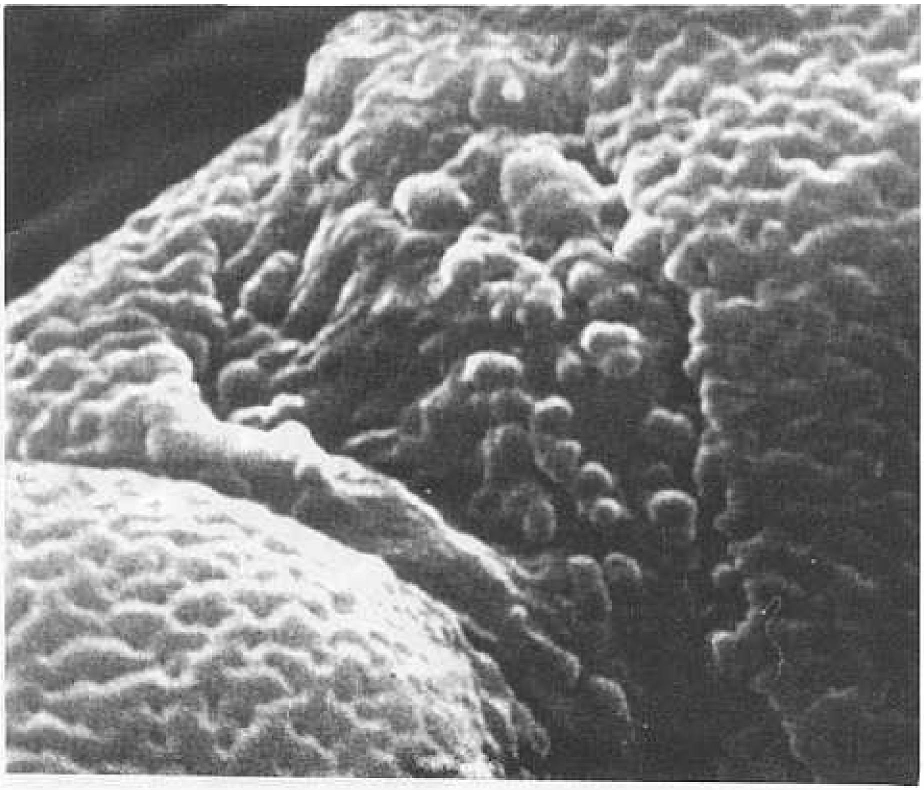


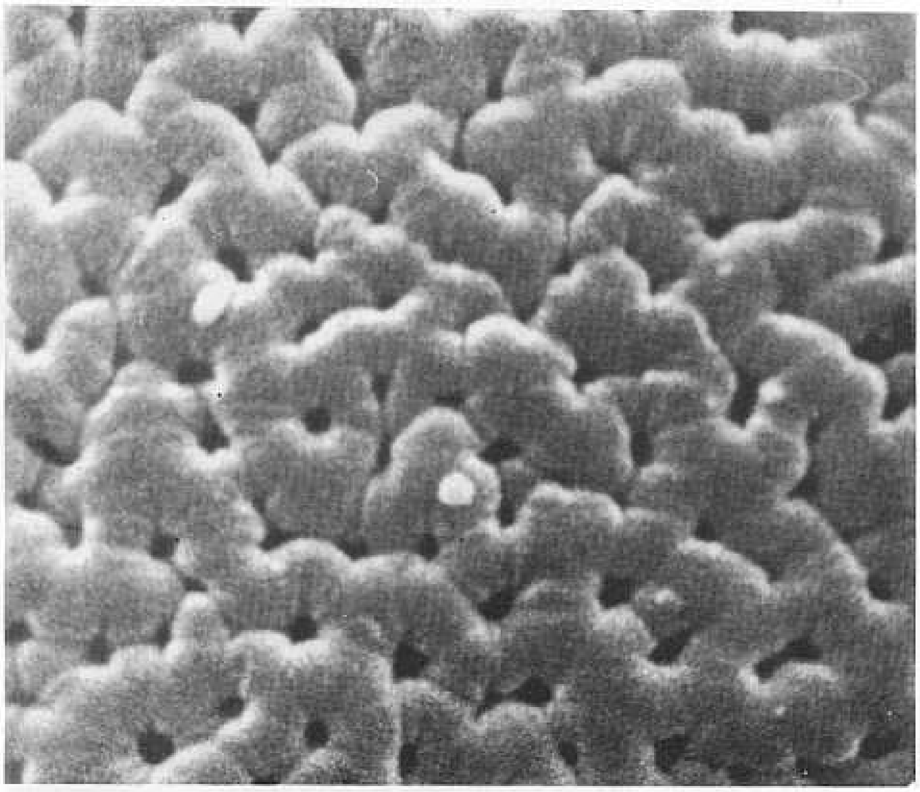
1. *Dipterocarpus grandiflorus* whole pollen grain.
2. *D. grandiflorus* tilioid structure of the outer layer and muri transitional to smooth.



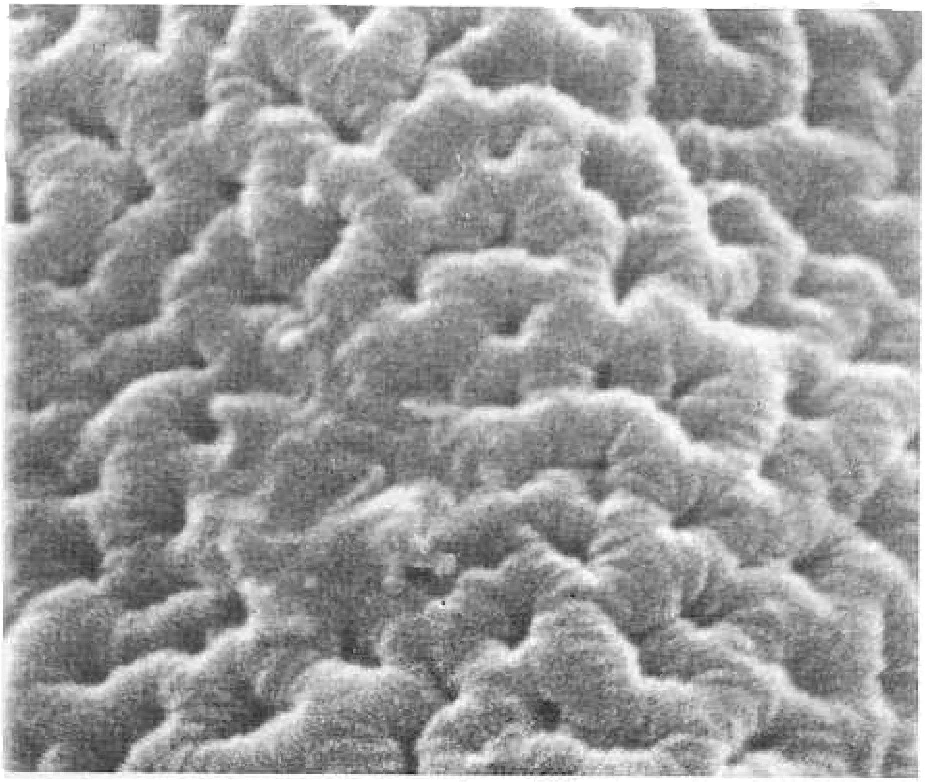


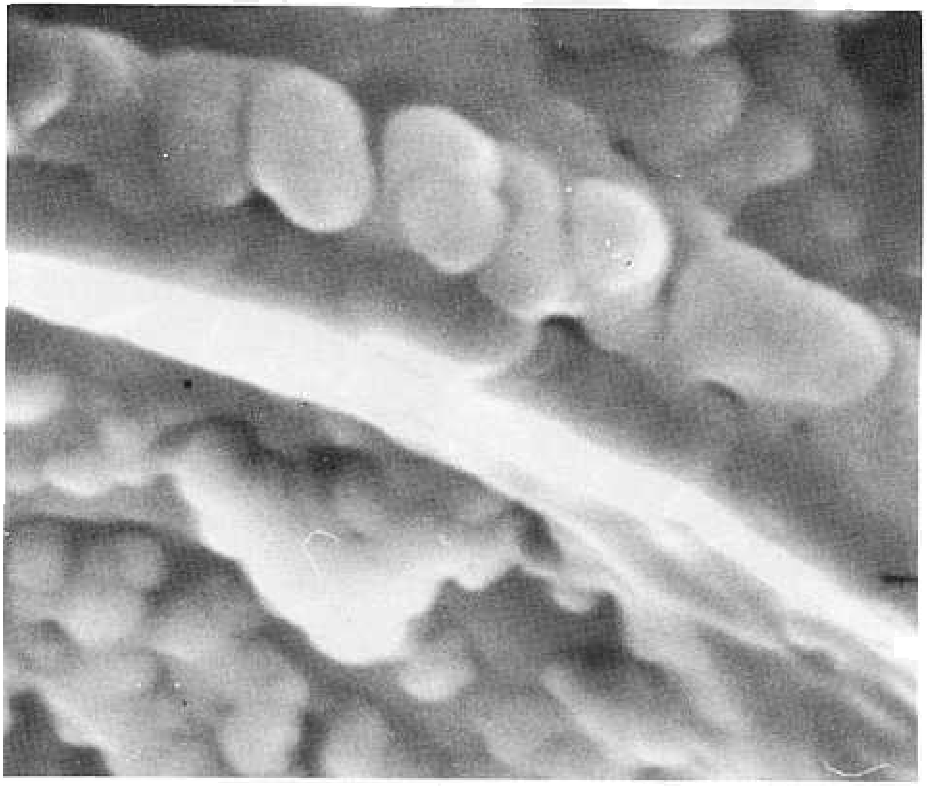
1. *Hopea odorate* whole pollen grain.
2. *H. odorata* reticulated tectum with crenulated muri of crotonoid pattern.





1. *Vateria indica* sculptured element on colpus.
2. *V. indica* reticulated tectum with muri transitional to smooth.





1. *Stemonoporus ceylanicus* tectum slightly crenelated with paralled pattern.
2. *S. ceylanicus* thick inner layer and U-shaped aspect of the outer layer.

tion would he chromosomal aberrations and gene mutations. **A** critical examination of the karyotypes of the different species shows that although there is basic similarity in the karyology, there are minor differences in the frequency **of** metacentric chromosomes and chromosomes of **L** and J-shapes. These variations in the karyology must have resulted from chromosomal aberrations. ***Shorea*** *robustn* and ***S.*** *roxburghii* have one pair of chromosomes with primary and secondary constrictions and the rest of the pairs have either median or sub median primary constrictions. The karyotype is basically similar in both the taxa. But the different arms of the chromosomes are of different lengths, although the total length of the chromosome complements is the same. These minor differences in **arm** lengths brought about by alterations and reinforced by gene mutation may be the real sources of speciation in this genus (Nanda, 1962). Thus it may be said that chromosomal aberrations and gene mutations are the only factors responsible for speciation in this family, polyploidy being almost of no significance. Palynology

Palynology (Contributed by G. Maury, Drnnoy, France)

The pollen grains of South Asian dipterocarps are mostly spherical, tricolpate with generally long and narrow colpi and thin apertural membrane supporting sculptural elements (Maury ***et al.,*** 1975). Some species have a new type of angiosperm exine with a thin inner layer (which belongs to the ectecine) and a strongly sculptured outer layer in which individual columella and tectum are fused into a tillioid structure. This structure is probably a result of fusion of inclined columellae and further deepening of the depression on top of the Y-shaped columellae.

Pollen types can he distinguished into two main groups viz., 3 layered exine (inner layer, columellae, tectum) as in ***Hopea*** and ***Shorea*** and 2 layered exine (inner layer, outer tilioiod layer) as in ***Dipterocarpus, Stemonoporus*** and ***Vatica.*** These broad groups can he further divided as follows:

I 3 layeredexine

I a T-shaped columellae ***(Hopea)***

I ai) muri crenelated with parallel pattern

I aii) muri crenelated with triangular crotonoid pattern (as in ***Hopea odorata).***

I b T and Y-shaped columellae ***(Shorea)***

I hi) muri crenelated with parallel pattern.

I bii) muri crenelated with crotonoid pattern.

I1 **2** layered exine

. I I a Thin basal layer **(as** in ***Dipterocarpus. Vatica)***

11 ai) laminae (inner layer) moderately reduced muri transitional to smooth pattern (as in ***Dipterocarpus grandi****floms)*

I1 **aii)** laminae strongly reduced, muri smooth ***(Vatica)***

I1 b Thick basal layer, presence of sperculum, muri crenelated with parallel pattern **(as** in ***Stemono****porus* ***ceylankcus, Vateriu indica).***

ECOLOGY

In this study, .a descriptive account of the forests and the characteristics of composition are given, without going into theoretical Considerations of the evolution and status of the ecosystems. Champion (19313, Hundley (1961), Andrews (1961), Champion and Seth (1968) and Stainton (1972) have brought out interesting ecological details of the dipterocarp forests of the region. Their systems of classification have more or **less** identical basis and the forests types described by them have been adopted for presenting the ecological characteristics of most of the dipterocarp species. The general survey of Sommer (1976) has brought out interesting features of these forests and stress the need for detailed investigation.

The sal forests of Bangladesh, India and Nepal have a facies of their own and the following generalisations for dipterocarp forests do not apply to them *in toto*.

As the synusiae are numerous in Tropical Rain Forests, their spatial arrangement is less obvious. However, with the "bewildering chaos of vegetation" (Richards, 1952), distinct patterns of special variation are discernible, implying an organised structure which lends itself to systematic vegetational studies (Singh, 1974).

Stratification, which is considered to be an important feature of the tropical rain forests, is clearer in manifestation in the dipterocarp forest. Wherever dipterocarps are present, the pattern of stratification is more easily conceivable and in fact they serve as indicators of the principal strata. For example, in the evergreen forests of Bangladesh, Burma and Andamans (India) *Dipterocarpus* spp., are invariably in the top canopy; in the evergreen forests of eastern India *Dipterocarpus macrocarpus, Shorea assamica* and *Vatica lanceaefolia* determine the strata; in the lowland evergreen forest of Western Ghats (India) *Dipterocarpus indicus, D. bourdilloni* and *Vateria indica* are the indicators of stratification. It is possible to distinguish five layers in the evergreen and to some extent semi evergreen forests of Bangladesh, Burma and eastern India and Andaman Islands (India). In similar forests of Western Ghats (India) there are only three layers. In Sri Lanka, although there is stratification, it is often difficult to distinguish the layers. One of the interesting features in all these forests is that the dipterocarps are invariably the indicators of the main strata. This is brought out in the profile diagrams for Andamans Semi-Evergreen Forests and West Coast Tropical Evergreen Forests of Kallar Valley (Western Ghats) which are representative examples.

A 'forest type' is an index of the cumulative effect of climatic and edaphic factors and the continuous variation within a tropical forest can be broken into fairly satisfactory descriptive entities by adopting forest type classification. Although, such a classification is extremely difficult in tropical forestry and a common platform for different schools of forest type classification is yet to be found (Arnaborg, 1960), satisfactory systems have been developed for the South Asian region and the dipterocarp forest broken into distinct forest types.

In Bangladesh the dipterocarp forest can be considered under (a) Tropical Moist Deciduous Forest and (b) Tropical Evergreen forest. ***Shorea*** *robusta* is the principal component of the former and the other dipterocarps are confined to the latter (Champion, 1936). The Tropical Evergreen Forest has been subdivided into

i) Chittagong Tropical Wet Evergreen Forest

ii) Chittagong Tropical Semi-Evergreen Forest and

iii) Chittagong Garjan Forest.

There is considerable overlapping as the Tropical Evergreen Forest is confined to a small area in and around Chittagong.

In Burma dipterocarps are found not only in the Tropical Evergreen Forest, Tropical Semievergreen Forest and Moist Deciduous Forest, but also in Dry Deciduous Forest. *Dipterocarpus obtusifolius, D. tuberculatus* and *Shorea siamensis* spread into very dry areas. There is a graded series of formations with typical wet evergreen forest at one end and dry scrub forest at the other extreme. It is significant that dipterocarps extend from one and of this graded series of formations to the other (Stamp and Lord, 1923; Hundley, 1961).

Champion and Seth (1968) have divided the forests of India into six major types.

1. Moist Tropical Forests
2. Dry Tropical Forests
3. Montane Sub Tropical Forests
4. Montane Temperate Forests
5. Sub Alpine Forests
6. Alpine Scrub.

Each of these Types is divided into Groups and Sub Groups. The dipterocarps are confmed to Moist Tropical Forests with exceptions like ***Shorea robusta. S. roxburghii, S. tumbuggaia et al.*** Dipterocarps other than ***Shorea*** are mostly found in the Groups, Tropical Wet Evergreen Forests and Tropical Semievergreen Forests, in three distinct zones. The sub groups are summarised in the table.

In Nepal the only dipterocarp, ***Shorea robusta*** occurs in Moist Deciduous Forests.

The natural vegetation of Sri Lanka has been classified into seven major groups (Andrews, **1961**).

1. Tropical Thorn Forest
2. Tropical Dry Mixed Evergreen Forest
3. Tropical Lowland Semi-Evergreen Rain Forest
4. Lowland Wet Evergreen Forest
5. Highland Wet Evergreen Forest
6. Tropical Montane Forest
7. Grass land

The dipterocarps are mostly confined to Lowland Wet Evergreen Forest and Highland Wet Evergreer Forest. Some species extend ment practices can be reformed to save the magnificient dipterocarp forests. **As** pointed out by Golley and Medina **(1975)** tropical ecology is plagued with a number of general. isations pertaining to inherent uniformity, stability of climate, closed nutrient cycling etc. In view of these generalisatons, there is a feeling of complacency as far as the tropical rain forests are concerned. The variations in composition, and 'ecosystem functions' in these forests are adequate proof to show that into Tropical Lowland Semi-evergreen Rain Forest and Tropical Montane Forest also.

Ecological studies in the tropics have gained a new momentum and several aspects of ecological problems in the South Asian region are receiving attention from investigators. But, these investigations are mostly confined to the forests in plains and except for ***Shorea robusta*** in India, Bangladesh and Nepal, much attention **is** not being paid to other dipterocarps. In Sri Lanka, however, dipterocarp zone **is** getting some attention

Type – Moist Tropical Forests
(Adapted from Champion & Seth, 1968)

Group	Sub Groups: North East India	South West India	Andamans
1. Tropical West Evergreen Forests	a) Assam Valley Tropical Evergreen Forests h) Cachar Tropical Evergreen Forests	d) Southern Hill-top Evergreen Forests e) West Coast Tropical Evergreen Forests f) West Coast Semi Evergreen Forests	i) Andaman Tropica1 Evergreen Forests
'. Tropical Semi Evergreen Forests	c) Cachar Semi Evergreen Forests	g) Tirunelveli Semi Evergreen Forests h) West Coast Secondary Evergreen Forests	j) Andaman semi Evergreen Forests

and it is hoped that much of the complex problems of the ecosystem will come to light soon. There is an urgent necessity to understand the intricate ecosystems of the rain forests in general and the dipterocarp communities in particular. It is only when the complex problems of these communities are well understood, that forestry manage- these generalisations are not valid. Hence, it is important that ecological investigations are intensified to unravel the complexities of these plant formations.

SILVICULTURE AND MANAGEMENT

The dipterocarp forests of the region consist of a number of plant formations differing in floristic compositions and association patterns. It is mainly the *Shorea* forests, which differ in structural details from the other dipterocarp forests. Mature or primary dipterocarp forests are extremely complex plant communities and "exist in a delicate but stable equilibrium with the other components of the ecosystem, climate, soil and animals" (Richards, 1952). Very little is known of the past history of these forests but it may not be incorrect to believe that they have persisted, changing perhaps siowly from the very remote past. After existing in a state of equilibrium for thousands of years, the eco-system has very recently (within the last 150 years) been subjected to massive disturbances, in the nature of wholesale destruction for agriculture and horticulture, excessive removal of commercially utilizable timber and alteration by improper systems of management. While the feeble cry of naturalists for total preservation of what is left of these forests is appreciable and commendable, it is doubtful whether such a demand is justified in the context of the growing demand for what these forests give out for human welfare. It is there that the role of management comes in. Evidences are not lacking to show that a managed ecosystem delivers the direct and indirect benefits to mankind in a better manner than a preserved ecosystem, without basically destroying the structure. The important conclusion has not been tested in a dipterocarp ecosystem but there is no reason to believe that despite its complexity and delicate ecological stability, these forests cannot withstand the shocks of well developed management practices. As the claim for total preservation may not generally be acceptable, it is in an appropriate understanding of the silviculture and stablislisation of management practices that the future of these magnificient forests lies. Apart from the biosphere reserves where total preservation is a "must", whatever is left of these forests deserve to be treated with greater respect and management systems applied with caution and expertise.

Phenological **and** Silviculatural characters

Most of the dipterocarps are wholly evergreen and the others are near the "border line between evergreen and deciduous, approaching the former state in moist localities and the latter in poor dry situations, while certain of these become wholly deciduous in dry regions" (Troup, 1921). Flowers are conspicuous as in *Dipterocarpus* (and few of them are scented too) or small but in very large numbers as in *Shorea* and *Hopea.* Fruiting is erratic and every year is not necessarily a good fruiting year. Germination is either hypogeous *(Dipterocarpus. Shorea)* or epigeous *(Hopea).* Viability in almost all cases is very low which is a factor of importance in preparations for natural regeneration and artificial regeneration operations. Added to this is the problem of irregular and at times inadequate fruiting which causes despair to the field forester.

All the dipterocarps are mesophytic. However, for descriptive purposes they are sometimes categorised as hygrophilous and xerophilous types (Troup, 1921). The former found in moister localities are invariably sporadic and the latter, often gregarious adapted to moderately or even typically dry localities. Some examples from the region are

Hygrophilous	Xerophilous
Dipterocarpus baudii	
D. bourdilloni	
D. indicus	*Dipterocarpus tuberculatus*

D. macrocarpus	*D. obtusifolius*
Hopea odorata	*Shorea obtusa*
H. parviflora	*S. roxburghii*
Parashorea stellata	*S. siameizris*
Shorea assamica	*S tumbuggaia*
Vateria indica	

The details of leaf shedding, flowering and fruiting collected from published literature, working plans, field observations etc., are summarised in the table.

Number of fruits (seeds) per unit weight is a very useful information to plan nurseries. Available information is presented below.

Species		Average No. of fruits per Kg.
Dipterocarpus alatus	..	130
***D.** costatus*	..	420
D. gracilis	..	150—200
D. grandiflorus	..	45
D. indicus	..	175
D. macrocarpus	..	105
D. turbinatus	..	155
Hopea odorata	..	4225
H. parui'ora	..	2465
H. utilis	..	225
Shorea assamica	..	485
S. robusta	..	530—770
S. roxburghii	..	880
S. tumbuggaia	..	460
Vateria indica	..	60

Regeneration

The silviculture and regeneration of the complex multistoreyeddipterocarp forests are difficult and complicated on account of the following factors:

i) Complexity of structure with varying demands on growth promoters like light, etc. In any regeneration operation, it is not the aim to reproduce the vegetal formation, but to favour the economically important species which are few in number. Thus, the percentage of profitably removable stems of exploitable species to the total number of all stems, or the intensity of commercial exploitation, is low. The number of overmature, defective, unsound, hollow, crooked and moribund stems of exploitable species is large. The manipulation of operations to provide conditions conducive to regeneration of favoured species is thus difficult.

ii) The exploitable species in the top canopies are frequently light demanders requiring almost complete removal of overhead shade after the seedlings stage, although some species of *Dipterocarpus* may tolerate shade up to pole stage. This requires a continuous manipulation of the canopy to pro. vide adequate light and the operations are beset with practical difficulties.

iii) Good seed years of the favoured species are irregular and infrequent. Seeds lose their viability rapidly and unless there is a happy coincidence of good seed fall, adequate rainfall following seed fall, and thoughtful advance preparations for regeneration, there is little hope of satisfactory regeneration.

iv) With the partial removal of the overhead canopy, there is normally a dense and profuse undergrowth which inhibits germination and further growth of seedlings, unless frequent weedings are resorted to.

While the above handicaps offer a challenge to natural regeneration, artificial reproduction is still more difficult because of the low viability of seeds, sensitivity to transplantation, light requirement at various stages of growth and purely economic reasons due to the very long gestation period for returns to the initial capital investment.

Despite the above difficulties, shortcomings and challenges, successful attempts to regenerate the dipterocarp forests have been made which lend strength to the hope of perpetuation of at least some of the species.

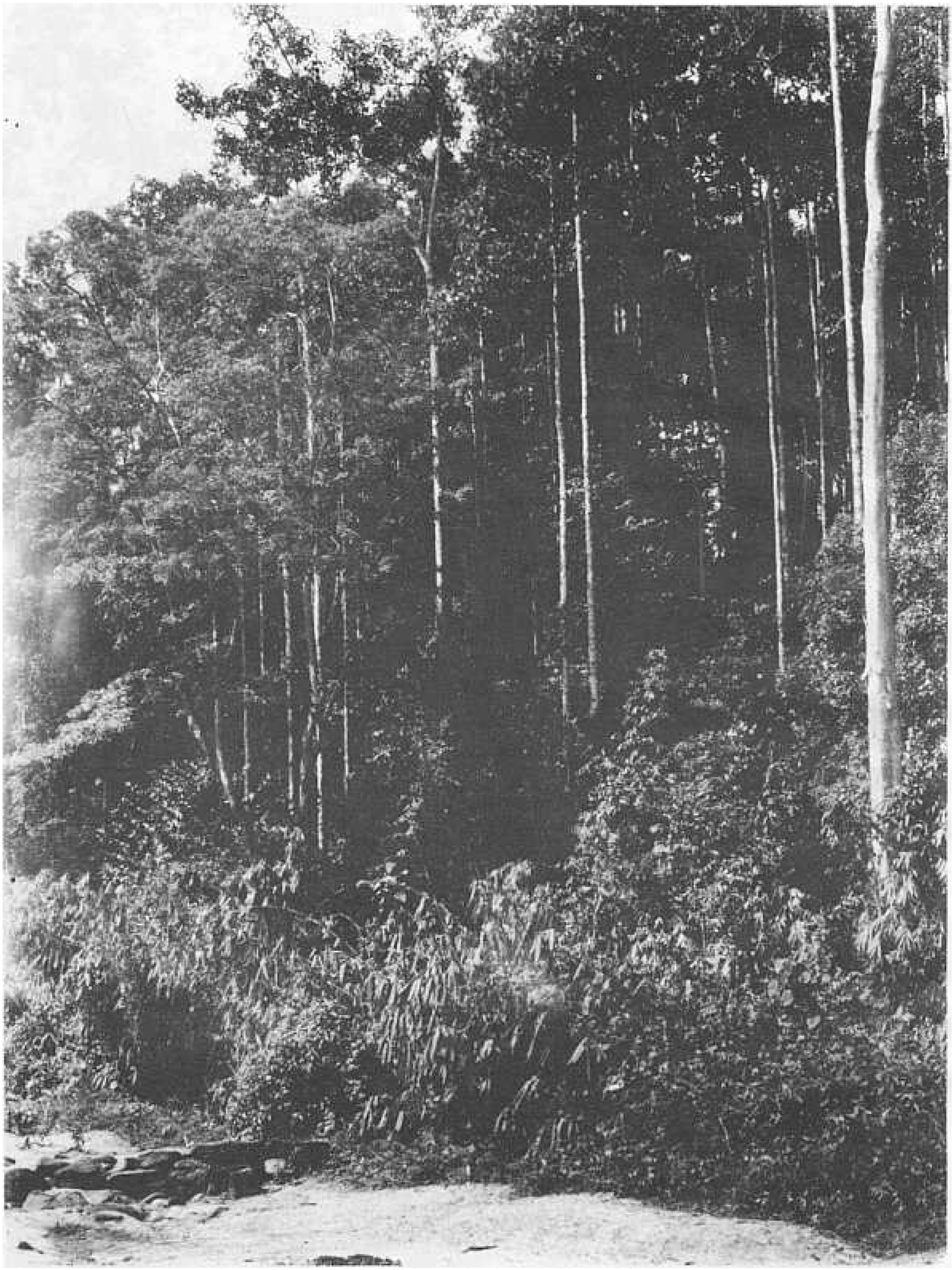
The systems of regeneration in vogue in the South Asian region can be broadly classified as follows:

1. Natural regeneration
   a) Monocyclic systems
   b) Polycyclic systems
2. Aided natural regeneration
3. Artificial regeneratron

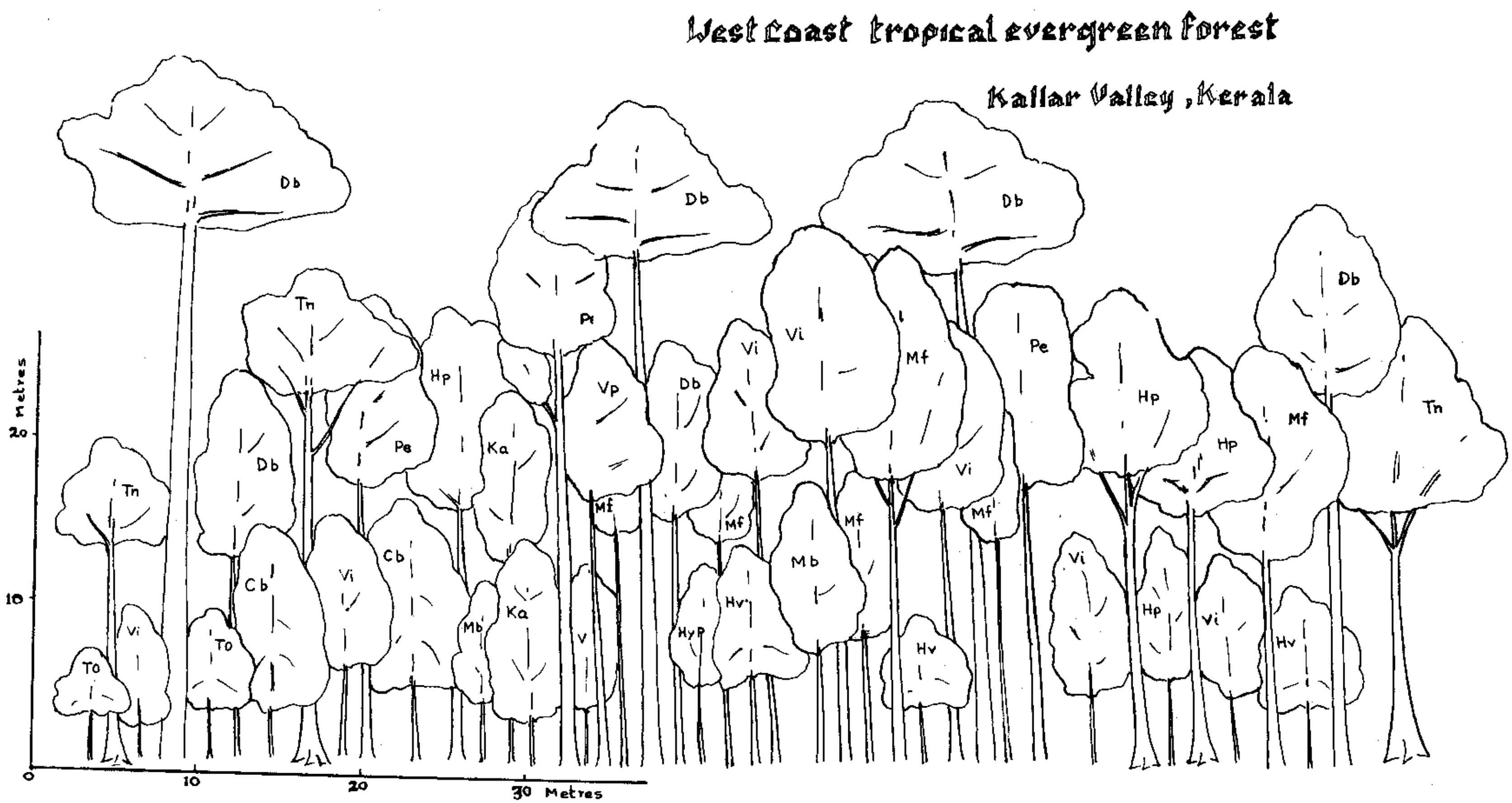
Stratification

in

***Dipterocarpus macrocarpus* forests of Assam (India)**
(Photo FRI)



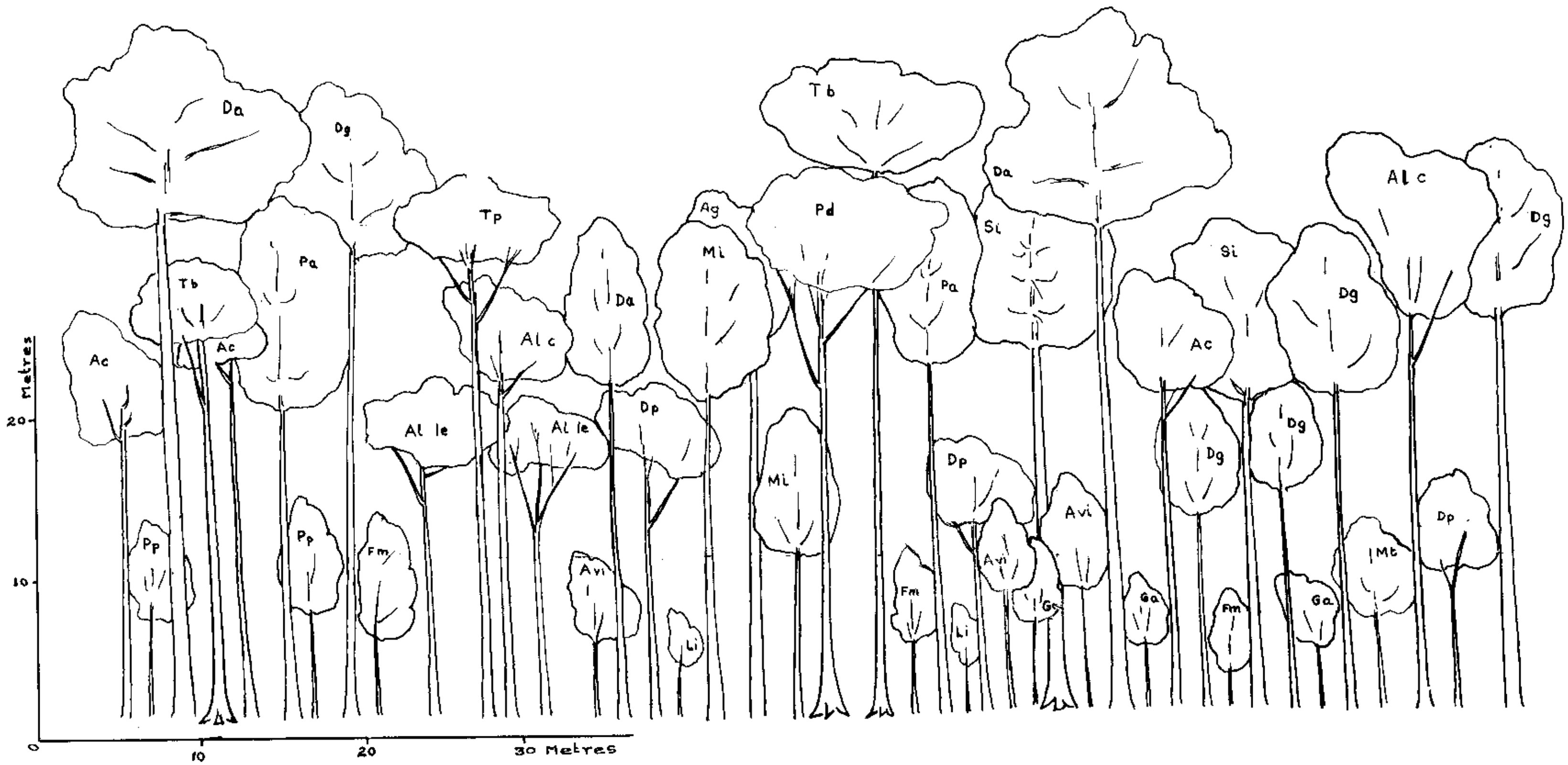
Low Land Wet Evergreen Forest
A General View Kottawa
(Photo FD Sri Lanka)



Legend

A l c	*Albizzia chinensis*	G a	*Garcinia andemanica*
Al le	*A. lebbeck*	L i	*Leea indica*
A vi	*Aporosa v i h a*	M i	*Myristica i y a*
A c	*Artocarpus chaplasha*	M t	*Macaranga tatiarius*
A g	*A. gomezrana*	P P	*Pometia pinuata*
D a	*Dipterocarpus alatus*	P d	*Pterocarpus dalbergioides*
D g	*D. gracilis*	P a	*Pteygota alata*
D P	*Dillenia pentagyna*	T b	*Terminalia bialata*
F m	*Fagraea morindaefolia*	T P	*T. procera*

Andamans semi-evergreen forest



Legend

C	b	*Carallia brachiata*
D	b	*Dipterocarpus bourdilloni*
H	p	*Hopeaparviflora*
H	v	*Humboldtia vahliana*
Hy	p	*Hydnocarpus pentandra*
K	*a*	*Knema attenuata*
M	b	*Myristica beddomei*
M	f	*Mesua ferrea*
P	*e*	*Palaquium ellipticum*
T	n	*Tetrameles nudiflora*
T	*o*	*Trema orientalis*
V	i	*Vateria indica*

Regeneration
of
Dipterocarpus turbinatus* and *Gmelina arborea
alternate lines 1.83m apart
Chittagong Hill tracts Bangladesh

PHENOLOGY			
Species	**Leaf** shedding	Flowering	Fruiting
Anisoptera *oblonga*		December—January	April—May
A. *scaphula*		April—May	June—July
Balanocorpus **erosa**		May	August—September
Cotylelobium lewisianum		,January	AprilLMay
C. *scabriusculum*		.4pril-May'	
Dipterocarpus alatus		January—March (Bangladesh & India) Deccmber (Burma)	March—May
D. bourdilloni		January-February	April—May
D. costatus		December—January (Bangladesh & Burma) March (Andamans, India)	.4pril-May (Bangladesh & Burma May—June (Andamans, India)
D. *gracilis*		December—January	May—June
D. *grandiflorus*		January March (some timesin Andamans)	May-June
I). ***glandulosus***		March—April	May—July
D. *hispidus*		April	May—June
D. *indicus*		December—January	April—May
D. *insipis*		April	May—July
D. kerrii		February	April
D. *macrocarpus*		April—May (Burma) January-. February (India)	June—July (Burma) March (India)
D. *obtusifblius*		November—January	March—April
D. *tuberculatus*	February—March	March—April	May
D. turbinatus	December (Andamans, India)	January—March (Andamans, India) March—April (Eastern India and Bangladesh)	May—July
D. zeylanicus		January- February	April—May
Hopea *brevipetiolaris*		April—June	July—September
H canarensis	March	April—May	July—August
H. *cordifolia*			
H.. discolor		April	June—July
H *glabra*		January-March	June—July
H. jucunda		April	May—June
H. *minutiflora*		March	
H . *oblotigifolia*		January—February	April-May
H. *odorata*		March- April (Burma) February- March (Andamans. India)	May—June
H. *parviflora*		January- March	May-June
It. *racophloea*		April—May	July—August

Species	Leaf shedding	Flowering	Fruiting
H. shingkeng		August-Septcmber	December—Fehruary
H. utilis		March—April	
H. wightiana		March- April	May—June
Parashorea stellata		March—April	April—May
Shorea affinis		April—May	May—June
S. assamica		August—October	January—February
S. congestiflora		Auguat-Sep tcmhcr	Scptembcr—November
S. cordifolia		March—April	
S. dyeri		January	
S. farinosa			June
S. gardneri		November—February	February—May
S. lissophylla		April	May—June
S. megistophylla		February—April	April—Ma):
S. oblongifolia		April—June	May—July
S. obtusa	March	March—April	May-June
S. ovalifolia		April—May	
S. robusta		February—April	April—June
S. roxburghii		December—March (Burma) February—March (India)	April-May (Burma) April—May (India)
S. siamensis	January—February	March	May—Junc
S. trapezifolia		April	August
S. tumbuggaia	February—March	March—April	June—July
S. worthingtoni		April	
S. zeylanica		March—May	May—July
Stemonoporus acuminatus		Sporadically at all times	
S. affinis		Sporadically at all times	
S. canaliculatus		April	May—June
S. ceylanicus		April	
S. cordifolius		April	
S. elegans		April	
S. gardneri		January—March	March—May
S. 1anceolatus		April	April
S. lancifolius		May	,July-Augu.it
S. nitidus		April	May—Junc
S. petiolaris		May	July
S. reticulatus		Scptembcr	Octobcr-Novcmbcr
S. revolutus,		Sporadically at all times	
S. rigidus		April	June—July
Vateria copal+ra		January-Fcbruary	April—May
V. indicn		January—March	May—July
V. macrocarpa		March	June
Vatica affinis		March	May-June
V. chinensis		February-March **(India)** May **(Sri I.ankii)**	June (India)
V. lnnceaefolia		May	J illy—August
V. obscura		May—July	August—Septcm ber

Natural regeneration

The natural regeneration techniques applied to dipterocarp forests belong to either monocyclic or poly-cyclic systems. In the monocyclic system all merchantable trees of and above a prescribed girth limit are removed in a single operation and the length of the cycle is approximate to the average rotation age of the trees. Except in those cases where merchantable trees are few and far between, the effect on the forest is rather drastic and the canopy is extensively altered and big gaps formed. The monocyclic systems are better known as Sbelterwood systems, and the aim is to obtain a fairly uniform crop for the subsequent harvest. Polycyclic systems are based on the principle of repeated removal of marked trees at predetermined intervals, called felling cycles, whose length is a sub-multiple of the computed rotation age of the principal species of trees. They aim to remove trees before they begin to deteriorate, leaving all appreciating stems to register increment.

Because of the relatively small number of valuable species and their availability in maturity classes, the poly-cyclic system is more expensive than the monocyclic system, but it has the advantage that the canopy is not disturbed drastically.

The crucial matter in the opera.tion of a polycyclic system, according to Whitmore (1975), is to control the damage to me regeneration at each felling cycle: Several other factors make polycyclic systems difficult to operate. Inadequate openings due to the removal of very few trees impedes regeneration and lessens girth increment of advance growth.

When an examination of the systems of regeneration in vogue is made against the above background, it is found that both monocyclic and polycyclic systems have been tried for a long time and some intricate combinations have also been attempted.

Monocyclic systems

Burma and the Andaman Islands (India!

The practice followed is more or less similar in Burma and Andaman Islands with minor modifications. The procedure followed can be summarised as follows (adapted from Banerjee 1954):

E-1 a) Climber cutting

b) Enumeration of commercial trees

E
(Year of Exploitation)

a) Extraction of commercial trees of and above the prescribed girth limit

b) Formation of a high canopy by girdling or felling noncommercial trees in the prescribed pattern (Canopy lifting).

R
(Year of Regeneration)

a) Preparation of seed bed

b) Second canopy lifting

R+1 Tending, cleaning and climber cutting, weeding.

R+2 – do –

R+5 or later Final canopy lifting, thinning (if necessary).

The object of the system is to regenerate the forests aiming at a mixture comparable to the natural forests of the locality, but with a greater proportion of the more valuable species, without fundamentally altering the eco-system. The history of the evolution of this system in the Andaman Islands is inteteresting and throws light on the painstaking efforts which made a standardization of the technique possible. Here, natural regeneration was first attempted in 1912 which consisted of weeding the gaps created by the felling of trees. As no pre-regeneration preparations were made, there was hardly any regeneration and it was impossible to suppress weed growth. These experiments were continued till about 1921 when it was concluded, with despair, that natural regeneration of the forests was impossible (Chengappa, 1937; 1944a, b, c, d, 1952). Trials were again initiated in the thirties. Early attempts resulted in the regeneration of predominantly deciduous species in the dipterocarp forests resulting in major changes in composition. In 1933, in an experimental area, cautious fellings of commercial trees were done and the canopy lifted to about 13 metres and all undergrowth was removed. Similar experiments were carried out with varying heights of canopy lifting. It was ultimately found that the canopy should first be lifted only up to 6 to 10 metres in the initial stage and then drastically after the regeneration has survived at least one summer. The final canopy lifting is carried out after the fifth year of regeneration.

Polyeyelic Systems

These systems are more commonly practised in the region. The techniques vary from classical selection fellings to concentrated fellings at long or short intervals. In general, the technique consists of the **suc**cessive removal of commercial trees against the rigid requirement of several safeguards. There is wide variance in the intensity of the initial fellings. The fellings are followed by tending operations to encourage advance growth and ***de*** *nouo* regeneration.

a) Kerala, India (Chandrasekbaran 1960; Iyppu, 1960; Nair, 1961)

The method adopted is a cautious selection felling. Prescriptions for supplementing the natural regeneration by artificial means are also made in various working plans. The felling cycle adopted is between 15 to 45 years. About 10 – 12 trees are marked for removal per hectare, subject to the condition that they are above the prescribed girth limit (normally 180cm for dipterocarps), and that the number of trees per hectare does not exceed the laid down limit.

b) Karnataka, India (Stracey, 1959)

The technique followed is similar to Kerala but the felling cycles are usually 30 years.

c) Assam, India (Srinivasan, 1951; Stracey & Saikia, 1960)

Selective fellings have been in vogue since regeneration of the forests commenced.
since the regeneration of the forests commenced.
Trees of and above the prescribed girth limit, varying from **2** to **3** metres, are removed in a felling cycle of ***25*** years. In some areas the felling cycle is reduced to 12 years.

Sri Lanka (de Rosayro, 1955; Forest Dept. Report, 1970)

Selection fellings are carried out in a cycle of 10 years (which may be reduced on the basis of enumerations to be carried out every 6th year) and trees of and above 1.5m girth are marked for felling. Fellings are followed by intensive tending operations to encourage regeneration. Advance growth of commercially important species, particularly ***Dipterocarpus zeylanicus,*** is maintained. During selection fellings first preference is given to overmature, defective and unsound trees. While marking, attention is paid to see that mother trees are at least 60m apart, and are felled only after regeneration is ensured.

Aided natural regeneration

This technique is practised in conjunction with the polycyclic system in Bangladesh and parts of India. Whenever gaps are created by fellings and natural regeneration is desired, seeds are broadcast-sown or dibbled. Wildlings (naturally grown seedlings from areas where their future growth is rendered doubtful due to suppression) and nursery grown seedlings are also planted out and weedings carried out to ensure the success of artificially raised seedlings. This technique, sometimes called “Gap regeneration”, has been successfully tried where natural regeneration was deficient. In Bangladesh, line sowings under the natural forest canopy are also in vogue.

Artificial Regeneration

Artificial regeneration of dipterocarps is not very widely practised except in respect of ***Shorea*** *robusta*. Different methods of artificial regeneration have been tried. The various techniques can be conveniently classified as follows:

i) Clearfelling followed by artificial regeneration
ii) Regeneration through artificial enrichment of the forest
iii) Raising plantations under top canopy

The first method is really not regenerating a dipterocarp forest with dipterocarp species. The original character of the forest is completely lost by planting entirely different species. In Bangladesh, wherever the polycyclic method of regeneration does not yield a satisfactory result, the natural stand is completely replaced by planting Teak or other species. The argument for adopting such a system **is** that the heterogeneous stand of dipterocarp forest is less valuable and perpetuation of the same character of the forest will continue to keep its value low. The cost of natural regeneration is also found to be high as compared to teak plantations with *taungya* (Ghani, 1956)

The second method consists of opening strips of variable width and broadcasting seeds or planting seedlings of several species among which are dipterocarps. In this system, the original character of the forest is maintained, although non-dipterocarp species may get preference because of the easier availability of their seeds and seedlings. The system has been recently tried in Sholayar forests of Kerala (India) and the results are not disappointing. Artificial regeneration of *Hopea* has been tried in "tunnels" (cleared strips) in Karnataka. For this purpose 3 – 5 metre wide strips are cleared of undergrowth. Besides ***Hopea,*** non-dipterocarp species like ***Mesua ferrea,*** *Artocarpus hirsuta,* etc., are also planted. Intensive cultural operations are continued till regeneration establishes itself. Planting *Hopea parviflora* under top canopy after clearing the undergrowth has given better results. In Bangladesh, the natural forest is clearfelled, leaving strips 80 – 100 m wide. In these strips of natural forest, na'tural regeneration operations are carried out to encourage advanced growth. Sowings of dipterocarp seeds are also undertaken periodically. In the clearfelled area seedlings of dipterocarps and other species like ***Gmelina arborea*** raised in nurseries are planted in line.

The third system is the most common artificial regeneration technique in Assam (India). In the earlier experimental days, small plots under forest canopy of moderate density were chosen and staked out all over at an espacement of **3** metres, after throughly clearing the weeds. Soil working was done in patches 0.33m in diameter and seeds of *Shorea assamica* were dibbled soon after collection. Seeds of' *Tephrosia candida* were sown around each patch to keep down the weed growth. Results were encouraging. With suitable modifications, this system has been applied with success for regeneration of *Dipterocarpus macrocarpus* and *Shorea assamica.* This **is** perhaps the single example of an organised "plantation" of dipterocarp other than *Shorea robusta* in the South East Asian region.

In Karnataka (India), underplanting of *Hopea parviflora* has been successfully tried. The top canopy is removed after the crop reaches near-pole stage.

In Karnataka and Kerala (India) another common method is the sowing of seeds in gaps created by the felled trees. This is different from aided natural regeneration in the sensc that no attempts are separately made to naturally regenerate the forests. Operations are limited to the sowing of seeds of species like ***Hopea*** *parviflora* and *Vateria indica,* along with many other evergreen species, in the gaps. Weeding is continued to free the successfully germinated seedlings. At the pole stage, the lower and intermediate canopies are removed.

I[is c)nly *Shorea robusta* among the dipterocarps, which is raised in large scale plantations. 'The regeneration methodologies for this species are discussed elsewhere.

WOOD

The South Asian dipterocarps constitute an important group of timber yielding trees with several end uses. Many of them are known in trade by different names such as Sal (Shorea robusta), Gurjan, Garjan, Hollong, Kanyin (Dipterocarpus spp.), Mekai (Shorea assamica) and Thingan(*Hopea odorata)*.

An important diagnostic feature of the dipterocarp wood is the presence of longitudinal resin canals which are frequently filled with white deposits. These canals are usually arranged in concentric arcs, though at times they may be found diffused. They are lined with thin epithelium. The growth rings are indistinct and the vessels range in size from extremely large to small. Tyloses often fill up the vessels. Various types of parenchyma are conspicuous as diffuse to irregular reticulum. Fibres vary from fine to extremely coarse and in heavier timbers, their walls are remarkably thickened and their lumen very narrow. Rays range from fine to moderately broad and vary greatly in length. The occurrence of Silicon dioxide and oxalate crystals is also a characteristic feature.

Sapwood and heartwood are usually indistinguishable and the variation in colour *is* extensive, the predominant colours being shades of yellow and reddish brown. The wood may be lustrous or dull. They are moderately hard and heavy to very heavy, the specific gravity ranging from about **0.5** to 1.00. Seasoning is often difficult and treatability restricted to only a few species. While many of them are fairly durable under cover, a few are durable in all situations.

While sal is one of the outstanding timbers of the region, Dipterocarpus timbers rank high in the plywood industry. They are excellent for veneering and the plywood industry in the region largely depends on them. After treatment, a number of dipterocarps are used as railway sleepers. A few species of Anisoptera, Dipterocarpus and Shorea are used for dug-outs and some Hopea species are useful in boat building. The wood of Vateria *macrocarpa* and Shorea stipuluris are reported to be usable in the match industry and the latter for manufacturing pencil slots also. Strong, heavy and durable timbers of some species of Dipterocarpus, Shorea and Vatica are suitable for jetty piles, posts, poles and in bridge construction. They are also used for a variety of purposes such as general construction, wagon building, low grade furniture, etc.

In short, the timbers of this family show a great range of variation in structure and properties, thus making them suitable for a number of end uses. A comparison of the properties of some of the important dipterocarps with teak helps in the understanding of their qualities as timber.

NON WOOD PRODUCTS

Oils and resins are important minor forest products obtained from dipterocarps, but their commercial utilisation is limited. They are known in trade as Gurjan oil, In oil, Chua oil, White dammar, Rock dammar, Sal dammar, etc. The methods of tapping resin varies considerably. The resin which exudes out is removed and the wound freshened periodically. Dry weather is generally preferred for tapping. Rock dammar obtained from Hopea *odorata* is used in the preparation of varnishes. Sal oil from seeds of Shorrea robusta has found a ready market within the region and abroad. India, for example, exported about 2,600 tonnes of sal oil during 1975—'76. Sal fat is a substitute for cocoa-butter and is used in confetionery. Sal seeds have good food value. The leaves and bark of species of Hopea, Shorea, Dipterocarpus, etc., are good sources of tannin. Thus, with a variety of end uses ranging from simple usage of bark, leaves, etc., by tribals to complex derivatives for industries, the non-wood products have considerable value.

Properties of Important Dipterocarps Expressed as Percentage of the Same Properties of Teak

Sl No.	Name of species		Weight	Strength as a beam	Stiffness as a beam	Suitability as a post	Shock resistance	Retention of shape	Shear	Hardness
1	*Dipterocarpus alatus*									
		a) India	100	90	100	90	95	60	105	85
		b) Burma	100	93	104	93	86	62	90	78
2	*D. bourdilloni*		103	96	117	94	78	58	74	67
3	*D. grandiflorus*									
		a) India	110	85	100	90	80	45	100	85
		b) Burma	113	107	123	112	91	50	95	89
4	*D. indicus*		110	110	145	120	105	45	100	85
5	*D. kerrii*	a) India	115	95	125	100	115	45	105	85
		b) Burma	117	98	130	102	105	. .	96	79
6	*D. macrocarpus*		107	103	124	107	95	54	91	89
7	*D. tuberculatus*		125	119	127	103	131	61	111	122
8	*D. turbinatus*		115	105	125	100	115	55	90	105
9	*Hopea glabra*		150	130	137	132	144	65	157	205
10	*H odorata*	a) India	110	100	100	95	100	75	110	130
		b) Burma	111	104	102	100	92	81	95	121
11	*H. parvif7ora*		136	126	125	123	119	70	132	82
12	*H. utilis*		146	149	154	142	158	67	151	213
13	*Shorea assarnica*		81	67	83	75	67	71	93	67
14	*S. obtusa*		155	140	158	143	140	58	131	180
15	*S. robusta*		120—30	105—20	110—30	105—20	115—45	55—60	110—50	120—70
16	*S. siamensis*		135	117	132	116	113	62	113	142
17	*Vateria indica*		86	75	100	85	65	50	80	60

Anisoptera

CHAPTER 111

ANISOPTERA Korth.

Moderate to large sized trees. Bark surface grey, often fissured. Twigs glabrous or with fascicled hairs. Leaves entire, finely reticulate; petiole slender, stipule small, caducous. Flowers in axillary or terminal racemes or panicles. Calyx cup shaped or deeply cleft; lobes unequal or subequal. Petals glabrous or thinly pubescent, white to yellowish white. Stamens 15 – 25; anthers with short or filiform awn. Ovary subglobose or conical crowned by stylopodium, style short, stigma 3 lobed Fruit belly ovoid to globular, crowned by calyx segments of which 2 are much enlarged (Hooker, 1874; Kurz, 1877 Symington, 1943).

Wood

Vessels moderately large, scattered, mostly solitary; fibres straight; parenchyma abundant, mainly diffuse, resin canals irregularly arranged. Wood yellowish grey to dark pinkish brown; straight to interlocked grained, coarse textured.

Uses

Good construction timber, suitable for plywood, boat building.

Distribution 3 species: Bangladesh, Burma and India.

ANISOPTERA CURTISII Dyer

Syn. ***Anisoptera*** *curtisii* Var. latifolia King.

Common name

Bur. Kahan – Kaunghmu

A moderate sized tree of about 2.5m girth. Bark surface dull grey brown; inner bark with yellow bands. Twigs slecder, stellate hairy towards the end. Leaves 7.5 – 10cm by 3 – 4.5cm, elliptic, ovate-oblong or oblong, acute, base rounded, glabrous above and softly hairy beneath; lateral nerves 12 – 25 pairs usually densely clothed with minute yellow scales; petiole about 1.5cm long, rough, with fulvous stellate hairs; stipule linear-oblong, caducous. Racemes axillary and terminal; flowers distinctly pedicelled, rather long. Sepals subequal, pubescent. Petals lanceolate, about 0.7cm long, creamy white. Stamens 25, anthers elliptical; connective prolonged into a filifom awn. Ovary subglobose; stylopodium as broad as the ovary, tomentose; style short, ***3*** fid, stigma minute. Fruit belly subglobose, shortly apiculate, 2cm in diameter; the 2 larger calyx lobes 4cm by 1.2cm, oblanceolate, rounded at apex; the 3 shorter lobes 1.2cm long, acuminate (Symington, 1943).

Distribution – Burma

Note:– This species has been reported from Burma (Hundley and Chit Ko Ko, 1961) but not well documented. Specimens could not be collected for detailed study.

ANISOPTERA OBLONGA Dyer

Syn. ***Anisoptera cochinchinensis*** Laness.
A. costata Pierre
A. *glabra* Pierre
Shorea neruosa Kurz

Common names

Bur.-Kaban, Kaban-bok, Kabansot

A large tree attaining a height of 30 – 10m and a girth of 3—5m with a straight hole for a considerable height. Bark surface brownish grey, deeply and boldly fissured; the blaze fibrous with fine light and dark brown layers. Leaves 10 16cm by 4.5 – 7.5cm, oblong or oblong-ovate or elliptic-oblong, rounded or acute, base rounded or almost cordate, glabrous above and pale beneath with numerous minute scales; lateral nerves 17 – 22 pairs, almost at right angles to the midrib and looping near the margin; petiole 1.5 – 2.5cm long, slightly thickened near the lamina; stipule linear-lanceolate, subfalcate, up to 1.2cm long, caducous. Panicle axillary; pedicel about 3mm long with fine tufts of hairs. Calyx deeply cleft, lobes ovate, the 2 larger ones blunt and the 3 smaller ones pointed. Petals oblong, white, thinly pubescent on the exposed part in the bud. Stamens about 25; anthers minute, furnished with slender awns. Ovary pubescent, crowned by the cylindrical stylopodium, terminating in 3 pointed styles. Fruit belly about 1.2cm long, more or less ovoid; the 2 larger calyx lobes ahout 10cm long and 1.2cm wide, strongly 3 nerved with somewhat oblique transverse veins; the 3 smaller ones about 0.7cm long, narrow and pointed (Parkinson, 1935).

Distribution – Burma

Found in the moist localities from Ataran to Mergui and to the Victoria point in the southern part of Burma.

Forest Types and Floristics

The species occurs scattered in the Evergreen Dipterocarp Forest (Champion, 1936), where the mean annual rainfall is over 250cm. The top canopy is almost all evergreen and unbroken. The differentiation into definite canopy layers is not often obvious.

Floristics

Ataran

I *Dipterocarpus alatus, Hopea odoratu, Mungiferu caloneuru, Purashorea* ***stellutu,*** *Anisoptera oblonga, Calophyllum* spp., *Pentuce burmanica.*

I1 *Toona* sp., *Syzygium* spp., *Livistonu speciosa.*

111 *Strobilunthes* sp., *Licuala peltuta, Pandunus* sp.

Silviculture and Management

Being scattered in the luxuriant Evergreen Dipterocarp Forest, natural regeneration is scanty and no special treatment has been adopted to induce regeneration.

Wood

Structure

A diffuse porous wood, vessels large to small, moderately numerous, 4 – 18/mm2, more or less uniformly distributed, occasionally aligned in oblique lines, solitary or in radial multiples of 2 – 3, round to oval; sometimes filled with tyloses.

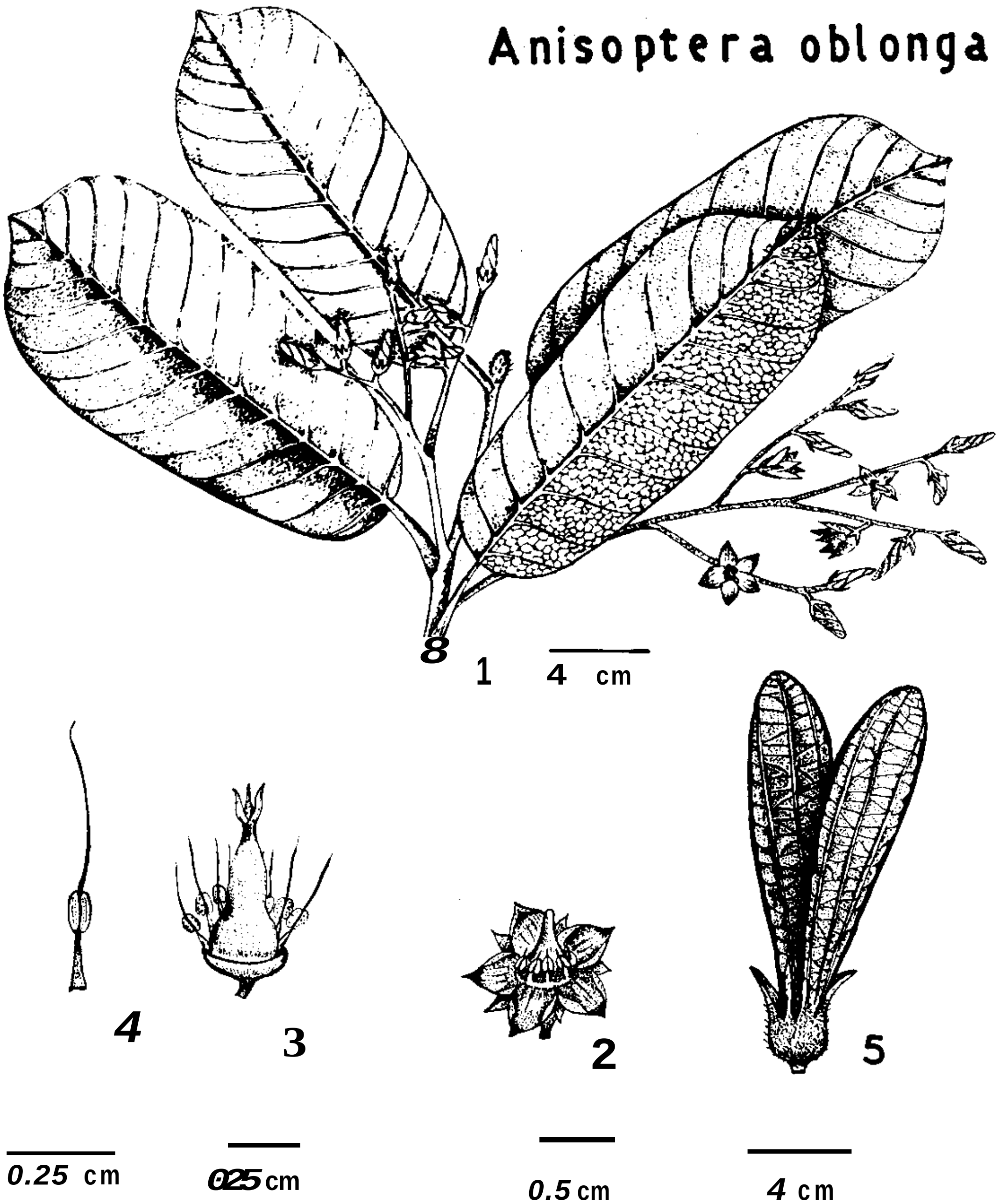
Rays broad to fine, not closely spaced, evenly distributed.

Resin canals small to very small, few and irregularly arranged, .mostly solitary, occasionally in groups of 2 or more in long tangential bands; white deposit present (Chowdhury and Ghosh, 1958).

Properties

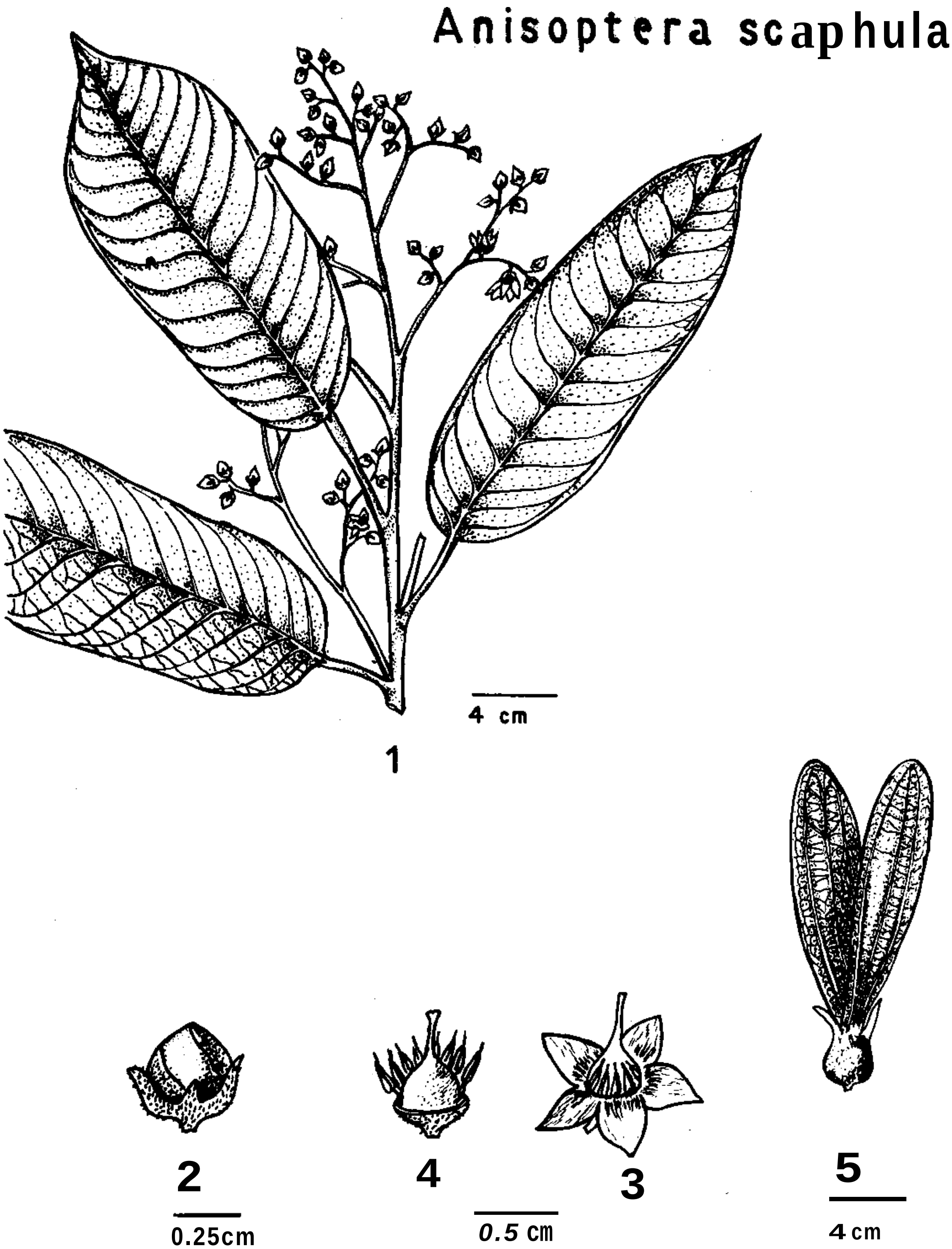
Wood a pale yellow to brownish yellow, turning brown to dark-pinkish brown; usually odourless hut fresh wood has a slight resinous smell; straight to interlocked grained, coarse textured, moderately hard and heavy.

Seasons slowly without developing serious defects; slight walping and surface cracking may, however, occur. When fully seasoned the timber is reported to retain its shape well. Not durable in exposed conditions, but fairly durable under cover and in contact with water. Easy to work and usually finishes to a lustrous smooth surface, except when extensively twisted-grained (Chowdhury and Ghosh, 1958).



Anisoptera *oblonga*

1. **Flowering shoot**
2. **Flower**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**



Anisoptera scaphula

1. **Flowering shoot**
2. **Flower bud**
3. **Flower**
4. **Stamens and Pistil**
5. **Fruit**

Uses

As the species is restricted in occurrence, the timber is not of much commercial value. It is usable as plywood and as a construction timber. Formerly it was used for making canoes, dug-outs and boat building.

ANISOPTERA SCAPHULA (Roxb.) Pierre

syn. *Anisoptera glabra* Kurz
Hopea scaphula Roxb.
Scaphula glabra Parker

Common names
Beng. Boilam.
Bur. Kaunghmu, Taungsagaing.

A large resinous tree with a straight hole attaining a height of 30 – 45m and a girth of 3 – 4.5m. Bark surface grey with greenish or brownish patches, peeling off in irregular flakes, rather thick. Young twigs thinly hairy, soon becoming glabrous. Leaves 12 – 20cm by 3.5 – 6cm, oblong or elliptic-oblong or oblong-lanceolate, shortly acuminate, base more or less rounded, glabrous on both sides; lateral nerves 16 – 22 pairs, petiole 2.5cm long, stipule linear-oblong or lanceolate, up to 2cm long, caducous. Racemes terminal, puberulous, flowers very shortly pedicelled. Calyx cup shaped, grey pubescent, the lobes unequal. Petals oblong-rounded, yellowish-white, glabrous. Stamens 15 – 20 anthers with a short awn. Ovary conical, narrowed into a minutely 3 lobed style. Fruit belly globular, 1.2cm in diameter; the **2** larger calyx lobes linear-ohlong, bluntly rounded and up to 12cm long and 1.5cm wide, strongly **3** nerved; the **3** smaller lobes narrow and pointed (Parkinson, 1935).

Distribution – Bangladesh, Burma, India

The species is of restricted occurrence and confined to Chittagong in Bangladesh and fairly well distributed in Arakan Yoma, Pegu Yoma and Martaban in Burma. It is also found in Tenasserim in lower Burma up to an altitude of 700m. As far as India is concerned, the species is reported in isolated localities in Assam (Santapau and Henry, 1973).

Forest Types and Floristics

This species is found in Chittagong Tropical Evergreen Forest, Bangladesh (Champion, 1936), Evergreen Dipterocarp Forest and Eastern Tropical Evergreen Forest of Burma (Champion, 1936; Hundley, 1961). The chief features of these forest types are high rainfall, high humidity and well drained soil. The rocks are mainly tertiary sandstones and shales. The forest is luxuriant with dense crowns climbers and canes are abundant.

Floristics

(i) South Tenasserim,. Burma (Evergreen Dipterocarp Forest)

Dipterocarpus alatus, Parashorea stellata, Anisoptera scaphula, Hopea odorata, Pentace burmanica, P. griffithii, Swintonia floribunda. Melanorrhoea glabra, Mangifera caloneura, Syzygium grande, Dysoxylum grande, Michelia champaca. Artocarpus calophylla, Baccaured sapida, Cinnamomum inunctum (Hundley, 1961).

Pegu Yoma, Burma (Eastern Tropical Evergreen Forest)

I *Dipterocarpus alatus, D. turbinatus, Parashorea stellata, Hopea odorata, Anisoptera scaphula, Pentace burmanica.*

II *Swintonia floribunda, Artocarpus lakoocha, Myristica* sp., *Syzygium* spp.

Ill *Oxytenanthera* sp., *Dendrocalamus brandisii, Liruala* sp.

Silviculture and Management

Phenology

Flowering is from December to January and the fruits ripen during April–May.

Natural regeneration

The species is a shade bearer in the early stages hut requires diffuse light for its further development. Because of the scattered nature of distribution and the luxuriance of growth of tree species in its habitat, natural regeneration is poor. In the past, attempts had been made to supplement natural regeneration by planting out seedlings raised in nursery. 'But this practice is not common now. In experiments carried out at Dehra Dun with freshly collected seeds from Chittagong, it was found that when sown with the wings upwards, the seeds suffered a high percentage of casuality and the surviving seedlings were found to be twisted. Clipping the wings and sowing the seeds upside down registered a higher percentage of survival and stronger, straighter seedlings (Laurie, 1940) Germination generally commences within 2 weeks of sowing and is completed within a month. Germination success is usually poor, in open beds it being 20% and in shaded beds 35%. Watering should be regulated to avoid damping off of the seedlings. The seedlings develop a fairly large taproot and are rather difficult to transplant. Transplanting should be done as soon **as** the plants are big enough to handle, i.e. 12 – 15cm high. Ball planting is recommended. Transplanting should be avoided when there is no prospect of immediate rain (Homfray, 1935).

Wood

Structure

Wood is diffuse, porous, vessels large, often plugged with tyloses, solitary, occasionally paired, somewhat unevenly distributed; vessel segments long and perforations simple.

Tracheids sparse, with numerous oval to elliptical narrow bordered pits.

Parenchyma abundant; paratracheal parenchyma sparse; metatracheal parenchyma abundant, often zonate forming 1 – 2 seriate tangential rows; parenchyma surrounding resin canals present; Silicon dioxide particles found in parenchyma.

Fibres fine to medium, rounded in the transverse section, non-septate, interfibre pits sparse.

Rays medium to fine, not closely spaced, evenly distributed, 1-7 (mostly – 5) seriate, heterogeneous, pale yellow infiltration occasional.

Resin canals longitudinal, solitary or 2–3 contiguous, scattered or zonate in uniseriate or rarely biseriate tangential rows at irregular and often distant intervals (Gottwald & Parameswaran, 1966; Pearson & Brown, 1932).

Properties

Wood a pale yellowish-grey, turning to light yellowish brown on exposure, lustrous when first exposed, interlocked grained, even and coarse textured, light to moderately heavy. Sp. gr. 0.475. Weight 593 Kg/m3 at 12 percent moisture content.

Shrinkage percentage green to oven dry

Radial	2.3
Tangential	7.1
Volumetric	10.9

Modulus of rupture (Kg/cm2)

Green	553.5
Airdry	747.7

Modulus of elasticity (Kg/cm2)

Green	867,800
Airdry	100,500

Maximum crushing stress (Kg/cm2)

Green	295.4
Airdry	360.7

Fairly easy to season without serious degrading. Not durable in open situations but fairly durable under cover and in contact with water. Graveyard test at Dehra Dun showed that untreated timber lasts for 22 – 53 months only. Not very refractory to treatment. Easy to work and finishes to a fairly smooth surface. Presence of silicon dioxide has a dulling effect on saws.

Uses

The wood is suitable for commercial grade plywood for tea chests and packing cases. It is commonly used for boat building in Bangladesh and in Burma. Can be used for general construction, interior joinery and vehicle bodies.

CHAPTER IV

BALANOCARPUS Bedd.

Small tree. Bark surface smooth. Twigs glabrous. Leaves entire, glabrous; petiole slender. Flowers in unilateral axillary panicled racemes. Calyx glabrous, lobes unequal. Petals bilobed. Stamens 15; filaments dilated at the base; connective terminating in a bristle. Fruit ovoid surrounded at the base by the enlarged truncate calyx lobes (Bourdillon, 1908; Gamble, 1915).

Wood

Vessels scattered or grouped. Parenchyma sparse, vasicentric. Rays heterogeneous, idioblasts present, oxalate crystals frequent. Resin canals in tangential rows (Chowdhury and Ghosh, 1958, Gottwald and Parameswarm, 1966).

Uses

Locally used as posts and beams.

Distribution 1 species : India.

BALANOCARPUS EROSA Bedd

A small tree attaining a height of 20 – 25m and a girth of 1 – 1.5m. Bark surface smooth, thin. Young twigs and petiole glabrous. Leaves 10 – 18cm by 2.5 – 5cm, oblong-lanceolate, rounded or unequally cordate at base, margin entire, glabrous on both surfaces; lateral nerves 12 – 14 pairs; petiole about 1cm long. Panicle axillary; flowers in unilateral glabrous racemes. Calyx glabrous, lobes unequal. Petals glabrous, bilobed. Stamens 15; filaments dilated at the base; anthers short, ovate; connective terminating in a bristle. Fruit ovoid, about 2.5cm long and 2cm in diameter, surrounded at the base by the equally enlarged truncate sepals (Bourdillon, 1908; Gamble, 1915).

Distribution – India

The species is of highly restricted occurrence. It is found sporadically in Tirunelveli District (Tamil Nadu) and the northern region of Kerala.

Forest Types and Floristics

The species is localised in Tirunelveli Semi-Evergreen Forest (Champion, 1936); characterised by small trees with an indistinct two or three storeyed canopy which is rather open during summer.

Note:– Most of the species of the genus ***Bolanocarpus*** Bedd. have been transferred to ***Hopea*** Roxb. or to ***Shorea*** Roxb. The status of ***Balanocarpus erosa*** Bedd. is yet to conclusively determined

Wood

Structure

Vessels scattered and frequently grouped tyloses sparse.

Parenchyma sparse, vasicentric and diffuse.

Rays heterogeneous, idioblasts present, oxalate crystals frequent (Gottwald and Parameswaran, 1966).

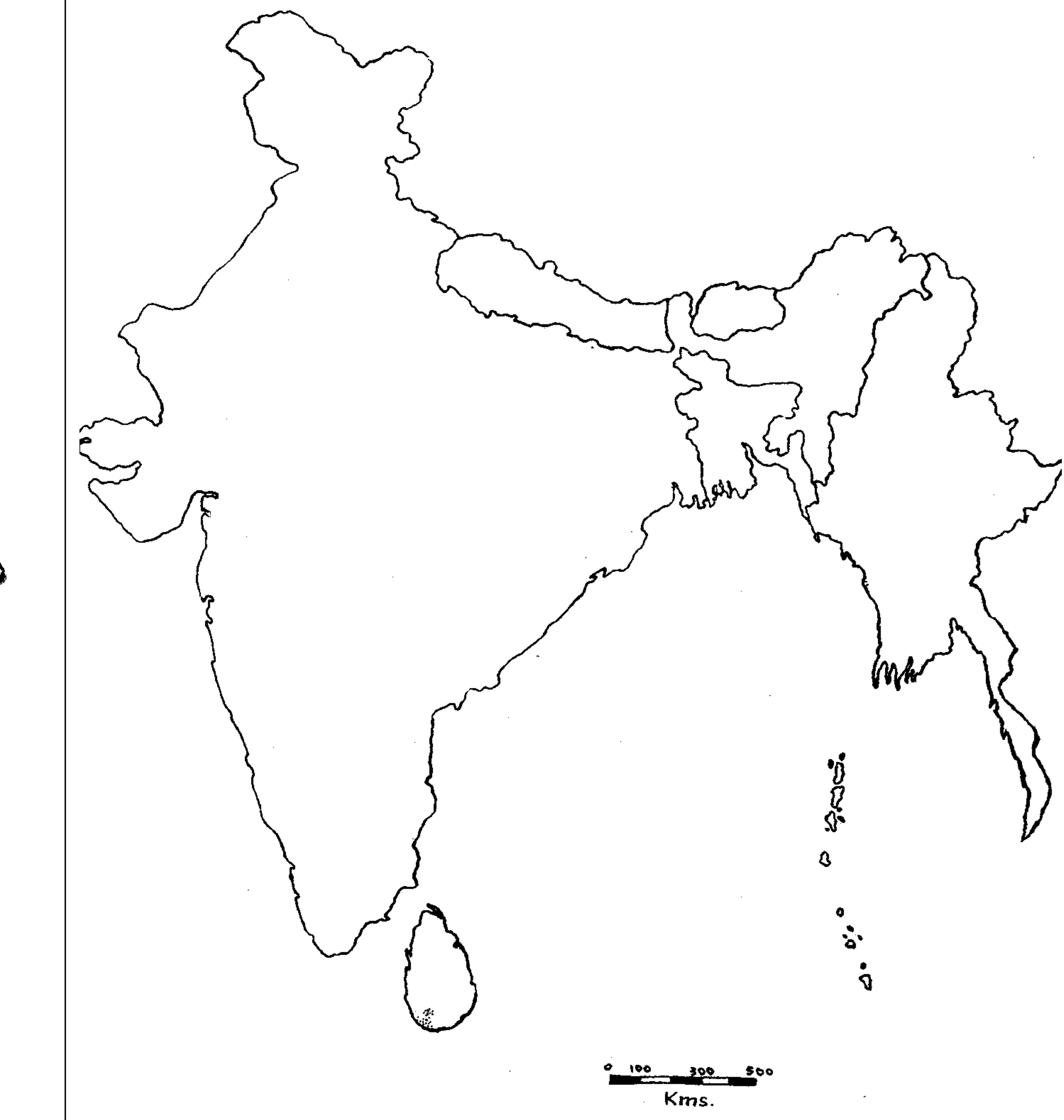
Properties

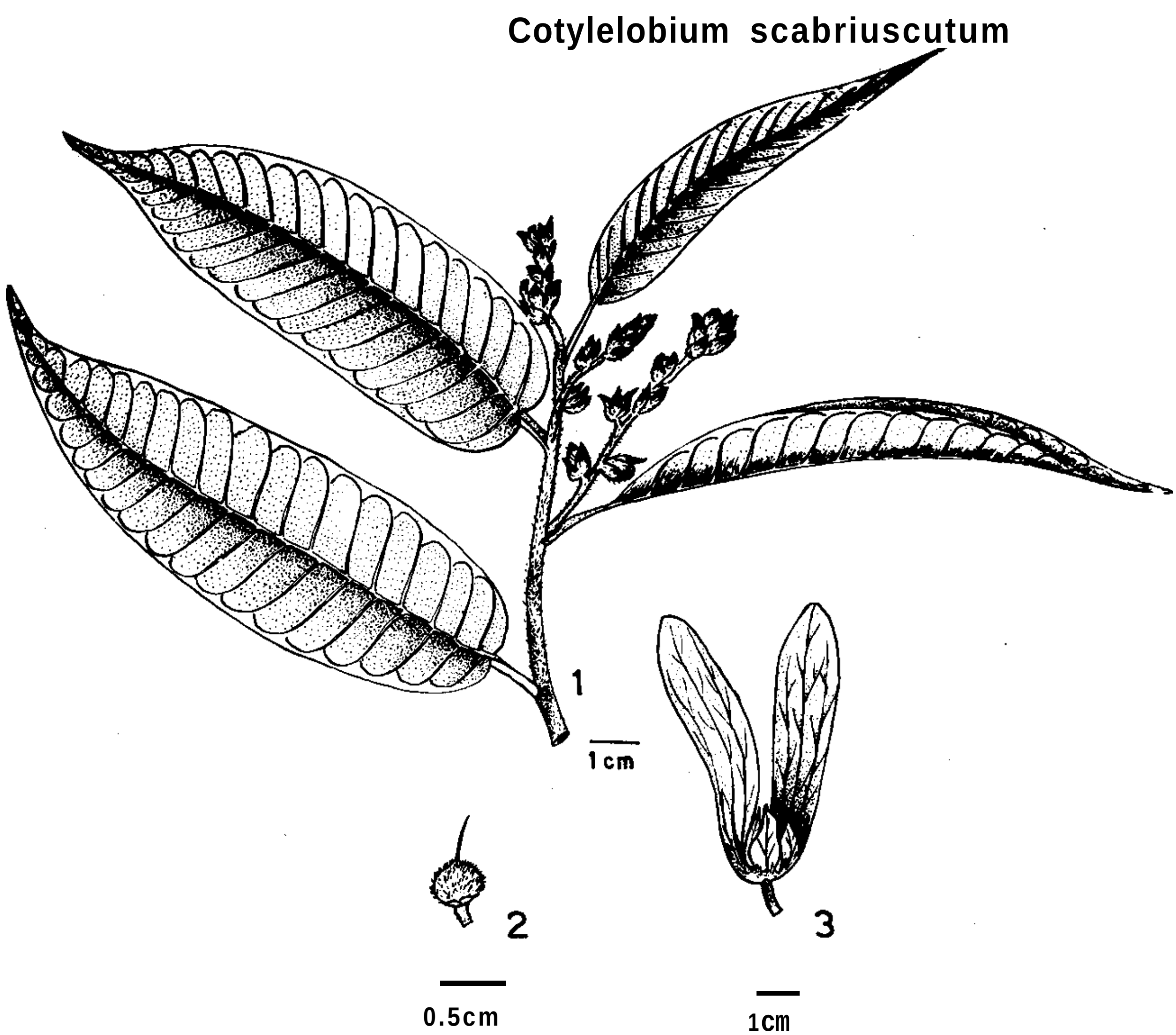
A tough wood, difficult to saw, reported to be durable.

Uses

As it is a relatively small sized tree of highly restricted occurrence, it is categorised as a secondary species with no recognized end use. Locally it is used for posts and beams.

Cotylelobium





Cotylelobium scabriusculum

1. **Flowering shoot**
2. **Pistil**
3. **Fruit**

CHAPTER V

COTYLELOBIUM Pierre

Medium sized to large trees. Bark surface greyish, becoming irregularly flaky. Young twigs pubescent. Leaves elliptic to oblong or ovate, lanceolate, coriaceous; petiole short; stipule fugaceous. Flowers in axillary or terminal panicles, nearly sessile. Sepals subequal. Petals cream coloured, more or less broadly elliptic oblong, pubescent on the parts exposed in the bud. Stamens 15, pairs alternating with single stamens; filaments short, deltoid, connate at the base; appendage to the connective less than 1/2 the length of anther, columnar or short. Ovary free from the calyx, ovoid or globose; style filiform, slender, stigma trifid. Fruit suhglobose or globose sometimes crowned by the persistent style; fruit calyx lobes unequal (Ashton, 1977).

Wood

Vessels numerous, small to medium sized, mostly solitary. Parenchyma vasicentric, Fibres radial. Rays heterogeneous. Resin canals single, scattered. Sapwood pale brown, heartwood dark brown, hard and fine grained (Gottwald and Parameswaran, 1966).

Uses

Suitable for construction and flooring.

Distribution 2 species: Sri Lanka.

COTYLELOBIUM LEWISIANUM (Trim. ex Hook. f.) Ashton

Syn *Stemonoporus lewisiunus* Trimen ex Hook. f.
Vatica lewisiana (Trim. ex Hook. f.) Livera
Vateria lewisiana (Trim. ex Hook. f.) Alston

Common names
Sinh. Mendora, Na-Mendora.

A large tree reaching a height of 35m and a girth of 4m with an irregular open crown. Bark surface pale grey, becoming irregular flaky. Young twigs and buds densely puberulent. Leaves 4 – 12.5cm by 2 – 6.5 cm, ovate to lanceolate, acuminate, base broadly cuneate to obtuse, coriaceous, glabrous except the midrib below; lateral nerves 8 – 10 pairs, obscurely elevated beneath; petiole 0.8 – 1.1cm long, puberulent. Panicle terminal or axillary, puberulent; flowers shortly pedicelled on branches forming 5-flowered cymes. Sepals subequal. Petals pale yellow, elliptic oblong, pubescent on the portions exposed in the bud. Stamens 15; appendage almost half as long as the abaxial anther cells, anthers glabrous. Ovary globose; style filiform, slender many times longer than the ovary; stigma trifid. Fruit 0.6cm in diameter, globose, verrucose, subtended by 0.4cm by 0.2cm sub-equal deltoid reflexed sepals (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs on rocky ridges in Hunawalkande in Pelmedulla and Kiribatgalle near Kohawatte of Ratnapura.

Forest Types and Floristics

This species which is endemic to Sri Lanka is generally gregarious in the restricted region of its distribution in the Highland Evergreen Forest (Andrews, 1961). As the stands are almost pure, the associates are few and un-important.

Silviculture and Management

Phenology

The flowers appear in January and the fruits ripen during April—May.

Natural Regeneration

The species regenerates naturally without any special effort.

Being localised in its occurrence, its value as timber is negligible and no management practices have been attempted. Except for local constructional purposes, the timber is hardly known in trade.

COTYLEIOBIUM SCABRIUSCULUM
(Thw.) Brandis

Syn. *Vateria scabriuscula* Thw.
Vatica scabriuscula A. Dc.
Sunaptea scabriuscula Trimen
Dyerella scabriuscula Heim.

Common names
Sinh. — Mendora, Na-Mendora.

A medium sized tree attaining a height up to 35m and a girth of 1.5m with a compact oblong crown. Young shoots tawny pubescent. Leaves 7.5-22cm by 2.4-8cm, narrowly oblong to lanceolate, acuminate, base broadly cuneate to obtuse, glabrous above and pubescent below; lateral nerves 17 - 23 pairs, slender but distinctly raised beneath, obscure above; petiole 1.3 – 1.6cm long. Panicle axillary or terminal: bracts narrowly ovate, obtuse; flowers distinctly pedicelled. Sepals subequal. Petals cream coloured, elliptic. Stamens 15; filaments short, deltoid, connate at base. Ovary ovoid; style linear. Fruit lcm in diameter, subglobose, crowned by the persistent style; the fruit calyx lobes unequal; the 2 larger lobes 5.5cm by 1.5cm lorate, obtuse, tapering towards the base; the **3** smaller lobes 2.5cm by 0.7cm, lanceolate-acute (Ashton, 1977; Trimen, 1893).

Distribution Sri Lanka

The species is found in the South Western Region from Kottawa northwards to Opata and north-westwards to Hewesse and Pelewatta It is also found in Nellowe and Kanneliya.

Forest Types and Floristics

This endemic species is a component of the Lowland Wet Evergreen Forest (Andrews, 1961). It is sometimes frequent on the deep leached soils which characterise the broad ridges below 300m altitude.

Floristics

Shorea spp., *Dipterocarpus reylanicus, D. hispidus. Vateria copallifera, Mesua ferrea, Cullenia* spp., *Myristica dactyloides, Kurrimia zeylanica, Calophyllum calaba, Carallia calycina, Urandra apicalis, Harpullia arborea, Pericopsk mooniana. Xylopia paruifolia,* List-*sea* sp., *Macaranga digyna. Syzygium nessianum, Bridelia moonii, Aporosa* sp., *Filicium decipien, Memecylon* spp.

Silviculture and Management

Phenology

Flowering in April—May.

Along with other species of the Wet Evergreen Forest, this species also regenerates more or less freely. No special efforts are made for its propagation in view of its localised occurrence.

Wood

Structure

Vessels numerous, small to medium sized, mostly solitary; tyloses absent.

Parenchyma vasicentric,

Rays medium,

Resin canals in irregularly spaced tangential rows.

Properties

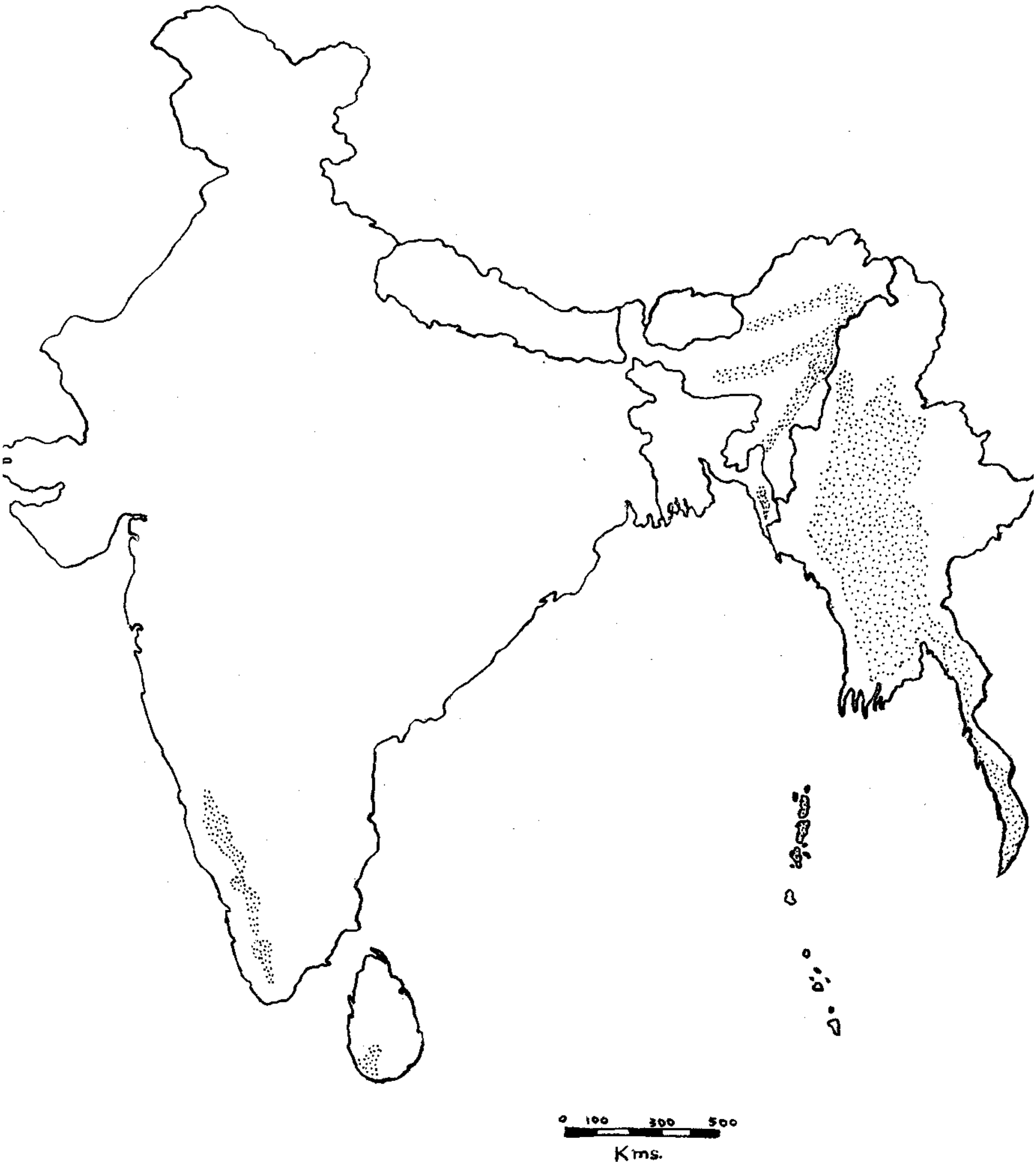
Sap wood pale greenish-yellow, heartwood reddish brown, hard and smooth; even textured and close-grained. Weight 866Kg/m3 at 12 percent moisture content.

Liable to warp during seasoning; fairly durable.

Uses

For general constructional timber, beams and bridge planks.

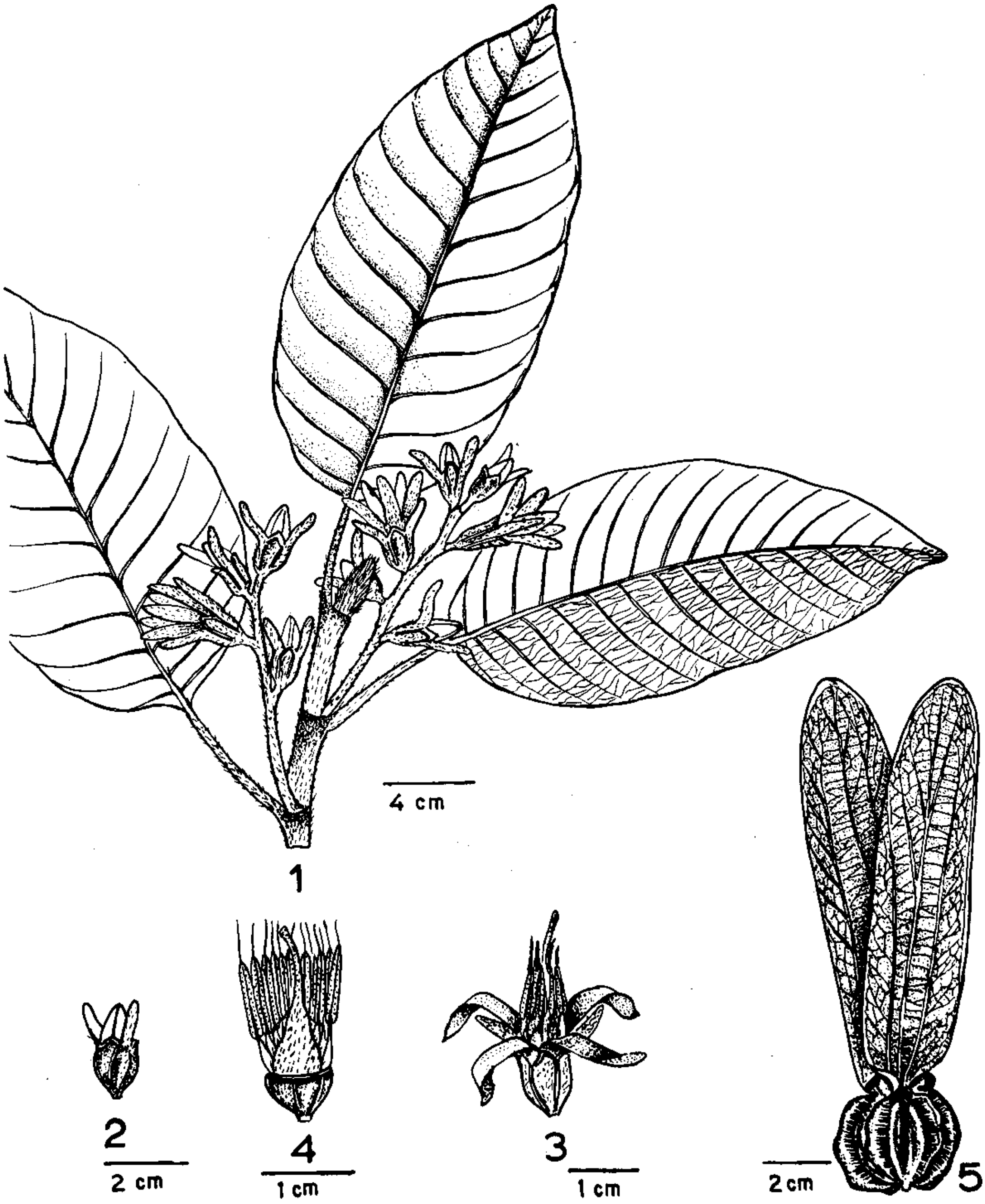
Dipterocarpus



Regeneration
of
***Dipterocarpus* *alatus* Natural pole crop Pyon Chung**
Reserve North Tongoo Division, Burma
(Photo FRI)

Dipterocarpus alatus
Girth 4.88m
Long Island
Middle Andamans, India
(Photo FRI)

Dipterocarpus alatus



Dipterocarpus *alatus*

1. **Flowering shoot**
2. **Flower bud**
3. **Flower**
4. **Stamens and Pistil**
5. **Fruit**

CHAPTER VI

DIPTEROCARPUS Gaertn.

Small to very large trees. Bark surface pale or dark grey to orange brown. Twigs pubescent, rarely glabrous, usually with distinct stipular scars. Leaves entire or corrugate or repand; patiole usually swollen just below the lamina; stipule large. Flowers in axillary racemes or spikes. Calyx with a free tubular base,smooth or ribbed, the lobes very unequal, 2 larger than the others. Petals somewhat cohering at the base, white or reddish, usually pubescent especially on the outer margin. Stamens 15 – many; filaments often flattened at the base; anthers linear; appendage to the connective long, filiform. Ovary pubescent, enclosed in the calyx tube; style filiform. Fruit belly smooth, ribbed or reticulate with 2 greatly enlarged calyx lobes (Ashton, 1977;Hooker, 1874;Kurq 1877).

Wood

Vessels predominantly large, abundant, scattered. Fibres straight. Rays distinct on smooth surfaces, radial; silicon dioxide present. Resin canals rarely solitary, mostly in short tangential groups. Wood brown to reddish brown, often with resinous odour, coarse textured, dull, heavy and hard (Chowdhury and Ghosh, 1958; Gottwald and Parameswaran, 1966).

Uses

Extensively used as commercial plywood timber, also used for railway sleepers after treatment. Used for dugouts and boat building. Suitable for jetty piles, poles and bridge construction.

Distribution 19 species: Bangladesh, Burma, India and Sri Lanka.

DIPTEROCARPUS ALATUS Roxb.

Syn. *Dipterocarpus gonopterus* Turcz.
D. ***ZemesZei*** Vesque
D. incanus Roxb.
D. unesbi Vesque

Common names
Beng. – Garjan, Dulia garjan.
Bur. – Kanyin, Kanyin-byu, Kayaing-bataing, Kyan-wa, Main hao.
Hind. – Gurjan.

A very large tree reaching a height of 45 – 55m and a girth of 4 5m with a cylindrical bole of about 20–30m. Bark thin, greyish and smooth. Young twig, petioles and inflorescence clothed with short tangled hairs. Leaves 10 – 20cm by 6 – llcm, elliptic or ovate-elliptic, acute or shortly acuminate, base cuneate or rounded, margin more or less repand, nearly glabrous on the upper surface except along the midrib; lateral nerves about 15 pairs, stellate pubescent on the lower side along the veins and midrib; petiole 2.5 3.5cm long; stipule 5 – 9cm long, stellate and more or less pilose. Spikes axillary, simple or branched; bracts 1.2cm long, lanceolate, caducous. Calyx tube rounded; the two largPr lobes linear-oblong. Petals oblong, pubescent outside. Stamens many; filaments flattened, the connective produced into a bristle. Ovary densely tomentose style 1cm long, stout, ribbed and pilose in the lower part. Fruit belly 1.8 –

2.4cm long, thinly stellate hairy, usually 5 winged to the base; the larger calyx lobes about 12cm by 2.5cm, 3-nerved in the lower half, often sprinkled with stellate hairs, the 3 smaller lobes orbicular (Hooker, 1872; Parker, 1927b; Parkinson, 1921).

Distribution – Bangladesh, Burma, India

In Bangladesh the species is found sporadically in Patya, Garjania, Idgaon Range, Rezu and Teknaf Ranges. Found chiefly on silt along the bottom of ridges and in valleys in moist and swampy areas. In Burma it is distributed from Akyab to Bassein and from Toungoo to Victoria Point (Parker, 1927b). In India it is restricted to the Andaman Islands only.

Forest Types and Floristics

In Bangladesh the species is found in Chittagong Tropical Evergreen Forest, Chittagong Garjan Forest and Chittagong Tropical Semi-Evergreen Forest (Champion, 1936). Rainfall is very heavy and the soil is reasonably retentive of moisture. The characteristic feature is the presence of large evergreen trees which form the bulk of the main canopy. The number of species is great and the mixture rather intimate, only a few species forming small consociations. In this forest type, *D. alatus* is mostly found scattered, emerging out of the main canopy. In moist and swampy areas the frequency of the species is greater.

In Burma this species is found in the Evergreen Dipterocarp Forest, the Eastern Tropical Evergreen Forest and South Burma Tropical Semi-Evergreen Forest (Champion, 1936; Hundley, 1961). Both the Evergreen Dipterocarp Forest and the Eastern Tropical Evergreen Forest are characterised by heavy rainfall and luxuriant vegetation. The canopy is generally unbroken but the tallest among the species emerge out of the top canopy. The lower storeys are also dense with a large number of species. The South Burma Tropical Semi-Evergreen Forest is intermediate between the typical Evergreen Dipterocarp Forest and the Tropical Moist Deciduous Forest. This is an intimate mixture of evergreen and deciduous species with the former dominating.

In the Andaman Islands the species is found in Andaman Tropical Evergreen Forest and Andaman Semi-Evergreen Forest, hut most often in the former (Champion and Seth, 1968). The forest is typically in the high rainfall areas with lofty, dense evergreen trees in an intimate mixture. ***D.** alatus* however occasionally forms consociation in the valleys.

Floristics

(i) Chittagong, Bangladesh (Chittagong Semi-Evergreen Forest)

I *Dipterocarpus costatus, D. turbinatus, D. alatus, Albizzia procera, A. odoratissima, Artocarpus chaplasha, Salmalia* sp., *Mangifera* sp.. *Duabanga* sp.. *Pterygota alata.*

I1 *Syzygium* sp., *Lagerstroemia **flosreginae**, Amoora* sp., *Trewia nudiflora, Macaranga denticulata, Calophyllum polyanthum, Dillenia* sp., *Stereospermum personatum. Terminalia belerica, **T.** chebula, Gmelina arborea, Schima wallichii, Artocarpus lakoocha.*

III *Meliosma pinnata, Callicarpa arborea, Vitex glabrata. Glochidion multiloculare, Cordia dichotoma.*

(ii) Tenasserim, Burma (Evergreen Dipterocarp Forest)

I *Dipterocarpus alatus, D. grandiflorus. **D.** turbinatus. Anisoptera scaphula, Parashorea stellata.*

II *Swintonia floribunda, Melanorrhoea glabra, Syzygium* spp., *Hopea odorata, Dysoxylum grande, Michelia champaca, Artocarpus calophylla, Baccaurea sapida, Cinnamomum innunctum.*

(iii) Pegu Yoma, Burma (South Burma Tropical Semi-Evergreen Forest)

I *Xylia dolobriformis, Dipterocarpus alatus, D. turbinatus.*

II *Homalium tomentosum, Gmelina arborea, Lagerstroemia* sp., *Careya arborea.*

111 *Bambusa polymorpha, Dendrocalamus* sp., *Cephalostachyum pergracile.*

(iv) Goplakabang, Andamans (Andamans Semi-Evergreen Forest)

I *Dipterocarpus alatus, D. gracilis, Pterygota alata, Pterocymbium tinctorium. Sterculia campanulata, Terminalia bialata, T procera, Albizzia chinensis, Sàlmalia insignis. Artocarpus lackoocha,* ***A.*** *chaplasha.*

I1 *Lagerstroemia hypoleuca, Dillenia pentagyna, Pometia pinnata, Myristica irya, Litsea panamonja, Talauma andamanica, Garcinia andamanica,* ***Aporosa*** *villosa.*

111 *Saprosma ternatum, Maesa andamanica, Micromelum pubescens, Clerodendrum uiscosum.*

Silviculture and Management

Phenology

In Bangladesh flowering is from January to March and fruiting in March. In Burma flowers appear from December onwards (Parkinson, 1931). In India leaf shedding is early in the hot season. The flowers appear from January to March. Fruits ripen from the end of March to the middle of May. Sometimes fruits are found in January itself hut these are invariably insect attacked.

Silvicultural characters

This species is essentially a shade bearer. The young crop can persist under heavy shade for years. It successfully comes up under shade unless otherwise suppressed by weed growth. For the first two years it does not tolerate heavy openings in the canopy. Once the seedlings are established (i.e., when they are 2 – 3 years old and about 120cm in height), heavy openings will not do any harm. The hark is comparatively thin and ill adapted to withstand the damage caused by fire. Seedlings and saplings, once burnt, hardly recover. Saplings up to 20cm girth coppice freely and above that the response is poor (Deans, 1936).

Natural regeneration

As the species responds to natural regeneration by suitable nianipulation of the canopy, it has been successfully regenerated. As regeneration follows exploitation in most of the areas, the number of seed bearers is not uniformly distributed and regeneration is in patches. To overcome this difficulty, seed is collected and sown in blank areas immediately after collection. While in Andamans, seeds are just dibbled at random, the practice in Bangladesh is to notch the seeds and dibble them 7.5cm apart in rows 15cm from one another in soil hoed to a width of %m. Each group of 3 rows is 2m apart from the other. In barren areas, seeds of *Syzygium grande* are also sown with those of 7. *alatus* to provide shade for young seedlings f the latter.

Trials have shown that April—May is the best period for collection of seeds. Seeds are collected from the ground under the mother trees. Before collecting, the ground is cleaned and old fallen seeds removed. Freshly fallen seeds are then collected daily so as to avoid insect attack. Because of the low viability, freshly collected seeds are immediately sown,, but if storage is inevitable, they may he spread in a well ventilated shady place for a couple of days. To ensure establishment of seedlings and their further growth, weedings are necessary during the first two to three years. In Bangladesh, thinnings are carried out in congested areas in the 5th, 10th, 15th and 25th years.

In view of the easy propagation by aided natural regeneration, artificial regeneration is not being practised. However, the species has been raised in nurseries in Bangladesh and the seedlings planted out in natural regeneration areas. In nursery beds germination commences in about 10 days and continues for a month and the best germination success obtained is 27%. Germination has been found to be better in shaded beds. In Burma, seeds buried to 1/3rd of their length in nursery beds apex downwards achieved successful germination. In the reversed position germination was slow and uncertain (Burma, Report on Forest Administration, 1920). In Bangladesh, one year old seedlings raised in nursery are planted out. Stumping has been found to he unsuccessful. The canopy is opened in stages after the 3rd year to allow diffused light to ensure further growth of saplings.

Wood

Structure

Vessels large, occluded with tyloses, the majority solitary, occasionally paired, close and evenly distributed, 2-5/mm2. Vessel segments long, truncate or abruptly short tailed, perforations simple, transverse; frequently containing deposits of reddish brown gum.

Tracheids abundant with numerous horizontally aligned, narrowly bordered elliptical pits.

Paratracheal parenchyma relatively sparse; metatracheal parenchyma fairly abundant, scattered or in short, tangential lines, parenchyma about the resin canal in rather broad tracts, orange or reddish brown gummy infiltration frequent in all types of parenchyma.

Fibres filiform, aligned in radial rows, non-septate, occasional orange or reddish brown infiltration.

Rays rather fine, 1 – 5 seriate, hetrogeneous; infiltration copious, orange or reddish brown.

Resin canals diffused or 2 to several contiguous, 2 – 8/mm2; contents white (Pearson and Brown, 1932).

Properties

Sapwood nearly white, heartwood reddish or greyish brown, fairly straight grained, even and very coarse textured, moderately heavy, specific gravity 0.574. Weight varies between 720 – 800Kg/m3 at 12 percent moisture content.

Shrinkage percentage green to oven dry

Radial	3.0
Tangential	7.5
Volumetric	10.8

Modulus of rupture (Kg/cm^2)

Green	661.5
Air dry	1020.7

Modulus of elasticity (Kg/cm^2)

Green	103,900
Air dry	151,900

Maximum crushing stress (Kg/cm^2)

Green	318.4
Air dry	552.1

The timber seasons well, but rather slowly. Scantlings converted from green logs split abnormally. Kiln seasoning is difficult and formation of moisture pockets is common. Not durable in the open; but lasts longer under cover, graveyard test at Dehra Dun having indicated a life of 45 – 71 months. The wood is slightly refractory to treatment as complete penetration of the preservative is difficult. However, treatment has been accomplished with a fair degree of success. Sawing satisfactory. Fairly easy to work with machine and hand tools; can be planed to a moderately smooth surface; difficult to stain, wax and polish (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Uses

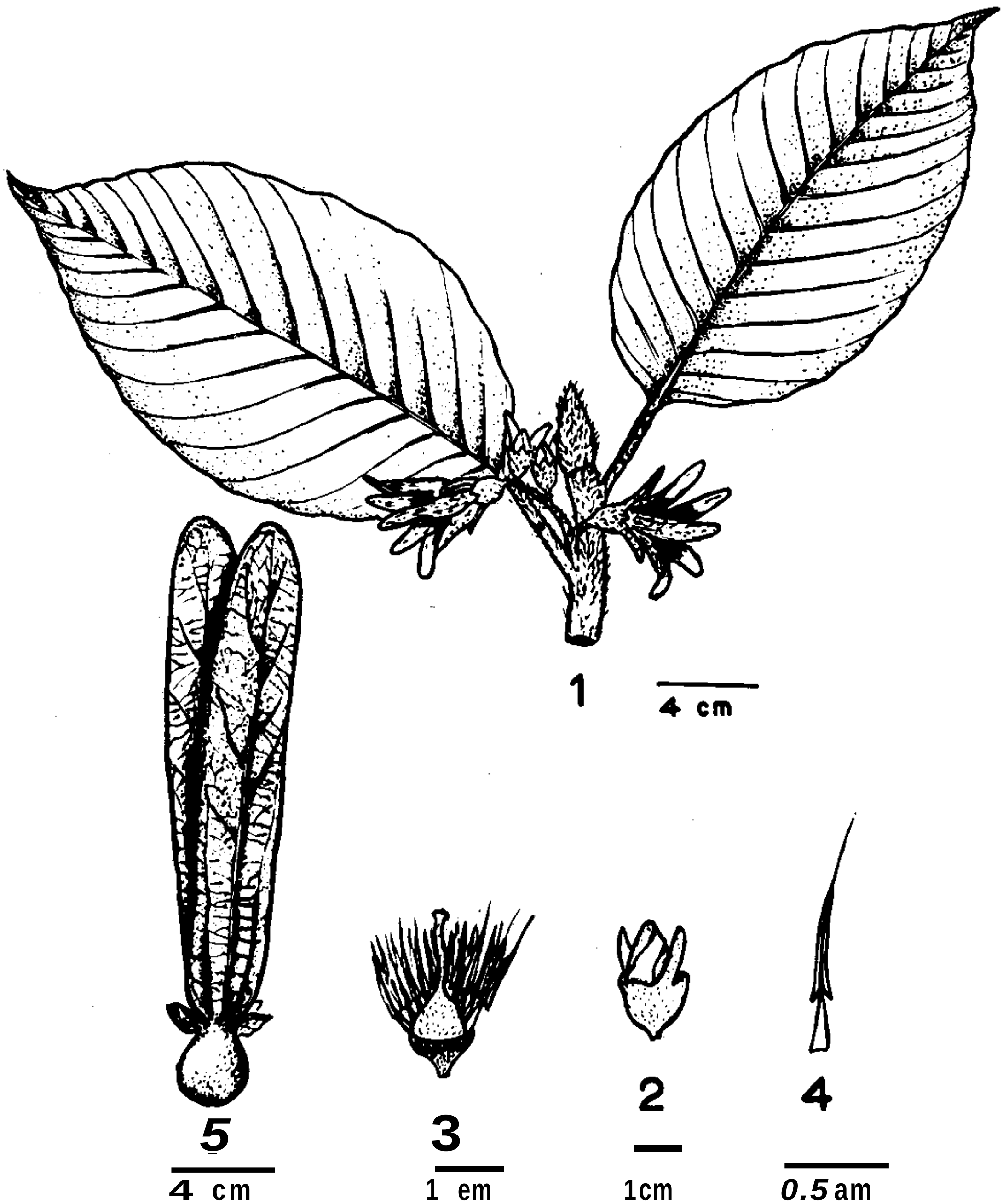
One of the principal species for commercial plywood. After treatment, it is extensively used for railway sleepers. In construction, used for components in the interior of buildings like beams, scantling etc. Used for boat building in Bangladesh.

Non wood products

The oleo-resin obtained from the species contains 71.6% volatile oil. It is obtained by cutting **a** deep notch towards the base of the tree. The notch is cut pyramidal in shape, the lower surface being hollowed out to receive the oil. The flow of oil is stimulated by lighting a small fire in the notch which is freshened at intervals by further chipping and burning. The yield is greatest during the hot weather. It is noticed that tapping within 18 months before felling is desirable and that the maximum quantity of oil is obtained if the tree is tapped on the side which bears the largest branch.

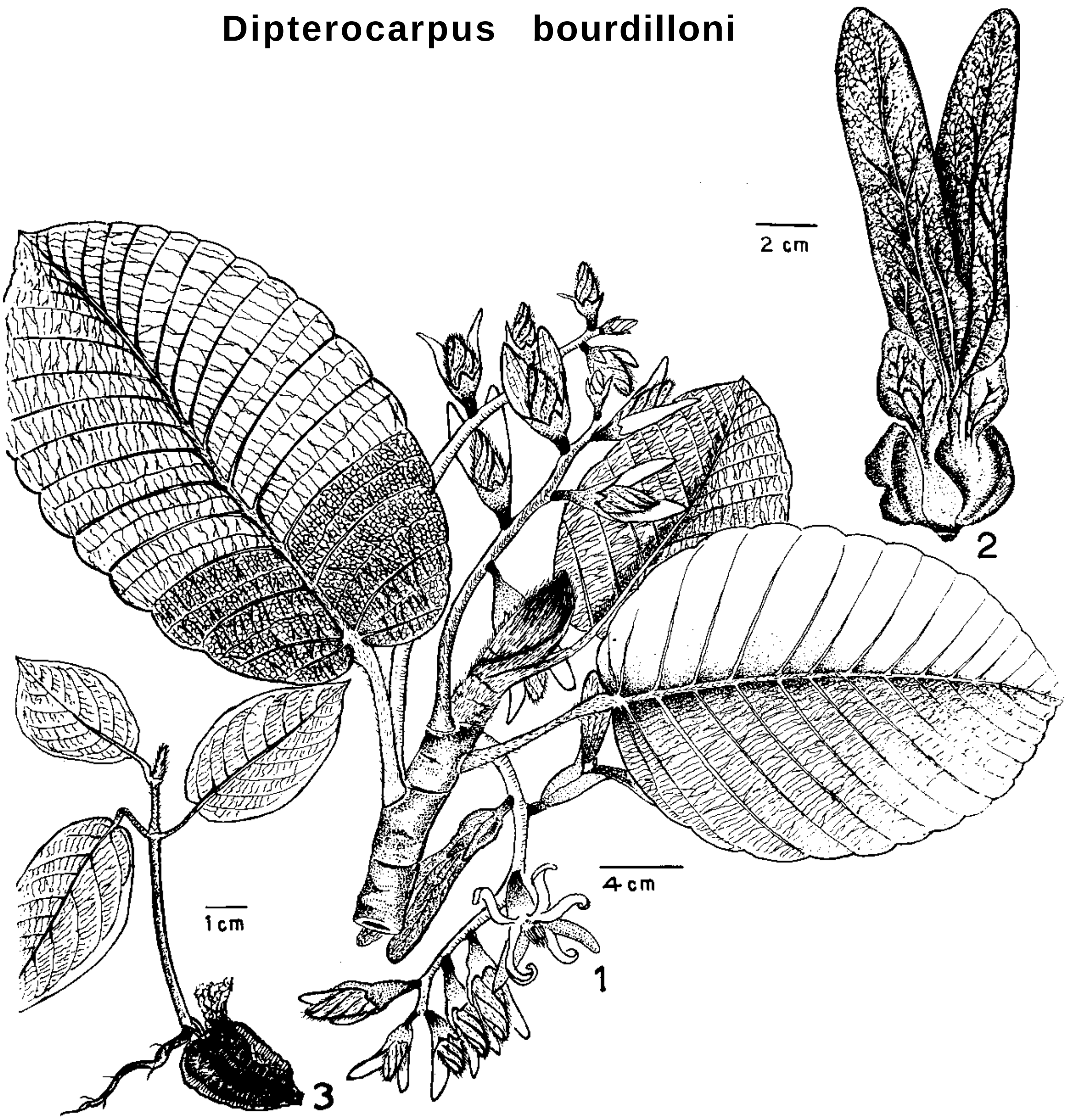
The oil has found localised uses in Burma. It is used by forest dwellers to burn torches made of rotten wood (Troup, 1907). The oil cloth used for Burmese umbrellas is sometimes waterproofed with this oil. It has

Dipterocarpus baudii



Dipterocarpus *budii*

1. Flowering shoot
2. Flower bud
3. Stamens and Pistil
4. stamen
5. Fruit

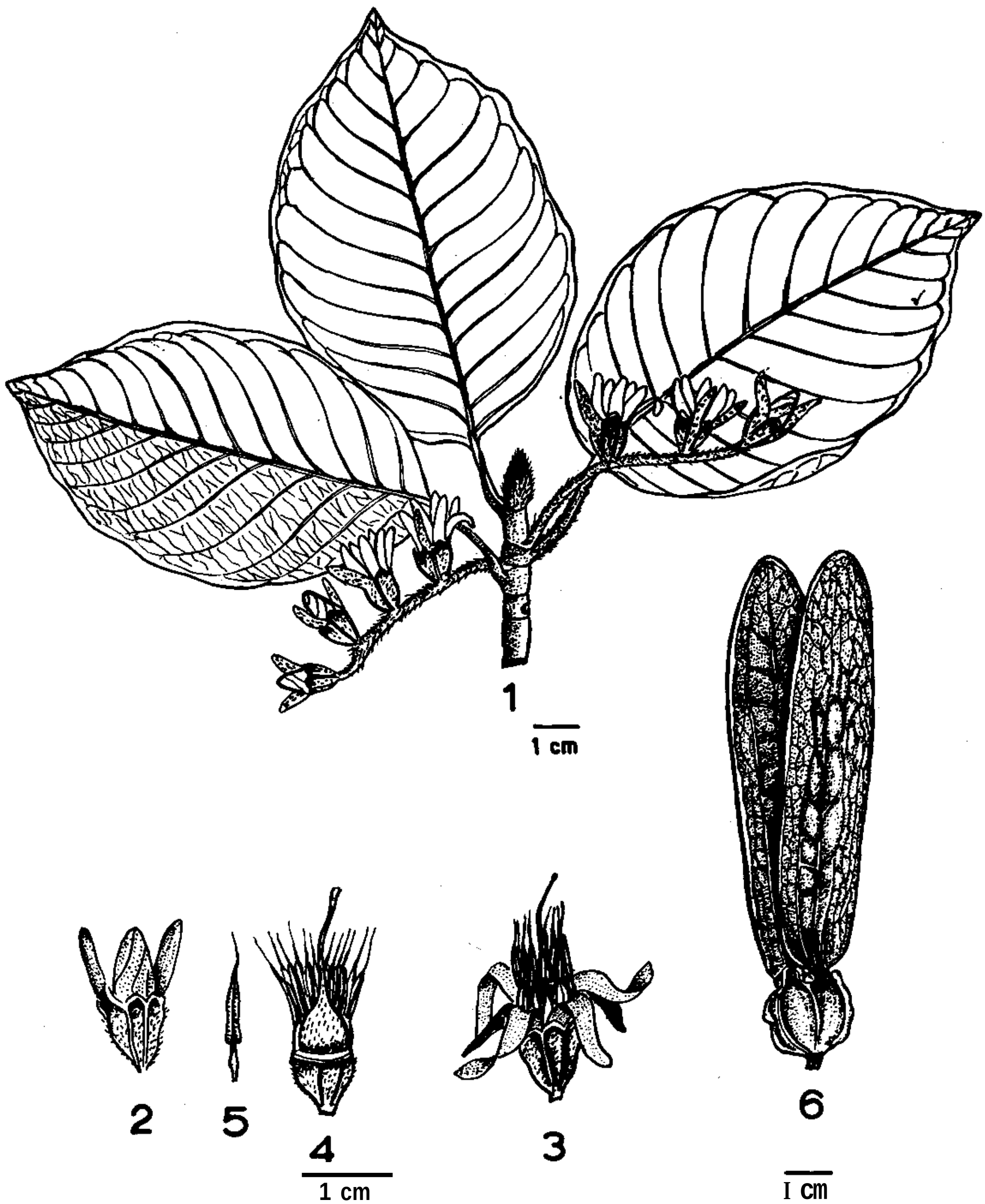


Dipterocarpus bourdilloni

1. **Flowering shoot**
2. **Fruit**
3. **seedling**

Dipterocarpus costatus
Single tree near Habang
Chittagong Hill tracts
Bangladesh
(Photo

Dipterocarpus costatus



Diptwocarpus costatus

1. **Flowering shoot**
2. **Flower bud**
3. **Flower**
4. **Stamens** and **Pistil**
5. **Stamen**
6. **Fruit**

also been tried as a substitute for linseed oil. In local medicines in Burma, it is used for the treatment of ulcers. The crude oil is also used for treating the sores in the hoof and foot disease of cattle. The resin has been used as a substitute for copaiba in the treatment of gonorrhoea. It has been tried as a varnish and used in preparation of lithographic ink. The bark is considered as a tonic and a hot decoction of it is used for rheumatism. Tapping of oil is, however, not very common because of the limited commercial end use.

DIPTEROCARPUS BAUDII Korthals

Syn. ***Dipterocarpus duperianus*** Pierre
D. scortechinii King

Common Names

Bur. – Kanju, Kokhe, Wettaung

A medium sized tree attaining a height of 24 - 30m and a girth of 1.8 – 2.7m. Bark surface smooth, pale in colour. Young twigs, densely covered with stiff brown fascicled hairs. Leaves 20 – 25cm by 11 – 18cm elliptic or elliptic-oblong, shortly acuminate, base subcuneate, rounded or slightly subcordate, margin ciliate, glabrous above except along the midrib, softly stellate pubescent beneath and pilose on the nerves; lateral nerves 10 – 20 pairs; petiole 3.5 – 5cm long, hairy; stipule 6.5cm long, hairy. Inflorescence simple, axillary; peduncle zigzag, shaggy like the twigs. Calyx tube 1.2cm long, campanulate, contracted at the base into a short pedicel like stalk, clothed with stellate and long adpressed hairs, the 3 shorter lobes variable, either very low and rounded or triangular, the 2 longer lobes linear oblong, about as long as the tube. Petals 5cm long, linear-oblong, stellate pubescent outside. Stamens many; connective produced in a bristle. Ovary densely pilose; style 1.2cm long, hairy in the lower half. Fruit belly ovoid-globose, 1.8 – 2cm in diameter and 1.5 - 2.2cm in length, glaucous and with scattered adpressed hairs, larger calyx lobe 12.5 – 22cm long, 2.2 – 3.5cm wide, sprinkled with stellate hairs, apex subacute or rounded, base abruptly narrowed, 3-nerved in the lower half, smaller lobes 2cm long rounded or ovate with recurved margins (Parker, 1931; Parkinson, 1931).

Distribution – Burma

Here its distribution is rather discontinuous. Occurs in the Arakan Yoma from about Sandoway southwards, at the southern end of Pegu Yoma and in Tenasserim from Tavoy to Victoria Point (Parker, 1931).

Forest type

The species is found scattered in the Southern Low Tropical Evergreen Forest (Champion, 1936).

Wood

Structure

The wood is diffuse, porous, vessels moderately large, few to moderately numerous (4 – 13 per mm^2), uniformly distributed, mostly solitary, few in radial or oblique pairs, oval to round in shape; tyloses often present.

Apotracheal parenchyma diffuse to very short or in broken, fine tangential lines; paratracheal parenchyma forms a thin layer, not conspicuous, parenchyma round the gumducts forms a several seriate layer.

Rays moderately broad to fine, brownish in colour, evenly distributed.

Resin canals vertical, fairly uniformly distributed, mostly solitary; white deposits fill up the cavity (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood fairly well demarcated, sapwood greyish, heartwood pale red to reddish brown, with gummy exudation on the end surface; straight to interlocked grained, coarse textured, moderately hard, moderately heavy (Chowdhury and Ghosh, 1958).

Uses

Along with other species of Burmese Dipterocarps used in construction and veneering.

DIPTEROCARPUS BOURDILLONI Brandis

Common names

Mal. – Karanjili, Charatanjili.
Tam. – Karanjil.

A large tree attaining a height of 50m or more and a girth of 5m with a clean straight bole of 30 – 35m. Bark grey, thick, the outer bark exfoliate in irregular flakes. Young branches and petiole densely covered with brown tomentum. Leaves 25 – 40cm by 12 – 20cm, elliptic oblong, base cordate or rounded, margin corrugate, ciliate when young, glabrous except along the midrib above, stellately pubescent beneath along the veins; lateral nerves about 15–25 pairs, oblique; petiole 3 – 4.5cm long, stout; stipules large, densely covered with stellate tomentum. Raceme axillary, 4 – 6 flowered, lower part of the peduncle tomentose; flowers shortly pedicelled, white, calyx tube with five ribs. Petals pubescent, 5cm long. Stamens many; the connective produced into a bristle. Ovary ovoid, tomentose; style short, cylindrical. Fruit belly with five winged ribs, furnished with a stalk at the base; the 2 larger calyx lobes up to 13cm by 1.5 - 2.5cm, 3 nerved up to the middle; the 3 smaller lobes ovate, recurved, up to 1.5cm long (Bourdillon, 1908; Gamble, 1915).

Distribution – India

This species is endemic to Kerala (India) and even here restricted to the evergreen forests of Kallar valley, Sholayar valley, Kulathupuzha, Ranni and Edamalayar. Mostly it is confined to river hanks. In view of its rarity, it is a species to he saved from the possible threat of extinction.

Forest Types and Floristics

The species occurs in West-Coast Tropical Evergreen Forest (Champion & Seth, 1968). The underlying rock formation in the West Coast Evergreen Forest, where the species is found consists principally of gneiss and of quartz and felspar. The disintegration of rock gives rise to various types of soil which are loamy in character. The soil **is** shallow and alluvial in Ranni, considerably deeper and consisting of chocolate coloured loam with a good admixture of sand in Sholayar valley and alluvial deposits in the Kallar valley.

Floristics

(i) Ranni, Kerala

Dipterocarpus indicus, D. bourdilloni, Cullenia exarillata, Hopea parviflora, Calophyllum elatum, Mesua ferrea, Machilus macrantha, Palaquium ellipticum, Canarium strictum, Artocarpus heterophyllus, Syzygium cumini, Dysoxylum malabaricum. Vitex altissima, Gluta travancorica, Lophopetalum wightianum, Alstonia scholaris, Acrocarpus fraxinifolius, Semecarpus anacardium, Polyalthia fragrans(Karunakaran, 1975).

(ii) Karapara and Sholayar Valley, Kerala

Anacolosa densiflora, Antiaris toxicaria, Calophyllum elatum, Toona ciliata, Cullenia exarillata, Dipterocarpus indicus, D. bourdilloni, Diospyros assimilis, Dysoxylum malabaricum, Elaeocarpus tuberculatus, Holigarna arnottiana, Hopea parviflora, Machilus macrantha, Knema attenuata, Palaquium ellipticum. Polyalthia fragrans, Vateria indica (Viswanathan, 1958).

(iii) Kallar Valley, Kerda

Dipterocarpus bourdilloni, Vateria indica, Bischofia jauanica, Knema attenuata, Hopea parviflora, Hydnocarpus pentandra, Mesua ferrea, *Tetrameles nudiflora, Trema orientalis, Humboldtia vahliana, Myristica magnifica, Gluta travancorica.*

Silviculture and Management

Phenology

Though the tree is essentially evergreen, during March most of the old leaves are shed. The new flush appears soon after the leaf fall. The flowering is during January to February and the fruits mature in April –May.

Natural regeneration

During good seed years, natural regeneration is satisfactory up to the seedling stage. Thereafter, unless attended to, mortality is high, probably due to excessive weed growth and overhead shade (Nair, 1961). **As** the species is localised, no serious attempt has been made for its propagation. In Kulathupuzha (Kerala) the species was raised along with other evergreen species in degraded forest by transplanting seedlings from their natural habitat. Weeding and hoeing the ground around the seedlings were undertaken. The seedlings established themselves well and the canopy was gradually opened by girdling the valueless species. The attempt, though of a minor scale, has been successful.

Wood

Structure

A diffuse-porous wood, vessels moderately large, moderately numerous, uniformly distributed, mostly solitary, a few in radial or oblique pairs, oval to round in shape; tyloses often fill up the vessels partially.

Parenchyma scanty to fairly abundant, apotracheal parenchyma diffuse fine tangential lines; paratracheal parenchyma, usually not conspicuous; parenchyma around the gum ducts fairly conspicuous.

Rays moderately broad to fine, brownish in colour not closely spaced, evenly distributed, often showing a conspicuous silver grain effect on the radial surface; Silicon dioxide particles present.

Resin ducts vertical, medium sized, fairly uniformly distributed in tangential groups of 2 to 10 (Chowdhury and Ghosh, 1958 Gottwald and Parameswaran, 1966).

Properties

Sapwood and heartwood fairly well demarcated, sapwood dirty white to greyish to pale yellowish-brown, heartwood pale red to reddish-brown, sometimes with an orange tinge darkening to red on exposure, occasionally with reddish streaks, often with gummy exudation on the end surface, moderately hard, moderately heavy; sp. *gr.* 0.574 (Chowdhury and Ghosh, 1958). Weight at 12 percent moisture content 705 Kg/m^3.

Shrinkage percentage green to-oven dry

Radial	4.5
Tangential	9.6
Volumetric	15.5

Modulus of rupture (Kg/cm^2)

Green	661.5
Air dry	1020.7

Maximum crushing stress (Kg/cm^2)

Green	311.7
Air dry	581.4

Nail holding and screw holding power are satisfactory.

It is moderately easy to air season and dries with little degrading. Kiln seasoning **is** difficult as the timber is liable to the formation of moisture pockets as well as warping (Chowdhury and Ghosh, 1958). The timber is fairly durable. Easy to work with machine and hand tools. It can also be turned bnt not recommended for fine turnery jobs. Owing to its natural colour staining is difficult. It is rather difficult to wax and polish (Sekhar, 1955).

Uses

Because of its restricted occurrence it is not particularly known in trade. Along with its *Dipterocarpus* associates, the timber is used in the plywood industry for manufacturing commercial grade plywood.

Non wood products

The species yields an opaque, straw yellow, viscid oleoresin which on standing deposits a crystalline unsaturated hydroxy ketone, C„ H„ **O,,** M.P. 125° – 126°C. When distilled with steam at 100°, 245° and 380° it gives 37%, 65% and 76% respectively of an essential oil.

DIPTEROCARPUS COSTATUS Gaertn. f.

Syn. *Dipterocarpus artocarpifolius* Pierre ex Lanes;.
D. incanus Craib
D. insularis Hance
D. obtusifolius Var. *costatus* Tardieu
D. parvifolius Heim
D. scaber Buch. Ham.

Common names

Beng. – Dulia garjan
Bur. – Kanhinni.

A moderate to large tree attaining a height of 28 – 35m and a girth of 2.5 – 3.5m. Bark surface dark brown, irregularly flaking; the blaze light brownish-yellow. Young twigs, petioles and inflorescence densely covered with yellowish grey tomentum of stellate hairs, sometimes densely pilose. Leaves 8.5 – 12.5cm by 5 – 7.5cm, ovate, ovate-oblong or more or less broadly elliptic, acute or shortly abruptly acuminate, base cuneate or rounded, rarely slightly cordate, margin usually distinctly repand, more or less densely tomentose with fine stellate hairs on both surfaces when young, becoming glabrous or nearly so above when old, but remaining pubescent beneath, coriaceous, midrib and main veins on the lower surface somewhat pilose or sometimes densely so, lateral nerves 10 – 14 pairs; petiole 1.3 – 2.5cm long, flattened or slightly channelled along the upper surface; stipules about 5cm long, densely stellate and more or less pilose. Spike axillary or terminal 3 - 6 flowered, somewhat zig-zag. Calyx tube campanulate with five ribs running down between the lobes and reaching the base of the tube; lobes 3 short rounded, 2 linear-oblong, the tube and lobes densely stellate and pilose. Petals oblong, tomentose outside. Stamens many; filament flattened at the base; the connective produced into a bristle. Ovary densely tomentose; style pilose towards the base. Fruit belly 1 – 1.2cm in diameter, more or less distinctly 5 ribbed, stellate and slightly pilose; the larger calyx lobes 6 – 9cm by 2 .2cm, sparsely stellate, 3-nerved to the middle or more (Parker, 1927b; Parkinson, 1921).

Distribution – Bangladesh, Burma, India

In Bangladesh the species is found in Chittagong and Cox's Bazar, being practically absent in Chittagong hill tracts. It is found sporadically as well as in gregarious patches from south of Sangoo river up to the Naaf, mostly in the Jaldi, Garjan, Rezu and upper parts of Teknaf (Homfray, 1935). Trees on shallow hill tops are stunted. In Burma it occurs sporadically from North Toungoo to Victoria Point (Parker, 1927b). In India it is restricted to the Andaman Islands and confined to hill slopes and hill tops in Middle Andaman Iiland.

Forest **Types** and Floristics

In Bangladesh the species is found in the Chittagong Semi-Evergreen Forest(Champion, 1936), characterised by an admixture of evergreen and deciduous species. The latter mostly in the lower canopy. In Burma it is confined to Burma Tropical Semi-Evergreen Forest (Champion, 1936) which is an intermediary between the evergreen and moist deciduous types. In the Andaman Islands, where the species **is** of restricted occurrence, it is found in the Southern Hilltop Tropical Evergreen Forest (Champion and Seth, 1968). As the locality is characterised by shallow soil, the trees are often stunted and the forest in general presents a dry appearance.

Floristics

(i) Bhimoriaghona, Bangladesh (Chittagong Semi-Evergreen Forest)

I *Dipterocarpus costatus, D. turbinatus, Swintonia* spp., *Holigarna* spp., *Mangifera longipes, Quercus acuminata, Syzygium grande.*

II *Quercus* spp., *Meliosma pinnata, Eurya* spp., *Xanthophyllum flavescens.*

III *Melastoma* spp., *Oxytenanthera* sp.

(ii) South Pegu Yoma, Burma (Burma Tropical Semi-Evergreen Forest)

I *Xylia dolabriformis, Dipterocarpus costatus, D. turbinatus, Homalium tomentosum, Gmelina arborea.*

II *Careya arborea.*

III *Bambusa polymorpha, Cephalostachyum* sp., *Dendrocalamus membranaceous.*

(iii) Middle Andamans, India (Southern Hilltop Tropical Evergreen Forest)

Dipterocarpus costatus, Mesua ferrea, Canarium manii, Harpullia arborea, Hopea helferi, *Cratoxylum cochinchinense, Memecylon caeruleum. Cryptocarya ferrarsi, Phoenix* sp. and some bamboos.

Silviculture and Management

Phenology

In Bangladesh and Burma the flowers appear in December—January and mature fruits are seen in April—May. In Andamans leaf sheds in the cold season, quickly followed by the appearance of new foliage. Flowering is in March and fruits ripen during May—June.

Natural regeneration

In Bangladesh the species is regenerated naturally supplementing the natural growth by sowing of seeds and planting out nursery grown seedlings. Sowing is done in lines and the procedure followed is the same as in the case of ***D.** alatus*. Apart from direct sowing, freshly collected seeds are sown in nursery beds to raise seedlings for planting out. About **1** Kg seeds are sown per bed. Germination commences in about a week and is complete in four weeks. The germination percent is about 25. The seedlings are planted out in August when they are about 10cm high. Frequent weeding and cleaning are necessary to avoid suppression. The rate of growth of seedlings is rather slow.

In India, due to the restricted occurrence and low economic value of the trees no regeneration operations are carried out.

Wood

Structure

A diffuse porous wood, vessels extremely large, the majority solitary, occasionally paired, rather close and quite evenly distributed, 2 – 4 per mm^2, perforations simple, transverse; reddish brown tyloses sparse.

Tracheids with numerous, horizontally aligned narrowly bordered, elliptical pits.

Parenchyma paratracheal, metatracheal and in broad interrupted bands. Paratracheal parenchyma relatively sparse; metatracheal parenchyma sparse; parenchyma about the resin canals extensive, frequently extending tangentially forming broad, 3 – 8 seriate bands orange or reddish-brown gummy infiltration frequent in all types of parenchyma.

Fibres filiform, non-septate, interfibre pits most numerous on the tangential walls, bordered, orange or reddish brown infiltration occasional.

Rays, slender, heterogeneous, 1-6 serrate.

Resin canals, solitary or 2 to several at intervals; contents white (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Properties

Sapwood and heartwood fairly well demarcated. Sapwood nearly white, heartwood reddish brown to brown, rather dull with rough feel, moderately heavy, sp. gr. 0.704; fairly straight grained, even and very coarse textured.

Weight at 12 percent moisture content 849 Kg/m^3.

Shrinkage percentage green to oven dry

Volumetric	13.3

Modulus of rupture (Kgicm^2)

Green	841.2
Air dry	1127.6

Modulus of elasticity (Kg/cm^2)

Green	129,200
Air dry	149,600

Maximum crushing stress (Kg/cm^2)

Green	424.2
Air dry	550.5

Fairly easy to season. Not durable in the open, fairly *so* under cover. It saws and works easily, finishing to a good surface (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

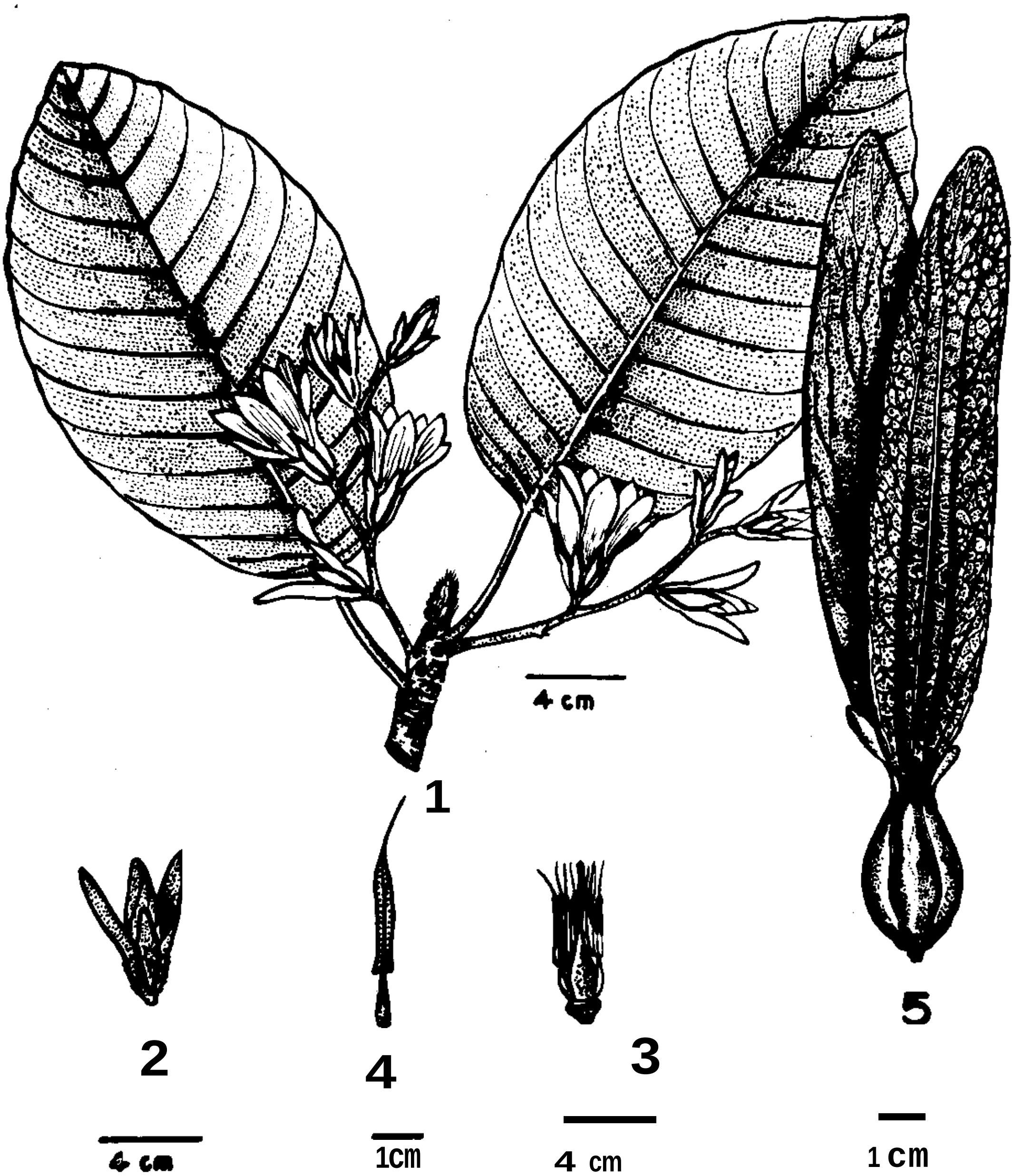
Uses

A good general construction timber in Bangladesh and Burma. In India, it has no recognised end use.

Non wood products

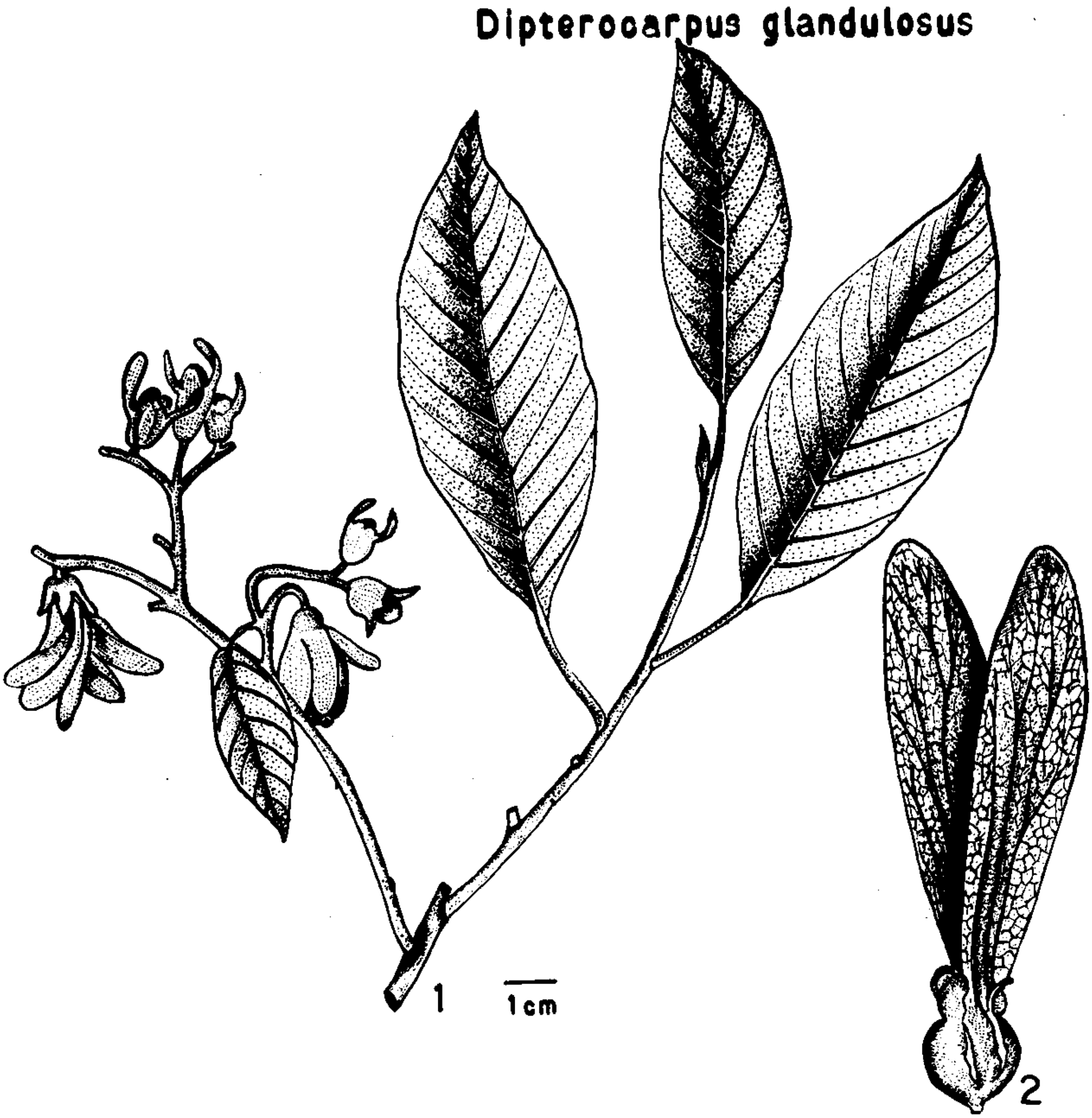
The species yields a resin when blazed. In Burma the resin is reported to be used for treatment of ulcers.

Dipterocarpus dyeri



Dipterocarpus dyeri

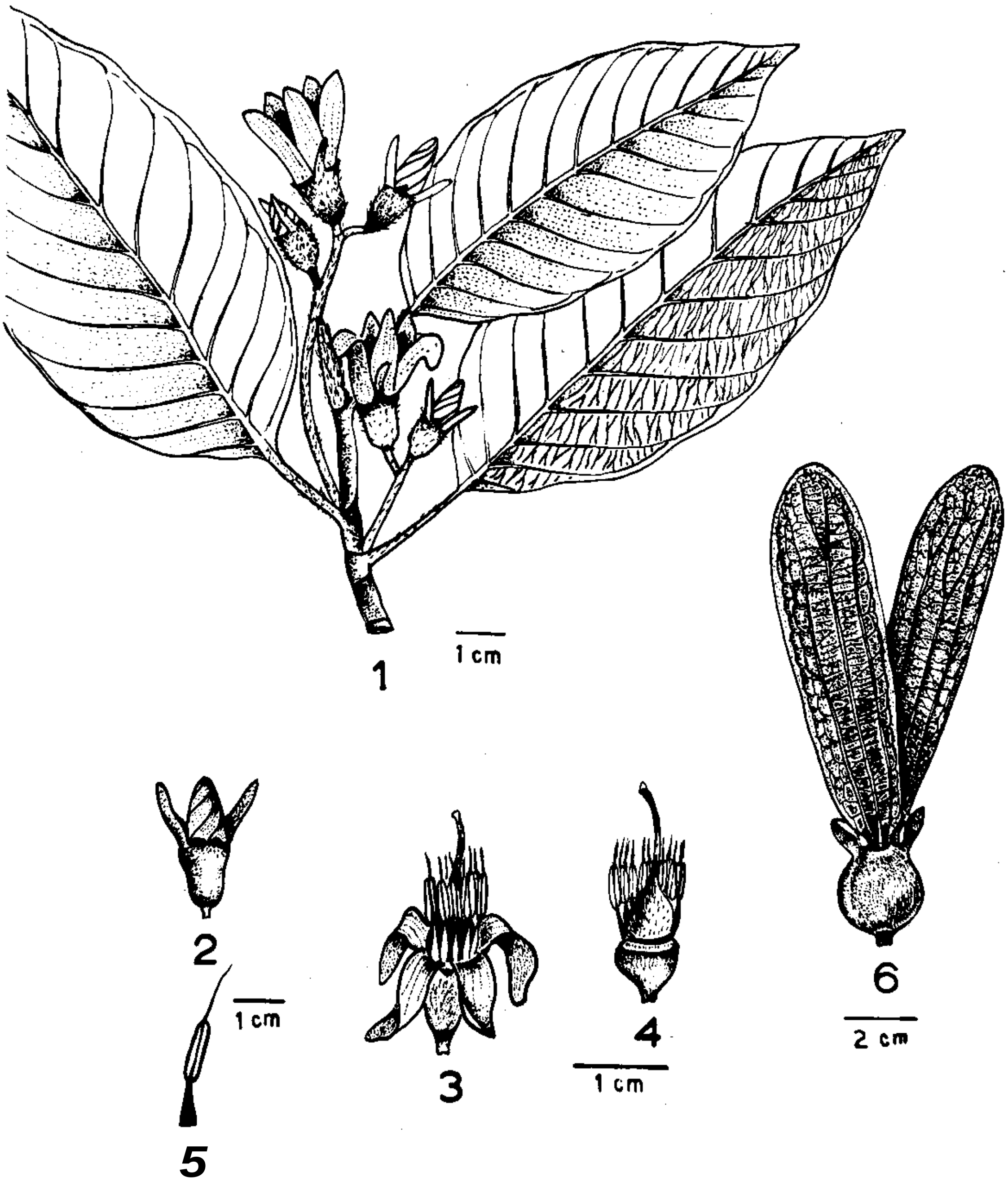
1. Flowering shoot
2. Flower bud
3. Stamens and Pistil
4. Stamen
5. Fruit



Dipterocarpus ***glandulosus***

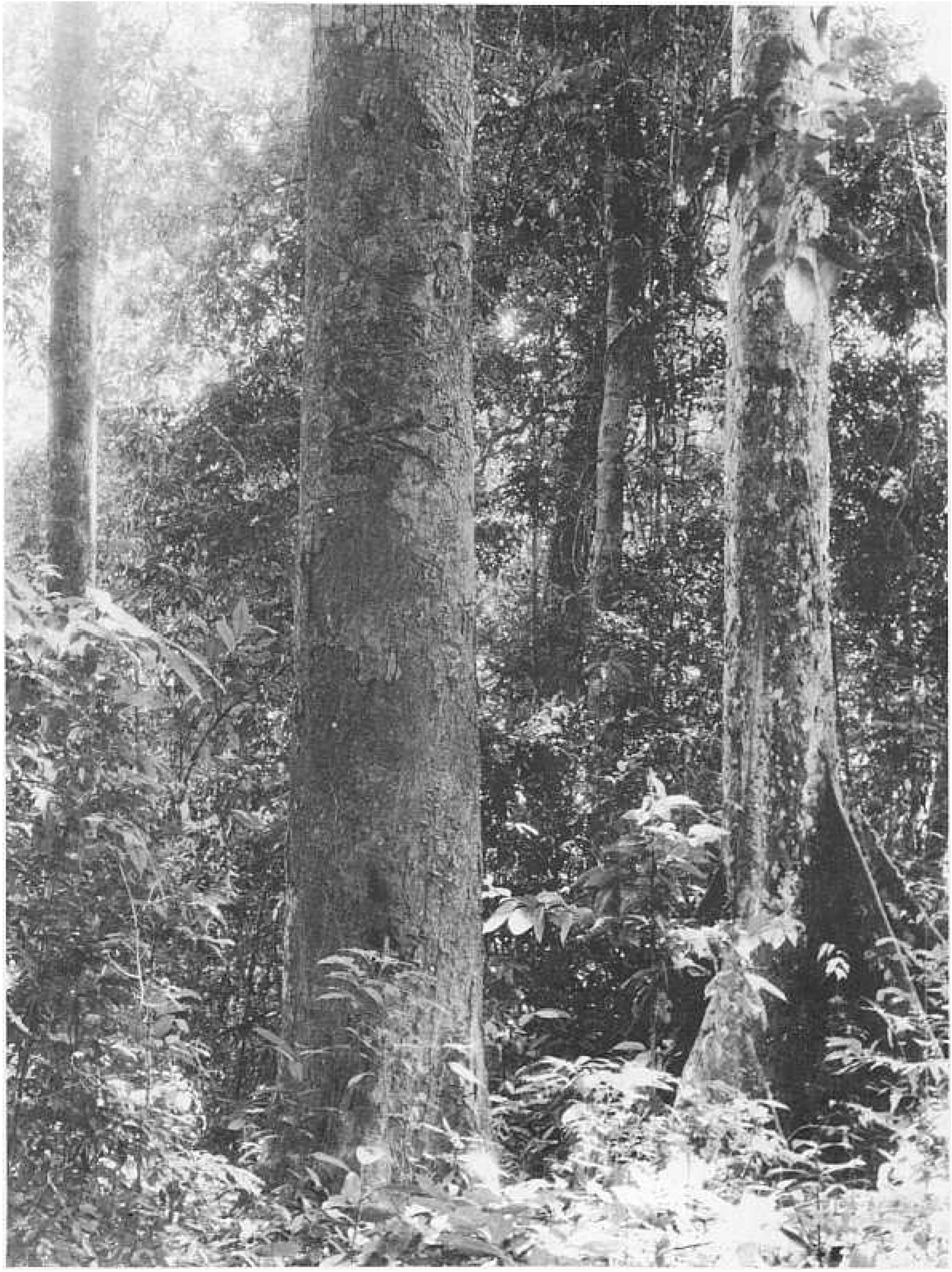
1. **Flowering shoot**
2. **Fruit**

Dipterocarpus gracilis



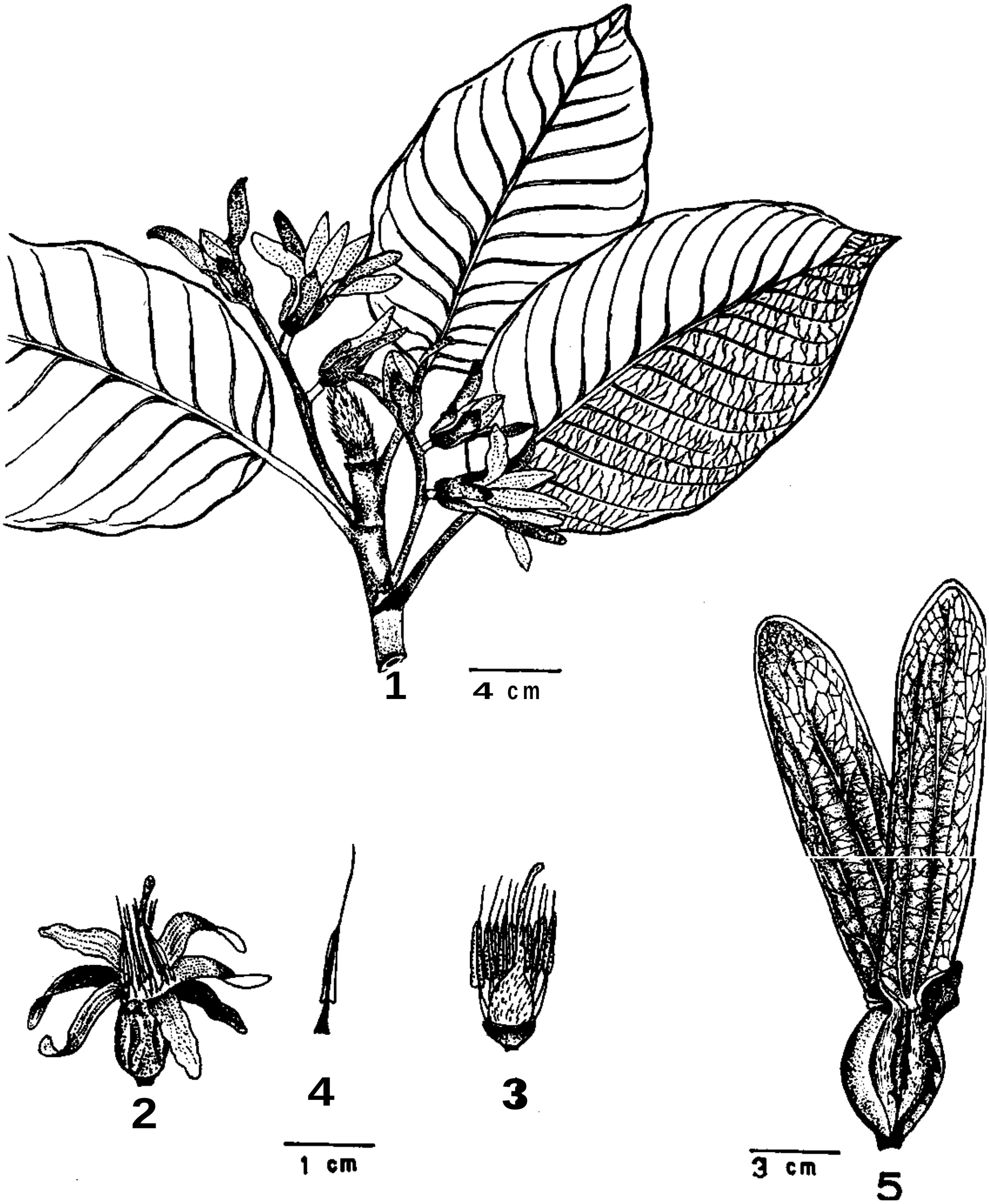
Dipterocarpus gracilis

1. **Flowering shoot**
2. **Flower bud**
3. **Flower**
4. **Stamens and Pistil**
5. **Stamen**
6. **Fruit**



Dipterocarpus gracilis **and** ***Buchanania***
(buttressed)
(Regeneration in open gaps)
Chittagong Hill tracts
Bangladesh
(Photo FRI)

Dipterocarpus grandiflorus



Dipterocarpus **grandiflorus**

1. **Flowering shoot**
2. **Flower**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

Dipterocarpus grandiflorus Natural regeneration area showing mixture of Gurjan *(D. grandiflorus)* with *Terminalia procera* and *Canarium euphyllum* in centre living poles are R to L *Sideroxylon longipeticlatum D. grandiflorus* and *Artocarpus chaplasha* Kyitaung, Middle Andemans (India)
(Photo FRI)

Dipterocarpus grandiflorus
Andamans, India
(Photo FRI)

Dipterocarpus hispidus
Gilimale
(Photo KFRI)

DIPTEROCARPUS DYERI Pierre ex De Laness.

A medium sized tree attainine a height of 24 – 32m and a girth of **2** – 3m. Bark surface smooth. Young twigs covered with scattered stellate hairs; terminal bud densely grey adpressed hairy. Leaves 15 – 25cm by 9 – I5cm, elliptic, rounded or shortly acuminate, rounded or slightly cordate at base, margin undulate; when young, small stellate and adpressed hairs are present on the midrib; lateral nerves 16 – 18 pairs; petiole 5 – 7cm long, glabrous or clothed with fine stellate pubescence and long adpressed hairs; stipule 15 – 20cm long, more or less pubescent on the outer side. Spikes axillary, more or less pubescent; flowers sessile or shortly pedicelled. Calyx tube ovoid-oblong, 1.6cm long, with five longitudinal ribs. Petals 5cm long, pink, glabrous within. Stamens many; filaments flattened at the base, connective produced into a bristle. Ovary adpressed hairy; style glabrous in the upper portions. Fruit belly 3 – 5cm long, 1.7 – 3cm in diameter, ovoid, usually with short pedicel like stalk at the base, contracted at the apex, glabrous or with scattered minute stellate hairs, sometimes glaucous, longitudinally ribbed; the 2 larger calyx lobes 15 – 22cm by 3 – 4.3cm, narrowed towards the base, apex rounded, usually with a few minute hairs, 3-nerved beyond the middle; the 3 smaller calyx lobes about 1.3cm long, linear lanceolate with reculved margins (Parker, 1931; Parkinson, 1931).

Distribution – Burma

The species is restricted to Mergui (Parker, 1931).

Wood

Structure

Wood diffuse porous, vessels moderately large, few to moderately numerous, uniformly distributed, mostly solitary, oval to round in shape, tyloses fill up the pores partially.

Parenchyma fairly abundant; apotracheal parenchyma diffuse; paratracheal parenchyma usually not conspicuous; parenchyma round the gum ducrs forms a several seriate layer.

Rays moderately broad to fine, brown in colour, not closely spaced, evenly distributed

Resin canals in tangential groups of **2** – 10 white deposits sometimes fill up the cavity of the ducts (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood fairly well demarcated, sapwood pale yellowish brown, heartwood reddish brown; interlocked grained and coarse textured, moderately hard and heavy.

The species being restricted in occurrence, it **is** not propagated either artificially or naturally. It has no distinct end use except localised utilization for minor constructional works.

DIPTEROCARPUS GLANDULOSUS Thw.

Syn. ***D. scabridus*** Thw.

Common name

Sinh. Dorana.

A large tree attaining a height of 45m and a girth of 3m with a straight cylindrical bole and a large emergent dense crown. Bark surface pale brown, verrucose-lenticellate, thinly irregularly flaky. Young shoots tawny pubescent. Leaves 6.5 – 13cm by 3 – 6.5cm, narrowly elliptic to lanceolate, shortly acuminate, base cuneate, coriaceous; lateral nerves 9 – 13 pairs, slender, prominent below, pubescent on both surfaces; petiole 1.5 – 2.5cm long, slender, prominently geniculate, tomentose; stipule 3.5cm long, lanceolate, tomentose. Racemes axillary, stellate hairy; flowers shortly pedicelled. Calyx tube narrowly campanulate, prominently and bluntly 5 winged, stellate pubescent. Petals narrowly oblong, pubescent outside. Stamens 15; appendage of the connective as long as the anther. Ovary conical, densely puberulent; stylopodium and style columnar, pubescent in the basal half. Fruit belly 5 ribbed, subglobose, 1.8cm in diameter, the 2 larger calyx lobes 10cm by 2cm, oblanceolate; obtuse; the smaller lobes Icm long, ovate (Ashtoh, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs in the South Western Region in Ambagamuwa, Kitugala, Siyane Korale, Kruvita Korale, Karawita, Ratnapura, Kanneliya, Bambarabotuwa, Balgoda, Rakwana and Kottawa.

Forest Types and Floristics

The species is scattered in the Lowland Wet Evergreen Forest (Andrews, 1961) and found more frequently in deep well-drained soil below 1000m altitude. The forest is typically multistoreyed and this species is in the emergent layer. Due to extensive tapping for resin in the past, it has been more or less exterminated in many areas.

Floristics

Kanneliya

I *Dipterocarpus zeylanicus, D. glandulosus, D. hispidus. Shorea congestiflora, S. trapezifolia, Artocarpus nobilis, Myristica horsfieldia, M. dactyloides, Mangifera zeylanica, Putranjiva zeylanica.*

II *Calophyllum soulattri. Kurrumia reylanica, Nelitris jambosella, Alseodaphne* sp., *Dillenia retusa, Gyrinops walla, Palaquium grande, Symplocos coronata, Mesua ferrea. Garcinia morella.*

III *Litsea* sp., *Aporosa latifolia, Semecarpus nigro-viridis. S. gardneri, S. subpeltata, Axinandra latifolia, Wormia triquetra, Acronichia pedunculata, Schumacheria castaneaefolia, Symplocos spicata.*

IV *Morus alba, Syzygium* spp, *Poliyalthia* sp., *Bragantia wallichii.*

Silviculture and Management

Phenology

Flowers appear in March–April and fruits ripen during May–July.

In view of the scanty distribution in the natural forest, regeneration is poor. No attempts for propagation have been made.

Wood

Structure

Vessels moderate to large, mostly solitary, tyloses common.

Parenchyma vasicentric to aliform.

Rays fine to medium sized.

Resin canals very common, mostly solitary and diffuse, occasionally in tangential rows.

Properties

Wood light brown, moderately hard and heavy, close grained. Weight 794 Kg/m^3 at 12 percent moisture content.

The timber is difficult to season, with a tendency to crack, cup and warp. Saws easily and finishes to a fair surface. Not durable in the open.

Uses

A constructional timber suitable for making planks and boards. It is also used for scaffolding and shuttering, and is sometimes used for props in mines and jetty piles.

DIPTEROCARPUS GRACILIS Bl.

Syn. *Dipterocarpus angustialatus* Heim.
D. bancanus Burck
D. fulyus Bl.
D. marginatus Korth.
D. pilosus Roxb.
D. skinneri King
D. vernicifluus Blco.
D. turbinatus Gaertn. f. Var. *andamanica* King

Common names

As. – Hollong, Hullung.
Beng. – Dhali Garjan, Sil Gargan
Bur. – Kanyaung, Kanyin byan, Kanyin-in, Red Kanyin.

A large tree reaching a height of 45m and a girth of 6m. Bark smooth, light grey. Young twigs grey pubescent, soon becoming glabrous or nearly so. Leaves 10 – 17.5cm by 6 – 8.5cm, elliptic, elliptic-oblong or elliptic-lanceolate, acute or shortly acuminate, base cuneate or rounded, margin slightly or not repand, rather coriaceous, upper surface adpressed hairy when young, remaining tomentose with minute fascicled nairs on the midrib and main nerves; lateral nerves **12 – 14** pairs; petiole 3.5cm long, tomentose;

stipules 5 – 7.5cm long, densely covered with fascicled and pilose hairs. Racemes axillary, simple, rarely branched, 3-6 flowered, rachis and peduncle minutely grey stellate, the lower flowers shortly pedicelled, the upper flowers subsessile. Calyx tube obconic, grey with minute stellate hairs; lobes 3 short, rounded, margin more or less reflexed, 2 linear oblong, densely grey tomentose. Petals linear-oblong, stellate-tomentose outside and ciliate on one margin, nearly glabrous within. Stamens many; filaments flattened; connective produced into a bristle. Ovary densely tomentose; style 1cm long, tomentose in the lower two fifths, glabrous on the upper three fifths. Fruit belly about 1.5 – 1.7cm in diameter, subglobose; the larger calyx lobes 11 – 12.5cm by 2 - 2.2cm, strongly 3 nerved almost to the middle or to far beyond the middle, strongly reticulate, sprinkled both on the wings and belly with small stellate hairs (Hooker, 1874; Kurz, 1877 Parker, 1927b; Parkinson, 1921; Parkinson, 1931).

Distribution – Bangladesh, Burma, India

In Bangladesh the species is found in Chittagong. In Burma it has a fairly wide distribution in Arakan, Pegu and Tenasserim, in the hills east of Sittang and in a small area east of Molumin. Best development is seen on the outer steep slopes of the Patkoi and Tippam Ranges. In India it is rather restricted and found in Upper Lakhimpur (Assam), Nagaland, Arunachal Pradesh and the Andaman Islands. In Naga Hills it occurs from the Kakodanga- river eastward usually scattered, but also in patches up to 330m elevation and extending in some cases from 12 – 16 Km into the plain (Parker, 1927b; Parkinson, 1931).

Forest types and floristics

In Bangladesh the species is found in groups and patches in the Chittagong Tropical Evergreen Forest (Champion, 1936) approximating a gregarious habit. In Burma the species is quite often gregarious forming an important component in the Evergreen Dipterocarp Forest and Eastern Tropical Evergreen Forest (Champion, 1936). In India it is a component in the Andaman Semi-Evergreen Forest (Champion & Seth, 1968), Assam Tropical Evergreen Forest (Champion, 1936) and Eastern Alluvial Secondary Semi-Evergreen Forest (Champion and Seth, 1968). Though mostly scattered, sometimes a gregarious habit is noticed in Assam.

Floristics

(i) Chittagong, Bangladesh (Chittagong Tropical Evergreen Forest)

I *Dipterocarpus turbinatus. D. gracilis.*

I1 *Chukrassia tabularis, Holigarna* sp., *Amoora* **sp.,** *Salmalia insignis, Syzygium grande, Caryota urens, Hopea odorata, Castanopsis* sp., *Artocarpus chaplasha, Lophopetalum fimbriatum, Pterospermum acerifolium, Vitex* spp., *Palaquium* sp., *Polyalthia* sp., *Alstonia scholaris, Tetrameles nudiflora, Schima wallichii.*

I1I *Bambusa tulda, Bambusa dulloa, Meliosma simplicifolia, Maesa ramentacea, Murraya paniculata, Clausena* sp. (Chaudhury, 1968; Ahamad, 1958).

(ii) Andamans, India

I *Dipterocarpus grandiflorus, D. gracilis, Artocarpus chaplasha,* A. *gomeziana, Calophyllum soulattri, Planchonia littoralis, Hopea odorata, Endospermum chinense. Planchonella longipetiolata.*

I1 *Myristica andamanica, M. glaucescens, Baccaurea sapida, Croton argyratus, Pterospermum aceroides, Caryota mitis, Cryptocarya* sp., *Memecylon* sp., *Euphorbia epiphylloides, Pseuduvaria prainii, Actephila excelsa.*

(iii) Lakhimpur, Assam, India (Assam Tropical Evergreen Forest)

I & I1 *Artocarpus chaplasha,* ***A.*** *heterophyllus, Dipterocarpus gracilis, Shorea assamica, Cinnamomum cecidodaphne, Dysoxylum binectariferum. Altingia excelsa, Mesua ferrea, Syzygium* spp., *Pterygota alata, Michelia champaca, Talauma phellocarpa, Amoora wallichii, Garcinia* spp., *Carallia lucida, Toona ciliata,* ***Ficus*** spp., *Kayea assamica, Vatica lanceaefolia, Gynocardia odorata.*

I11 *Dendrocalamus hamiltonii, Bambusa pallida.*

(iv) Hollongapar, Assam (Eastern Alluvial Secondary Semi-Evergreen Forest)

I *Tetrameles nudiflora, Stereospermum personatum. Terminalia myriocarpa, T. citrina, Dipterocarpus gracilis, Artocarpus chaplasha, Castanopsis hystrix, Aquilaria agallocha.*

I1 *Macaranga* spp., *Mesua ferrea, Amoora wallichii, Vatica lanceaefolia, Pseudostachyum polymorphum.*

Silviculture and Management

Phenology

Flowering in December-January. Fruiting May—June.

Silvicultural characters

The species is a shade hearer in the early stages, but requires adequate sunlight for further development. The mature trees stand out from the canopy with the characteristic crown.

Natural regeneration

The species is regenerated following general prescriptions of an irregular shelter-wood system in Bangladesh and India. In a monocyclic operation, the commercially valuable trees in the mixed forest are extracted, taking adequate care to retain uniform shade. Being a strong shade bearer, the species regenerates fairly well. After the seedlings establish themselves, the canopy is lifted in stages, as sapling and poles require light. In Bangladesh aided natural regeneration has been tried with success. Planting out nursery grown seedlings in natural regeneration areas has been found more promising than direct sowing of seeds. In shaded nursery beds the seeds germinate easily, the germination percent being **64.** In unshaded beds the germination percent is only 55. Regular watering of the beds is necessary. 15cm high seedlings are planted out. It is reported that stumps sprout with reasonable success (Homfray, 1935), but stump planting is not in vogue.

Wood

Structure

Vessels large to very large, the majority solitary, occasionally paired, fairly close and quite evenly distributed, 4 – 8/mm^2 ;perforations simple; occasionally with deposits of reddish brown gum.

Tracheids sparse, with numerous horizontally oriented, narrowly bordered, elliptical pits.

Parenchyma paratracheal, metatracheal, and encircling all resin canals; paratracheal parenchyma relatively sparse, forming a narrow, 1-several seriate sheath, metatracheal parenchyma sparse, frequently forming short, uniseriate tangential lines, parenchyma about the resin canals rather extensive, occasionally extending tangentially; reddish brown gummy infiltration frequent in all types of parenchyma.

Fibres filiform, arranged in radial rows, non-septate, interfihre pits most numerous on the tangential walls, bordered, with slit-like, nearly vertical orifice; reddish brown infiltration occasional.

Rays rather coarse, **1-7** seriate, heterogeneous: reddish brown infiltration copious.

Resin canals solitary or occasionally 2 to several at intervals; contents white (Pearson and Brown, 1932).

Properties

Sapwood greyish or brownish white, heart-wood light red to uniform reddish brown; dull with rather rough feel, fairly straight to somewhat interlocked grained, even and coarse textured; moderately heavy, sp. gr. approximately 0.71, weight at 12 percent moisture content 720.83 Kg/m^3. The timber is moderately easy to air season. Kiln seasoning is difficult. The timber does not split or warp excessively, though somewhat liable to cupping if cut in large dimensions. It is not durable in exposed conditions but lasts fairly well under cover, especially in well ventilated situations. It is not refractory to treatment. Saws with ease and machines well working to a smooth surface, takes a fair polish.

Uses

Used in the plywood industry for commercial grade plywood As a constructional timber it is popular as planks and scantlings for interior use. After treatment used as railway sleepers.

DIPTEROCARF'US GRANDIFLORUS Blanco

Syn. ***Dipterocarpus blancoi*** B1.
D. grandiflorus Griff.
D. griffithii Mig.
D. motleyanus Hook. f.
D. pterygocalyx Scheffer

Common names
Hin. – Gurjan
Bur. – Kanyin byan, Kanyin.

A large tree reaching a height of 35 – 45m and a girth of 2 – 4m or more. Bark light grey, peeling off in flakes. Young parts covered with tawny scales or galbrous. Leaves 15 – 22cm by 7.5 – 12cm, elliptic-ovate, shortly acuminate, base rounded or subcordate, margin more or less undulate, coriaceous, glabrous on both surfaces; lateral nerves 12 – 20 pairs, very prominent beneath; petiole 5 – 7cm long; stipule 16cm by 3cm, more or less stellate. Inflorescence axillary, sometimes branched, glabrous or tomentose. Calyx tube more or less five winged, glabrous; the 2 larger lobes 2.5 – 3cm; the 3 shorter lobes, wavy or more or less reflexed. Petals mealy outside. Stamens many, anthers linear; the connectives produced into a bristle. Ovary densely tomentose. Fruit belly 5 – 6cm long, up to 3.5cm in diameter, oblong of ellipsoid, with 5 wings, lcm wide running the whole length; the 2 enlarged calyx lobes 13-20cm by 3 – 4.5cm, 3 nerved for the three quarters of their length or throughout, reticulate, glabrous; the 3 smaller lobes 2cm long, round, with recurved margins (Hooker, 1874, Parker, 1931; Parkinson, 1921).

Distribution – Burma, India

In Burma it occurs all along the eastern slopes and southern end of the Arakan Yoma, the Pegu Yoma and Tenasserim (Parker, 1931). In India it occurs in the Andaman Islands.

Forest Types and Floristics

In Burma the species is found in the Evergreen Dipterocarp Forest (Champion, 1936) which is characterised by the presence of lofty trees and a large number of species. The top canopy is mostly unbroken and the canopy differentiation is not ***so*** apparent. In India it is found in Andamans Tropical Evergreen Forest which generally has a profusion of species and large trees. Consociations are rare and ordinarily two thirds or more of the upper canopy trees are of ***Dipterocarpus*** spp., The undergrowth is often a tangle of canes, climbing bamboos and lianes. Deciduous species also occur which are usually gregarious.

Floristics

(i) Porlobjig, Andamans

I ***Dipterocarpus grandiflorus, D. gracilis, Artocarpus chaplasha, A. gomeziana. Calophyllum soulattri; Artocarpus*** sp., ***Dysoxylum grande, Baccaurea sapida, Cinnamomum inunctum Michelia champaca*** (Hundley, 1961).

Silviculture and Management

Phenology

In Burma flowering is in January and fruits ripen during May-June. In the
man Islands also flowering is generally in January and fruiting during May-June. But in some localities flowering has been noticed in February, May and October (Parker, 1931).

Silvicultural characters

The species is essentially a light demander. Although in seedling stage it can tolerate shade, its further development is dependent upon adequate light. This important requirement is to be satisfied to obtain regeneration. In natural forest it is often seen that saplings and poles exist in a suppressed condition because of lack of light. If there happens to be a break in the canopy accidently or by actual manipulation, the apparently suppressed plants recover and shoot their heads upwards. Thus heavy shade does not cause total mortality but rather impedes normal growth. The species is not a good coppicer.

Natural regeneration

The species has been successfully regenerated in the Andaman Islands (Chengappa, 1944). Before the seedfall the ground is cleared of leaf litter and debris. A light burning helps considerably. The viability of the seed is very low. In natural conditions, unless the seed-fall is immediately followed by a good shower, germination does not take place. After germination shade is heavily reduced by proper manipulation of the cans py. Wherever stocking is poor, freshly collected seeds are dibbled in the next season. Even this operation is not always necessary as germination in natural forest is quite satisfactory. The canopy is lightened to keep pace with the growth of seedlings and saplings.

Wood

Structure

A diffuse porous wood, vessels moderately large, few to moderately numerous, 4 – 13/mm^2, uniformly distributed, mostly solitary, a few in radial or oblique pairs, oval to round in shape, filled with tyloses.

Parenchyma scanty to fairly abundant; apotracheal parenchyma diffuse; paratracheal parenchyma forming a thin layer, usually not conspicuous, fairly conspicuous round the gum ducts forming a several seriate layer.

Rays moderately broad to fine, brownish in colour, not closely spaced, evenly distributed, often showing a conspicuous silver grain effect on the radial surface.

Resin canals vertical, size rather variable, fairly uniformly distributed; white deposits sometimes fill up the cavity of the ducts (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood fairly well demarcated sapwood pale yellowish-brown, heartwood reddish-brown, sometimes with an orange tinge, darkening to red on exposure, occasionally with reddish streaks, often with gummy exudation on the end surface; straight to interlocked grained, coarse textured, moderately hard and heavy; sp. gr. 0.606. Weight at 12 percent moisture content 753 Kg/m^3.

Shrinkage percentage green to oven dry

Radial	4.0
Tangential	11.5
Volumetric	19.1

Modulus of rupture (Kg per cm^2)

Green	628.5
Air dry	1015.6

Modulus of elasticity (Kg per cm^2)

Green	117,100
Air dry	151,300

Maximum crushing stress (Kg per cm^2)

Green	317.4
Air dry	542.5

Moderately easy to air season. It dries with little degrading. Kiln seasoning is difficult. Fairly durable. Easy to work with machine and hand tools (Chowdhury and Ghosh, 1958).

Uses

A good timber for commercial grade plywood. In Andamans used as general construction timber and as jetty piles after treatment.

Non wood products

The species yields an oleo-resin which changes into a semiplastic mass on long exposure. The oleo-resin is obtained by cutting a semicircular niche about a metre high from the ground level. The niche is freshened frequently, to ensure regular flow. The exudation has a thick honey like con. sistency, reddish brown in colour and has a characteristic balsamic odour. It consists of about 35% volatile oil and a hard, yellow, lustrous resin. The resin when dissolved in linseed oil and turpentine gives a varnish. The resin residue left after distillation of essential oil has the following physico-chemical characteristics (Karnik and Batia, 1965).

Acid value	17.3
Ester value	15.3
Non-saponifiable matter percent	78.4
Colour of intensity (Lovibond)	red = 45
Tintometer, 1.25cm cell	yellow = 14

DIPTEROCARPUS HISPIDUS Thw.

Syn. *Dipterocarpus oblongifolius* sensu Thw. *D. D. oblongus* A.Dc.

Common name

Sinh. Dorana

A large tree attaining a height of 45m and a girth of 4m with a straight bole and a dome-shaped crown. Bark surface orange-brown, flaky. Young parts densely covered with tufts of long fulvous hairs. Leaves 11.5 – 18.5cm by 6.5 – 9.5cm, oblong-ovate, shortly acuminate, base rounded or cordate; lateral nerves 14 – 24 pairs, straight, prominent below and shallowly depressed above; petiole 2.7cm long, hispid; stipule 20cm long, oblong-elliptic, obtuse, tawny hispid. Racemes axillary, hispid; flowers about 5cm long, pedicels hairy. Calyx hispid, the 2 larger lobes oblong. Petals densely stellate hairy outside. Stamens 15; connective shorter than the anther. Ovary pubescent; stylepodium and style glabrous except the basal one-third. Fruit belly 3cm in diameter, subglobose, smooth; the two larger fruit sepals 17cm by 4cm, linear-obovate, obtuse, 3 nerved; the 3 shorter lobes 1.5cm by Icm broadly elliptic-obtuse (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

This endemic species is fairly common in Kuraipilaikanda, Kitugala, Gilimale of Ratnapura, Nellowe-Pelawatte Road and Kottawe of Galle.

Forest Types and Floristics

The species is common in Lowland Wet Evergreen Forest (Andrews, 1961) and fairly abundant in moist localities below 1000m The forest is characterised by a preponderance of tall trees, diversity of species and canopy formation.

Floristics

Kanneliya

Dipterocarpus glandulosus. Calophyllum soulattri, Agrostictachys coriacea, ***Litsea*** *glutinosa, Nothopeg'a beddornei,* ***Carn-*** *pnosperrna nobilis, Symplocos* sp., *Mernecyion grande, Meliosma simplicifolia, Mangifera zeylanica, Pseudocarpa championii, Ficus callosa, Garcinia cornbogia. Chaetocarpus castanocarpus, Hopea jucunda.*

Silviculture and Management

Phenology

Flowering in April fruiting during May-June.

The species regenerates freely but no systematic management is in vogue to ensure proper regeneration.

Wood

Structure

Vessels few to moderate, large, mostly solitary; tyloses common.

Parenchyma vasicentric to aliform.

Rays medium.

Resin canals mostly solitary and scattered.

Sapwood pale pinkish-white, heartwood light pinkish to dark reddish-brown, contains a considerable amount of oleo resin, has a characteristic odour, fairly straight grained, even and coarse textured, moderately bard and heavy. Weight 778 Kg/m^3 at 12 percent moisture content.

Seasons slowly with a marked tendency to crack and warp unless carefully handled. Not refractory to treatment, penetration of preservatives satisfactory under pressure. Easy to saw and work, finishes to a fairly smooth surface. Not durable in open situations, fairly durable under cover.

Uses

Extensively used for railway sleepers after treatment, a good general construction timber for rafters, beams and boards; used in shuttering and scaffolding. It is popular as a marine timber for piles and underwater structures. Due to the fairly smooth finish, the timber is used for furniture. It is one of the principal plywood timbers of the region.

Non wood products

The resinous exudation has dipterocarpol, dammarenediol and ocotillone (Bandaranayake *et al.,* 1975).

DIPTEROCARPUS INDICUS Bedd.

Common names

Hind. – Guva
Kan. – Guga, Challana, dhuma
Mal. – Kakka, Kalpayin, Vellayani, Vavungu.
Tam. – ennai.

A lofty tree attaining a height of 45 – 50m and a girth of 5m or more with a straight clean bole and an elevated round – headed crown which stands generally well above the rest of the canopy in natural forest. Bark surface light-grey, smooth and sometimes exfoliate in irregular flakes. Young shoots covered with adpressed tomentum. Leaves 15 – 25cm by 6 – 12cm, ovate, acute or acuminate, base rounded or slightly cordate, coriaceous, margin undulated; lateral nerves looped; petiole **2.5** – 5cm long, often swollen just below the leaf blade; stipule large, caducous, tomentose. Racemes axillary. Flowwers large, fragrant. Calyx tube campanulate, glabrous, lobes 3 short, **2** linear. Petals pubescent. Stamens many; anthers elongated; connective produced into a bristle. Ovary slightly tomentose; style filiform, pubescent. Fruit belly broadly turbinate, 2.5 – 3cm long by 2 – 2.5cm in diameter, glabrous; the **2** larger calyx lobes 9.5 – 15cm; the 3 smaller lobes less than 3cm long (Bor, 1953; Bourdil-Ion, 1908; Gamble, 1915).

Note: – Some authors (Gottwald & Parameswaran, 1966; Talbot, 1909) consider ***Dipterocarpus indicus*** Bedd. as a synonym of ***D. turbinatus*** Gaertn. f. **In** view of the physiognomic and taxonomic differences they are described as separate species in this study.

Distribution – India

The species is of common occurrence in the evergreen forests of South India It extends from southern ghats of North Kanara in Karnataka southwards all along the western ghats down to southern Kerala. It is common in Gersoppa, Agumbe, Bisle, South Kanara and Coorg in Karnataka State, Tirunelveli and Shenkottah of Tamil Nadu and most parts of Kerala. The most luxuriant growth is between 300 – 760m altitude (Kadambi, 1954 a).

Forest Types and Floristics

The Southern Tropical Wet Evergreen Forest (Champion and Seth, 1968) where this species is found is characterised by dense tree growth with a large number of soecies. Although consociations are rare ***D.*** *indicus* is sometimes seen semi-gregariously in the West Coast Tropical Evergreen Forest. The species extends to the Southern Tropical Semi-Evergreen Forest also. But in this forest its distribution is scanty.

The greater part of the forest types in which this species is found have crystalline rock, usually gneiss or granite, though it extends over the metamorphic rocks, shales and even quartzites.

The soil over a considerable portion of the tract **is** ferruginous sandy loam in hill slopes (Wynad, Kerala) or pale red clay of moderate depth (North and South Mangalore, Karnataka) or red loam (Coorg, Karnataka). The presence of surface boulders makes the ferruginous loam frequently shallow but often up to 3m deep. In the valley the soil is gravelly loam redeposited from elsewhere and of laterite and granitic composition, very rich in humus, the layer of decaying vegetable matter being often 7.5cm or more deep. The drainage is always good as the topography of the area is rugged (Kadambi, 1950a; Sarma, 1934).

Floristics

(i) Agumbe, Karnataka (West Coast Tropical Evergreen Forest)

I ***Dipterocarpus*** *indicus, Poeciloneu**ron** indicum.* ***Mesua ferrea, Hopea parviflora,***

Calophyllum elatum, Machilus macrantha, Elaeocarpus tuberculatus and *Palaquium ellipticum.*

I1 *Myristica* sp., *Syzygiurn* sp., *Dysoxylum* sp., *Stereospermum* sp., *Lagerstroemia* sp., *Garcinia* sp., *Ficus* sp., *Bischofia jauanica, Nephelium* sp, *Amoora canarana, Tonna ciliata, Vitex leucoxylon, Pithecolobium bigeminum, Mangifera indica, Diospyros ebenum, Elaeocarpus serratus, Olea dioica.*

111 *Macaranga* sp., *Maesa* sp., *Ardisia* sp., *Ficus* sp., *Erythrina* sp., *Syzygium* sp., *Miliusa* sp., *Grewia* sp., *Cinnamomum zeylanicum. Hydnocarpus pentandra, Aglaia odoratissima. Aporosa lindleyana. Walsura* sp., *Semecarpus anacardium.*

IV *Morinda* spp., *Ixora* spp., *Boehmeria* sp., *Macaranga* sp., *Callicarpa tomentosa, Meiogyne lawii* (Champion and Seth, 1968).

(ii) Nelliampathy – Palghat, Kerala (West Coast Semi-Evergreen Forest)

I *Dipterocarpus indicus, Vateriu indica, Artocarpus hirsuta, Dysoxylum mulabaricum. Artocarpus fraxinifolius, Hopea parviflora, Filicium decipiens, Kingiodendron pinnatum. Elaeocarpus* spp., Bischofia javanica, Toona ciliata.

I1 *Myristica* spp., *Litsea* spp., *Hydnocarpus Qentandra, Pterygota alata, Vitex altissima, Schleichera oleosa. Cinnamommum* SPP.

III *Leea indica. Calamus* sp., *Arenga wightii* (Champion and Seth, 1968).

Silviculture and Management

Phenology

The species is typically evergreen, but owing to the great difference in the moisture conditions prevailing between the wet and the dry seasons the density of the leaf cover varies greatly in different seasons. At the onset of the dry season there is a heavy shedding of the old leaves. The flowering period is from December to March, depending upon the localities, the peak being in January and early February (Kadamhi, 1950c). The fruit ripens in April – June. Fruiting is irregular. In certain localities alternate years are good seed years.

Silvicultural characters

The species is shade tolerant in the early stages and seeds germinate even under dense shade. Experiments in Chandanathode (Kerala) and Topslip (Tamil Nadu) have shown that survival of the seedlings is better ensured under shade (Mad. Ann. Rep. Silvi. Res. 1939—40). Once established, the sapling can make sufficent progress only if it gets adequate light. Otherwise its growth stagnates (Kadambi, 1954aaa). The species is sensitive to fire, its thin bark being ill-adapted to withstand fire injury. If the damage from fire exceeds slight superficial scorching, the trees are killed outright. The coppicing power of the species is very poor (Kadambi, 1954 a).

In Agumbe – Kilandur (Karnataka) there is a preponderance of mature trees of the species as well as young regeneration in seedling and early sapling stages. But the frequency of other stages in growth is very poor. This clearly indicates the need for light in post establishment stages of growth. Because of the dense overhead canopy the regeneration could not progress beyond seedling or early sapling stage.

Natural regeneration

Natural regeneration of this species is satisfactory. In felled areas where the canopy has been disturbed, the regeneration is often copious. A clear germinating bed and well drained soil are the essential requirements to ensure establishment of seedlings. As the viability of the seed is about a week only, unless seedfall is immediately followed by rain, natural regeneration fails. In favourable years when the premonsoon and monsoon rains are both timely and adequate, germination is plentiful (Kadambi, 1954 a).

In areas subjected to heavy exploitation the ingress of light assists in the rapid disintegration of litter and felling and extraction operations expose the soil. In favourable seed years, therefore, elephant drag paths and interior cart-tracks are packed with seedlings. A good number of them perish during the ensuing dry season, but may survive under shade. Excessive weed growth in such areas, however, smothers the seedlings and kills them outright.

In felled areas where natural reproduction is abundant, the regeneration is tended and encouraged to progress by lifting the canopy in three stages (1) the first stage (2) the intermediate stage (3) final stage. In the first stage ali the undergrowth except the seedlings and poles of ***D.** indicus* and its commercially valuable associates are removed. In the intermediate stage middle level canopy is suitably manipulated to allow adequate sunlight. This is acomplished by the removal of non-commercial species. In the final stage the top canopy is manipulated to allow more sunlight for the saplings and poles (Kadambi, 1949).

Although experimental data have shown that a mono-cylic system of regeneration is suitable, the common practice still followed is the poly-cyclic system where the mature trees are. removed in 20 – 30 years felling cycles. Some of the management practices are summarized below.

1) North Kanara (Karnataka)

The management is under selection system with an exploitable girth limit of 2.13m. A rotation of 200 years has been prescribed. The natural regeneration is supplemented by planting wildings and nursery seedlings.

2) Ghat forests of Coorg (Karnataka)

A cautious selection system has been adopted with an exploitable girth limit of 2.3m. A rotation of 150 years with 30 years felling cycles has been prescribed in the working plans. Canopy is lifted in 3 stages to facilitate natural regeneration (1) year of felling (2) 7 – 8 years after felling and (3) 24 years after felling. Gaps in which natural regeneration fails are stocked by dibbling freshly collected seeds or planting out nursery seedlings.

Although this species is one of the principal components of the evergreen forests of **S.** India, reliable data are not available about growth and yield. A local volume table prepared by Kadambi (1949) has given the following girth/volume relationship.

Girth class (cm)	Volume (cm^3)
210 – 240	2.15
240 – 270	4.42
270 – 300	6.03
300 – 330	7.08
330 – 360	8.07
360 – 390	9.09
390 – 420	9.83
420 – 450	11.04
450 – 480	11.72

Artificial regeneration

In view of the response of the species to natural regeneration and the requirement of shade in early stages, no organized efforts have been made to raise plantations. Seedlings have, however, been raised in nurseries to supplement natural regeneration.

The species can be raised by direct sowing or by planting out entire seedlings (Silvi. Res. Rpt; Madras, 1946—47). Stump planting is not satisfactory although it has been reported that experiments in Coorg (Karnataka) resulted in 50% sprouting of stumps in stray cases. The maximum germination percent obtained in nursery is 41 in Tamil Nadu (Silvi. Res. Rpt, Madras: 1938-39; 39—40). Nursery seedlings can be planted out when 3 months old, but one year old seedlings appear to be more suitable. The best time to plant out is early August as borne out by experiments at Karian shola, Kerala.

Seeds should be collected soon after they fall and sown in shaded nursery beds 15cm apart or preferably in containers. It is better to clip the wings and sow the seeds apex downwards. Germination is complete within 2 - 3 weeks. Judicious watering and weeding should be done till the planting season. Seedlings attain a height of about

50cm by then. Light over head shade should be provided during summer months (Rai, 1978). It is observed that the development of the tap root is very fast in the seedlings (as much as 20cm within **2** months).

Wood

Structure

Vessels large to medium sized, the majority solitary, occasionally paired, quite close and fairly evenly distributed, 5 – 9/ mm^2 ; perforations simple, transverse; tyloses sparse, occasionally with deposits of reddish brown gum.

Tracheids 'sparse, with numerous horizontally aligned, narrowly bordered, elliptical pits.

Parenchyma paratracheal, metatracheal, and in rather broad-interrupted hands; paratracheal parenchyma relatively sparse, forming a narrow, one to several seriate (mostly one) sheath, metatracheal parenchyma fairly abundant, scattered; parenchyma about the resin canals in rather extensive tracts; 3-8 seriate; reddish brown gummy infiltration fairly abundant in all types of parenchyma.

Fibres filiform, more or less aligned in radial rows, non-septate, interfibre pits most numerous on the longitudinal walls, bordered; reddish brown infiltration occasional.

Rays fairly fine, mostly 3-4 seriate, heterogeneous, reddish brown infiltration copious.

Resin canals solitary or frequently two to several at intervals; contents white (Pearson and Brown, 1932).

Properties

Sapwood and heartwood not well demarcated. When dry, sapwood greyish white, heartwood light red to light brownish red, dull with somewhat rough feel witb characteristic odour, fairly straight, interlocked grained, even and coarse textured, moderately heavy, sp. gr. 0.62 (Pearson and Brown, 1932). Weight at 12 percent moisture content 753 Kg/m^3.

Shrinkage percentage green to oven dry

Radial	6.0
Tangential	11.4
Volumetric	18.9

Modulus of rupture (Kg per cm^2)

Green	789.1
Air dry	1245.2

Modulus of elasticity (Kg per cm^2)

Green	162,900
Air dry	201,400

Maximum crushing stress (Kg per cm^2)

Green	411.1
Air dry	719.4

The timber is fairly durable compared to other species of ***Dipterocarpus.*** Grave yard test at Dehra Dun indicated a life of 25 – 37 months. The timber is refractory to treatment, the heartwood has been found to be moderately treatable but not always with complete penetration of the preservative. Easy to work with machine and hand tools. Renders itself to easy sawing and can be planed to a fairly smooth surface. Has an attractive grain when quarter sawn. It is rather difficult to stain, wax and polish. It can be turned to a rather rough finish (Chowdhury and Ghosh, 1958; Sekhar, 1955).

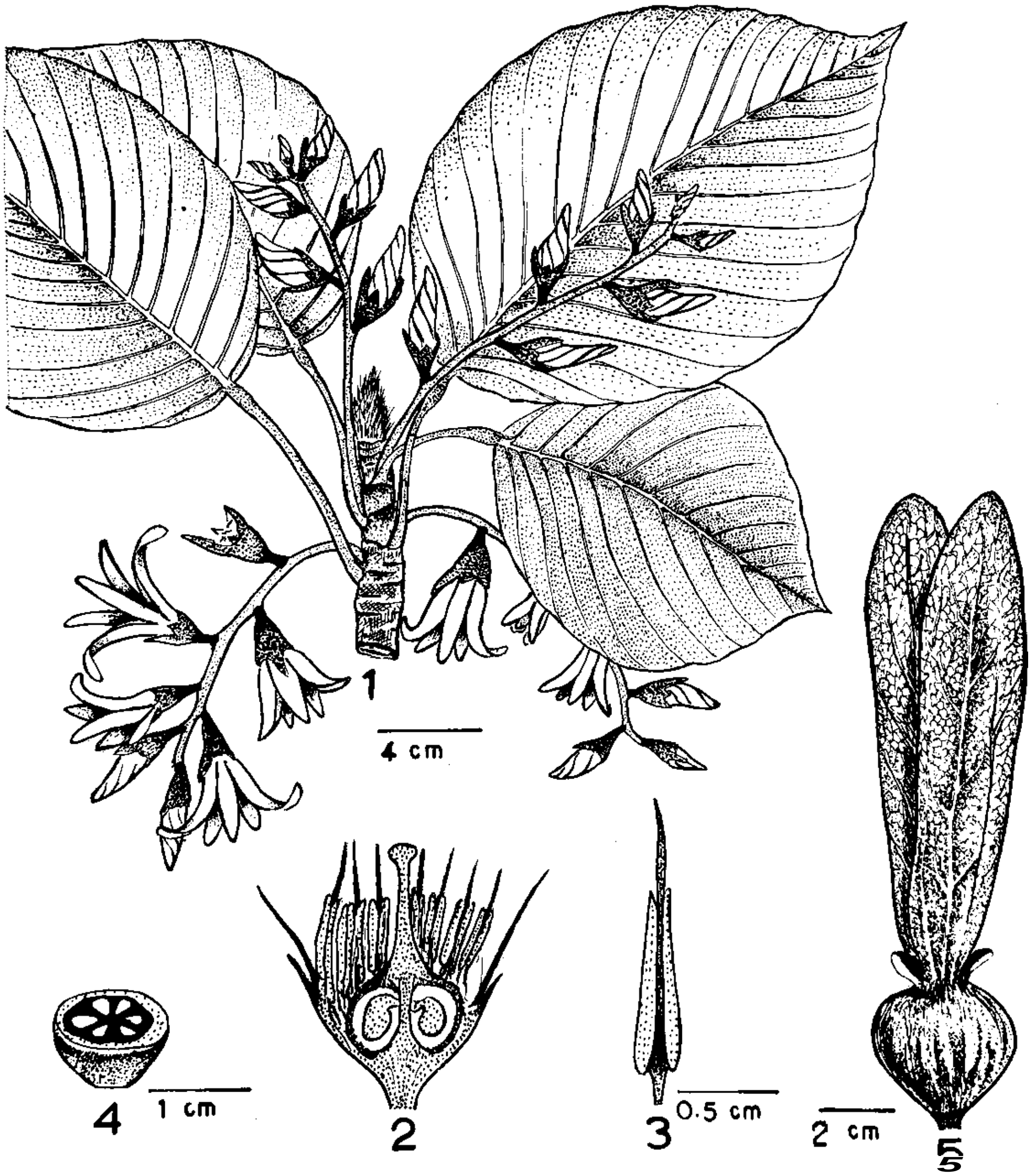
Uses

One of the important plywood timbers of South India. It is extensively used for commercial grade plywood. Occasionally used in rail coaches. Non-ply quality logs are diverted to general construction purposes. Although the timber when treated is suitable for railway sleepers, it is not in use because of the demand in plywood industry.

DIPTEROCARPUS INSIGNIS Thw.

A large tree attaining a height of 45m and a girth of 4.5m and straight bole. Bark surface pale chocolate-brown, thickly flaky. Young twigs hispid. Leaves 7 – 12cm by 4 – 6cm, ovate to elliptic, acuminate, base narrowly to broadly obtuse, glabrous above

Dipterocarpus indicus



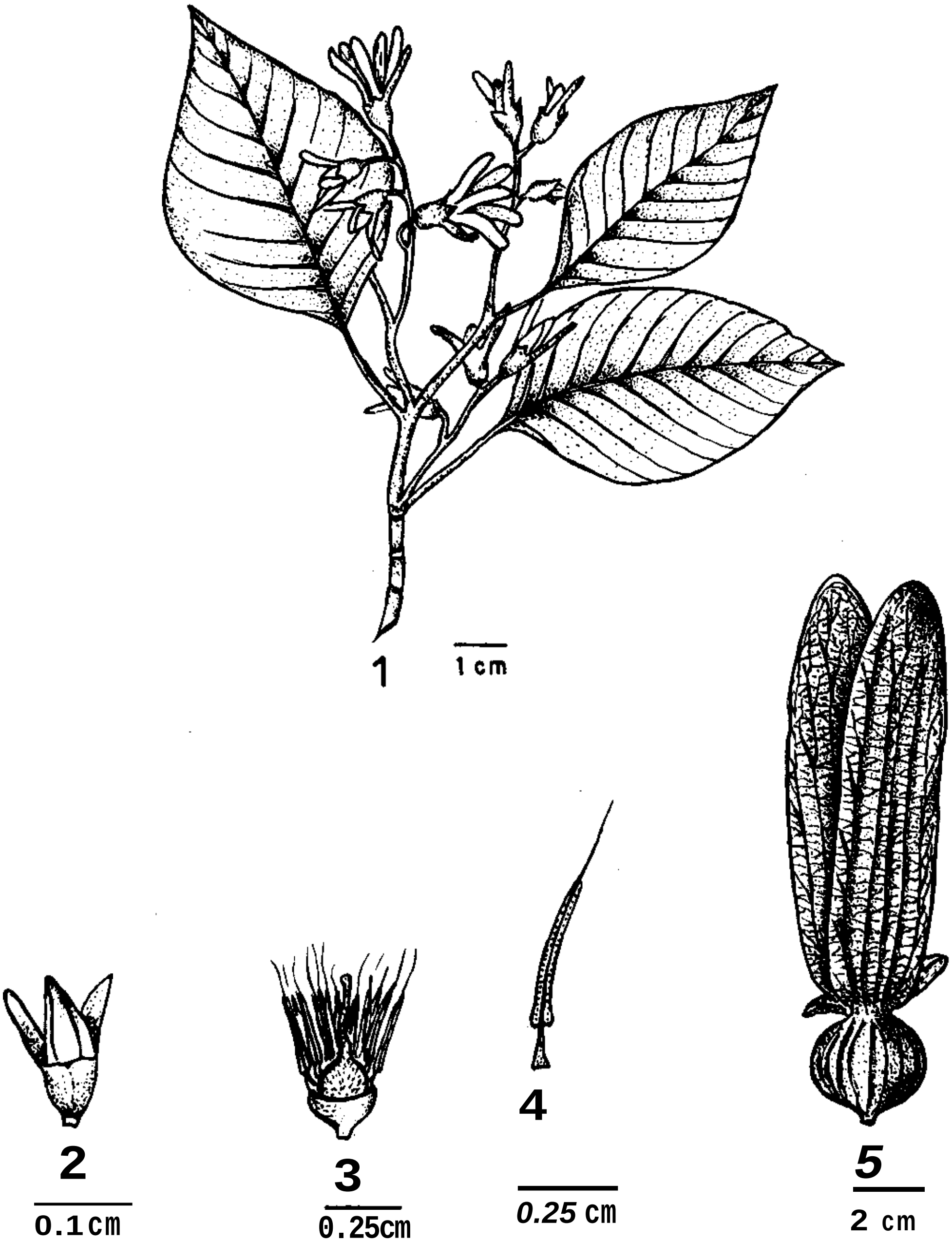
Dipterocarpus indicus

1. **Flowering shoot**
2. **L.S. of Flower**
3. **Stamen**
4. **T.S. of** ***ovary***
5. **Fruit**

Dip terocarpus insignis

1. **Flowering shoot**
2. **Fruit**

Dipterocarpus kerrii

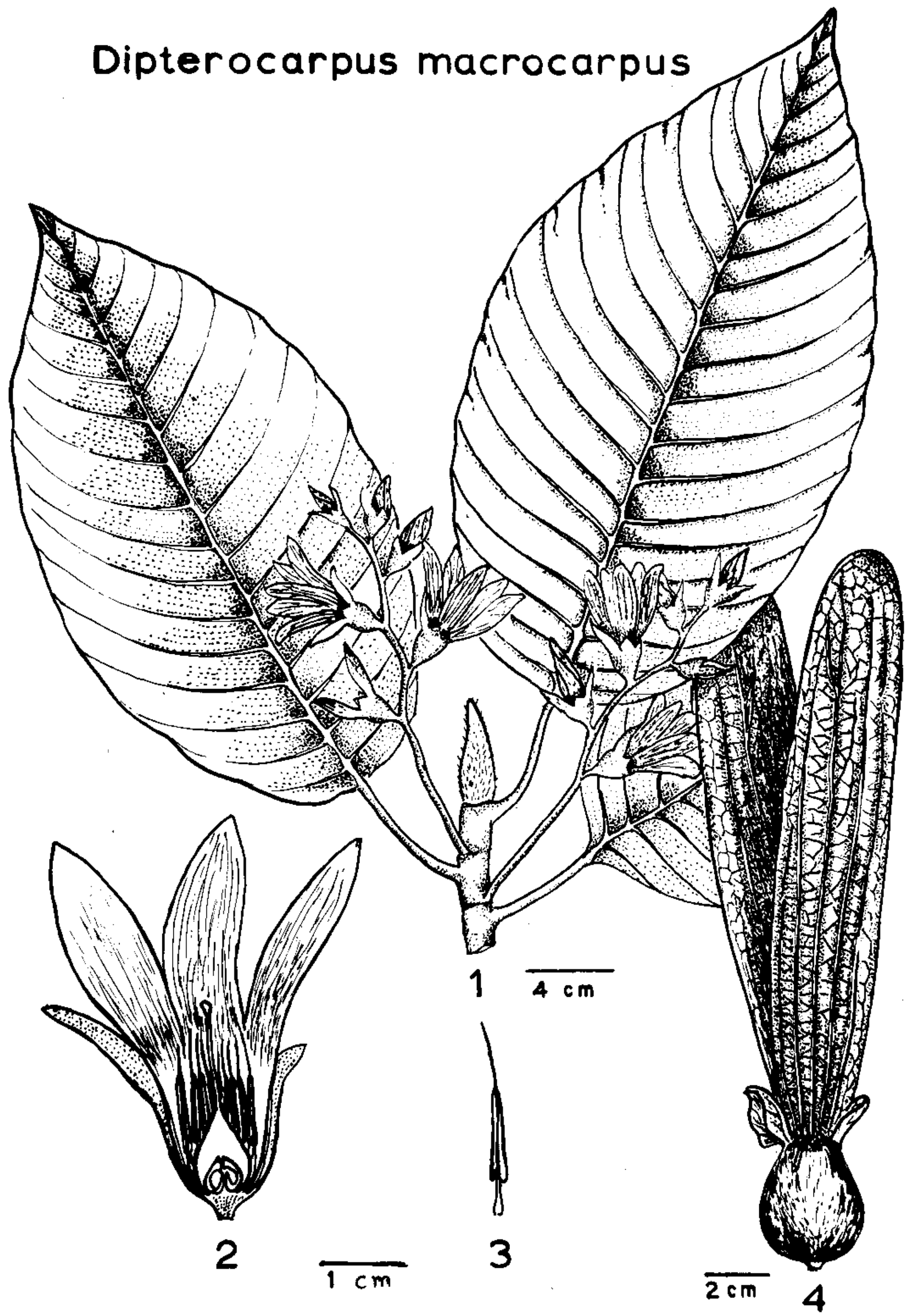


Dipterocarpus *kerrii*

1. **Flowering shoot**
2. **Flower bud**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

Dipterocarpus kerri
Pole crop in 1951–1952 regeneration area
South Andamans Division
Andamans, India
(Photo FRI)

Dipterocarpus macrocarpus



Dipterocarpus macrocarpus

1. **Flowering shoot**
2. **L.S. of Flower**
3. **Stamen**
4. **Fruit**

and rufous hispid on veins beneath; lateral nerves **10** – 12 pairs, straight, prominent below and depressed above; petiole **1.5** – 2.3cm long, hispid; stipule hairy. Racemes axillary, sparsely tomentose; flowers sessile. Calyx tube oblong, prominently 5 winged, glabrous; the two larger lobes as long as the tube, the 3 smaller lobes truncate. Petals ovate-oblong, densely pubescent outside. Stamens many; anthers very slender; appendage shorter than the anther. Ovary conical, shortly pubescent. Fruit belly fusiform, with five wings, 2cm in diameter; the larger calyx lobes 9.5cm by 2cm, lorate, obtuse at apex; the 3 shorter lobes 0.5cm long, sinuate, glabrous (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

Restricted in occurrence, confined to Kanneliya, Gilimale, Ratnapura and Himiduma.

Forest Types and Floristics

The species is scattered in the Lowland Wet Evergreen Forest (Andrews, 1961). It **is** mostly seen on undulating land with moist soil.

DIPTEROCARPUS KERRII King

Syn. *Dipterocarpus cuneatus* Foxw.
D. obconicus Foxw.
D. perturbinatus Foxw.

Common names

Bur. – Kanyin ni, Kanyin pyan.
Hind – Gurjan

A large tree attaining a height of 30-38m and a girth of 2 – 4m. The bark surface dark grey, peeling off in flakes. Young twigs and buds glabrous. Leaves 7.5 – 13.5cm by 5 – 7.5cm elliptic, elliptic-ovate or ovate-lanceolate, shortly acuminate, base cuneate, margin repand, glabrous; lateral nerves 8 – 12 pairs; petiole 2.5 – 3.2cm long, rather slender; stipule 3.5 – 6cm long, glabrous outside, densely silky pilose within. Inflorescence axillary 2 – 4 flowered, simple or branched, the lowest flower often distinctly pedicelled and all appearing pedicellate owing to a contraction at the base of the calyx. Calyx tube Icm long, glabrous; lobes **3** broad, rounded, scarcely 1mm long, 2 linear – oblong, 8mm long. Petals finely stellate, tomentose without, hoary within. Stamens many; filaments flattened at the base, connective produced into a bristle. Ovary densely tomentose; style glabrous in the upper 2/5th. Fruit belly 2.5 – 3cm diameter, globose or broadly turbinate, glabrous; the 2 enlarged calyx lobes 7 – 13.5cm by 2.3cm, glabrous (Parker, 1931; Parkinson, 1921).

Distribution – Burma, India

In Burma this species occurs from Mergui to Victoria Point. Though it grows in pure patches near Bokypin, Mergui, it is normally not gregarious (Parker, 1931).

In India it is confined to Andamans, localized in Goplakabang and Mt. Harriet Range. It occurs rather gregariously here but is confined to a very restricted area.

Forest Types and Floristics

In Burma the species occurs in the Southern Low Tropical Evergreen Forest (Champion, 1936). In Andaman Islands it is found in the Andaman Tropical Evergreen Forest (Champion & Seth, 1968). The top canopy is very irregular.

Floristics

(i) Goplakabang Valley – South Andamans.

Dipterocarpus grandiflorus, D. gracilis. D. kerrii, Artocarpus sp., *Planchonia littoralis, Hopea odorata, Pterospermum* ***aceroides****, Myristica andamanica. Macaranga andamanica, Mussaenda macrophylla,* ***Leea*** sp., *Euodia glabra, Licuala peltata.*

(ii) Bokypin – Lower Burma

Dipterocarpus kerrii. Mesua sp.. *Hopea* spp., *Syzygium* sp. and *Dillenia* spp. (Hundley, 1961).

Silviculture and Management

Phenology

The flowers appear in February and fruits in April.

Natural regeneration

Wherever the species occurs gregariously regeneration is prolific. Advantage of this feature is taken to encourage dense crops of young seedlings and saplings. The canopy is gradually lightened and middle storey species eliminated to obtain a closely stocked mature crop.

Wood

Structure

Wood is diffuse porous, vessels moderately large, mostly solitary, very few in radial or oblique pairs, uniformly distributed.

Parenchyma scanty to fairly abundant. Apotracheal parenchyma diffuse; paratracheal parenchyma forming a thin layer, usually not conspicuous; parenchyma around the gumducts forming a several seriate layer.

Rays uniseriate and multiseriate, moderately broad to fine, brownish in colour, not closely spaced, evenly distributed.

Resin canals often solitary, uniformly distributed, white deposits sometimes fill up the cavity of the ducts (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood fairly well demarcated, sapwood dirty white to yellowish brown, heartwood pale red to reddish brown; gummy exudation present, straight to inter locked grained and coarse textured; moderately hard and heavy, sp. gr. 0.616. Weight at 12 percent moisture content 785 Kg/m^3.

Shrinkage percentage green to oven dry

Radial	5.8
Tangential	12.3
Volumetric	19.1

Modulus of rupture (Kglcm’)

Green	715.7
Air dry	1281.1

Modulus of elasticity (Kg/cm^2)

Green	136,200
Air dry	186,000

Maximum crushing stress (Kglcm^2)

Green	324.3 .
Air dry	691.8

The timber is not durable, it splits easily. Not easy to saw and peeling qualities are poor (Chowdhury and Ghosh, 1958).

Uses

In the Andaman Islands the logs are used as jetty piles and timber for construction.

DIPTEROCARPUS MACROCARPUS Vesque

Common names

As. – Hollong, hullong
Bur. – Kanyin

A very large tree attaining a height of 40 – 50m and a girth of 4 to 6.5m with a small spherical crown. Bark smooth, light grey with many large raised warts. Young twigs, petioles and inflorescence densely covered with grey tomentum of short stellate hairs. Leaves 25 – 45cm by 13 – 22cm elliptic – oblong or slightly elliptic-ovate or rounded, margin repmd or corrugated, ciliate especially when young, glabrous except along the midrib above when mature, softly pubescent beneath along the veins; lateral nerves 18 – 25 pairs, oblique; petiole 3.5 – 5cm long; stipule upto 8.5cm long, membranous, densely stellate pubescent or rarely glabrous. Spikes axillary, 3 – 6 flowered, the lowest Elower usually distinctly pedicelled, peduncle somewhat zig-zag, simple, rarely branched. Calyx tube turbinate, pubescent, usually the basal portions for a length of 3mm contracted into a pedicel like structure; lobes **3** short, broad, obtuse, 2 linear oblong about 1.5cm long. Petals subfalcately oblanceolate, membranous towards the margins, finely grey tomentose. Stamens many; filaments flattened at base; connective produced into a bristle. Ovary densely tomentose. Fruit belly 2.5 – 3cm in diameter, 2.5 – 3.5cm long, dotted with minute stellate hairs, more or less contracted at the apex, furnished with a short stalk at the base; larger calyx lobes orbicular-ovate, 15 – 22cm by 2 – 5cm, strongly 3-nerved to the apex or nearly to it, basally 5 nerved sparsely dotted with small stellate hairs (Parker, 1935).

Distribution – Burma, India

In Burma the occurrence of this species is widely separated. It is very common in Tenasserim and Myitkyina. There is no record of its occurrence between these two localities (Parker, 1935). It is the commonest Dipterocarp of Eastern India and well known as 'Hollong'.in trade. The evergreen forests where this species occurs are calied Hollong forests. It is found extensively in Upper Assam, Arunachal Pradesh, Nagaland, Manipur, Tripura, parts of West Bengal and Meghalaya. It is one of the principal commercial trees of this tract.

Forest Types and Floristics

In Burma the species is found in the Northern Burma Tropical Evergreen Forest (Champion, 1936). It is an important constituent in the top canopy, mostly scattered, but occasionally forming almost pure patches. Deciduous species are interspersed. The lower storeys are dense with evergreen species. 1n.India the species has a wide distribution in the Assam Valley Tropical Wet Evergreen Forest characterised by a luxuriance of growth. This species, along with *Shorea assamica,* is spread over vast stretches with *Vatica lanceaefolia* in the under storey. The forest, commonly referred to as Hollong forest, is the most valuable evergreen forest of the area. The species is also found in the Eastern Alluvial Secondary Semi-Evergreen Forest where it is scattered, intermixed with a number of evergreen and deciduous species.

In its natural habitat the species is found on different soil formations. It flourishes best on well drained soil, especially rich in sandy loam, In Jaypore (Assam, India) the soil is of recent alluvial formation over tertiary sand stones and shales. The zone of distribution of the species is characterised by heavy rainfall, the average ranging from 250 – 270cm. It is capable of withstanding extremes of temperature ranging from 5°-38°C.

Floristics

(i) Kachin, Northern Burma (Tropical Evergreen Forest)

Dipterocarpus turbinatus, D. macrocarpus, Shorea assamica, Dysoxylum binectariferum. Acrocarpus fraxinifolius, Mesua ferrea, Toona sp., *Syzygium* spp., *Chukrassia* spp., Quercus spp., *Castanopsis* sp., *Dendrocalamus hamiltonii* and *Cephalostachyum pergracile* (Hundley, 1961).

(ii) Assam, India (Assam Valley Tropical Wet Evergreen Forest)

I *Dipterocarpus macrocarpus, Shorea assamica, Artocarpus chaplasha, Amoora wallichii, Michelia champaca, Altingia excelsa, Canarium resiniferum. Cinnamomum cecicodaphne, Duabanga grandiflora, Toona ciliata, Terminalia myriocarpa.*

I1 *Vatica lanceaefolia, Dysoxylum binectariferum, Castanopsis* sp., *Talauma hodgsoni, Dillenia indica, Kydia calycina.* The bamboos are *Dendrocalamus hamiltonii* and *Teinostachyum dullooa.*

I11 *Leea acuminata, Laportea crenulata, Alpinia allughas, Mussaenda glabra, Calamus erectus, Calamus flagellum* and climbers like *Tylophora* spp., *Vitis* spp., *Acacia acuminata, Caesalpinia bonducella.*

(iii) Lakhimpur, Assam (Eastern Alluvial Secondary Semi-Evergreen Forest)

I *Ailanthus grandis, Pterospermum* sp., *Albizzia lucida, Stereospermum* sp., *Terminalia citrina. T. bellerica, Dipterocarpus macrocarpus, Anthocephalus cadamba.*

I1 *Macaranga* sp., *Mallotus albus, Zanthoxylum* sp., *Alstonia* sp., *Actinodaphne* spp., *Litsea monopetala, Bambusa pallida, Pseudostachyum* sp., *Dendrocalamus hamiltonii.*

Laportea sp., *Melastoma* sp., Osbeckia spp. (Champion and Seth, 1968).

Silviculture and Management

Phenology

In Burma flowering starts in April or May (Parkinson, 1931) and fruiting is in

June-July. In India the flowers appear from January *to* February and the fruits mature in February—March.

Silvicultural charcaters

The species is a shade bearer in the early stages. In concentrated regeneration operations a cover-crop has *to* be provided without which the seedlings will not survive. Being gregarious in habit, it is comparatively simple to ensure regrowth.

Natural regeneration

The natural regeneration of this species is excellent. With proper attention for shade in the early stages and manipulation to allow light at later stages, the species has been very successfully regenerated in Assam and Arunachal Pradesh. The regeneration is so plentiful that a good area presents the picture of a closely stocked plantation. The presence of advanced growth in sapling and pole stages is taken advantage of in natural regeneration operations which follows felling. Regeneration surveys carried out in unworked and worked out areas in Assam give an idea of the extent of natural regeneration.

	Name of Reserv	No. of seedlings/ hectare	No. of saplings/ hectare
Unworked area	Kathang Reserve Forest	2000	1625
	Namphuk Reserv Forest	1425	1250
Worked area	KathangReserv Forest	300	250
	NamphukRererve Forest	650	350

To ensure natural regeneration, normally the undergrowth is removed after the area **is** subjected to commercial exploitation. This operation **is** further continued over a period of **3** years. The incidence of weed and climbers like *Mikania cordata* is particularly at its peak during the rains. Regeneration gets completely smothered by the invasion of *Mikania*. This results in the death of a good percentage of seedlings. Hence, shrub cutting is an essential requirement to ensureregeneration.

Once the sapling reaches a height of about 2m, manipulation of the canopy is necessary to allow light. The operation-consists of removal of the mid-canopy to the extent necessary. Although the saplings are capable of survival under shade, they will remain in a suppressed condition unless the canopy is properly manipulated (Das, 1974).

As evident from the above details good natural regeneration is obtained in Assam and Arunachal Pradesh by a mono-cyclic felling operation following an irregular shelter wood system. It is for this species that a proper system of natural regeneration has almost been perfected, unlike the majority of *Dipterocarpus* spp.

Artificial regeneration

Successful plantations have been raised in Assam, in areas which do not respond *to* natural regeneration operations due to over exploitation and other management deficiencies. Different methods of artificial regeneration are being followed, but the easiest and the least expensive method is to dibble freshly collected seeds in lines under top canopy shade. One metre wide lines hoed to a depth of 15 - 20cm are laid 5m apart from centre to centre and seeds dibbled 0.5 *to* 1m apart in the centre of the line. In the first year 2 weedings are carried out, one in June—July and the other January/February. In the second and third years also two weedings are carried out. Subsequently up to the nineth year one climber cutting is done every year. In areas subjected to heavy weed growth a weeding every year is necessary even after the third year up to the sixth year. Where the dibbled seeds fail to germinate the gaps are filled by planting out one year old nursery seedlings.

This species coppices well even in the sapling stage and suppressed saplings are given a new lease of life by coppicing. This operation is carried out at the time of weeding. The seedlings are liable to he browsed and an essential pre-requisite for successful artificial regeneration is protection from grazing up to about five years.

Silvicultural thinnings are carried out in the 16th and 36th year of the plantation. The number of stems per hectare after the second thinning is around 300.

Fairly reliable data on the rate of growth of this species is available. From the Tree Increment Plots of Jaipur (Assam) the rate of growth has been computed as follows.

Diameter range in cm		No. of Years
From	20 – 30	31
	30 – 40	26
	40 – 50	24
	50 - 60	24

'The statistics of growth and yield collected at Dibrugarh (Assam) have indicated that the average rate of girth increment per year is about 8.5cm up to a girth of 2.1m Hence a rotation of 84 years has been fixed to yield logs suitable for the plywood industry (Das, 1974).

Wood

Structure

The wood is diffuse porous, vessels moderately large, few to moderately numerous 4 – 13/mm^2, uniformly distributed mostly solitary, oval to round in shape; tyloses fill up the vessels partially but sometimes occlude them completely.

Parenchyma scanty to fairly abundant; apotracheal parenchyma diffuse or very short; paratracheal parenchyma forming a thin layer, usually not conspicuous; parenchyma round the gum ducts forming several seriate layer.

Rays moderately broad to fine, brownish in colour, not closely spaced, evenly distributed.

Resin canals vertical, fairly uniformly distributed, usually in tangential groups of 2 – 10; white deposits sometimes fill up the cavity of the ducts; (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood fairly well demarcated; sapwood dirty white to pale yellowish brown, heartwood light red to reddish brown; sp. gr. 0.595; weight 720.83 Kg/m^3 at 12 percent moisture content.

Shrinkage percentage green to oven dry

Radial	5.2
Tangential	10.3
Volumetric	17.6

Modulus of rupture (Kglcm^2)

Green	722.8
Air dry	1209.1

Modulus of elasticity (Kg/cm^2)

Green	133,400
Air dry	170,400

Maximum crushing stress (Kg/cm^2)

Green	353.6
Air dry	636.6

The species seasons slowly and does not split or warp excessively, though it is liable to cupping in wide sections. Kiln drying is very difficult. It is easily treatable with preservatives and the penetration is good. Grave yard tests at Dehra Dun have shown a durability of 29 – 46 months (Chowdhury and Ghosh, 1958).

Uses

Used extensively for manufacturing commercial grade plywood. It is the most important species for this end use in the eastern region of India. It is also used for manufacturing marine plywood in eastern India and Burma. After treatment it is a good timber for railway sleepers. Non-ply quality timber is used for general construction purposes after seasoning.

DIPTEROCARPUS MANNII King

Common names

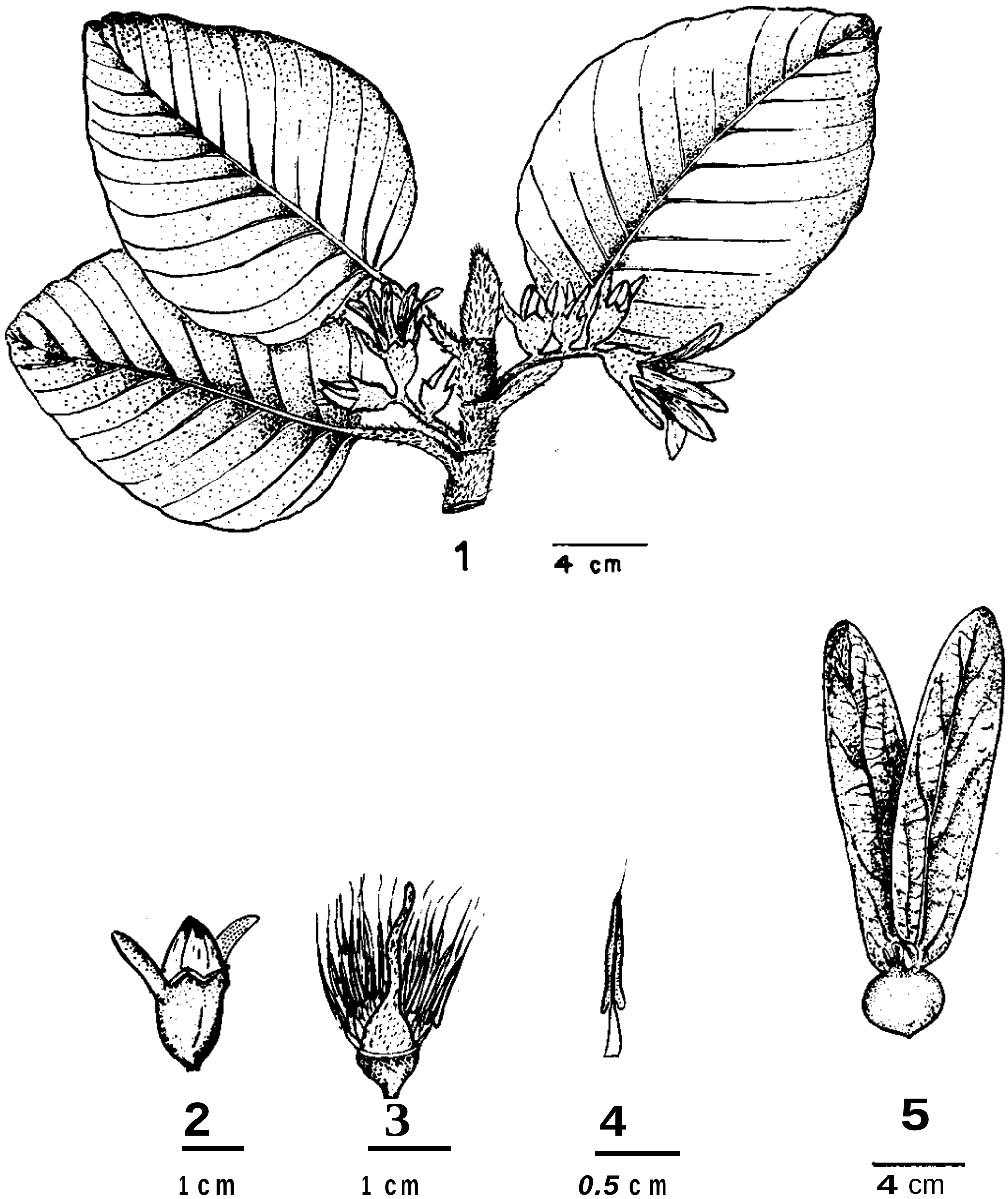
As. – Hollong, Holong.

A large tree attaining a height of 40m and a girth of 4m or more. Bark pale, bluish grey outside, vertically fissured. Young shoots stout, nearly terete, grey, with slightly

Dipterocarpus macrocarpus
Tree of girth at b.h. 5.28m
Total height about 30.48m
Clear bole about 21.34m

Disoi Reserve
Sibsagar Division
Assam (India)
(Photo FRI)

Dipterocarpus obtusifolius

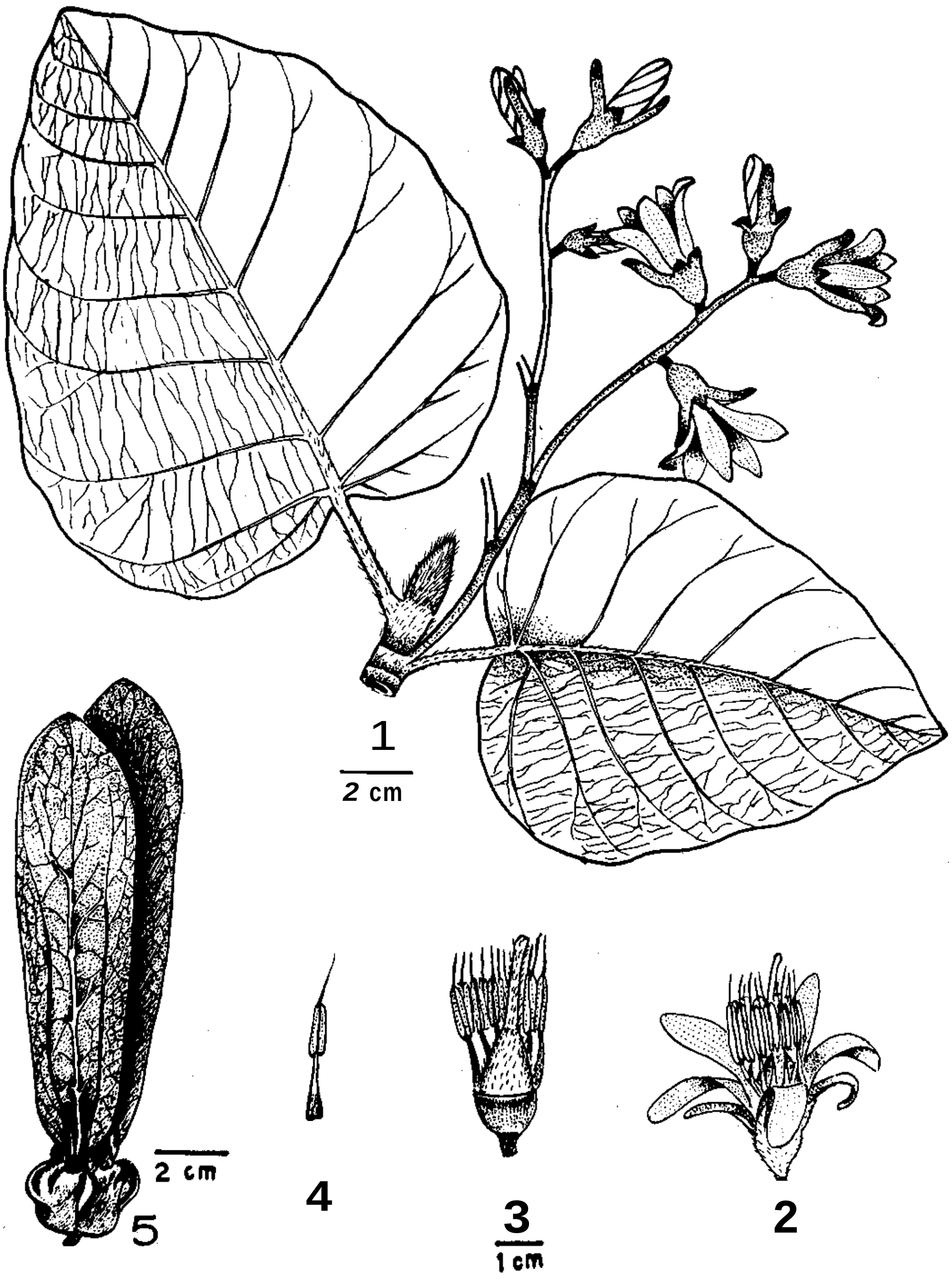


Dipterocarpus obtusifolius

1 **Flowering shoot**
2. **Flower bud**
3. **StamensandPistil**
4. **Stamen**
5. **Fruit**

Dip arpus tusifolius
(Herbarium
(Photo

Dipterocarpus tuberculatus



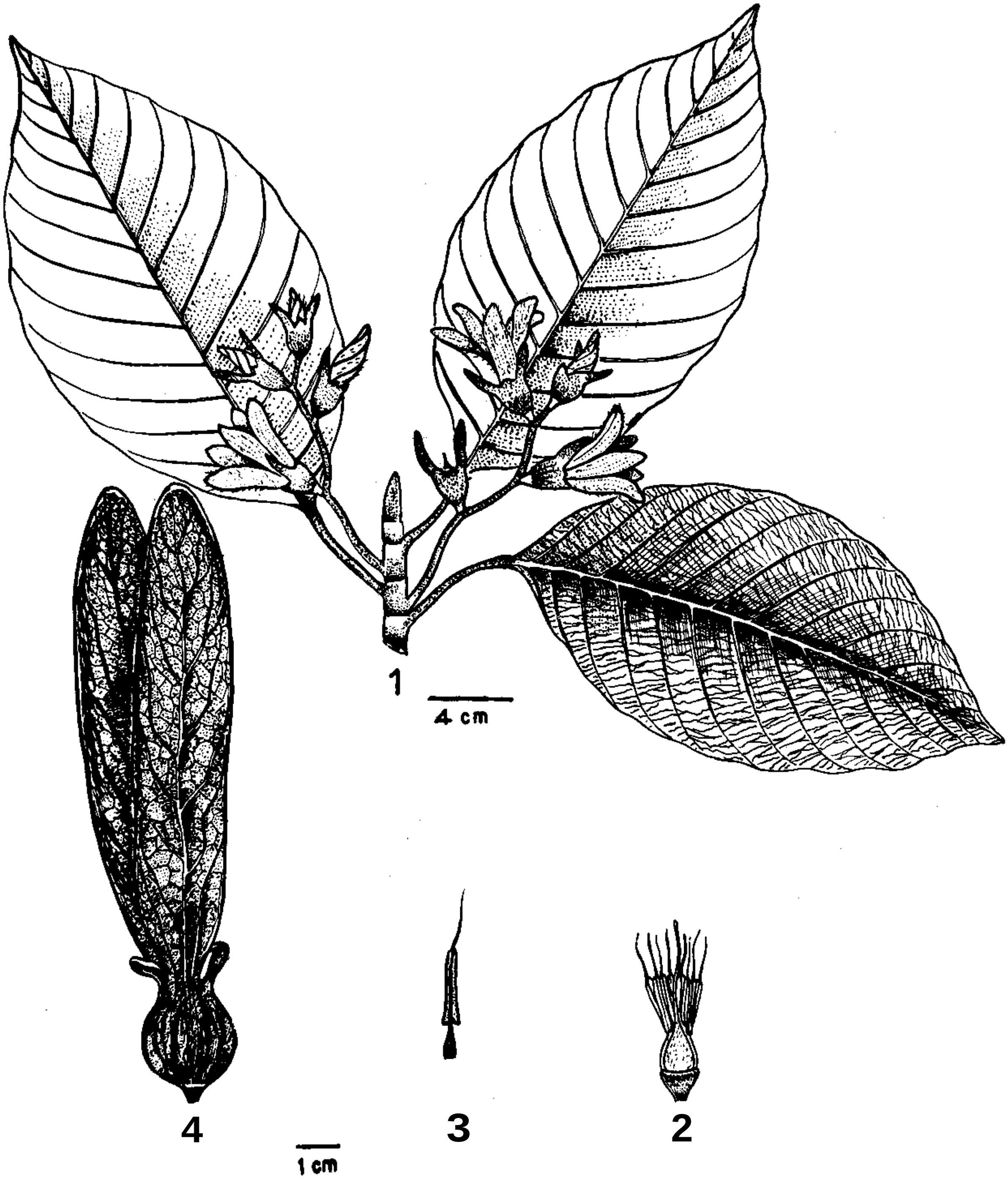
Dipterocarpus tuberculatus

1. **Flowering shoot**
2. **Flower**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

Dipterocarpus tuberculatus **forest**
Toungoo Division
Burma
(Photo FRI)

Dipterocarpus turbinatus

Dipterocarpus turbinatus



Dipterocarpus turbinatus

1. **Flowering shoot**
2. **Stamens and Pistil**
3. **Stamen**
4. **Fruit**

Dipterocarpus turbinatus
Regeneration
Guitar Island
Andamans, India
(Photo FRI)

oblique prominent scars of the fallen stipules. Leaves 17 – 30cm by 10 – 18cm, elliptic ovate or oblong, shortly acuminate, subcoriaceous, plaited, parallel to the lateral nerves in bud, repand or shallowly cuneate and thinly ciliate along the margins, glabrate above, softly stellate pubescent along the nerves beneath; lateral nerves 16 – **22** pairs; petiole 3 – 7.5cm long, rather stout, stellate pubescent; stipule 10 – 13cm long, lanceolate, stellately silky pubescent outside, glabrous and with 13 – 15 very fine longitudinal nerves inside. Inflorescence axillary; flowers nearly subsessile. Calyx tube, velvety pubescent outside, the smaller lobes broadly triangular with a recurved margin, the larger lobes 1.2 – 2cm long. Petals oblanceolate or strap-shaped, membranous, faintly close nerved, pubescent on exposed parts outside. Stamens about 25; filaments dilated; connective produced into a bristle. Ovary globose, brown silky, tapering into a style. The fruit belly globose with a constricted neck; the larger calyx lobes 17.5 22.5cm long by 3-4cm wide with three longitudinal nerves, the smaller ones about 2cm long, erect with recurved margins (Kanjilal, *et al.* 1934).

Distribution – India

This species is reported from the forests of Sibsagar and Lakhimpur in Assam (India) (Kanjilal, *et* **al.** 1934). Even here it is sporadic and rare in occurrence. In forestry and trade it is known by the common name Hollong.

DIPTEROCARPUS OBTUSIFOLIUS Teysm. ex Mig.

Syn. *Dipterocarpus punctulatus* Pierre
D. vestitus Wall. ex Dyer

Common names
Bur. – Inbo, in, Kanyingook

A small decidous tree, attaining a height of 6 – 24m and a girth of 1 – 1.8m, with an umbrella like crown. Bark rough, grey outside and reddish-brown inside, longitudinally fissured and slightly transversely cracked. Young shoots, petiole and inflorescence clothed with fine stellate hairs which are more or less hidden by tufts of shaggy hairs. Leaves 15 – 25cm by 7 – 13cm, ovate to ovate-oblong, rounded or obtuse at base, margin repand and ciliate, coriaceous, clothed on the upper surface with fine adpressed or small stellate hairs, glabrous when old except along the midrib, lower surface finely tomentose with longer hairs on the main veins; lateral nerves 10 – 15 pairs; petiole 3 – 4.2cm long, stout, stipule 7 – 12cm, hairy or glabrous. Flowers in axillary 3 – 7 flowered spikes, peduncle markedly zig-zag; bracteoles narrowly linear. Calyx tube campanulate, sometimes contracted at the base into a pedicel like stalk, finely stellate canescent to densely grey hirsute, lobes **3** short rounded, **2** linear-oblong, rather longer than the tube. Petals 3.5 – 5cm long, reddish, stellate or adpressed hairy outside. Stamens many; filaments flattened; connective produced into a bristle. Ovary densely hairy; upper portions. of the style glabrous. Fruit belly 2.3 – 3.5cm in diameter, usually depressed globular, slightly hairy and stellate towards the base and apex; the 2 larger calyx lobes 10 – 15cm by 2.4 – 4cm, sprinkled with stellate hairs, margins near the base abruptly reflexed, the 3 smaller lobes 1.2cm long, oblong with reflexed margins (Hooker, 1874; Kurz, 1877; Parker, 1931; Parkinson, 1931).

Distribution – Burma

The species is confined to Burma and common in Sittang and Prome (Kurz, 1877). The tree grows gregariously in dry forest up to an altitude of 950 metres (Troup, 1921).

Forest Types and Floristics

The species is one of the Xerophilous dipterocarps and occurs in the *Indaing* forest where rainfall is typically low. The type is characterised by the prevalence of *Dipterocarpus tuberculatus* and takes its name from *Indaing* forest.

Floristics

Prome, Burma

I *Dipterocarpus tuberculatus. D. obtusifolius, Heterophragma sulfurea, Terminalia* sp.. *Lophopetalum wallichii.*

II *Tectona grandis, Xylia dolabriformis, Shorea obtusa, Buchanania* sp., *Lannea coromandelica, Shorea siamensis. Melanorrhoea usitata, Dillenia pulcherrima, Gardneria erythroclada.*

Ill *Strychnos* spp., *Grewia aspera, Gardenia obtusifolia, Clerodendrum* sp., *Cycas* sp.

In the higher elevations the species is sometimes associated with *Quercus* spp., *Engelhardtia colebrookiana, Schima bancana* and *Castanopis tribuloides.*

Silviculture and Management

Phenology

The flowering period is from November to January. Fruits ripen in March-April (Parker, 1931).

Silvicultural characters

Its occurrence is generally gregarious and sometimes in extensive pure patches in the *Indaing* Forests Although the species extends into the regions of heavy rainfall, it cannot establish itself in moist evergreen forests, but clings to localities with drier types of soil and subsoil. In the dry hot season the tree becomes quite leafless. It is adapted by its thick rough bark to withstand the annual fires.

Wood

Structure

Vessels large to very large, the majority solitary, occasionally paired, quite evenly distributed, 3 - 6 per mm',

simple, transverse; tyloses generally abundant, occasionally with deposits of reddish-brown gum.

Tracheids sparse, with numerous horizontally aligned, narrowly bordered elliptical pits.

Parenchyma paratracheal, metatracheal and in broad interrupted bands; paratracheal parenchyma relatively sparse, forming a narrow 1-several (mostly one) seriate sheath; metatracheal parenchyma relatively sparse; parenchyma about the resin canals extensive; reddish brown gummy infiltration frequent in all types of parenchyma.

Fibres libriform, non-septate, interfibre pits most numerous on the tangential walls, bordered, reddish-brown infiltration occasional.

Rays fine, 4—7 per mm heterogeneous, reddish brown infiltration copious.

Resin canals, solitary or 2-several at intervals (1—4 per mm^2), contents white (Gottwald and Parameswaran, 1966; Pearson and Brown, 1932).

Properties

Sapwood nearly white when first exposed; heartwood pale red to light reddish brown; straight to somewhat interlocked grained, even and coarse textured sp. gr. 0.596; weight at 12 percent moisture content 881 Kg/m^3.

Modulus of rupture (Kg/cm^2)

Green	708.4
Air dry	1238.5

Modulus of elasticity ($Kglcm^2$)

Green	115,400
Air dry	144,300

Maximum crushing stress (Kg/cm^2)

Green	362.5
Air dry	495.5

The timber seasons without difficulty, it is somewhat liable to warp and cup. It is not durable in exposed conditions. Grave yard tests at Dehra Dun showed a durability of 38 – 45 months. Timber is moderately hard and can be worked to a smooth surface (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Uses

A fairly good constructional timber being suitable for planks and scantlings, occasionally used as railway sleepers.

DIPTEROCARPUS TUBERCULATUS Roxb.

Syn. *Dipterocarpus cordatus* Wall. ex **A.** DC.
D. grandiflorus Wall.
D. granda'folius Teysm.

Common names

Bur. – in, Eng.

A medium sized tree, deciduous or nearly so, with a straight bole and stout branches. In favourable localities it attains a height of 25 – 35m and a girth of 2.5 – 3.5m. Bark surface dark grey, thick, rough and longitudinally fissured. Young shoots covered with dense stellate tomentum, sometimes glabrous. Leaves 20 – 30cm by 15 – 20cm cordate ovate, usually repand. glabrous on both surfaces or stellate pubescent on the lower surface; lateral nerves 9 – 16 pairs, petiole 5 – 7.5cm long, glabrous or shaggy. Inflorescence axillary simple or branched, the lowest flower often distinctly pedicelled; peduncle stellate – pubescent; bracteoles 1 – 1.8cm long, linear-lanceolate, those of the lower flower much bigger than the upper ones, caducous. Calyx tube campanulate, contracted at the base into a distinct pedicel like stalk, glabrous or stellate pubescent, lobes 3 short, obtuse, 2 linear-oblong rather longer than the tube. Petals 3.5cm long, pubescent outside. Stamens many filaments flattened; connective produced into a bristle. Ovary densely pubescent; style densely adpressed, hairy below, somewhat glabrous at the top. Fruit belly 2–3 2cm long, ovoid or almost globular, glabrous or slightly stellate and pilose, furnished with tubercles at the upper end; the 2 larger calyx lobes 11 – 20cm by 2.5 – 4cm, 3 nerved for $^{3}/_{4}$ of their length, usually glabrous, the 3 smaller ones almost orbicular, recurved (Hooker, 1874; Kurz, 1877; Parker, 1927b).

Distribution – Burma

It is essentially a Burmese species. Though reported from Manipur, India (Deb, 1960) and Chittagong, Bangladesh (Zamen, Private Communication), its occurrence has not been well documented. In Burma it grows gregariously up to an altitude of 950m (Troup, 1921). Its range of distribution extends from Myitkyina and Upper Chindwin District the the north to the Mergui District in the south. It occurs in the northern and southern Shan States and stretches eastwards. The most gregarious growth is between the Irrawaddy and Chindwin rivers in Upper Burma. East of the Sittang river the trees grow continuously along the foothills west of Irrawaddy below Mandalay. It occurs in patches of varying sizes from Myitkyina in the north to Mandalay in the south (Kurz, 1877; Parkinson, 1931).

Forest Types and Floristics

In Burma the species is spread over extensive areas mainly in the drier tracts and locally in the regions of higher rainfall. The forest is characterised by the preponderance of this species and commonly referred to as *Indaing* Forest. Most commonly the forest in which the species is the principal component has laterite with red clayey soil. In such areas *D. tuberculatus* is often found as an almost pure stand. On hard ferruginous laterite with silicious pebbles, where the soil is shallow, the forest is open and the species, does not attain large dimensions. Best growth is found on flat or undulating land with porous well drained soil (Champion, 1936; Troup, 1921) In India the species is reported in Cachar Tropical Semi-Evergreen Forest (Champion & Seth, 1968), occasionally dispersed in Kabaw valley.

Floristics

(i) Allanmyo and Prome, Lower Burma.

I ***Dipterocarpus tuberculatus. Heterophragma sulfurea, Terminalia*** sp., ***LophoQetalum wallichii, Dipterocarpus obtusifolius.***

I1 ***Tectona grandis, Xylia dolabriformis, Shorea obtusa, Buchanania lanzan, Lannea coromandelica, Shorea siamensis, Melanorrhoea usitata, Aporosa macrophylla, Dillenia pulcherrima.***

I11 ***Dendrocalamus strictus, Strychnos*** sp., ***Grewia aspera, Clerodendrum*** sp., ***Cycas siamensis, Strobilanthes auriculata.***

(ii) Katha Burma

I ***Dipterocarpus tuberculatus, Lagerstroemia parviflora. Terminalia*** sp., ***Tectona grandis.***

I1 *Shorea siamensis, Strychnos* sp., *Careya arborea. Gardenia erythroclada, Dillenia pulcherrima, Acacia catechu.*

I11 *Phoenix acualis, Cycas siamensis.*

(iii) Kahaw Valley, Manipur, India

I *Tectona grandis, Dipterocarpus turbinatus, D. tuberculatus, Melanorrhoea usitata, Duabanga grandiflora, Xylia dolobriformis, Dillenia pentagyna, Lagerstroemia paruiflora, Gmelina arborea.*

I1 *Terminalia citrina, Emblica officianalis, Engelhardtia spicata, Saurauia roxburghii, Cassia fistula, Symplocos racemosa.*

Ill *Wendlandia grandis, Buddleia asiatica, Woodfordia fruticosa, Leea robusta, Maughania stricta, Desmodium pulchellum, Licuala peltata, Hedychium villosum, Elatostema platyphyllum.*

Creepers and climbers often form a dense mass. *Entada phaseoloides, Mucuna bracteata, Hoya parasitica* and *Pothos scandens* are common.

Silviculture and Management

Phenology

In Burma leaves are shed in February – March. Large pink flowers appear in March – April. Fruits ripen in May (Parkinson, 1931).

Silvicultural characters

The tree is a light demander. It is fire resistant to a remarkable degree. Saplings which are burnt back show great power of recovery from the base and send up stout stems. It has the capacity to thrive on dry localities. Young trees coppice well.

Natural regeneration

Natural regeneration is satisfactory. If seed fall is followed by rains, the seeds germinate immediately and seedlings establish themselves without difficulty. Lack of rain, however may cause failure of the seedling crop, particularly in dry localities. Under suitable conditions the seedlings come up in enormous numbers, and the profusion with which natural reproduction takes possession of the ground is one of the remarkable characteristics of this species (Troup, 1921). Being a strong light demander, it is only where the crop is sufficiefitly open that natural reproduction establishes itself in profusion. The seedlings in early stages are usually burnt hack by annual fires; but being firt resistant they recover themselves remarkably well.

In very poor localities where the soil is too shallow reproduction fails to establish. In areas where the soil condition is unfavourable due to had aeration, hoeing the soil stimulates reproduction. In such areas freshly collected seeds are also sown.

Being a light demander and gregarious in habit the species is well adapted for concentrated natural regeneration. In a monocyclic system, all that is necessary is to prepare the ground before seedfall, and carry out light hoeing or raking to ensure good regeneration.

As the species regenerates itself satisfactorily it is not usually necessary to plant out nursery raised seedlings as a supplementary measure. However blanks can be filled up by direct sowing and planting out nursery seedlings. Trials have shown that direct sowing is not as successful as planting out seedlings. In nursery, seeds are dibbled 10cm apart in open beds. In shaded beds the germination percent is lesser (56) as compared to unshaded beds (83). Watering the beds is necessary in the dry season. Seedlings are planted out with a ball of earth when they are almost 6cm high. Stump planting **also** has shown reasonable success (Homfray, 1935).

Wood

Structure

Vessels large, the majority solitary, occasionally paired, close and quite evenly distributed, **2** – 7/mm^2 ; perforations simple, transverse tyloses abundant.

Tracheids relatively sparse, with numerous horizontally aligned, narrowly bordered, elliptical pits.

Parenchyma paratracheal, metatracheal, and encircling all resin canals; paratracheal parenchyma relatively sparse, forming a narrow, 1-several seriate sheath; metatracheal parenchyma fairly abundant, scattered or in short, tangential usually uniseriate lines; parenchyma about the resin canals conspicuous; reddish brown gummy infiltration frequent in all types of parenchyma.

Fibres filiform, aligned in radial rows, non-septate, interfibre pits most numerous on the tangential walls, bordered, reddish brown infiltration occasional.

Rays fine, 5 – 7/mm, 1–6 seriate, heterogeneous, reddish brown infiltration copious, occluding many cells.

Resin canals diffuse or 2-several at intervals, contents white.

Properties

Sapwood greyish or reddish-white, heartwood reddish-brown, turning darker on exposure with short, whitish, tangential lines at irregular but relatively close intervals; dull with rather rough feel, fairly straight or somewhat interlocked grained, even and coarse textured, moderately heavy, sp. gr. approximately 0.73. Weight at 12 percent moisture content 849 Kg/m^3.

Modulus of rupture (Kg/cm^2)

Green	815.3
Air dry	1197.7

Modulus of elasticity (Kg/cm^2)

Green	123,300
Air dry	156,400

Maximum crushing stress (Kg/cm^2)

Green	396.7
Air dry	567.2

The timber seasons somewhat slowly and there is tendency towards warping and splitting. It is fairly durable. Graveyard tests at Dehra Dun have indicated a life of 38 – 67 months. The timber lends itself readily to treatment. Easy to saw and work, finishing to a fair surface, but does not take a polish (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Uses

In Burma it is mainly used for constructional purposes as beams, scantlings, planks, floor boards, etc. It is also used in ship building as masts and spars and sometimes for heavy packing cases and rough furniture. Occasionally dug-outs are made from good logs. The timber is used as railway sleepers after treatment. In India and Bangladesh because of the restricted occurrence, there is no recognised end use.

Non wood products

The species is the principal source of the oleo-resin known in Burma as "in oil". It is obtained by making a pyramidal incision in the trunk, 60 – 90cm above the ground, and collecting the exudate periodically. The wounds are repeatedly freshened to induce further flow. Freshly collected oleo-resin is a pale brown substance; sp. gr. 1.029; acid val. 17.8 and ester Val. 0 On steam distillation it yields a yellow brown essential oil. The oil is used for varnishes, for water proofing bamboo baskets and umbrellas (Parry, 1921).

The young leaves contain 10 – 12% tannin and may be used in direct light leather tanning. The bark contains 24 percent tannin (Rodger, 1943).

DIPTEROCARPUS TURBINATUS Gaertn. f.

Syn. ***Dipterocarpus laevis*** Buch. Ham.
D. jourdainii Pierre
D. turbinatus Dyer

Common names

As. – Gurjan, Gurjankuroisal, Kherjong.
Beng. – Garjan, Telya garjan, Tikyagurjan, Tekigurjan.
Bur. – Kanyin, Kanyin – in.
Hind. – Gurjan

A lofty tree attaining a height of
and a girth of 5m with a clean cylindrical bole and an elevated crown. Bark surface light grey, yellowish brown inside; exfoliating in irregular rounded flakes. Young twigs

glabrous except for a ring of pubescence just beneath the stipular scars, or covered with a dense felt of minute grey stellate hairs. Leaves variable 12.5 – 22cm by 6 – 15cm, elliptic, or oblong-ovate, rarely oblong, acute or acuminate, base cuneate, rounded or very slightly cordate, margin more or less repand, glabrous on both surfaces, coriaceous; lateral nerves 12 – **16 pairs,** parallel; petiole 2.5 – 3.5cm long, glabrous; stipule 5 – 15.5 cm long, densely grey stellate and slightly pilose. Flowers in axillary 3–7 flowered spikes, peduncle glabrous and glaucous, the lowest flower often shortly pedicelled. Calyx tube campanulate, 1 – 1.2cm long, smooth, glabrous, the lobes unequal, the 3 shorter lobes rounded 0.2crn long, the **2** larger ones linear-oblong, about 1.2cm long. Petals 2.5 – 3.5cm long, linear, pubescent outside. Stamens many; filaments flattened; anthers linear, connective produced into a bristle. Ovary minutely tomentose; style stellate pubescent in the lower half, glabrous above. Fruit belly **2** – 2.8cm in diameter and 2.8 – 3.5cm long, ovoid, smooth; the 2 larger calyx lobes 11 – 17.5cm by 2.5 – 3cm, glabrous, more or less glaucous, strongly reticulate, 3-nerved in the lowest third, the 3 smaller lobes deltoid-ovate (Hooker, 1874; Parker, 1927b).

Distribution – Bangladesh, Burma, India

In Bangladesh the most frequent occurrence of this species is in the eastern part of Chittagong, Chittagong hill tracts and Cox's Bazar. In Burma the species is found on the eastern slopes ***of*** the Pegu and Arakan Yoma, and from Martaban down to Tenasserim. In India it is distributed in Assam, Meghalaya, Manipur and the Andaman Islands.

Forest Types and **Floristics**

In Bangladesh the species occurs scattered in the Chittagong Tropical Evergreen Forest and Chittagong Tropical Semi-Evergreen Forest (Champion, 1936). In Burma the species has a comparatively wide distribution in the Burma Tropical Semi-Evergreen Forest and Burma Tropical Moist Deciduous Forest (Champion, 1936). In India it is mostly found in the Cachar Tropical Evergreen Forest, Cachar Tropical Semi-Evergreen Forest, Andaman Tropical Evergreen Forest and the Andaman Semi-Evergreen Forest (Champion & Seth, 1968).

Floristics

(i) Chittagong, Bangladesh (Chittagong Tropical Semi-Evergreen Forest)

I ***Dipterocarpus gracilis, D. turbinatus.***

I1 ***Chukrassia tabularis. Holigarna-sp., Amoora*** sp., ***Salmalia*** **insignis**, ***Syzygium grande, Caryota urens. Hopea odorata, Castanopsis*** sp., ***Artocarpus chaplasha, Lophopetalum fimbriatum. Pterospermum acerifolium, Vitex*** sp., ***Hydnocarpus*** sp., ***Turpinia*** sp., ***Alstonia scholaris, Tetrameles nudiflora, Schima wallichii.***

I11 ***Melocanna baccifera, Bambusa tulda, B. dullosa. Meliosma simplicifoliu, Maesa ramentacea, Micromelum pubescens, Murraya paniculata, Clausena excavata*** (Chaudhury, 1968; Ahamed, 1958).

(ii) Myitkyina -- Burma (Burma Tropi. cal Semi-Evergreen Forest)

I ***Dipterocarpus macrocarpus, D. turbinatus. Shorea assamica.***

I1 ***Dysoxylum binectariferum, Acrocarpus fraxinifolius. Michelia*** **sp., *Toona*** **sp**., ***Chukrassia*** **sp., *Syzygium*** **sp**., ***Quercus*** **sp., *Castanopsis*** **sp., *Mesua ferrea.***

111 ***Dendrocalamus hamiltonii, Cephalostachyum*** sp., ***Alsophila*** sp.

(iii) Andamans, India (Andaman Tropical Evergreen Forest)

Dipterocmpus grandiflorus. D. alatus. D. turbinatus. Hopea odorata. Artocarpus chaplasha. A. gomeriana, Calophyllum soulattri. Mimusops elengi. Terminalia bialata. Myristica iriya. Dense undergrowth of Canes, and climbing bamboo ***Dinochloa andamanica*** are frequent.

(iv) Cachar, Lower Assam (Tropical Semi-Evergreen Forest)

I&II *Dipterocarpus turbinatus, Artocarpus chaplasha. Mangifera sylvatica. Persea owdenii. Syzygium spp., Palaquium polyanthum. Amoora sp., Mesua ferrea. Calophyllum polyanthum. Aquilaria agallocha. Canarium sp., Podocarpus neriifolia.*

111 *Melocanna baccifera. Bambusa balcooa* and evergreen undergrowth with a few palms.

Silviculture and Management

Phenology

In Bangladesh and Eastern India leaves are shed in January – February and flowers appear in March – April. Fruiting is from May to July. In Andamans the species is leafless for a short while in December and the new leaves and flowers appear in January March. Fruiting is from May to July.

Silvicultural characters

The species is hygrophilous and to a great extent requires damp moist soil. It is mostly sporadic, but in Burma it occasionally forms pure groups or patches of varying extent. It is a shade bearer particularly in the earlier stages of growth. It is fire tender and the saplings which are burnt down have poor power of recovery, and are killed outright. It is a poor coppicer (Troup, 1921).

Natural regeneration

An irregular shelter wood system with local modifications has been found to be suitable for obtaining good regeneration. Monocyclic felling after leaving some mother trees, followed by preparation of the ground at the time of seedfall, ensures copious germination. Being a shade bearer it is advisable to retain the middle canopy till the seedlings establish themselves. To obtain uniform regeneration sowing in lines, or preferably dibbling (with the wings sticking out) in lines is resorted to. About 80% germination has been reported in Chittagong (Homfray, 1935). The species has been raised in nursery and planted out in the natural regeneration areas. In the nursery seeds are sown in beds. Shading is not necessary. Germination commences in about a week and is completed in four weeks time. Germination percent of about 85 has been reported. 15cm high seedlings with a ball of earth are planted out in the regeneration areas during the rainy season. The seedlings establish temselves satisfactorily. It is, however, essential that the seedlings, after removal from the nursery beds, are planted out immediately. Stumping of one year old seedlings has been tried with reasonable success. But direct sowing or planting out seedlings are preferable. As the species is extremely sensitive to fire it is essential that adequate fire protection measures are adopted (Blanford, 1915; Homfray, 1935).

In Andamans it has been particularly noticed that regeneration up ta the seedling stage is abundant. Further development is impeded due to the thick mass of undergrowth through which the seedlings are unable to penetrate. Here preparation of the ground by a light burning and lightening the undergrowth have provided excellent conditions for regeneration (Chengappa, 1934a, b, c; Roger, 1906).

Wood

Structure

Vessels very large to extremely large, the majority solitary, occasionally paired, close and quite evenly distributed, 2 – 7/mm^2, perforations simple, transverse; tyloses abundant, reddish brown.

Tracheids sparse, horizontally aligned, pits narrowly bordered, elliptical.

Parenchyma paratracheal, metatracheal, encircling all resin canals; paratracheal parenchyma relatively abundant forming a narrow, one to several seriate sheath; metatracheal parenchyma abundant, scattered or in short, tangential, usually uniseriate lines; parenchyma about the resin canals conspicuous; reddish brown gummy infiltration frequent in all types of parencliyma.

Fibres librifonn, fine, aligned in radial rows, non-septate, interfibre pits most numerous on the tangential walls, bordered; gummy infiltration frequent.

Rays heterogeneous, rather coarse, 6 – 8/mm, **1** – 7 seriate, reddish brown gummy infiltration copious.

Resin canals present. longitudinal, solitary or 2-several at intervals, mostly 7 – 10 seriate upto 5/mm^2 ; contents white.

Properties

Sapwood greyish or brownish-white, heartwood reddish brown with lighter interrupted tangential lines (resin canals) at irregular and relatively close intervals, with rather rough feel, fairly straight or somewhat interlocked grained, even and coarse textured; moderately heavy, sp. gr. 0.655. Weight 800Kg/m3 (l'urkayastha *et al.* 1976).

Shrinkage percentage green to oven dry

Radial	4.2
Tangential	8.9
Volumetric	15.0

Modulus of rupture (Kg/cm^2)

Green	774.9
Air dry	1203.4

Modulus of elasticity (Kg/cm^2)

Green	142,000
Air dry	161,900

Maximum crushing stress (Kg/cm^2)

Green	412.2
Air dry	575.5

The timber seasons somewhat slowly. Moderately easy to air season. For quick drying, the timber is partially air seasoned and finally kiln dried. The timber is not durable in exposed conditions. Grave yard tests at Dehra Dun have shown a life of only 29 to 38 months. Under cover the timber lasts much longer. Easy to saw and work. Polishes well, though it requires a good deal of filling (Chowdhury and Ghosh, 1958; Gottwald & Parameswaran, 1966; Pearson and Brown, 1932).

Uses

The timber is popular as commercial grade plywood. It is also used as rafters, scantlings and planking in construction work. In Chittagong it is used in boat building. In Burma it is popular for dug-outs.

Non wood products

The species is the principal source of 'Kanyin Oil' of Burma and the 'Garjan Oil' of Bangladesh. A cone shaped cavity is cut into the trunk, Im from the ground and a fire lit to char the surface of the wound when the oleoresin starts flowing out, which is periodically removed. When the flow stops, the wound surface is burnt or scraped or a fresh wound made to induce further flow. The season of collection is November-May and a tree of 2m girth is reported to yield 9Kg of resin in one season. The exudate is faintly acidic and milky. When allowed to stand, it separates into 2 layers – a brown oil which floats on the surface and a viscous, whitish grey emulsion below. A pale yellow oil with a balsamic odour is obtained (yield 46%) through steam distillation of the oleo resin (Parry, 1921).

The gurjan oil of commerce is the oleoresin from ihe species mixed with minor quantities of oleoresin from *Dipterocarpus alatus, D. costatus* and *D. macrocarpus.* It is a viscid fluid highly fluorescent and transparent, dark reddish brown in colour when seen against light. It undergoes oxidation when exposed to the atmosphere. The essential oil consists of two distinct sesquiterpenes, Alpha and Beta gujunene. The resin left after distilling of the volatile oil, contains gurjunic acid, $C_{22}H_{34}O_4$ (Finnemore, 1926).

The oleoresin is applied externally to ulcers, ring worm, and other cutaneous infections. It is a stimulani to mucous surfaces and also diuretic (Kirtikar and Basu, 1918; Martindale, 1958). It is an ingredient of lithographic ink and anticorrosive coating compositions for iron. It is occasionally used as a preservative for timber and bamboo. Mixed wiih powdered dammar from *Shorea obtusa* or *S siamensis* and kneaded to a proper consistency, it forms a dark brown paste used for caulking boats and for water proofing bamboo baskets which are sometimes used for carrying water.

The properties of oleoresin obtained from *Dipterocarpus grandiflorus. D. tuberculatus* and *D. turbinatus* are compared below (Karnik and Bhatia, 1965).

	D. grandiflorus	D. tuber-culatur	D. turbi-natlls
Specific gravity	0.9291 at 35°C	0.9001	0.9271
Optical rotation.	-19.13-	-99'40'	-37°C
Refractive index	1.4990 at 35°C	1.5007	1.5007
Acid number	1.58	0	0
Ester number	8.4	0	1.9
Solubility in 95% alcohol	Soluble in 7 volr.	Soluble in 6 and more TOIS.	Soluble in 7 or more vols.

DIPTEROCARPUS ZEYLANICUS Thw.

Syn *Dipterocarpus turbinatus* sensu Moon

Common name

Sinh. – Hora.

A large tree attaining a height of 40m and a girth of 4m with a dense hemispherical crown. Bark surface pale orange brown, smooth when young and becomes irregularly flaky when old. Young twigs more or less densely pubescent. Leaves 10 – 25cm by 7.5 – 14cm, ovate to elliptic, acute, base obtuse or subcordate, thickly coriaceous, pubescent on the veins beneath; lateral nerves 15 – 18 pairs, prominent beneath and depressed above; petiole 2 – 5cm long, puberulent; stipule 12 – 15cm long, oblong, pubescent, caducous. Racemes axillary, drooping, pubescent, flowers 4.5cm in diameter, pedicels 0.5 – 1.3cm long, stellate pubescent. Calyx tube campanulate, the 2 larger lobes oblong, the 3 others truncate. Petals oblong, obtuse, recurved at end, pubescent on the portions exposed in bud. Stamens 15; appendage shorter than the anther. Ovary pubescent; style and stylopodium columnar. Fruit belly 2.5cm in diameter, subglobose with 5 prominent ribs; the 2 larger calyx lobes 13cm by 3cm, lorate, obtuse, tapering at the base; the 3 shorter lobes 3cm by 2cm, oblong, obtuse (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

The species has a fairly wide distribution in Bettegodda and Deltota (Kandy). Momragla, Siyambualamdura, Indikada (Colombo) and Lunugala (Boddulla).

Forest Types and Floristics

An important and common species in the Lowland Wet Evergreen Forest where it occurs generally scattered below 1000m altitude. In river banks and well-drained alluvium the species is often gregarious. It often extends to Lowland Semi-Evergreen Forest (Andrews, 1961), where it is mostly scattered. In the Wet Evergreen Forest which is generally storeyed, the top canopy consists essentially of dipterocarps among which this species is predominant. In the Semi-Evergreen Forest, the species occurs in moist localities and occupies the emergent layer.

Floristics

(i) Indikada (Lowland Wet Evergreen Forest)

I *Dipterocarpus zeylanicus, D. glandulosus, D. hispidus, Vatica* spp., *Hopea* spp., *Shorea congestiflora. S. affinis, Palaquium petiolare, P. thwaitesii, Xylopia parvifolia, Mangifera zeylanica, Myristica dactyloides, Wormia triquetra, Canarium zeylanicum.*

I1 *Nelitris jambosella, Kurrimia reylanica, Chaetocarpus castanocarpus, Gyrinops walla, Mesua thwaitesii, Anisophylla* sp., *Garcinia morella, Calophyllum bracteatum, C. tomentosum, Carallia brachiata, Dillenia retusa.*

111 *Symplocos coronata, Alseodaphne* sp., *Semecarpus nigouiridis, S. gardneri, Euodia lunu-ankenda, Schumacheria castaneaefolia, Humboldtia laurifolia, Diospyros insignis.*

IV *Memecylon* sp., *Psychotria* spp., *Bragantia wallichii.*

(ii) Lunugala (Lowland Semi-Evergreen Forest)

I *Dipterocarpus zeylanicus, Canarium reylanicum, Alstonia scholaris, Vitex pinnata, Xylopia parvifolia, Mangifera zeylanica, Hopea brevipetiolaris.*

I1 *Diospyros walkeri, Semecarpus obscura, Artocarpus nobilis, Chaetocarpus cast-*

anocarpus. C. coriaceous, C. pubescens. Carallia brachiata, Syzygium spp., ***Mimusops elengi, Neolitsea involucrata, Bridelia retusa, Pterospermum canescens, Ficus callosa.***

I11 ***Wormia triquetra, Dillenia retusa, Garcinia combogia, Xylopia championii, Nothopegia beddomei, Ouratea zeylanica, Acronychia pedunculnta*** (Holmes, 1956).

Silviculture and Management

Phenology

Flowering is in January to February and Fruiting during April-May.

Natural Regeneration

The species regenerates freely and the seedlings establish themselves without much difficulty. As fruiting is regular and generally copious, with high dispersal potential, the. Wet Evergreen Forest shows a high incidence of regeneration in the seedling and sapling stages. Being shade tolerant, further development of the regeneration is also not impeded.

Growth data

The average girth increment in natural forest is as follows:

Wood

Structure

Vessels few to moderate, large, mostly solitary; tyloses very commo.n.

Parenchyma vasicentric to aliform confluent.

Rays medium sized.

Resin canals abundant, mostly uniseriate, but found in tangential rows also.

Properties

Sapwood pinkish-white, heartwood pinkish-red to dark reddish-brown, has a characteristic odour, fairly stiaight grained, uneven and coarse textured. Weight 775Kg/m^3 at 12 percent moisture content.

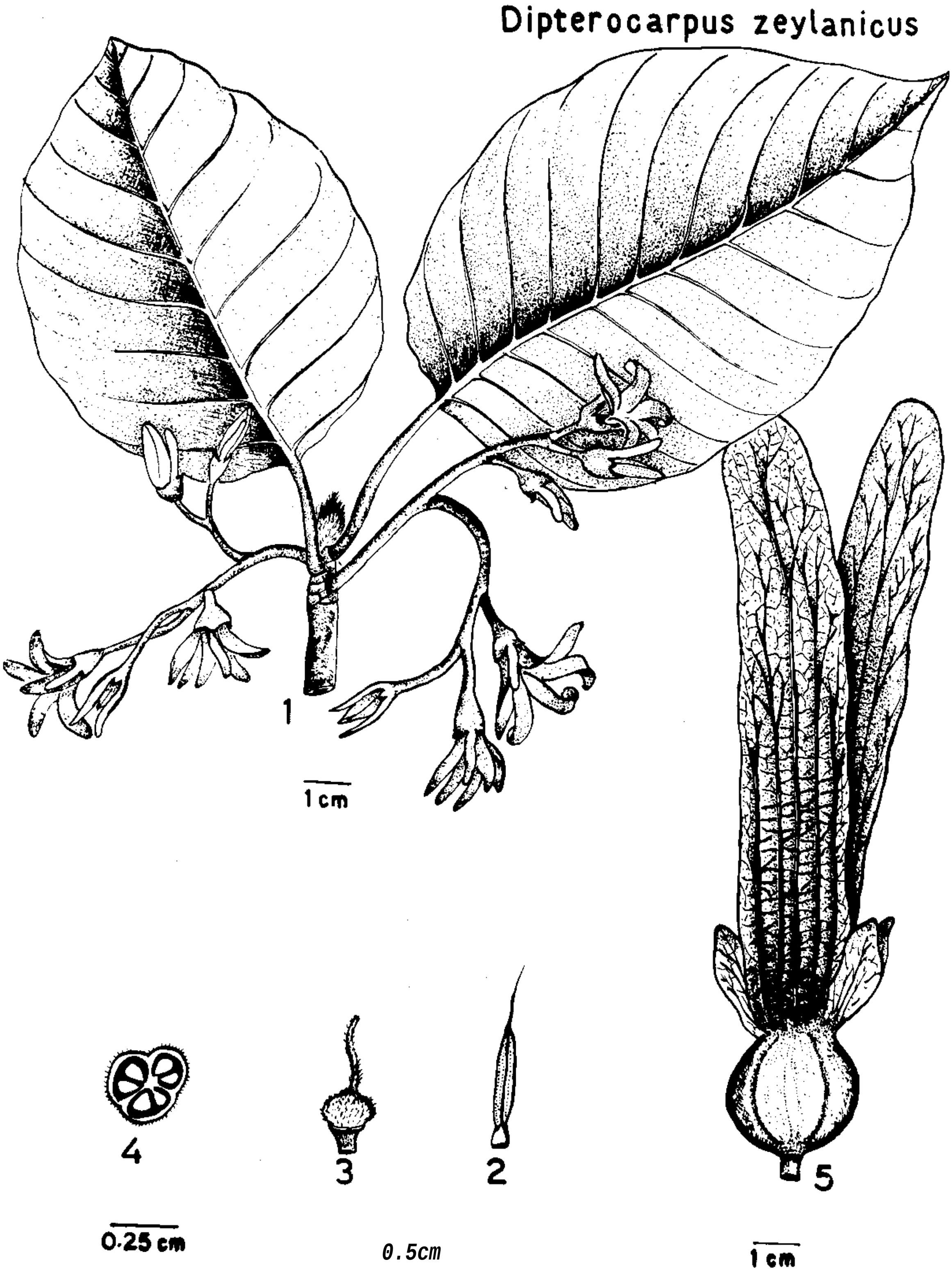
Seasons slowly, not durable in open conditions but fairly durable under cover. Not refractory to treatment and penetration of preservatives satisfactory under pressure. Saws easily and finishes to a fair surface.

Uses

An important plywood species of the Island. It is also extensively used for railway sleepers and as a general purpose construction timber. Also used for construction of railway wagons and in marine works, as jetty piles.

Girth class in cm	0—30	30—60	60—90	90—120	120—150	150—180	180—210	210—240
Average girth incre-ment	–	1.05	1.33	1.43	1.53	1.50	1.35	1.20
No of years of pa-ssage the girth class	–	29	23	21	20	20	21	25
Age of the tree with girth corres-ponding to top of girth class	–	X+15	X+38	X+59	X+79	x+99	X+120	X+145

Where X = age of a tree of 45 cm girth.

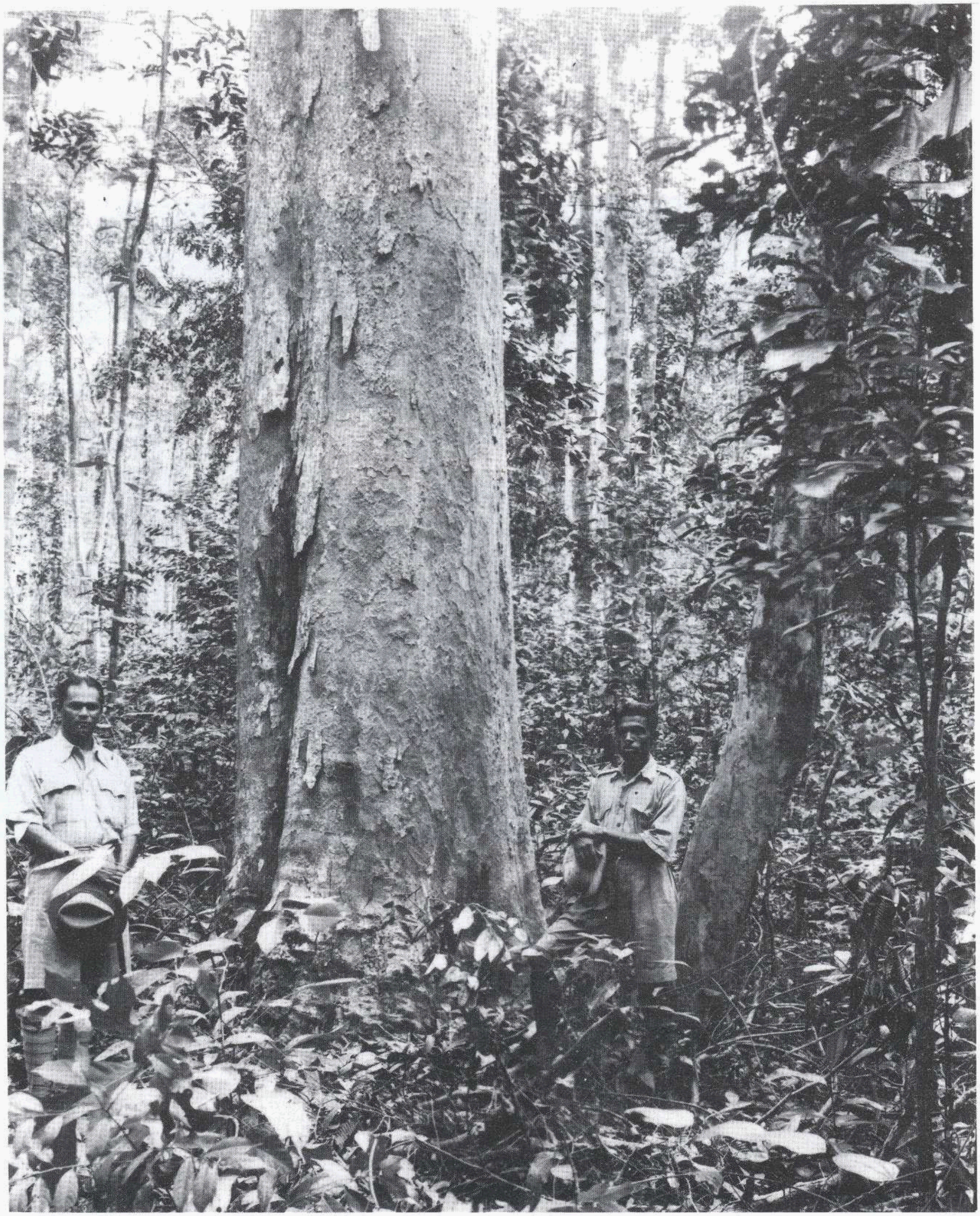


Dipterocarpus zeylunicus

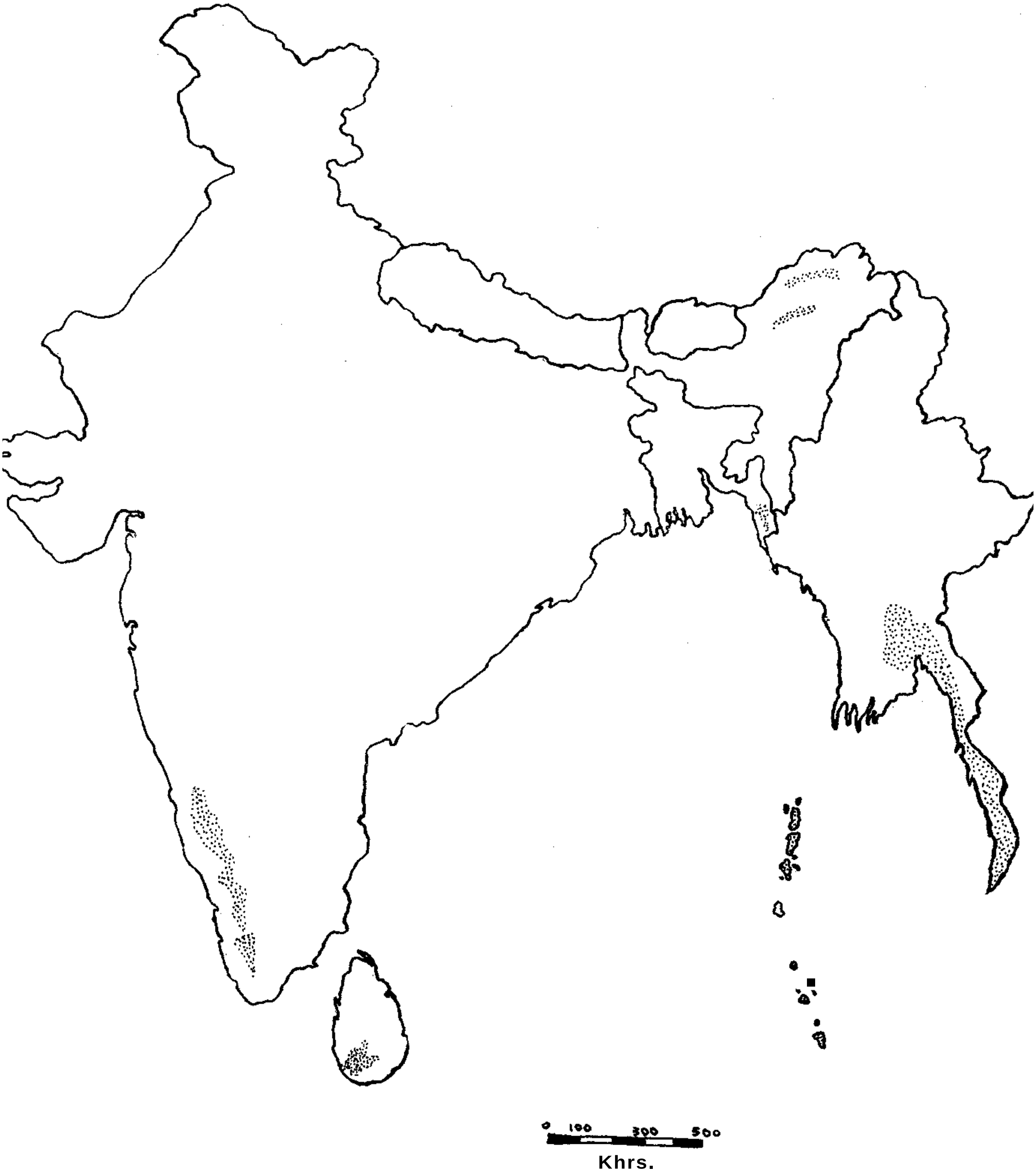
1. **Flowering shoot**
2. **Stamen**
3. **Pistil**
4. **C.S. of the *Ovary***
5. **Fruit**

Dipteroearpus ***zeylanicus***
Natural Regeneration
Ramapura
(Photo FD Sri Lank)

Dipterocarpus zeyianicus
Railway Sleepers
Boosa
(Photo FD Sri Lanka)



Hopea



CHAPTER VII

HOPEA Roxb.

Small to large trees. Bark surface at first smooth, becoming cracked and flaked. Twigs glabrous or pubescent. Leaves glabrous, entire or slightly undulate; stipule small, deciduous or inconspicuous. Flowers in terminal or axillary panicle. Flower sessile or shortly pedicellate. Sepals unequal or subequal, glabrous or pubescent. Petals slightly connate at the base, entire or crispate. Stamens 10—15; filaments slightly connate at the base; appendage to the connective slender. Ovary ovoid to conical; stylopodium prominent, style short, stigma minute. Fruit ovoid, apiculate, surrounded by the base of the accrescent sepals, two of which are much enlarged (Ashton, 1977; Gamble, 1915; Hooker, 1874; Kurz, 1877).

Wood

Vessels small to medium sized, seldom form oblique groupings. Fibres straight to slightly alternating spiral. Parenchyma diffuse, sometimes vasicentric. Rays arranged in regular tiers. Resin canals tangential. Sapwood yellowish grey, heartwood yellow to bright golden brown (Chowdhury and Ghosh, 1958, Gottwald and Parameswaran, 1966).

Uses

A popular construction timber and an excellent sleeper wood. Used for boat building.

Distribution 18 species: Bangladesh, Burma, India and Sri Lanka

HOPEA BREVIPETIOLARIS (Thw.) Ashton

Syn. ***Shorea brevipetiolaris*** Thw.
Balanocarpus *zeylanicus* Trimen
B. ***brevipetiolaris*** (Thw.) Alston

Comon name
Sinh. – Dunmala.

A medium sized tree attaining a height up to 35m and a girth of 3m with a dense irregular crown. Bark surface yellowish brown, irregularly scaly. Young parts densely puberulent. Leaves 5 – 13cm by 3 – 7cm, ovate to ovatelanceolate, tapering to acuminate-obtuse, rounded or subcordate at base, coriaceous, glabrous; lateral nerves 5 – 7 pairs, slender, somewhat sinuate and frequently bifurcating apically, midrib prominent beneath; petiole 0.4 – 1.3cm long, thick rugose, glabrous or pubescent. Panicle slender, terminal or axillary, pubescent; flowers shortly pedicelled, on short spreading branches. Sepals subequal, ovate, obtuse, glabrous. Petals oblong-ovate. Stamens 10 or 15, anthers subglobose; connective appendage slender, as long as the anther. Ovary ovoid-conical, tapering into a short style. Fruit 1.3cm long, ovoid, apiculate; the enlarged sepals 0.6cm,long, broadly oval, obtuse (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

Highly restricted and known only from Doluwe Kande, Dun Kande and adjacent hills north east of Kurunegala.

Forest **Types and** Floristics

This endemic species is confined to the Lowland Semi Evergreen Rain Forest (Andrews, 1961) b.etween 500 to 700m elevation. It is sporadic but becomes semigregarious in the upper parts of ridges, where the growth is rather stunted.

Floristics

Kurunegala

I. *Vitex pinnata, Alstonia scholaris, Hopea brevpetiolaris, Dipterocarpus zeylanicus, Canarium zeylanicum. Mangifera zeylanica.*

I1 *Diospyros walkeri, Semicarpus obscura, Artocarpus nobilis. Chaetocarpus castanacarpus, C. pubescens, Syzygium* spp., *Mimusops elengi, Neolitsea involucrata, Ficus callosa.*

I11 *Wormia triquetra, Dillenia retusa, Garcinia combogia, Xylopia championii, Nothopegia colebrookiana, Acronychia pedunculata.*

Silviculture **and** Management

Phenology

Flowering in April-June; fruiting July-September.

Being sparse and scattered in distribution regeneration is generally wanting.

As the bole is irregular in shape and branching low, the species has little timber value.

HOPEA CANARENSIS Hole

Common name

Kan. – Malai haiga

A small tree attaining a height of 20m with a fairly straight bole and a girth of 2m. Bark pale brown, smooth. Young shoots glabrous. Leaves 10 – 17cm by 4 – 8cm, ovate-oblong, obtuse or acuminate, base rounded or cordate, coriaceous, glabrous on both surfaces; latcral nerves 6 – 10 pairs, their axils often with glandular swellings; stipule small, deciduous. Panicle axillary glabrous; flowers 2–4 together; bracteoles at the base of the pedicel, glabrous dorsally and minutely hairy on the inner surface, caducous. Sepals glabrous, the 2 outer ones large, ovate-oblong to deltoid, obtuse. Petals contorted, falcate-oblong, connate at the base, glabrous. Stamens **15,** adnate to the base of the petals; filaments much dilated at the base, the alternate ones bear two anthers. Ovary glabrous or sparsely pubemlous above; stylopodium stout, ovoid or oblong; style short, minutely 3–lobed. Fruit ovoid, 1 – 1.5cm long, enclosed by the base of the sepals, the 2 outer enlarged lobes broadly elliptic, *5* – 9cm by **1.5** – 2.2cm with 9 – 12 longitudinal nerves (Hole, 1919).

Distribution – India

The species is endemic to India, and so far recorded in South Kanara District of Karnataka State only. Even here it is seen occasionally in the hill forests.

Authentic information about its ecology, silvicultural characters, wood and utilization is not available. In forestry it is still not recognised as a commercial species of value.

HOPEA CORDIFOLIA (Thw.) Trimen

Syn. *Vatica ? cordifolia* Thw.
Isauxis cordifolia Hook. f.

Common names

Sinh. – Mendora, Uva Mendora

A medium sized tree reaching a height of 30m and a girth of 3m with a dense crown oblong or irregular in shape. Bark surface grey brown, fissured, and flaking in small oblong flakes. Young twigs densely tawny pubescent. Leaves 8 – 21cm by 4.5 – 12cm, ovate-falcate, subacute, cordate at basc, glabrous; lateral nerves 6 – 9 pairs, the first 2 – 3 pairs arising together from the base, prominent below and elevated above; petiole 1.5 – 2.5cm long, stout, densely pubescent; stipules very small, caducous. Panicle axiliary; flowers pale yellow, buds ovoid, tomentose. Sepals ovate, acute to subacuminate. Petals oblong-ovate, glabrous except the portions exposed in bud. Stamens 15; appendage slender, twice as long as the anther. Ovary ovoid-conical, glabrous, tapering into the short glabrous style. The fruit is enclosed by the bases of the calyx lobes; the 2 larger lobes 9.5cm by 2.5cm, broadly spatulate, tapering at the base; the **3** shorter lobes 1.2cm by 0.8cm, ovate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is restricted to the dry zone of Uva along Walawe and Kirindi Oyas and their tributaries.

Forest Types and Floristics

This endemic species is confined to Tropical Dry Mixed Evergreen Forest **(An**drews, 1961). where it **is** abundant in restricted localities.

Floristics

Uva

Alstonia scholaris, Trewia nudiflora, Canarium zeylanicum, Diospyros ebenum. Manilkara hexandra, Hopea cordifolia, Alseodaphne semecarpifolia, Mangifera zeylanica. Syzygium spp., *Hydnocarpus* sp., *Chloroxylon swietenia, Adina cordifolia, Acronychia pedunculata, Polyalthia acuminata, Euphoria longana.*

Silviculture and Management

Phenology

The flowers appear in April.

The species being of restricted occurrence and of low timber value, is not propagated. Where it occurs gregariously natural regeneration is satisfactory, hut no treatment is attempted to ensure establishment and subsequent development of seedlings.

Wood

Structure

Vessels very small, numerous, mostly solitary but sometimes in groups; tyloses not frequent.

Parenchyma vasicentric.

Rays fine.

Resin canals solitary, diffuse and scattered

Properties

Wood dark yellowish-brown, sapwood and heartwood not differentiated, hard and heavy, fine textured and straight grained Weight 925 – 1094Kg/m^3 at 12 percent moisture content.

Seasons slqwly, moderately durable, refractory to treatment. Easy to saw and work, Finishes to a smooth surface.

Uses

Popular as a construction timber.

HOPEA DISCOLOR Thw.

Common names

Sinh. – Rata Dun, Peely Dun.

A large tree reaching a height of 45m or more and a girth of 4m The crown is dome shaped with many slender straight radiating branches. Bark surface dark reddish brown, deeply and irregularly fissured; inner bark reddish brown, fibrous. Young twigs softly pubescent. Leaves 4 – 7cm by 1.3 – 3.5cm, lanceolate-ovate, acuminate or caudate-obtuse, rounded at base, glabrous above, densely brown scurfy beneath; lateral nerves 6 – 7 pairs, ascending, relatively straight; petiole 0.6 – lcm long, slender, scurfy. Panicle terminal or axillary; flowers shortly pedicelled, secund on short spreading branches. Sepals nearly equal, broadly ovate, subacute, glabrous. Petals linear-lanceolate, hairy outside. Stamens 15; the appendage nearly thrice the length of the anthers. Ovary ovoid, with more or less prominent columnar style. Fruit ovoid, apiculate, partially covered by the thickened bases of the sepals; the 2 larger fruit sepals 8cm by 2.5cm, obtuse; the 3 smaller ones 0.6cm by 0.4cm, ovate, acuminate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

Highly restricted and found in Kanneliya, Hiniduma and Ratnapura.

Forest Types and Floristics

This endemic species is rather rare and found in highly restricted localities in the Lowland Wet Evergreen Forest (Andrews, 1961). It is generally gregarious in small groups and found on ridges between 300 to 800m altitude.

As the species is found mostly in pure patches, the associates are few and not important.

Silviculture and Management

Phenology

Flowering in April and fruiting during June-July.

In its restricted natural habitat regeneration is plentiful. Being shade tolerant, the species is able to establish itself in undisturbed areas, but no systematic regeneration operations are carried out.

Wood

Structure

Vessels numerous, medium to large, mostly solitary, sometimes in groups of 2 – **3;** tyloses common.

Apotracheal parenchyma vasicentric to aliform.

Rays fine.

Resin canals solitary, in regularly spaced tangential lines.

Properties

Wood reddish brown, fine textured and straight grained; hard and strong. Weight 960Kg/m3 at 12 percent moisture content.

Seasons slowly and liable to warping and cupping. Refractory to treatment.

HOPEA GLABRA W:& A.

Syn. *Hopea wightiana* Var. *glabra* Bedd.

Common names

Kan. – Malchegge.
Mal. – Ilappongu, Irumbagam, Naithambagam.
Tam. – Kong, Karaikkongu.

A small resinous tree reaching a height of 18 – 21m and a girth of 1.5m. Bark dark brown to dirty red, peeling off in irregular flakes. Leaves ahout 10cm by 3.5cm, lanceolate, obtuse or shortly acuminate, rather shining on both surfaces; lateral nerves about eight pairs, petiole 1.2cm long; stipules small, deciduous and inconspicuous. Panicle, axillary, glabrous, flowers pedicelled; bracts small, lanceolate, obtuse. Sepals ovate, obtuse, glabrous. Petals pubescent. Stamens 10 – 15, anthers orbicular; appendage about three times **as** long as the anther. Ovary narrowly conical and slightly constricted above the centre; style with a simple pointed stigma. Fruit belly smooth, ovoid or ellipsoid, pointed, 1.8cm long, the two larger sepals in fruit about 4cm by lcm, reddish, the three smaller sepals nearly as long as the fruit belly (Bourdillon, 1908; Gamble, 1915; Parker, 1935).

Distribution – India

The species is ***of*** restricted occurrence, found in Tirunelveli in Tamil Nadu, South Kanara in Karnataka and Kerala.

Forest Types and Floristics

The species **is** sporadic in the Semi-Evergreen Forests of Tirunelveli in Tamil Nadu, South Kanara (Karnalaka) and the West Coast Semi-Evergreen Forests of Kerala. Typically this forest type is intermediate between Tropical Evergreen and Moist Deciduous Forests with evergreen and deciduous species intimately mixed (Champion & Seth, 1968).

Floristics

Palghat, Northern Kerala (West Coast Semi-Evergreen Forest)

Hopea glabra, Cullenia exarillata, Elaeocarpus tuberculatus. E. munroii, Palaquium ellipticum. Mesua ferrea, Calophyllum *elatum. Canarium strictum, Vateria indica, Poeciloneuron indicum Dysoxylum malabaricum. Artocarpus heterophyllus. Polyalthia coffeoides, Cinnamomum zeylanicum, Litsea wightiana, Mastixia arborea, Drypetes* sp., *Myristica laurifolia, Hydnocarpus pentandra, H. alpina, Garcinia spicata. Scolopia crenata, Xanthophyllum flavescens, Actinodaphne hookeri, Euonymus anplatus, Agrostistachys indica, Sauropus alhicans, Leea indica. Macaranga roxburghii, Linociera malabarica, Laportea crenulata, Callicarpa tomentosa, Calamus* spp., *Pinanga dicksonii* (Chand Basha, 1977).

Silviculture and Management

Phenology

Flowering period is from January to March and fruiting from June to July. As it is sporadic in occurrence, no concentrated efforts have been made to regenerate the species. When the mixed semi-evergreen forests are taken up for regeneration this species is also favoured in the general treatment.

Wood

Structure

Vessels very small, soIitary, occasionally radially paired or 3-4 grouped, close and quite evenly distributed, 15 – 23 per mm^2; perforations simple; brownish yellow gummy deposits occasionally present.

Tracheids, sparse, with numerous, horizontally aligned, oval or elliptical, narrowly bordered pits.

Parenchyma, paratracheal, paratracheal zonate, metatracheal and in fine tangential bands. Paratracheal parenchyma abundant, metatracheal parenchyma sparse, scattered or in short, usually uniseriate; tangential bands of parenchyma which appear at fairly wide and irregular intervals 1 – **10** seriate, usually 1 – 4 seriate; gummy infiltration brownish – yellow, abundant.

Fibres libriform, extremely fine nonseptate; brownish-yellow gummy infiltration occasional.

Rays fine, close, 8 – 11 per mm, 1 – 5 seriate, heterogeneous, occasionally confluent vertically; gummy infiltration copious, brownish-yellow, granular; crystals frequent.

Resin canals solitary or 2 – 3 contiguous, tyloses occasionally present, a single tylosis sometimes filling the resin cavity; contents yellowish-white (Pearson and Brown, 1932).

Properties

Wood light greyish or creamy brown and often with darker streaks, with occasional white tangential resin canals, rather lustrous when first exposed, somewhat interlocked grained in narrow bands and often curly grained in the radial plane, very fine and even textured. The wood is heavy, strong and hard, sp. gr. 0.869; weight at 12 percent moisture content 1073Kg/m^3.

Shrinkage percentage green to oven dry	
Radial	4.3
Tangential	8.7
Volumetric	12.4
Modulus of rupture (Kgjcm^2)	
Green	1067.3
Air dry	1263.7
Modulus of elasticity (Kglcm^2)	
Green	147,900
Air dry	160,700
Maximum crushing stress (Kglcm^2)	
Green	581.4
Air dry	710.5

Seasons slowly and liable to end splits and surface cracks if not properly seasoned. Air seasoning under shade has given better results. The timber is very durable, grave yard tests having shown a life of 244 months. Very refractory to treatment, penetration being practically nil. The timber is rather hard to work and saw. Due to interlocked grain and hardness peeling is not satisfactory. A good finish is possible despite the difficult working condition and once finished it takes a good polish.

Uses

The timber is mainly used for construction of buildings, bridges, piles, rice pounders, platform boards and ladders.

HOPEA HELFERI (Dyer) Brandis

Syn. *Hopea andamanica* King
H, dealbata Hance
H. mavis Kurz ex Brandis
Shorea helferi Kurz
Vatica helferi Dyer

Common names
Bur. – Thingan-gyank, Thinga
Hind. – Thingan.

A medium sized tree attaining a height of 20 – 37m and a girth of 2 – 3m in Burma. In Andamans it rarely attains this size. Bark smooth, reddish-brown, peels off in flakes; blaze pinkish. Young shoots thinly pubescent. Leaves 10 - 18cm by 3.5 – 7cm, more or less oblong, acute or acuminate, the base rounded or cordate, coriaceous, lateral nerves 13 – 17 pairs; petiole 0.5 – 1.3cm long, channelled above. Panicle terminal or from the axils of upper leaves, grey stellate tomentose; flowers in rows of 4 – 12 on racemes, bracteoles minute, caducous. Sepals unequal, the 2 larger ovate oblong and obtuse, the 3 smaller rather more pointed and thin. Petals pale yellow, narrowly elliptic-oblong. Stamens 15, minute; anthers with a fine hairy appendage. Ovary cylindric, slightly tapering upwards and constricted about the middle, glabrous; style short, pointed. Fruit belly ovoid, apiculate, glabrous, surrounded by the base of the enlarged sepals, the two larger ones 5 – 8cm by 1 – 1.2cm, narrowly oblong or oblanceolate, apex rounded, glabrous, 7 – 9 nerved, the 3 smaller sepals ovate and

3 – 4mmlong.

Distribution – Burma, India

In Burma its distribution ranges from Tavoy to Tenasserim. The only record of this species in India is in the hills of Middle and North Andamans where it is occasionally found.

Forest Types and Floristics

In Burma the species is found rather sporadically in the Southern Tropical Secondary Evergreen Forest (Champion, 1936) which is considered to be intermediate between giant evergreen and moist deciduous types. Here large sized trees are relatively scarce mainly due to unfavourable edaphic conditions. In Andamans the species is occasionally found in the Southern Hill Top Tropical Evergreen Forest (Champion and Seth, 1968) which is considered to be an inferior edition of the Tropical Wet Evergreen Forest of this region. The forest is characterised by the comparatively stunted growth of tree species due to less favourable conditions of soil and exposure to wind. Champion and Seth (1968) consider this type of forest as an edapho-climatic climax forming a transition td the Subtropical Montane type.

Floristics

(i) South Tenasserim, Burma

I *Schima* sp., *Dillenia parvifora, Hopea helferi, Cinnamomum inunctum Dysoxylum grande.*

11 Bamboo

(ii) South Andamans, India

I *Dipterocarpus costatus, Mesua ferrea, Canarium manii, Harpullia cupanioides, Cratoxylonformosum, Hopea helferi, Euphorbia trigona, E. epiphylloides.*

I1 *Memecylon* sp.. *Cryptocarya* sp., and bamboos.

Silviculture and Management

As the species occurs in relatively poorer sites and is distributed sporadically, it has not been regenerated. Selective fellings are carried out in Burma for good quality logs. In the Andaman Islands the timber is not extracted a d the forests in which the species grows are not subjected to any treatment.

Wood

Structure

Wood diffuse porous, vessel small to medium sized, moderately numerous, rather uniformly distributed, usually round; plugged with tyloses.

Apotracheal parenchyma diffuse in irregular fine net-like structure; paratracheal parenchyma inconspicuous; parenchyma in tangential lines usually associated with bands of gum canals at irregular intervals.

Fibres irregular in arrangement, pits sparsely distributed.

Rays rather fine, spindle shaped, not closely spaced, evenly distributed.

Resin canals very irregularly distributed, duct orifices sometimes filled with whitish-yellow deposits and show up conspicuously on the longitudinal surface; ripple marks indistinct (Chowdhury and Ghosh, 1958).

Properties

Sapwood pale yellow, turning pale brown on exposure, heartwood yellowish-brown to brownish-red, sometimes with dark streaks interlocked grained, medium textured, usually very hard, moderately heavy. Timber **is** not durable. Heartwood very refractory to treatment; side and end penetration almost nil. Wood is difficult to saw, but can he brought to a fairly fine finish (Chowdhury and Ghosh, 1958).

Uses

In India there is no specific end use as the species has not entered the trade due to its very restricted occurrence. In Burma it finds local usage for constructional purposes. It has a good reputation in boat building, but due to the limited supply, is not very popular.

HOPEA GRIFFITHII Kurz

A moderate sized tree of girth up to 2.5m. Twigs slender, smooth. Bark smooth in young trees, becoming irregularly fissured, peeling off in small oblong flakes; inner hark reddish. Leaves 7 – 10cm by 2–5 – 3cm, ovate to elliptic-lanceolate, caudate-acuminate, glabrous on both surfaces; lateral nerves 10 – 12 pairs, very faint; petiole 0.8cm long, slender. Panicle axillary, glabrous; flowers almost sessile, dark red; bracts minute, lanceolate-acute. Sepals slightly united at the base, glabrous. Petals velvety outside. Anthers suborbicular, appendage twice as long. Fruit belly ovate, pointed; the 2 larger fruit sepals oblanceolate, obtuse (Hooker, 1874; Kurz, 1877; Symington, 1943).

Distribution – Burma

Note: – This species **is** originally described from Burma and reported to be cofmed to Tenasserim and Mergui. Its ecology, silviculture etc. are not documented.

HOPEA JACOB1 C.E.C. Fischer

A small tree. Twigs slender, dark-brown. Leaves 5.5 – 8.5cm by 2.5 – 4cm, ovate, caudate-acuminate, obtuie or subacute, base rounded, margin entire, subundulate; lateral nerves 5 – **6** pairs, the irregular tertiary nerves and the fine reticulations slightly prominent below; petiole 0.8 – lcm long. Panicle axillary and terminal, solitary or two, narrowly racemose, shorter than the leaves; bracts minute, flowers up to 7 in a branch; pedicels very short, rather stout. Sepals coriaceous, the inner with thin margins, subcircular, 1.5mm long. Petals oblong, obtuse, 0.3cm long, minutely ciliate and minutely puberulous without. Stamens 15; filaments short, the lower half dilated and abruptly narrowed into a filiform upper half, anthers round, flat, with a fine, straight arista 2% – 3 times as long. Ovary subglobose, with a narrower ovoid stylopodium nearly as long, slightly constricted between the two, together 1.25mm long; style very short (Fischer, 1932).

Distribution – India

This endemic and rare species is reported from Coorg (Karnataka). (Despite efforts specimens could not be collected. Only the type sheet with the Botanical Survey of India was availabe for examination).

HOPEA JUCUNDA Thw.

Common name

Sinh. Piniberaliya.

A medium sized tree reaching a height of 25m and a girth of 2m with a dense oblong crown with pendant branches. Bark surface purplish brown, flaky; inner bark pale brown. Young twigs puberulent. Leaves 3.5 – 11cm by 1.5 – 5.5cm, ovate, abruptly caudate-acuminate, base broadly cuneate, subequal; lateral nerves 3 – **4** pairs, arched, slender, more or less prominent below and obscurely depressed above; petiole 0.5 – 1.2cm long, puberulent, panicle axillary, lax; flowers shortly pedicelled, secund on short branches. Sepals broadly ovate, subacute, glabrous. Petals lanceolate, thrice as long as the sepals, silky outside. Stamens 15; appendage slender, 4 times as long as the anther. Ovary ovoid; style columnar. Fruit 1.5cm by 1cm, ovoid, apiculate; the two larger sepals 8cm by 2.5cm, obtuse, tapering towards the base; the 3 shorter sepals 0.6cm, broadly ovate, mucronate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found in Kanneliya, Hiniduma, Sinharaja forest, Ambagamuwa and Lubugama catchment forest.

Forest Types and Floristics

The species is fairly widespread in the Lowland Wet Evergreen (Andrews, 1961) on hill slopes below 1000m elevation. It is also found on ridge tops on leached and skeletal soils. Hence the species has two distinct distributional patterns and based on this Ashton has recognized two ecotypic sub-species.

Floristics

Kanneliya

Dipterocarpus glandulosus, D. hispidus, Calophyllum sp., ***Agrostistachys coriacea, Hopea jucunda, Litsea glutinosa, Campnosperma reylanica, Nothopegia colebrookiana, Artocarpus nobilis, Semecarpus*** sp., ***Mangifera reylanica, Ficus callosa, Chaetocarpus castanocarpus.***

Silviculture and Management

Phenology

Flowers appear in April and fruits ripen during May–June.

Where the species is frequent, especially along stream hanks and hill slopes, regeneration is satisfactory under heavy shade. No regeneration operations are carried out.

As the tree is rather small and thin-boled, it has limited timber value.

HOPEA MICRANTHA Hook. f.

A large tree. Twigs minutely lepidote. Leaves 5 – 6cm by 2 – 3cm, elliptic-ovate or lanceolate, caudate-acuminate, coriaceous, glabrous on both surfaces, midrib prominent, petiole 0.6cm long, puberulent. Panicle terminal or axillary, hoary-puhescent; flowers distinctly pedicelled. Petals pubescent. Anthers suhorbicular, appendage about as long. Fruit belly conical; 2 larger sepals 3.5cm long, oblanceolate, obtuse (Hooker, 1874).

Distribution Burma

Note. – The species has been reported from Burma (Hundley and Chit **ko ko,** 1961) but detailed information is wanting.

HOPEA MINUTIFLORA C.E.C. Fischer

Common names

Bur. – Mai-ka-kein,
Magale, Tingan – Pwe.

A small tree attaining a height of 20m. Twigs terete, thinly covered with reddish-brown fascicled hairs. Leaves **6** – 13cm by 2.3 – **4cm,** lanceolate, gradually tapering to a blunt point, base rounded, glabrous above except the pubemlous midrib, thinly puberulous below with short fascicled hairs; lateral nerves 8 – 10 pairs, ascending, prominent below. Panicle axillary and terminal, tomentose; flowers in unilateral racemes. Sepals grey-felted, the 2 larger oblong, rounded, the 3 smaller subacute. Petals falcately ovate-oblong, obtuse, 0.3cm long, grey pubescent. Stamens 10, glabrous; filaments flat; anthers elliptic-oblong; connective awn as long as the anther. Ovary subglobose, pubescent; style very short, glabrous; stigma minutely 3 lobed. Fruit belly 0.4cm long, apiculate; the two larger fruit sepals 3.5 – 4.7cm by 1.2 – 1.6cm, oblanceolate, rounded, 6 – 7 nerved, minutely puberulous (Fischer, 1927).

Distribution – Burma

Restricted to South Tenasserim and Victoria Point. Flowering specimens of the species have been collected in March (National Herbarium, Calcutta).

Note. – The species has not been studied in detail.

HOPEA OBLONGIFOLIA Dyer

A medium sized tree attaining a height of 25m or more. Bark dark grey with a pinkish fibrous blaze. Young twigs glabrous or almost so. Leaves 15 – 25cm by 4 – 8cm oblong, elliptic-oblong or narrowly oblong, acuminate, the base rounded and conspicuously oblique, glabrous except along the veins; lateral nerves 12 – 14 pairs, rather prominent beneath and almost parallel; petiole 1 – 2cm long, grooved above, glabrous or slightly pubescent. Panicles axillary, flowers many, arranged in 5 – 8 flowered racemes, 1,3cm across, pedicels with small scale-like bracteoles. Sepals ovate deltoid, the outer ones glabrous or nearly so, unequal in size, three being larger than the other two, the longest about 6mm long. Petals white or pale yellowish, oblong and somewhat subfalcate, glabrous except the outer edges which are pubescent. Stamens very small, about 15; anthers orbicular; connective produced into a slender hair-like awn. Ovary thinly hairy in the upper portion and prolonged upwards into a columnar stylopodium which is crowned by a pointed style. Fruit belly ovoid or ellipsoid and pointed at the apex, smooth, glabrous, up to 3 cm long and 1.7cm in diameter; the two larger sepals in fruit 10 – 15cm by 2.5 – 3cm, oblanceolate or narrowly oblong-oblanceolate, rounded at the apex with about 8 – 11 veins running nearly the whole length of the wings, the three smaller ones narrow and apparently deciduous at maturity (Parkinson, 1937).

Distribution – Burma

The species occurs in South Tenasserim from Tavoy to Victoria Point. Its distribution is very restricted and sparse (Parkinson, 1937).

Silviculture and Management

Phenology

The flowers appear in January-February and the fruits ripen during April-May. Being an extremely restricted species, the floristics of the region in which it occurs, silvicultural details, etc., are wanting.

Wood

Structure

Vessels small to medium sized, moderately few, rather uniformly distributed, more often in groups of oblique chains, usually rounded, plugged with tyloses.

Parenchyma fairly abundant; apotracheal parenchyma diffuse in a irregular fine net-like Structure; parenchyma in tangential lines usually associated with bands of gum canals at irregular intervals.

Rays rather fine, not closely spaced, evenly distributed, often shows ray flecks on the radial surface.

Resin can.). small, very irregularly distributed, duct orifices sometimes filled with whitish-yellow deposits. Ripple marks indistinct (Chowdhury & Ghosh, 1958).

Properties

Sapwood pale yellow turning pale brown on exposure, heartwood yellowish brown to brownish red, interlocked grained; medium textured, hard, moderatelv heavy (Chowdhury and Ghosh, 1958).

Uses

As the species is localised to limited areas it is not common in trade and there is no definite end use. Locally it is used as a construction timber.

HOPEA ODORATA Roxb.

Syn. Hopea decandra Buch. Ham. ex Wt.
H. wightiana Mig. ex Dyer
H. eglandulosa Roxb.

Common names

Bur. – Sawkwai, Thingan, Thinsingan, Thingan byu.

Hind. – Rimda, Safed thingan, Thingan

A large tree reaching a height of 45m with a clear bole of 25m and a girth of 3.5m or more. The branches spreading, branchlets drooping. Bark surface dark brown, smooth. Leaves 10– 15cm by 3.5 – 5cm, ovate or oblong lanceolate, acute or obtusely acuminate, base rounded, often oblique, margin undulate, glabrous on both surfaces; lateral nerves about 12 pairs, their axils often glandular; petiole 1.5cm long. Panicle terminal or from the exterior axils, tomentose, drooping; flowers shortly pedicelled, fragrant; bracts cordate, acute, villous, caducous. Sepals unequal, ovate, obtuse, slightly pubescent. Petals yellow, oblong, falcate, puberulous. Stamens 10; filaments flattened at base, alternating ones larger and bifid; appendage about the same length. Ovary ovoid; style as long as the stamens; stigma simple. Fruit ovoid, apiculate, glabrous, surrounded by the enlarged sepals; the two larger ones 4cm long, oblong, somewhat narrowed at base, 9–10 nerved, the three smaller ones as long as the fruit belly (Hooker, 1874; Kurz, 1877).

Distribution – Bangladesh, Burma, India

In Bangladesh it is not common and is is confiped to Chittagong. In Burma the distribution of this species extends southwards from Pyinmana through Pegu into Tenasserim. It grows sporadically in P e p Yoma. In the western side of the Pegu Yoma it extends as far north as Tharrawaddy. In India the species is found only in the Andaman and Nicobar Islands.

Forest Types **and** Floristics

The species is one of the most hygrophilous of all dipterocalps and found sporadically in the Evergreen and Moist Deciduous Forests. The frequency of its occurrence is very low in Chittagong, and rather low in the Andaman Islands. It is only in Burma that its frequency is comparatively more in the Evergreen and Moist Deciduous Forests: It thrives on deep rich soil commonly along the banks of streams and in damp situations.

Floristics

(i) Ataran, S. Burma (Evergreen Dipterocarp Forest)

I *Dipterocarpus alatus*, *Hopea odorata*, *Mangifera caloneura*, *Parashorea stellata*, *Anisoptera* sp., *Calophyllum* sp., *Pentace burmanica.*

I1 *Toona* sp., *Syzygium* sp., *Livistona speciosa.*

I11 *Strobilanthes* spp., *Licuala peltata*, *Pandanus* sp. (Champion, 1936).

(ii) Andamans, India (Andamans Tropical Evergreen Forest)

I *Dipterocarpus grandiflorus*, D. *gracilis. Hopea odorata*, *Calophyllum soulattri*, *Mimusops elengi*, *Artocarpus chaplasha. Planchonia littoralis.*

11 *Myristica andamanica*, *M. glaucescens*, *Baccaurea sapida*, *Croton argyratus*, *Pterospermum aceroides*, *Caryota mitis*, *Cryptocarya* sp., *Memecylon* sp., *Euphorbia epiphylloides* (Champion and Seth, 1968).

Silviculture **and** Management

Phenology

In Burma the small white, fragant flowers appear in March – April. The fruits ripen in May – June. In Andamans the flowering is in February – March and fruiting in May – June.

Silvicultural characters

The species is scattered and dispersed. It is a strong shade bearer in the early stages and can tolerate shade in the pole stage also. Fire is uncommon in its natural habitat. It is fire sensitive and in the event of are occurrence of fire the younger crop gets killed (Homfray, 1935). It is very slow growing and a poor coppicer.

Natural regeneration

Because of the dispersed distribution, it is difficult to obtain natural regeneration by the popular irregular shelter wood system practised in the evergreen forests. Wherever mother trees are present regeneration is possible in the vicinity and fairly successful regeneration has been obtained in Burma and the Andaman Islands. Attempts have also been made in Bangladesh to sow the seeds directly in natural regeneration areas and to plant out nursery raised seedlings. Direct sowing in lines 15cm apart with overhead shade provided by a cover crop has given successful results (Chaudhury, 1968). In nursery, seeds sown in shaded beds 8cm- apart, germinated within a fortnight. Seedlings planted out in the regeneration areas establish themselves well, the pre-requisite being immediate planting out. The viability of seeds is very low, being less than a week. Under controlled temperature (15^0) and moisture the seeds have been reported to remain viable up to 2 months (Tang and Tamari, 1973).

Artificial regeneration

Small experimental plantations have been raised in Rajendrapur (Bangladesh). Seedlings raised in the nursery are planted out in moist barren areas under a cover crop which **is** subsequently removed. The efforts are quite successful.

Wood

Structure

Vessels medium sized, pores round to oval, scattered, tyloses abundant.

Tracheids sparse, with numerous, oval to elliptic, horizontally oriented pits.

Parenchyma abundant, paratracheal, metatracheal, paratracheal-zonate; and in tangential bands; paratracheal parenchyma forming a 1-4 seriate sheath; metatracheal parenchyma scattered or in short, uniseriate, tangential rows; tangentid bands of parenchyma appear at irregular intervals, 10 - 14 seriate forming concentric arcs; pale lemon-yellow infiltration scanty in all types of parenchyma.

Fibres non-libriform, non-septate, interfibre pits simple, sparse, confined largely to the radial walls.

Rays fine heterogeneous.

Resin canals, solitary or 2-3 contiguous; contents pale yellowish-white (Pearson and Brown, 1932).

Properties

The sapwood pale-yellow, heartwood yellow to olive brown, with white tangential lines (resin canals) at irregular intervals, lustrous when first exposed hut becomes dull with age, broadly and shallowly interlocked grained, medium smooth, moderately heavy, sp. gr. 0.637. Weight at 12 percent moisture content 753Kg/m^3.

Shrinkage percentage green to oven dry	
Radial	3.4
Tangential	6.5
Volumetric	9.3
Modulus of rupture (Kg/cm^2)	
Green	808.7
Air dry	963.9
Modulus of elasticity (Kg/cm^2)	
Green	106,400
Air dry	117,400
Maximum crushing stress (Kg/cm^2)	
Green	441.3
Air dry	471.8

Seasons slowly and it is essential to season in the shade. Heartwood is fairly durable and grave yard tests have indicated a maximum life of 10 years. It has been reported that as railway sleepers it lasted for 16 to 18 years, as dug-outs over 60 years and as sea going boats, 25 years. The wood is very refractory to treatment, penetration being almost nil. It is difficult to saw and blunts tools. Can be brought to a fine finish (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Uses

A good constructional timber. Also used for low grade furniture. In Bangladesh and Burma a favoured timber for boat building.

Non wood products

The tree yields a resin known as 'Rock Dammar' in commerce. The resin is yellow with a slight odour and shiny fracture and solidifies in nodules on exposure to air. It is fairly hard and completely soluble in turpentine and partially in alcohol. The resin has been classed commercially as a second quality dammer and can be used in the preparation of varnishes for indoor decorative work. It is also used for caulking boats and mounting microscopic objects. A composition prepared by mixing the resin with bees wax and red ochre is used for fastening spear and arrow heads by tribals in Burma and the Andaman Islands. The resin in powder form has styptic properties and used as an ointment for wounds and sores in Burma (Chopra *et al*, 1956).

The leaves contain 10% tannin in the absolutely dry condition. The leaves have a softening effect and are used in crude tannery. The bark is astringent (Kirtikar and Basu, 1918 Howes, 1953). It has tanning properties also. The tannin extract is a distinctly rich one and the yield is quite good. The leather tanned with this has the merit of being particularly strong (Pilgrim, 1924).

HOPEA PARVIFLORA Bedd.

Common names

Kan. – Kiral boghi, Bovige, Urippu, Bogmara.
Mal. – Irumbagam, Thambagam, Kamhagam.
Tam – Kongu, Pongu, Vellaikongu, Karankongu, Irumbakam

A large tree reaching a height of 30 – 37m and a girth of 4 – 6m, with a clear cylindrical bole of about 20m. Bark surface light brown or greyish, mottled with white markings, smooth in young trees, somewhat rough and rusty brown in old trees. The branchlets reddish-brown, slightly pubescent. Leaves 8 – lOcm by 3 – 3.5cm, ovate or oblong, acute, apiculate or bluntly acuminate, base cordate or subcordate, margin slightly undulated, glabrous on both surfaces; lateral nerves about 10 pairs, often forked, their axils often glandular; petiole about Icm long; stipules small, deciduous or inconspicuous. Panicle axillary or terminal, grey tomentose; flowers small, ebracteate, sessile or shortly pedicelled, cream coloured and fragrant. Sepals pubescent, lanceolate, obtuse, imbricate with membranous margins. Petals glabrous, tip dilated and crispate. Stamens 15 or rarely 10, slightly conate; anthers ovate; connective produced into a subulate point. Ovary glabrous; style short, subulate. Fruit belly 0.7cm long. closely surrounded by the base of the accrescent sepals, the two larger ones linear-oblong, 4.5 – 6cm long,the 3 smaller linear, as long as the fruit belly (Bourdillon, 1908; Gamble, 1915; Hooker, 1874).

Distribution – India

It is one of the most common species of the genus with a wide distribution in South Western India. It stretches from Honavar southwards through Hassan, Sagar, Shimoga, Chickmagalur, Coorg in Kamataka to South Kerala and extends to Tirunelveli in Tamil Nadu. In Honavar it occurs in the upper valley of the Sharavati River.

It is fairly common in Agumbe, Varahi and Manibyle forests. Although sporadic in many localities, it is abundant and gregarious in the ghat forests and it forms about **85%** of the tree species in Chokkadabail. In Kerala also it is sometimes seen as pure patches as in Kulathupuzha (Menon, 1945).

The species thrives up to 1000 m elevation. It occurs on the upper slopes and ridges or at the edge of the forest in the evergreen zone. In the moist deciduous and semi-evergreen zone it occurs on the undulating slopes of the foot hills.

Forest Types and Floristics

The species is found in the West Coast Tropical Evergreen Forest, Southern Hill Top Tropical Evergreen Forest, West Coast Semi-Evergreen Forest and West Coast Secondary Evergreen Dipterocarp Forest (Champion & Seth, 1968). In the West Coast Tropical Evergreen Forest which is characterised by high rainfall, and altitude up to 1200m, the species is rather sporadic but attains good dimensions. In the Southern Hill Top Tropical Evergreen Forest which is considered to be an inferior edition of the typical wet evergreen forest, exposure to wind is a common feature and the edaphic conditions also are not very favourable. In such forest, although the frequency of occurrence of the species is more, the trees do not attain large dimensions. The West Coast Evergreen Forest is an intermediate between Tropical Evergreen and Moist Deciduous forests with an intimate mixture of evergreen and deciduous species. This type of forest is mainly found on hill slopes from 450 – 1050m and on plains. The species is semi gregarious or gregarious. In the West Coast Secondary Evergreen Dipterocarp Forest the growth of trees is poor and the soil is generally lateritic. Here the species is often gregarious and the frequency of its occurrence is quite marked

Floristics

(i) Agumbe, Karnataka (West Coast Tropical Evergreen Forest)

I *Dipterocarpus indicus, Hopea parviflora. Poeciloneuron indicum. Mesua ferrea, Dysoxylum malabaricum. Calophyllum elatum, Machilus macrantha, Palaquium ellipticum.*

I1 *Myristica* sp., *Euphoria longana, Lansium anamallayanum. Meiogyne pannosa, Humboldtia brunonis, Aglaia odoratissima, Hopea wightiana.*

111 *Strobilanthes* spp., *Pinanga dicksonii, Arenga wightii, Pandanus sp.*

(ii) Tirunelveli, Tamil Nadu (Southern Hill Top Tropical Evergreen Forest)

I *Calophyllum datum. Dysoxylum malabaricum, Hopea parviflora. Cullenia exarillata, Artocarpus hirsuta. Lophopetalum wightianum, Tetrameles nudiflora.*

II *Syzygium cumini, Cinnamomum zeylanicum Etaeocarpus serratus, Macaranga roxburghii.*

111 Dense evergreen shrubs and reeds.

(iii) Kulathupuzha, Kerala (West Coast Semi-Evergreen Forest)

I *Artocarpus hirsuta, Adina cordifolia, Hopea parviflora Lagerstroemia lanceolata. Terminalia paniculata. Terminalia alata. Salmalia malabarica, Tetrameles nudiflora, Vitex altissima, Holoptelia integrifolia, Vateria indica. Lophopetalum wightianum, Pterocarpus marsupium, Calophyllum elatum. Terminalia bellerica, Machilus macrantha, Grewia tiliaefolia.*

I1 *Polyalthia fragrans,Canarium strictum, Cinnamomum zeylanicum, Aporosa lindleyana. Mallotus philippensis, Xanthophyllum flavescens, Emblica officinalis, Bridelia retusa. Albizzia odoratissima.*

III *Clerodendrum* sp., *Glycosmis pentaphylla, Strobilanthes* sp.

IV *Entada phaseoloides, Butea parvi*flora, *Strychnos colubrina, Dioscorea* sp.

(iv) South Kanara, Karnataka (West Coast Secondary Evergreen Dipterocarp Forest)

I *Hopea parvifora, Hopea wightiana, Vateria indica. Diospyros macrophylla.*

I1 *Aporosa lindleyana, Olea dioica.*

111 *Memecylon sp., Syzygium caryophyllatum.*

The species is capable of thriving in a variety of rock formations and soil types. In South Kanara the underlying formation consists of metamorphic schists and crystalline gneiss with granite and quartzose intrusions. Extensive areas of laterite overlie the parent rock to various depths often 30m or more giving rise to a deep red loam when fully disintegrated. The principal rock under the laterite throughout the ghat forest, where the species abounds, is a granatoid-gneissic or gneissic formation, generally coarse grained and often highly quartzose. On the plateaux the gneiss is frequently found metamorphosed on the surface into yellowish or reddish felspathic, easily disintegrating rock. The species can tolerate a wide range of rainfall, 87 – 750cm, the optimum precipitation range being 250 – 375cm/annum.

Phenology

The species sheds its leaves in drier areas in December – January and the new flush appears soon thereafter. The small cream coloured fragrant flowers appear from January to March and fruiting is from May to June. It is a good seeder and seeding is prolific in a cycle of 4 – *6* years.

Silviculturalcharacters

The species is hygrophilous. It is not a heavy shade bearer except in the seedling stage and light is a prerequisite for its development from the sapling stage. Viability of seeds is low and 20 days old seeds lose their viability completely.

The species attains good dimensions in deep well drained loam, but it can tolerate a variety of edaphic features.

It is sensitive to heavy congestion; weeds and undergrowth in evergreen forests account for the death of a large number of seedlings and saplings in early stages. The pole crop also thrives best in complete vertical freedom. Weeding and soil working round seedlings tend to hasten its establishment. It is not a good coppicer.

Natural regeneration

Natural regeneration of this species is satisfactory, important requirements being adequate soil moisture and light manipulation. In well drained deep moist soil cleared of leaf litter, regeneration is abundant provided there is adequate shade and timely rainfall. Soil working affords better facilities for regeneration. For establishment of the recruits, good weeding is necessary. For further development, manipulation of the canopy for ,admission of light is essential.

In South Kanara, where improvement fellings have been carried out, there is dense regeneration about the parent trees. Subsequent removal of parent trees has left behind a well established even aged crop. In the dense evergreen forest although regeneration is satisfactory, its further development is dependent upon removal of overhead shade at intervals.

The best way to induce and establish regeneration is to:

1. Remove all undergrowth and expose the soil before seedfall.
2. Lighten the upper canopies in the sapling stage.
3. Clearfell the top canopy trees when the pole stage is reached (Kadambi, 1954a).

Areas where the regeneration is wanting or inadequate, can be stocked by planting out nursery grown seedlings or wildings collected from areas of profuse regeneration. Freshly collected seeds are sown in shaded nursery beds. Germination percentage is between 60 and 7O.Germination starts in about 10 days and is over in about 20 days. One or two year old seedlings can be planted out. Experiments in Karnataka have shown that even 3 year old seedlings can be planted out. Overhead shade is essential to ensure establishment of the transplanted seedlings.

Where the pole crop is dense, silvicultural thinnings are advantageous. The rate of growth is moderately fast compared to other *Dipterocarpus,* after the crucial early years of its establishment. According to data recorded in the increment plots in Kamataka, the current annual increment gradually increases till the tree attains the size of about 2m girth, after which it falls (Kadambi, 1954a). In Kerala the following age/dimension relationship has been seen (Troup, 1921).

Age (years)	Heigbt (m)	Girth (cm)
10	8	43
11	–	48.5
12	14	58
14		65

The forest in which this species occurs is generally managed under an irregular shelter wood system, or in some cases a slection system.

Artificial regeneration

Artificial regeneration operations consisting of broadcast sowing of seeds in clear-felled areas and line sowing under teak plantations have been tried in the past. But the results were not encouraging.

Wood

Structure

Vessels small; perforations simple, transverse; tyloses abundant; lemon yellow gummy deposits occasional. Tracheids sparse, with numerous oval or elliptical, narrowly bordered pits.

Parenchyma paratracheal, paratracheal-zonate, metatracheal and in fine tangential bands; paratracheal parenchyma abundant, metatracheal parenchyma abundant, scattered or in short usually uniseriate tangential rows; tangential bands of parenchyma 7 – 11 seriate.

Fibres libriform, extremely fine, non-septate, interfibre pits simple; pale lemon yellow gummy infiltration occasional.

Rays fairly close, shows a tendency for tier like arrangement, 1-5 seriate, heterogeneous; infiltration pale-lemon yellow crystals numerous.

Resin canals solitary or 2-3 contiguous, zonate, inserted in tangential bands of parenchyma in uniseriate rows; contents yellowish-white (Pearson and Brown, 1932).

Properties

Wood bright reddish brown when first exposed, ageing to dark reddish brown with a purplish cast, with white lines at irregular intervals, dull, with smooth feel, broadly and shallowly interlocked grained, even and fine textured, heavy to very heavy; sp. gr. 0.794. Weight 929 Kg/m^3 at 12% moisture content.

Shrinkage percentage green to oven dry

Radial	3.8
Tangential	8.1
Volumetric	11.5

Modulus of rupture (Kg per cm^2)

Green	808.7
Air dry	963.9

Modulus of elasticity (Kg per cm^2)

Green	106,400
Air dry	117,400

Maximum crushing stress (Kg per cm^2)

Green	441.3
Air dry	471.8

It dries slowly. Under shade drying is even and better. It can be kiln seasoned without difficulty and degrading. Very durable and reported to be immune to white ants. Lasts fairly long in contact with water. The timber is refractory to treatment. Difficult to saw and work and peeling is extremely difficult.

Uses

A popular constructional timber. In rural areas it is used for making road rammers, rice pounders, platform boards and ladders. It is considered to be a versatile timber and in Karnataka it is often called 'Malanad teak'.

Non wood products

Bark is a good tanning material, especially for heavy leather. It contains 14% to 28% pyrocatechol tannins and 5% to 10% non-tannins. It is particularly suitable for tanning in admixture with other tanstuffs. Tanning with a mixture of 2 parts of *Hopeu* and 1 part of Myrobalan barks resulted in a reddish brown leather of good quality which compared favourably with wattle tanned leather and was more resistant to mould growth. A solid extract containing 70% tannin and 22.6% non-tannin has been prepared (Howes, 1953). It is an astringent, with a slow speed of diffusion.

HOPEA RACOPHLOEA Dyer

Syn. ***Hopea malabarica*** Bedd.

Common names

Kan. – Neduvar gongu
Mal. – Naikambagom, Kolalu, Valikerapongu
Tam. – Karum Kongu

A small tree attaining a height of 20m and a girth of 1.5m. Bark blackish, peeling in strips young shoots glabrous. Leaves 10 – 11cm by 5 – 6cm, ovate, shortly caudate, acuminate, base acute, both surfaces glabrous; lateral nerves 4 – 5 pairs, obliquely curved, equally prominent on both surfaces with large glands; petiole 1 – 3cm long. Panicle axillary or terminal, the branchlets glabrous; flowers shortly pedicelled, pinkish yellow, 2 – 4 together. Sepals glabrous, the two .outer larger ovate-acuminate, the inner three smaller and pointed. Petals pubescent. Stamens 15; connective produced into a subulate point. Ovary obconical; style short, subdate. Fruit belly closely surrounded by the base of the fruit sepals; base thickened, gibbous; the two larger ones 7cm by 2cm, oblong, tip truncate or rounded, inconspicuously 10-nerved, reddish (Bourdillon, 1908; Gamble, 1915; Hooker, 1874).

Distribution – India

A restricted species found scattered in parts of Karnataka and Kerala. It is recorded in South Kanara and Coorg (Karnataka), Moovattupuzha (Kerala).

Forest Types and Floristics

This species occurs scattered in the West Coast Tropical Evergreen Forest (Champion and Seth, 1968) and is confined to restricted localities.

Floristics

Moovattupuzha, Kerala

I *Acrocarpus fraxinifolius, Ailanthus triphysa, Antiaris toxicaria, Artocapus hirsuta, Elaeocarpus tuberculatus, Dipterocarpus indicus, Dysoxylum malabaricum, Hopea parvifora, H. racophloea, Palaquium ellipticum, Vateria indica, Actinodaphne hookeri, Aporosa lindleyana, Baccaurea courtallensis. Canarium strictum, Hydnocarpus pentandra, Myristica beddomei.*

I1 *Pygeum wightianum, Xanthophyllum flavescens* (Viswanathan, 1956).

Silviculture and Management

Phenology

Leaf shedding is during February – March. Flowers appear in April – May and fruits ripen in July—August.

Being a species of restricted occurrence and scattered widely in the evergreen forests, it is of no commercial value. Hence silvicultural characteristics have not been studied and efforts for propagation not made.

Uses

Limited. In localities where the species occurs, the timber is used for construction after crude fashioning.

HOPEA SHINGKENG (Dunn) Bor

Syn. *Vatica shinkeng* Dunn

Common name

As. – Shinkeng

A small tree attaining a height up to 1 10m. Bark greyish-brown, thick. Young branches dark brown, glabrous. Leaves 9 18cm by 3 – 6cm, lanceolate, oblong, elliptic-oblong or elliptic, obtusely acuminate or obtusely caudate at the tip, base somewhat oblique, glabrous on both sides lateral nerves **7** – 8 pairs, nerves depressed above and prominent below; petiole 0.6 – 1cm long. Panicle axillary, each branch bearing 4 – 10 shortly pedicelled small flowers. Sepals broadly lanceolate, acute, glabrous outside. Petals oblong, subfalcate, obtuse, or lacerate at the tip, prominently longitudinally nerved, the outer margin and portions of the outer surface covered with a dense, short adpressed pubescence. Stamens 15; filaments broadly dilated at the base, connective produced into a very slender awn. Ovary glabrous, surmounted by a cylindrical stylopodium, which is crowned by a short style and stigma. Fruit belly 2cm long, globose, shortly acuminate, enclosed by the base of the persistent and enlarged sepals; the 2 outer ones ovate-obtuse, striate, 3cm long, the 3 inner 1 – 1.5cm long (Bor, 1941)

Silviculture and Management

Phenology

Flowering is during August-September and fruiting from December-January (Bor, 1941).

Because of its highly restricted occurrence and limited timber value, no attempts have been made to propagate this species.

Wood

Structure

Wood is diffuse porous. Vessels numerous, 20/mm^2, uniformly distributed, mostly solitary, usually round; tyloses may partially fill up the vessels.

Parenchyma not conspicuous, apotracheal parenchyma scattered or diffuse in aggregates; paratracheal parenchyma abundant, vasicentric to aliform; parenchyma surrounding resin canals irregularly placed.

Rays moderarely broad to fine, not closely spaced.

Resin canals small to very small, often in tangential lines, irregularly and widely spaced; whitish-yellow deposits present in the canals (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood not well demarcated, wood pale yellowish-brown, darkening on exposure to deep reddish brown; interlocked grained, fine and even textured, hard, heavy (Chowdhury and Ghosh, 1958).

Uses

Not known in trade. Locally used as house posts.

HOPEA UTILIS (Bedd.) Bole

Syn ***Balanocarpus utilis*** Bedd.
Dioticarpus barryi Dunn
Hopea longifolta Dyer

Common name
Tam. – Karankongu.

A medium sized tree with a straight clear bole of 18 – 24m and a girth of 2 – 2.4m. Bark smooth, dark brown, often with greyish patches. Young shoots pubescent. Leaves 12 – 17cm by 2.5 – 3.5cm, linear-lanceolate, entire, base rounded, glabrous on both surfaces, lateral nerves 10 – 12 pairs, the tertiary nerves parallel, prominent and visible on both surfaces of the leaf; stipule minute, deciduous. Flowers small, shortly pedicelled in unilateral panicled racemes. Sepals imbricate, slightly united at the base. Petals pubescent, crenulate. Stamens 15; filaments dilated at the base; anthers short ovate, exceeded by the apical awn, which is three times the length of the anther. Ovary ovate; style short. Fruit belly globose, apiculate, 1.5cm in diameter, enclosed at the base of the thickened and accrescent sepals which attains 2.5cm length and spread horizontally (Bourdillon, 1908; Gamble, 1915).

Distribution – India

It is of highly restricted occurrence in Tirunelveli and Courtallam (Tamil Nadu), Thenmala and Silent Valley (Kerala); between 300 to 1000m altitude. It is generally found on hill sides bordering large rivers or on the banks of ravines.

Forest Types and Floristics

The species occurs in the Tirunelveli Semi-Evergreen Forest (Champion and Seth, 1968) which is confined to the eastern slopes of the western ghats in the southern region between 250 – 550m. It is a narrow strip between the wet evergreen and the moist deciduous forests.

Floristics

Tirunelveli

I ***Hopea parviflora, H. utilis, Pterospermum*** sp., ***Kingiodendron pinnatum, Stereospermum personaturn. Dalbergia latifolia, Artocarpus heterophyllus, Chukrassia tabulark***

I1 ***Aglaia*** sp., ***Euphoria longana, Drypetes*** sp., ***Carallia*** sp., ***Diospyros*** sp., ***Bischofia jauanica.***

III ***Strobilanthes*** sp., ***Glycosmis*** sp.

Silviculture and Management

Phenology

Flowering is between March-April and the .fruits ripen during the rainy season and onwards up to October. It is seen that 2 or **3** good seed years are followed by 2 or **3** poor seed years (Kadambi, 1957a).

Silvicultural characters

The tree is a strong shade bearer. The seedlings respond favourably to cleanings done in the lower canopy. Freedom of the canopy on all sides is an important factor encouraging its growth. The species exhibits a tendency to come up in groups (Kadambi, 1957a). It is fire tender. It does not coppice well.

Natural regeneration

The species regenerates profusely under and around the mother trees. In the initial stages it requires shade, but later development depends upon diffused light. Natural regeneration is supplemented by sowing or dibbling seeds after clearing the ground cover. Dibbling is found to be better than sowing. Attempts have been made to raise seedlings in nursery for planting out in the regeneration areas. As the viability of seed **is** extremely low, freshly collected seeds are sown in shaded nursery beds. Germination commences from **3** 8 days (Raja Singh, 1961), and is complete in about **10** – 12 days. Germination percent is 67 - 72 (Kadambi, 1957a). About 1 year old seedlings are planted out in the rainy season. Good shade is essential for the first **2** years. Thereafter the canopy has to be suitably manipulated for admission of light. An irregular shelter wood system with aided regeneration is ideally suited for propagation of the species.

Artificial regeneration

Although restricted in occurrence, efforts have been made to raise this species artificially by sowing and dibbling seeds in clearfelled areas outside its natural habitats. Experimental plantations of some extent have been raised in Palghat and Wynad in Kerala and Coimbatore in Tamil Nadu. As shade is essential in the early stages, a cover crop of ***Tephrosia*** *candida* or a shade crop of ***Trema*** *orientalis* has been tried. The plantation with ***Tephrosia*** *candida* cover crop has been successful to some extent (Kadambi, 1957a).

In Karianshola (Tamil Nadu) nursery grown seedlings have been transplanted in clearfelled areas after raising a shade crop. Here also the success has been reasonably good.

The species **is** slow growing, particularly in the younger stages. As compared to planting in clearfelled areas, planting in natural forest has registered a 'better rate of growth.

Wood

Structure

Vessels very small, majority in clusters, others solitary and encircled by a narrow interrupted sheath of parenchyma, 15 95/ mm^2 **;** perforations simple horizontal to somewhat oblique; tyloses abundant, lemon yellow or orange brown gummy deposits occasional

Tracheids, sparse, pits numerous.

Parenchyma paratracheal, paratracheal zonate and metatracheal, in cambiform rows of elongated units along the grain; paratracheal parenchyma relatively sparse; metatracheal parenchyma relatively abundant, the cells scattered or forming short tangential 1-2 seriate lines; orange brown gummy infiltration present in all types of parenchyma.

Fibres libriform, extremely fine, non-septate, pits sparse.

Rays Y – 10/mm, 1-4 seriate, heterogeneous, orange brown gummy deposits occluding many ray cells present; crystals abundant.

Resin canals arranged in concentric, uniseriate tangential rows spaced at distant and irregular intervals, deposits white.

Properties

Wood light-olive brown to pale yellowish brown, with tangential lines at irregular intervals, somewhat lustrous, shallowly interlocked grained, very heavy and hard, sp. gr. 0.844; weight at 12 percent moisture content 993Kg/m^3.

Shrinkage percentage green to oven dry

Radial	4.8
Tangential	8.2
Volumetric	12.6

Modulus of rupture (Kg/cm^2)

Green	553.5
Air dry	747.7

Modulus of elasticity (Kg/cm^2)

Green	86,800
Air dry	100,500

Maximum crushing stress (Kg/cm^2)

Green	295.4
Air dry	360.7

Somewhat difficult to season and is liable to surface cracking, may also warp and develop heart-shakes. Highly refractory to treatment, penetration being extremely poor. It is a durable timber. Being a tough wood it **is** difficult to saw and work with hand tools and difficult to plane to a smooth surface due to interlocked grain.

Uses

Mainly for local constructional purposes as posts. beams and rafters. In rural areas used as the hub of cart wheels and tool handles.

HOPEA WIGHTIANA Wall.

Common names.

Kan.	–	Haiga, Hiral bogi, Kalbom, Kurihouga, Malaihiaga.
Mal.	–	Pongu, Ilapong.
Mar.	–	Kalhoni.
Tam	–	Ilapongu,Kongu.

A small tree attaining a height of 10-15m and a girth up to 2m. Bark dark grey, smooth, exfoliating in irregular patches in old trees. Young twigs and petiole of the new leaves pubescent. Leaves 13 – 24cm by 5 – 7cm, ovate or ovate-oblong, obtuse or subacute, rounded at the base, glabrous; lateral 6 – 10 pairs, obliquely curved, petiole 1.2cm long. Panicle axillary; flowers shortly pedicelled, yellowish, tinged with red, arranged in one sided racemes along the branches of the panicle; bracts small, lanceolate. Sepals ovate, imbricate, the two outer ones blunt and long, the inner ones rather smaller and more pointed. Petals falcate-oblong, glabrous except the portion exposed in bud. Stamens 10, filaments dilated at the base, alternate one carrying **2** anthers; anther ovate, with a long filifonn appendage. Ovary narrowly conical, constricted about the middle, style short; stigma subulate. Fruit belly lcm long, ovoid, apiculate, glabrous, surrounded by the base of the accrescent sepals, the two enlarged ones 5.5 – 10cm by 1 – 1.5cm with 7 – 9 fine longitudinal veins joined by inconspicuous transverse ones, glabrous and reddish when ripe (Cooke, 1903, Gamble, 1915, Parker, 1935).

Distribution – India

A comparatively common species found in South Western India. It is often gregarious covering extensive tracts from North Kanara in Kamataka spreading southwards to South Kerala. It extends to Tirunelveli District in Tamil Nadu also. In the lower regions, the tree does not attain even moderate dimensions.

Forest Types and Floristics

In the West Coast Tropical Evergreen Forest (Champion & Seth, 1968) the species is mostly found along the hill slopes particularly in the lower altitudes. In Tirnnelveli Semi-Evergreen Forest and West Coast Secondary Evergreen Dipterocarp Forest (Champion and Seth, 1968) the species is often gregarious.

Floristics

(i) East Kanara, Kamataka (West Coast Tropical Evergreen Forest)

I *Dipterocarpus indicus, Calophyllum elatum.* **C.** *apetalum. Holigarna arnottiana,* ***H.*** *grahamii,* ***Olea*** *dioica, Hopea wightiana, Lophopetalum wightianum, Polyalthia cof feoides, Machilus macrantha, Mangifera indica, Chrysophyllum roxburghii.*

I1 *Aglaia roxburghiana, Euphoria longana. Aporosa lindleyana, Lancium anamallayanam. Nothopegia colebrookiana, Litsea* spp., *Flacourtia montana, Caryota urens, Arenga* sp.

I11 *Strobilanthes* spp., *Psychotria* spp.

(ii) North Mangalore, Kamataka (West Coast Secondary Evergreen Dipterocarp Forest)

I *Hopea parviflora,* ***H.*** *wightiana, Vateria indica, Diospyros microphylla.*

I1 ***Aporosa*** *lindleyana, Olea dioica.*

I11 *Memecylon* sp., *Syzygium* sp.

Silviculture and Management

Phenology

The flowers appear in March to April and the fruits ripen in May to June. The inflorescence is often infected and converted into a globular, echinate mass, resembling Spanish chest nuts.

Silvicultural characters

An essentially hygrophilous species. The species is shade hearing in the younger stages. It is only beyond the pole stage that light is required. Reported to coppice fairly well.

Natural regeneration

It is easy to obtain natural regeneration of the species. It **is** common to see seedlings, saplings and poles in good numbers. The treatment required is efficient weeding and climber cutting. .No special operation is. necessary to prepare the seed beds in areas where leaf litter is not heavy. In areas where the species is not gregarious, regeneration is found near the mother tree only. weeding and cleaning operations are adequate to establish the regeneration. After the pole stage is reached, light overwood removal is necessary. Experiments with sowing, dibbling and planting out nursery **grown** seedlings in Kerala have shown that dibbling under overwood shade gives satisfactory results (Iyppu, 1960). Stump planting is not successful.

Artificial regeneration

Artificial regeneration to establish plantations in clearfelled areas has been attempted, but with little success.

The rate of growth as determined from the data of Tree Increment Plots in Kanara (Karnataka) is as follows (Mathauda, 1953).

Diameter class (cm)	Number of years required to cross the diameter class.
10- 15	26
I5 – 20	22
20 – 25	19
25 – **30**	17
30 – 35	16
35 – 40	14
40 – 45	14
45 – 50	14
50 – 55	13
55 – 60	14

Wood

Structure

Vessels small, majority solitary or radially paired, occasionally in groups of 3–6, quite evenly distributed, 15 – 23/mm^2 ; perforations simple, transverse; tyloses abundant pale lemon yellow gummy deposits occasional.

Tracheids sparse, with numerous oval or elliptical narrowly bordered pits.

Parenchyma, paratracheal paratracheal-zonate, metatracheal and in fine tangential bands; paratracheal parenchyma abundant; metatracheal parenchyma sparse, usually in uniseriate tangential lines; tangential bands of parenchyma at irregular or more or less close intervals, 1–8 seriate; pale lemon-yellow gummy infiltration abundant.

Fibres filiform, extremely fine, non-septate, interfibre pits simple, nearly vertical;

pale lemon-yellow gummy infiltration occasional.

Rays, fairly close, 6—9 per mm, heterogeneous infiltration pale lemon-yellow, crysstals numerous.

Resin canals, solitary or 2—3 contiguous, zonate, contents yellowish-white (Pearson and Brown, 1932).

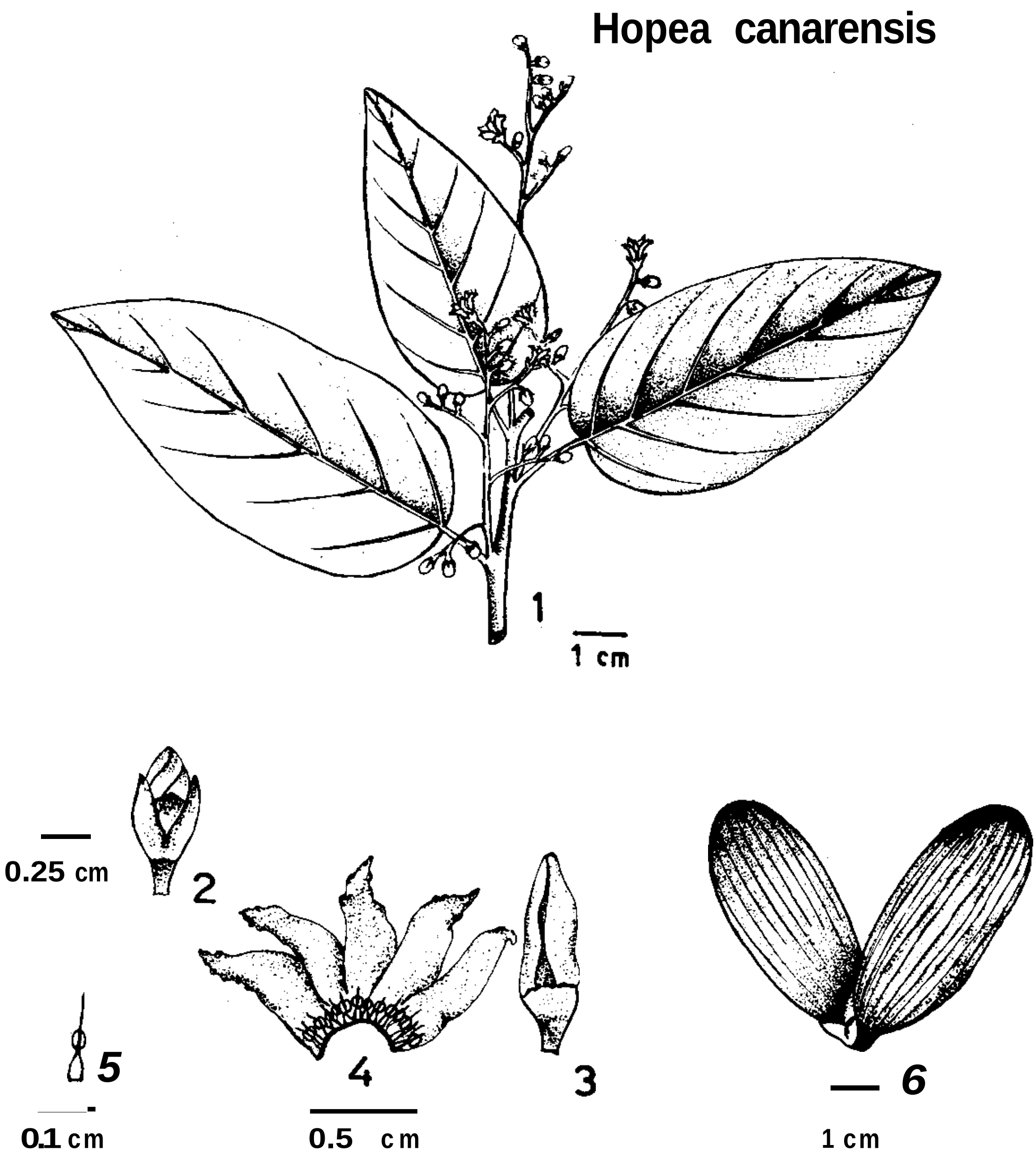
Properties

Wood reddish brown, somewhat lustrous, irregularly interlocked grained and often wavy or curly grained in the radial plane, fine and even textured, hard and heavy. Weight at 12 percent moisture content 993.15 – 1089.26Kg/m^3.

The timber does not season well, liable to surface cracking, fairly durable. Very refractory to treatment. Moderately hard to saw and work (Pearson and Brown, 1932).

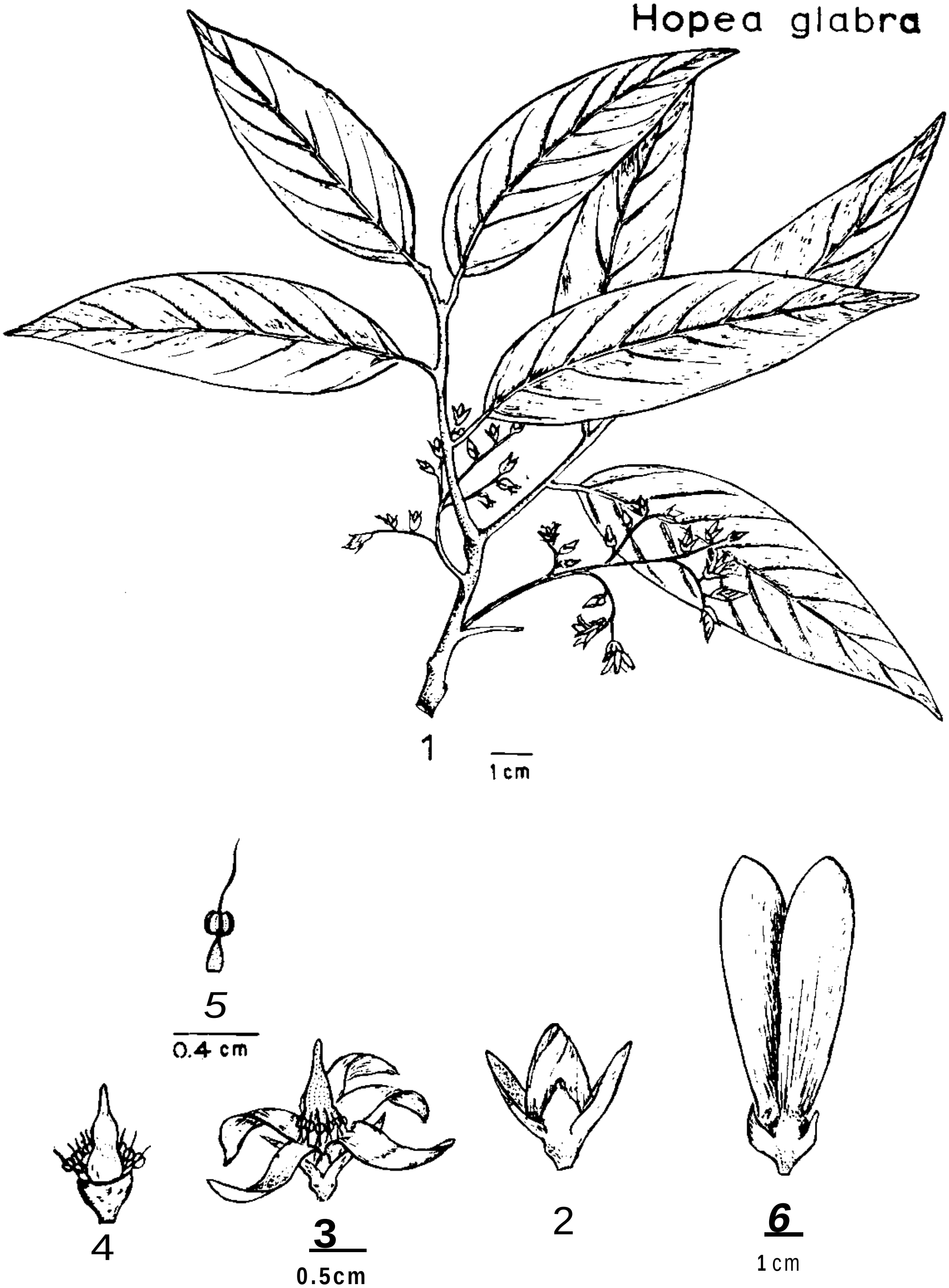
Uses

Mainly used for constructional purposes.



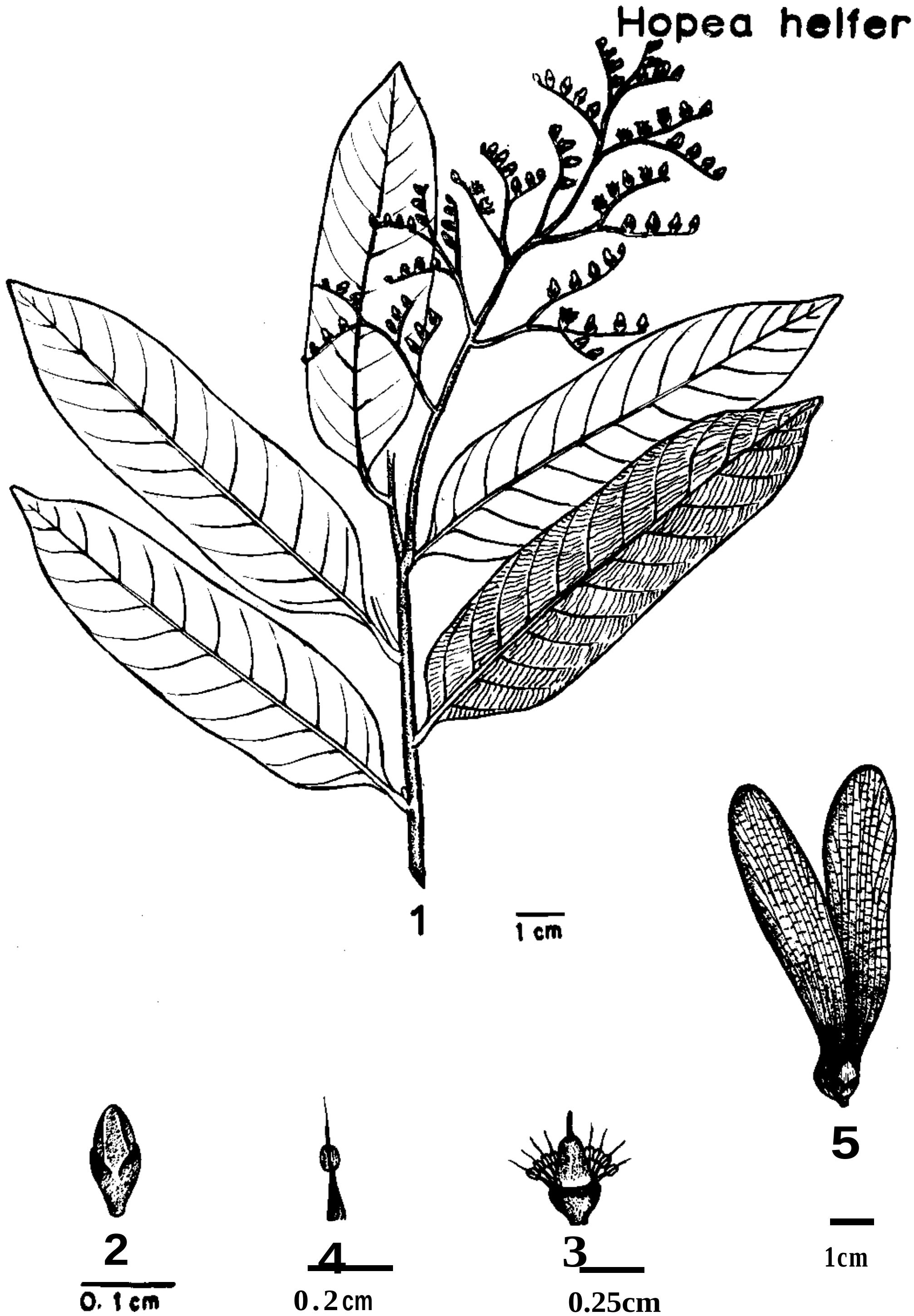
Hopea canarensis

1. **Flowering shoot**
2. **Flower bud**
3. calyx
4. **Corolla and androecium**
5. **Stamen**
6. **Fruit**



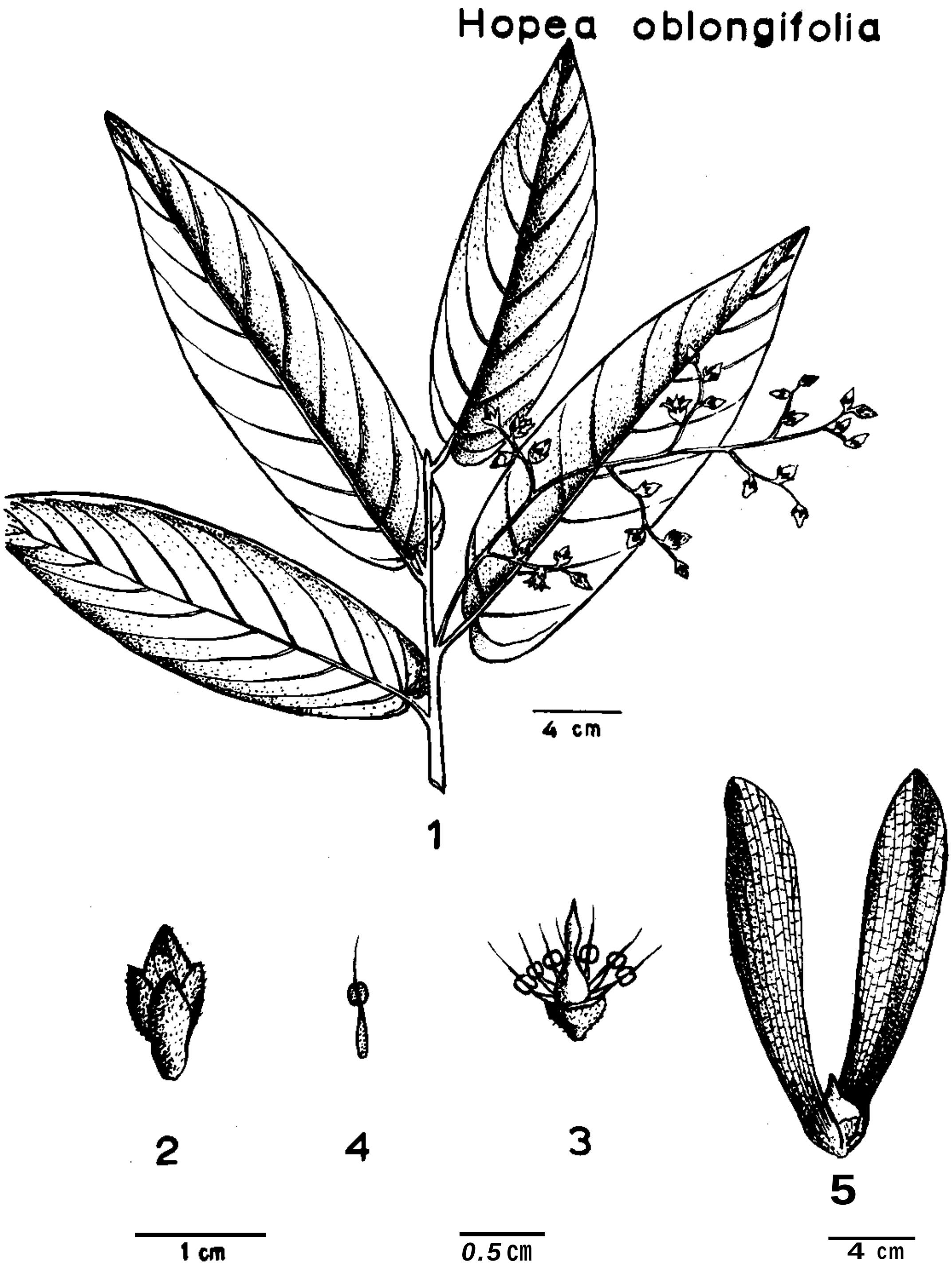
Hopea glabra

1. **Flowering shoot**
2. **Flower bud**
3. **Flower**
4. **Stamens and Pistil**
5. **Stamen**
6. **Fruit**



Hopea helferi

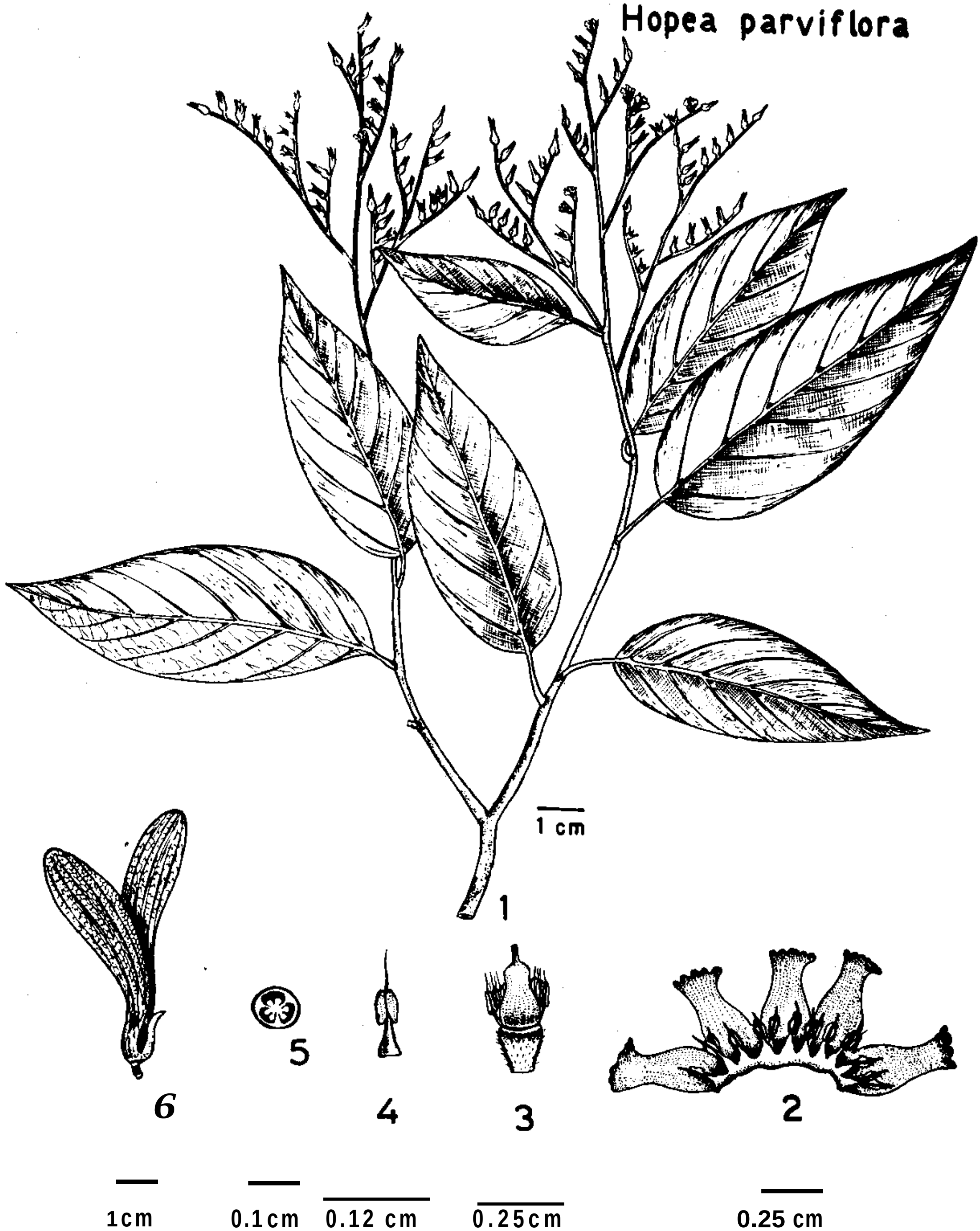
1. **Flowering shoot**
2. **Flower bod**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**



Hopea oblongifolia

1. **Flowering shoot**
2. **Flower bud**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

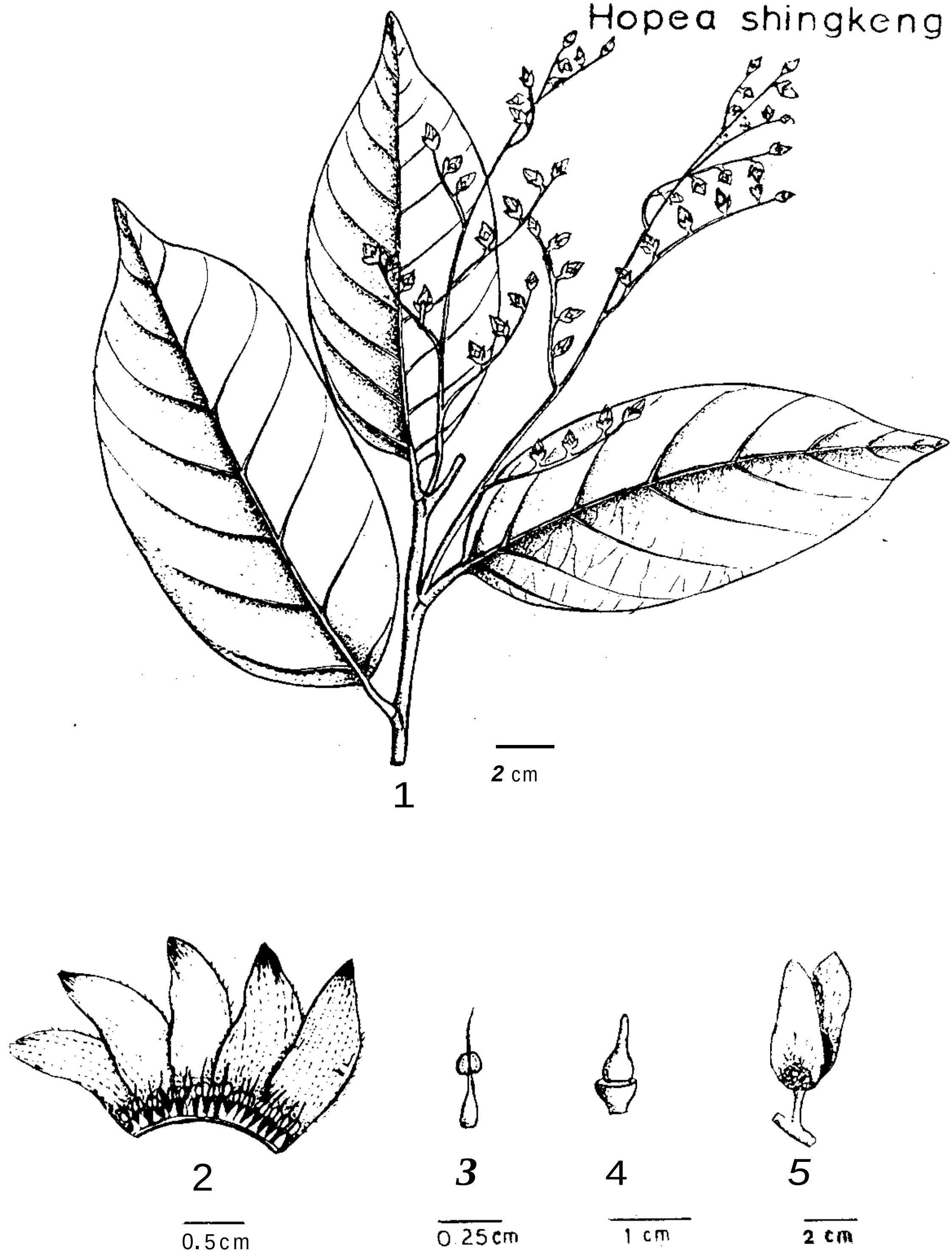
Hopea odorata
Natural regeneration
Andamans, India
(Photo FRI)



***Hopea** parviflora*

1.	**Flowering *shoot***	4.	**Stamen**
2.	**Corolla and androecium**	5.	**C.S. of the Ovary**
3.	**Stamens and Pistil**	6.	**Fruit**

Hopea parviflora
Poles – Lower storey
Karnataka, (India)
(Photo FRI)

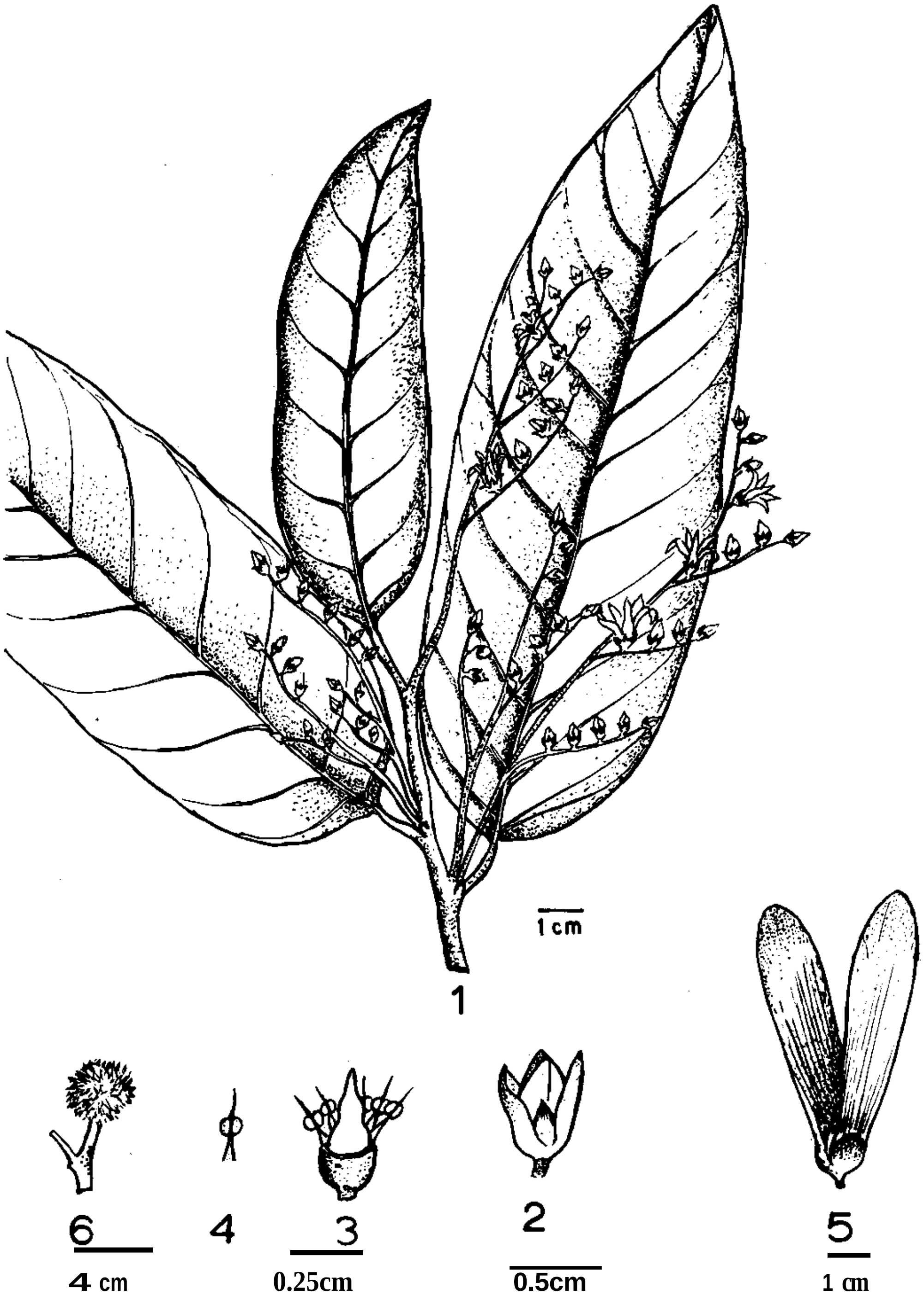


Hopea ***shingkeng***

1. **Flowering shoot**
2. **Corolla and androecium**
3. **Stamen**
4. **Pistil**
5. **Fruit**

Hopea utilis
Silent Valley – Kerala
(Photo KFRI)

Hopea wightiana



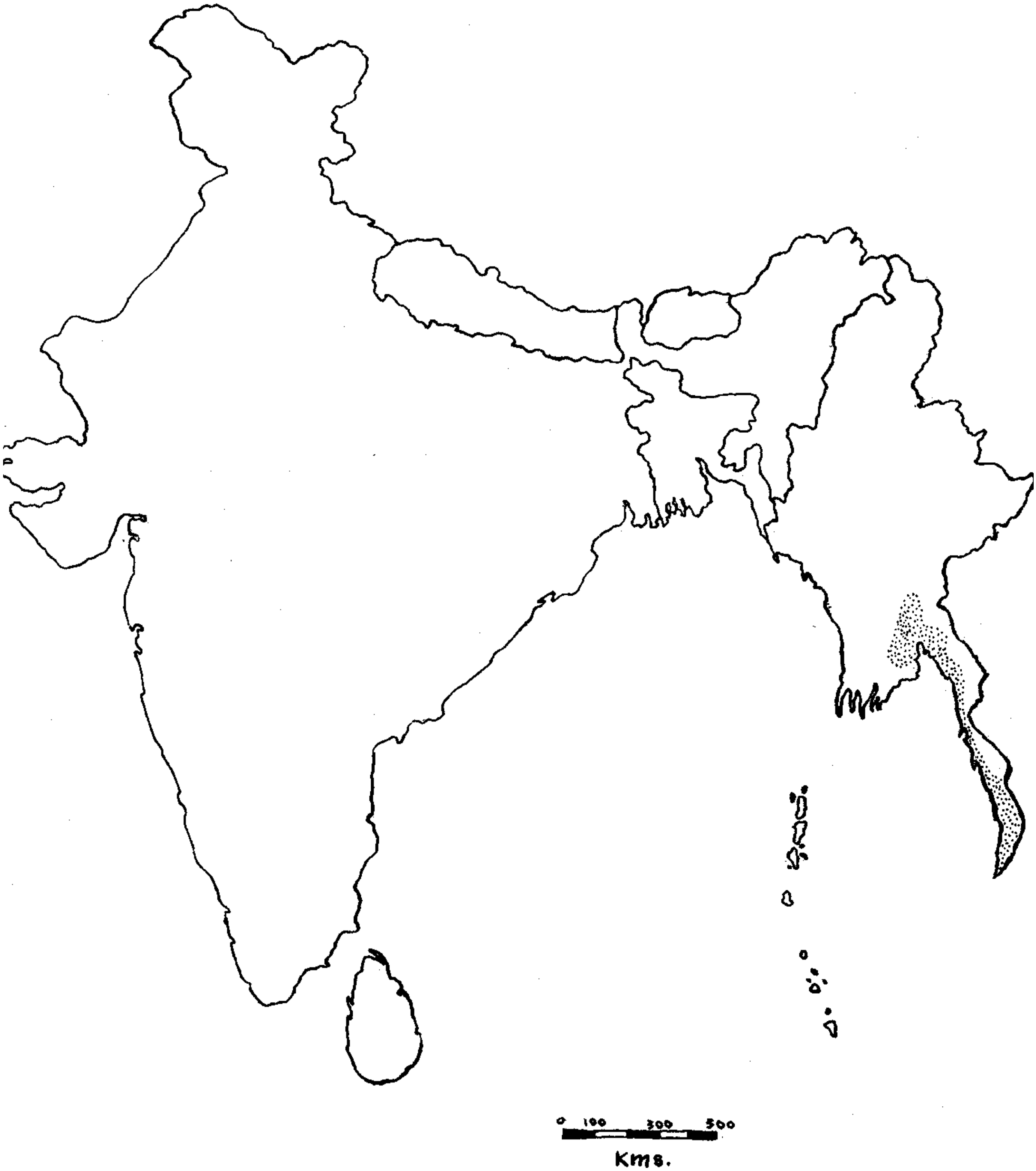
Hopea wightiana

1. **Flowering shoot**
2. **Flower bud**
3. **Stamens** and **Pistil**

stamen

5. **Fruit**
6. **Gall**

Parashorea



CHAPTER VIII

PARASHOREA Kurz

Large trees. Bark surface dark brown, regularly fissured. Twigs glabrous or minutely pubescent. Leaves entire, glabrous, nerves prominent; petiole slender. Flowers in axilla*ry* racemes or panicles, pubescent. Petals broadly strap shaped ***or*** obovate, pubescent. Stamens 15—20; filaments short; anthers linear, connective appendage short. Ovary ovate to subglobose, densely hairy; style cylindrical. or filiform. Fruit belly obovoid, tomentose; calyx lobes in fruit equally enlarged or two slightly shorter (Kurz, 1877).

Wood

Vessels fairly large, scattered, parenchyma mostly forming prominent eyelets around the vessels. Resin canals in tangential rows. Sapwood grey, heartwood ysllowish grey to reddish grey turning to brown, coarse textured, lustrous, moderately heavy (Chowdhury & Ghosh, 1958; Gottwald and Parameswaran, 1966).

Uses

A good heavy constructional timber, suitable for railway sleepers, used as cart wheels, ploughs and dugouts.

Distribution 2 species : Burma.

PARASHOREA BUCHANANII (C.E.C. Fischer) Svm.

Syn. ***Shorea buchananii*** C.E.C. Fischer

A large free. Twigs terete, brown with scattered, small, round, corky warts, minutely stellate, pubescent upwards. Leaves 15 — 22.5cm by 6 — 10cm, oblong, elliptic or ovate-elliptic, base rounded, entire, glabrous above, scattered with minute stellate hairs and minute reddish-brown glands below; lateral nerves 12—17 pairs, prominent below. Racemes axillary, 8 — 14cm long, more or less densely covered with grey, stellate tomentum, bracts persistent, oblong, obtuse. Calyx lobes unequal, grey stellgte tornentose without, finely pubescent within. Petals broadly strap shaped or obovate, rounded, tomentose on both surfaces. Stamens 15 — 20, quite glabrous; filaments expanded at base, filiform above; anthers linear-oblong, connective produced into a short acute, slightly curved awn. Ovary subglobose, densely hairy; stylopodium very short, style slender, hairy below and glabrous above (Fischer, 1926).

Distribution — Burma

Confined to Tagwin chaung, in Myitkyina.

Note: — This species is reported from Burma (Fischer 1926; Hundley and Chit ko ko, 1961) Where it is highly restricted. Details wanting.

PARASHOREA STELLATA Kurz

Syn. ***Shorea cinerea*** Fischer
S. stellata Dyer

Common names

Bur. — Kabba, Kadut, Kudutni, Kadutpya, Kaunghmu, Kawwa, Thingadu.

A large evergreen tree attaining a height of 45m with a straight bole of 18m and a girth of 3 – 6m. Bark surface dark brown, longitudinally fissured, rough, peeling off in irregular rounded flakes; blaze pale-brown. Leaves 10 – 15cm long, oblong-lanceolate to ovate-lanceolate, acute or obtuse, base more or less unequal, coriaceous glabrous; lateral nerves slightly curved and prominent, the net venation very faint; petiole 1.5 – 2.5cm long. Inflorescence mostly axillary, racemose, forning greyish puberulous rather short panicles; flowers small, cream coloured, almost sessile. Calyx greyish-velvety, the lobes oblong. Petals broadly oblong, greyish pubescent outside. Stamens 15; filaments short; anthers linear, hirsute. Ovary ovate or oval, style rather long, greyish tomentose. Fruit belly 1.7cm long, obovoid, tawny tomentose, the enlarged calyx lobes about 10cm by 1.5cm linear-lanceolate, obtuse, tapering to a very obscurely dilated base, strongly 7-nerved, puberulous (Kurz, 1877).

Distribution – Burma

The species is found in the evergreen forests of Martaban, Tenasserim and in the eastern slopes of the Pegu Yoma (Troup, 1921).

Forest Types and Floristics

The species is confined to the Evergreen Dipterocarp Forest, Eastern Tropical Evermeen Forest and the Southern Secondary Tropical Semi-Evergreen Forest (Champion, 1936;Hundley, 1961) of Burma.

Floristics

(i) South Tenasserim (Evergreen Dipterocarp Forest)

Dipterocarpus alatus., D. grandiflorus, Anisoptera sp., *Parashorea stellata, Hopea odorata, Pentace burmanica, P. griffithii, Swintonia floribunda, Syzygium grande, Dysoxylum grande, Melanorrhoea glabra, Mangifera caloneura, Michelia champaca, Cinnamomum inunctum.*

(ii) Martaban (Eastern Tropical Evergreen Forest)

Dipterocarpus alatus, D. turbinatus, Parashorea stellata. Anisoptera glabra, Hopea odorata, Pentace burmanica, Swintonia floribunda. Artocarpus lackoocha, Croton oblongifolius, Myristica sp., *Amoora* sp., *Syzygium* sp.

Silviculture and Management

Phenology

Flowers appear in March – April and fruits ripen in April – May (Troup, 1921).

Natural regeneration

The species regenerates freely provided seedfall is followed by adequate rainfall. Successful germination depends upon the timely commencement of the rain. Seed loses its viability quickly. The species is very slow growing and the natural reproduction fails to establish itself when other fast growing species smother the young seedlings. Hence an essential operation is to free the seedlings. Once the sapling stage is reached there is no fear of mortality due to natural causes.

Wood

Structure

Vessels large, solitary, radially paired or in groups of 3–5, evenly distributed, 2-7/mm^2 ; perforations simple, transverse; tyloses sparse.

Tracheids sparse, usually peripherally flattened about the vessels, pits numerous. long, pits numerous.

Parenchyma abundant, paratracheal, metatracheal, and surrounding all resin canals; paratracheal parenchyma forming one to several seriate sheath; metatracheal parenchyma scattered and in short, tangential, usually uniseriate rows; parenchyma surrounding the resin canals in 2–8 tangential hands; brownish yellow infiltration present.

Fibres semi-libriform, rather fine, more or less definitely aligned in radial rows, non-septate, interfibre pits simple.

Rays fine, rather distant (5 – 6/mm), 4 – 5 seriate, heterogeneous, pale-brownish-yellow, gummy infiltration abnndant.

Resin canals solitary or in uniseriate tangential rows at irregular intervals; contents white (Pearson and Brown, 1932).

Properties

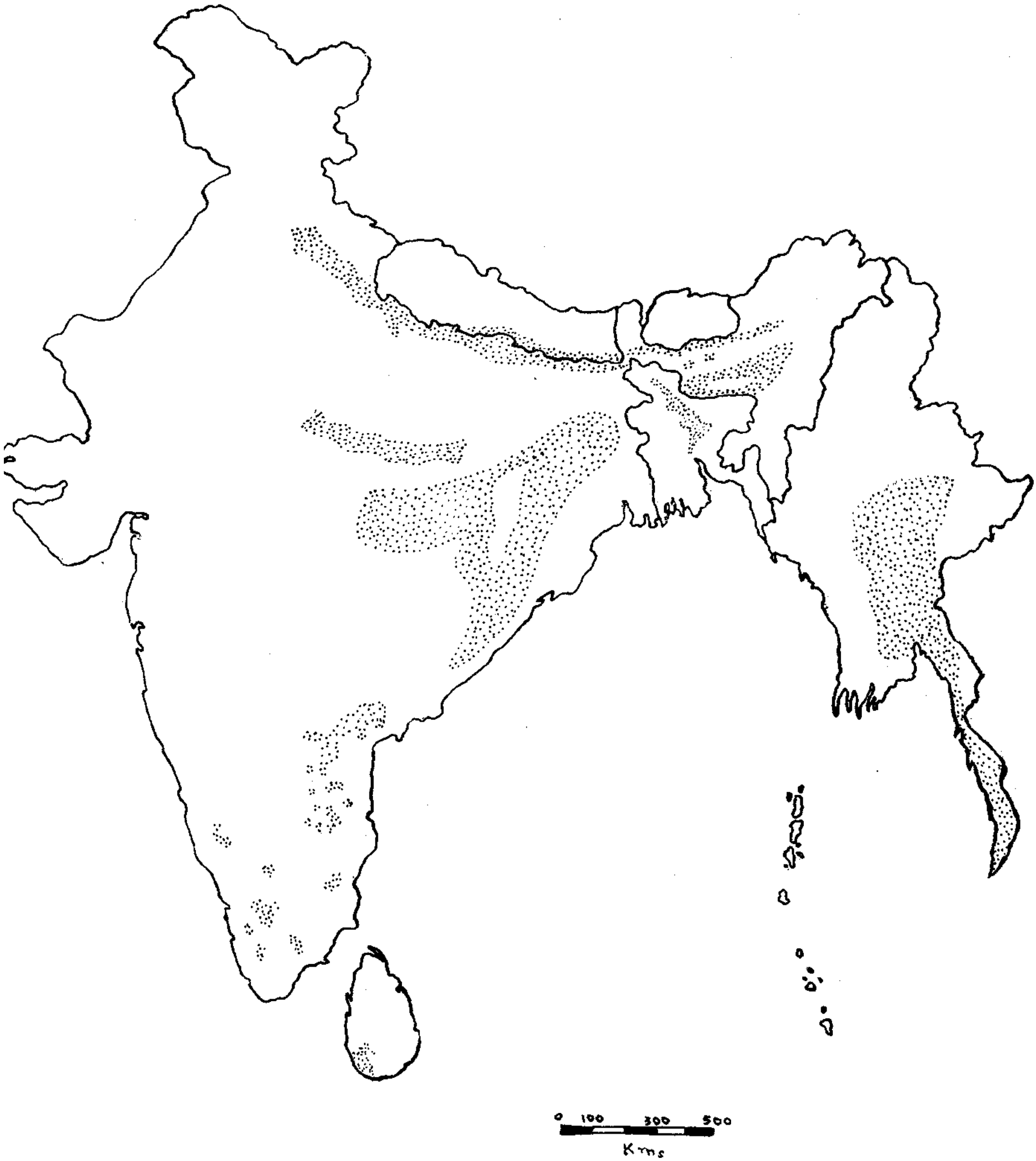
Sapwood grey, heartwood brown to dark olive, rather lustrous when first exposed, with rather rough feel, broadly and shallowly interlocked grained, even and very coarse-textured; moderately heavy, sp. gr. 0.76. Weight at 12 percent moisture content 21Kg/m^3

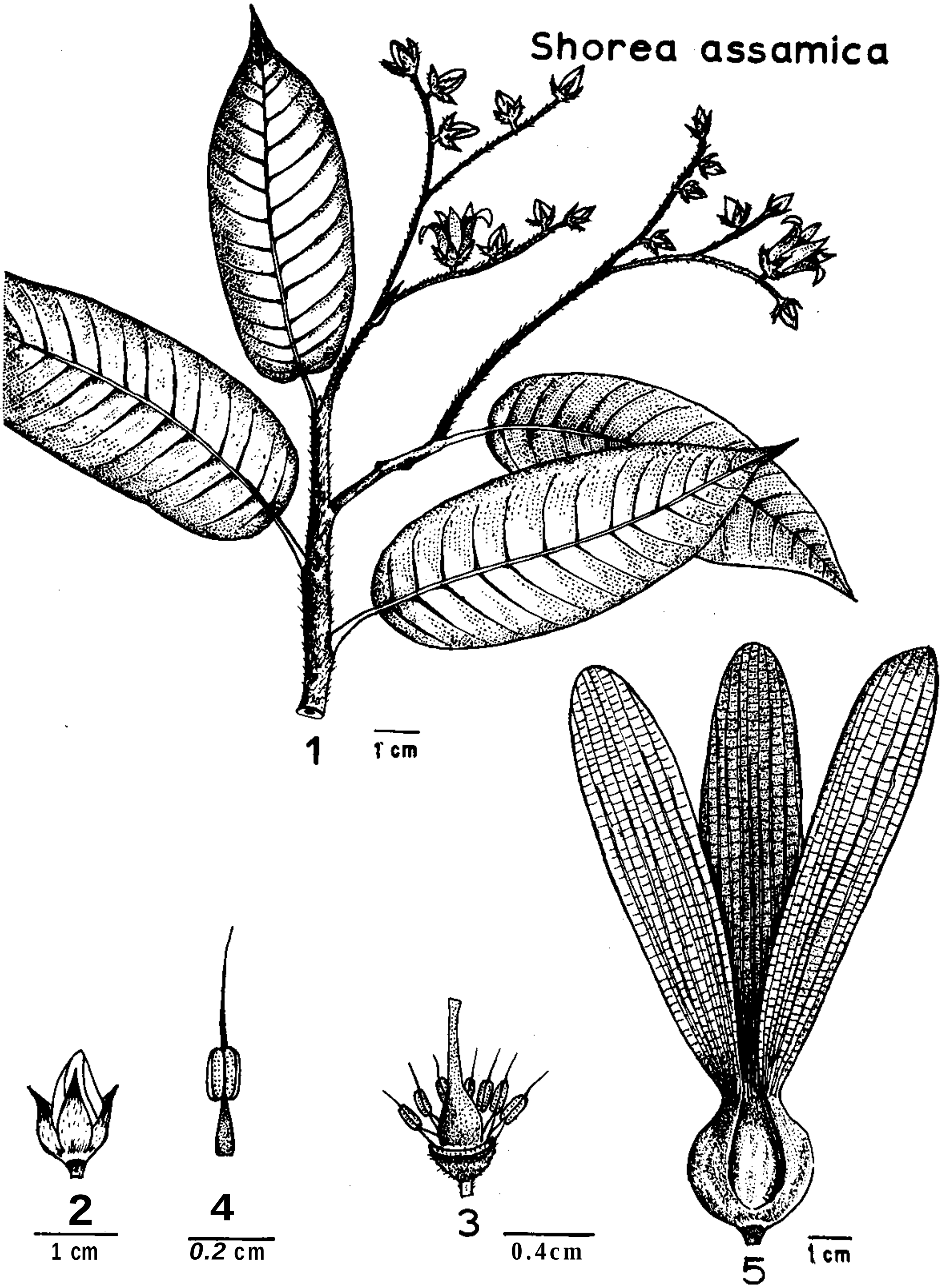
The timber seasons with difficulty, slow drying and somewhat liable to warp and twist. Kiln seasoning possible but slow. Moderately durable in exposed positions and fairly durable under cover and in contact with water. Treatment difficult.

Uses

A good heavy constructional timber; suitable for railway sleepers. Also used as posts, cart wheels, ploughs and dug outs.

Shorea

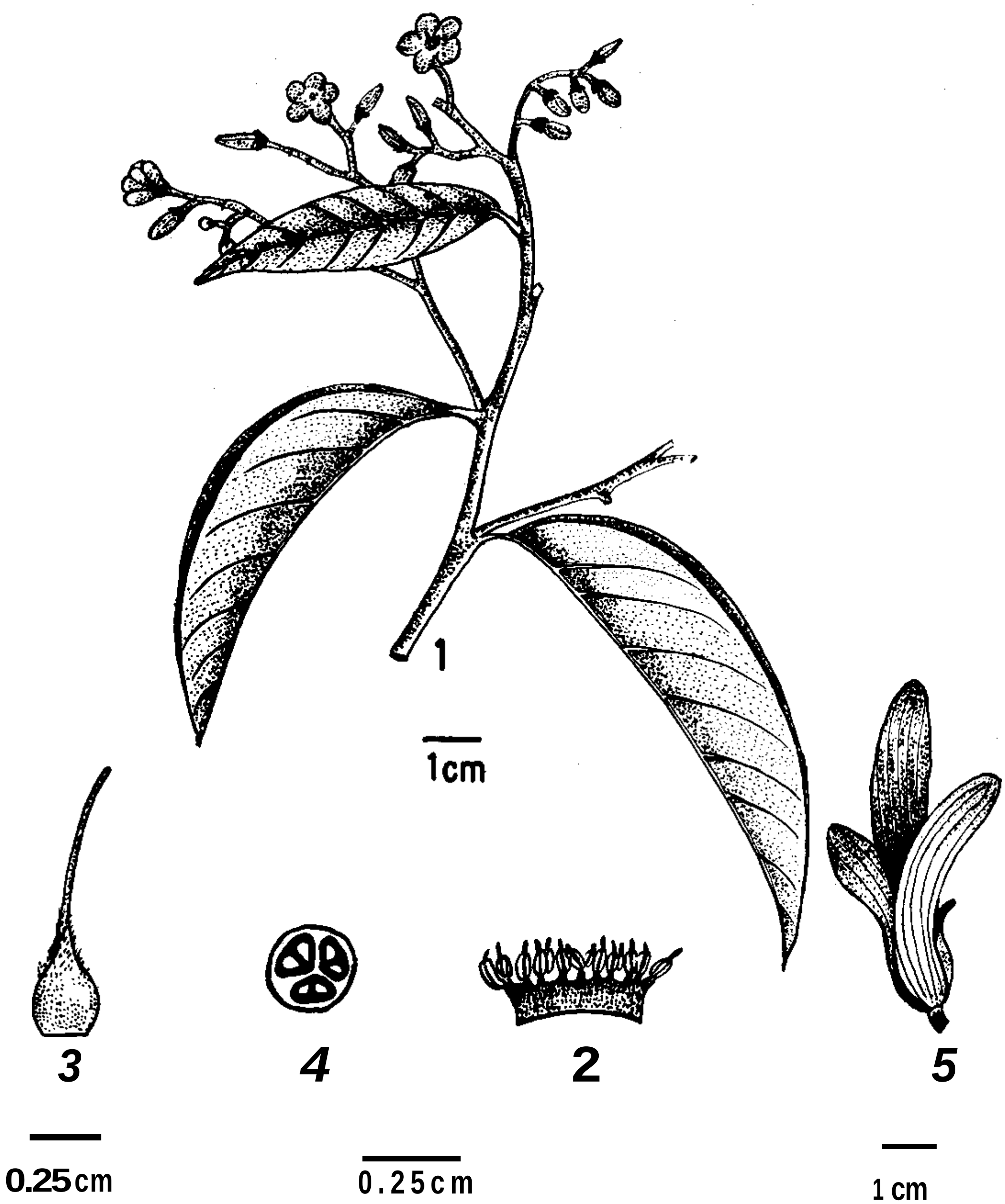




Shorea assamica

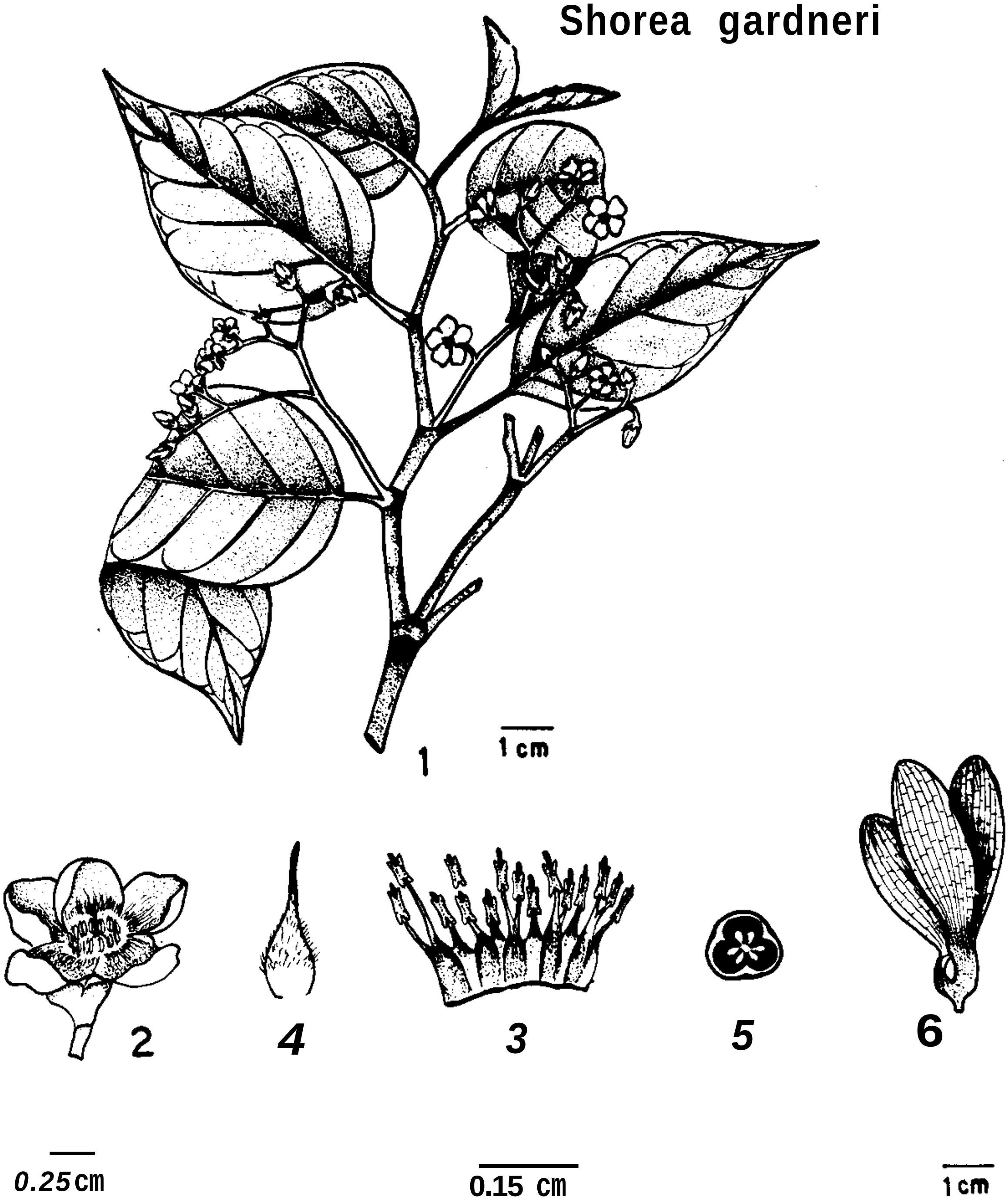
1. **Flowering shoot**
2. **Flower bud**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

Shorea congestiflora



Shorea congestiflora

1. **Flowering shoot**
2. **Stamens**
3. **Pistil**
4. **C.S. of the Ovary**

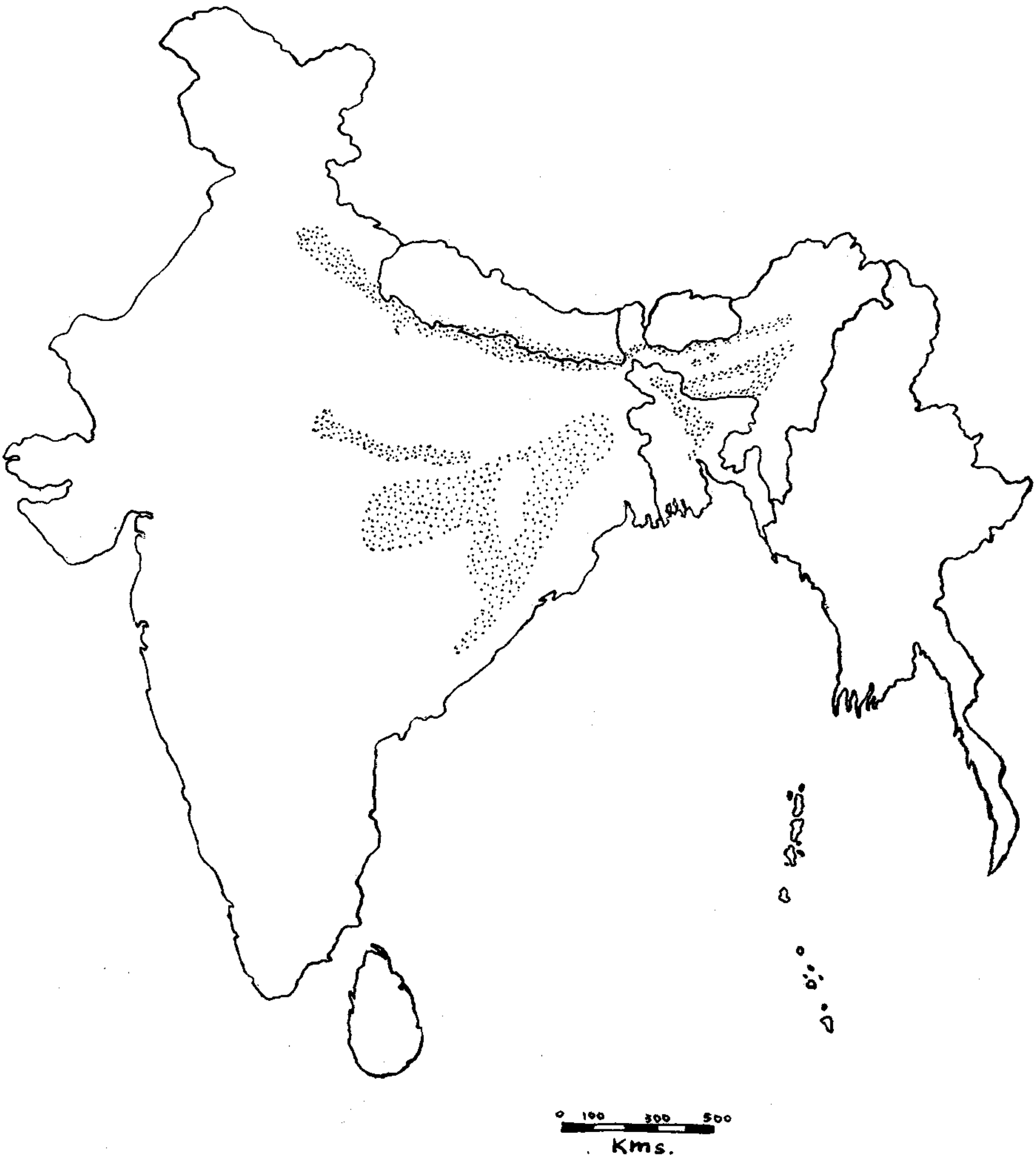


Sborea gardneri

1. **Flowering shoot**
2. **Flower**
3. **Androecium**
4. **Stamens enlarged**
5. Pistil
6. **Fruit**

Shorea avalifolia
Tapering Bole
Peradeniya garden
(Photo KFRI)

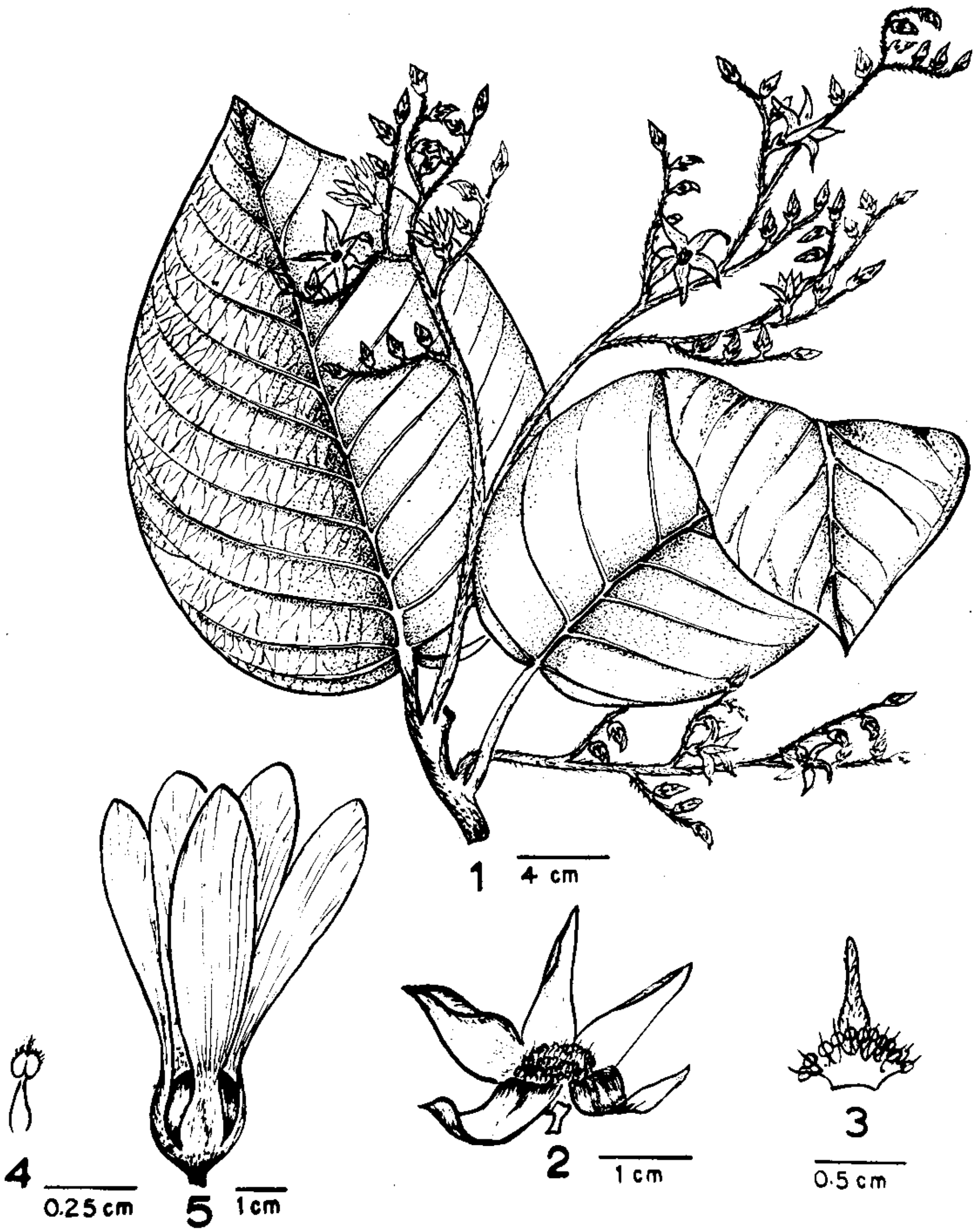
Shorea robusta



quali
near Haldwani

Shorea robusta
Protected tree 2.08m g.b.h.
Lakhmanmandi
Haldwani (India)
(Photo FRI)

Shorea robusta

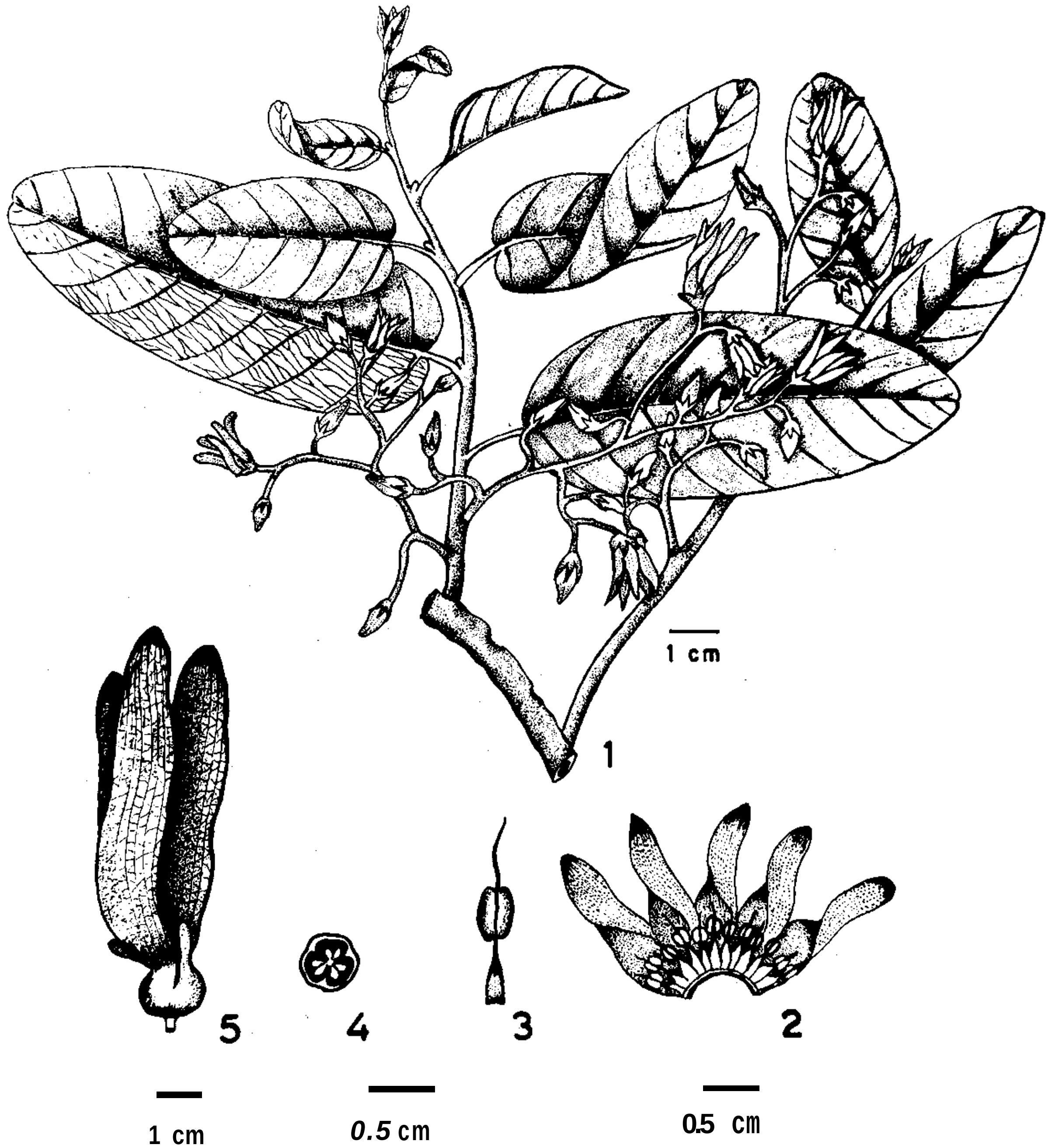


Shorea robusta

1. Flowering shoot
2. Flower
3. Stamens and Pistil
4. Stamen
5. Fruit

Shorea roxburghii

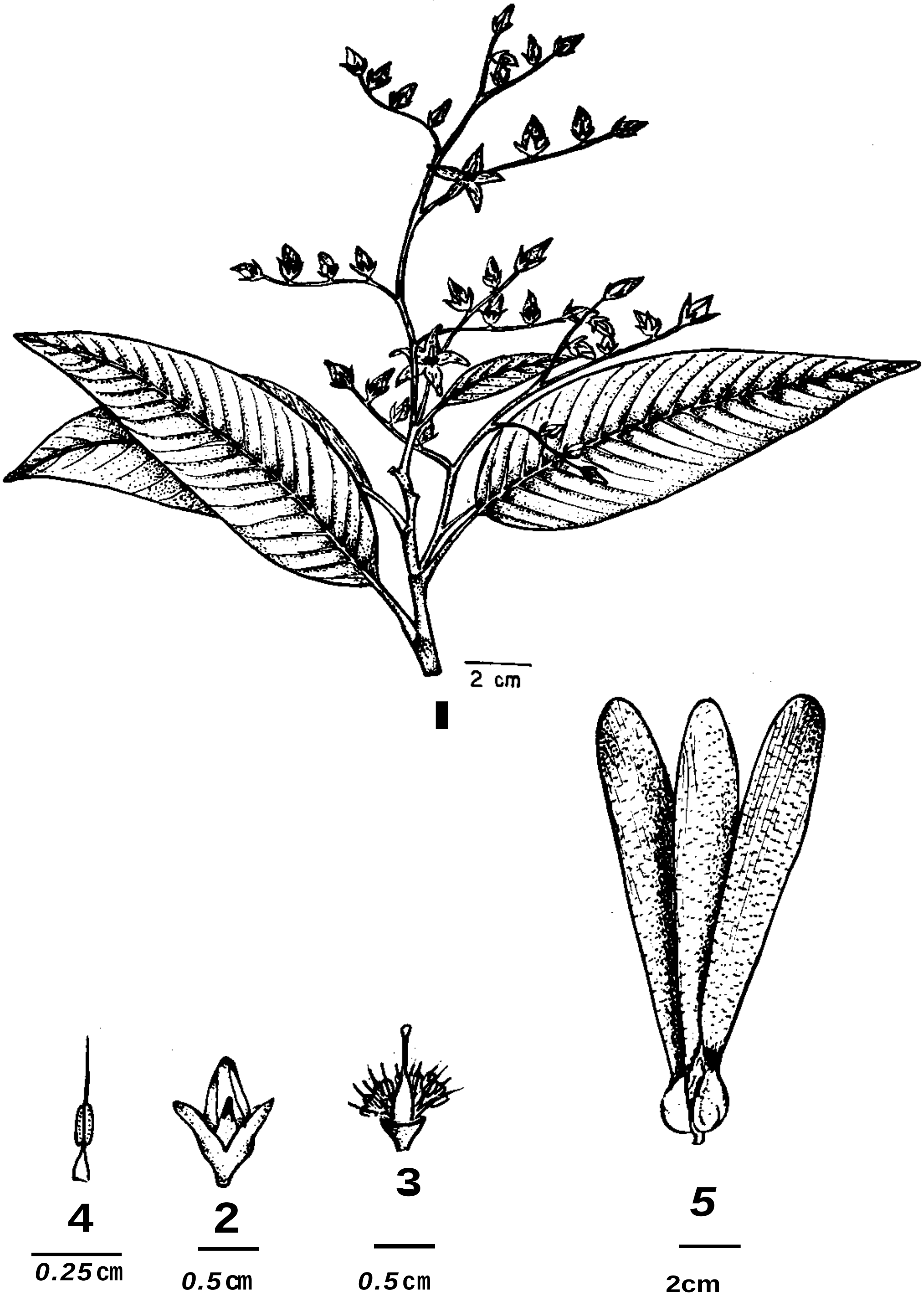
Shorea roxburghii



Shorea roxburgbii

1. **Flowering shoot**
2. **Corolla and androecium**
3. **stamen**
4. **C.S. of the ovary**
5. **Fruit**

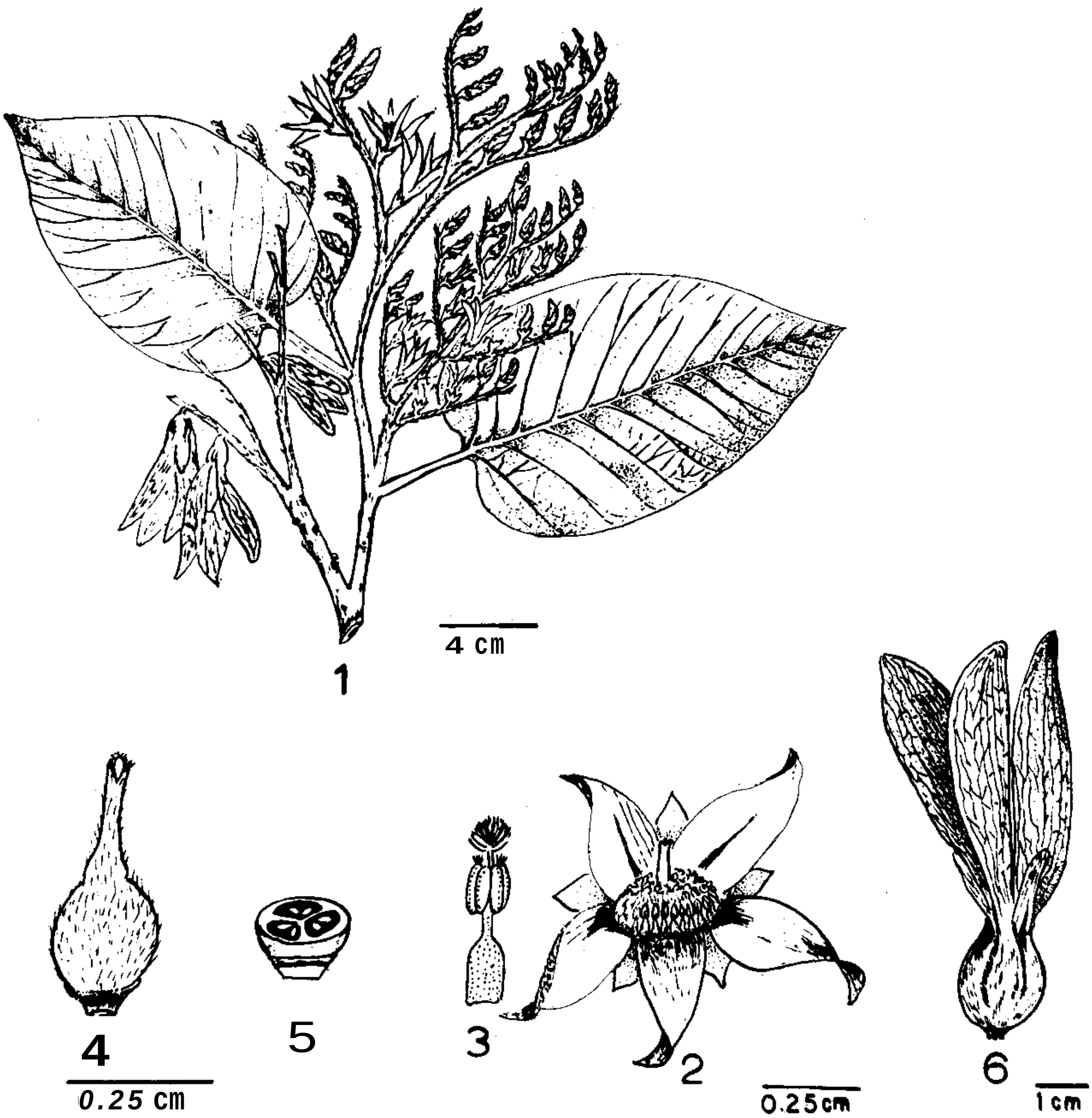
Shorea sericeiflora



Shorea *sericeiflora*

1. **Flowering shoot**
2. **Flower bud**
3. **Stamens and Pistil**
4. **Stamen**
5. **Fruit**

Shorea tumbuggaia

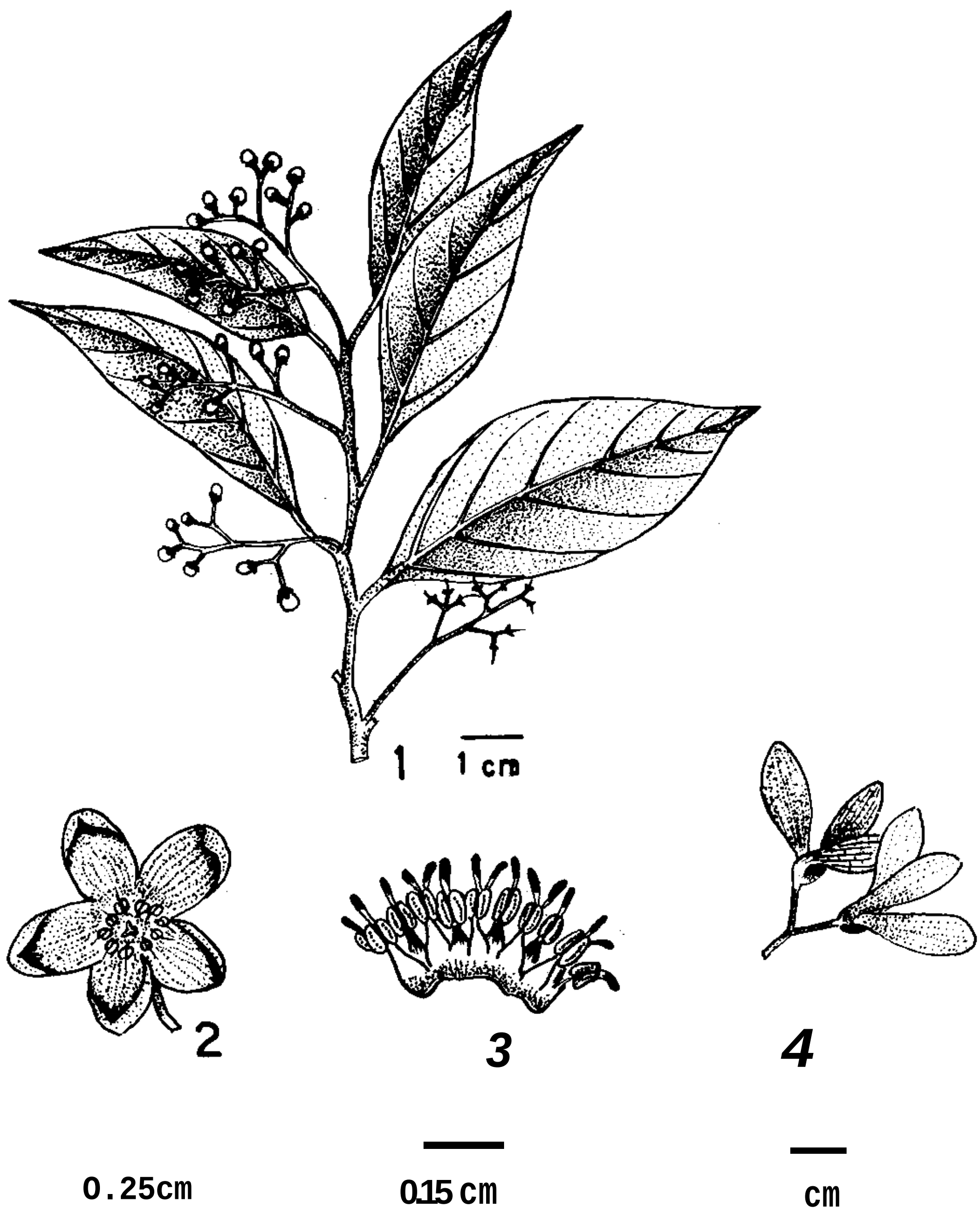


Shorea tum buggaia

1.	Flowering shoot	4.	Pistil
2.	Flower	5.	T.S. of ovary
3	Stamen	6.	Fruit

Shorea siamensis **(Ingyin)**
Bole Ataran Division
Burma
(Photo FRI)

Shorea zeylanica



Shorea zeylanica

1. **Flowering shoot**
2. **Flower**
3. **Stamens**
4. **Fruits**

CHAPTER IX

SHOREA Roxb.

Small to very large trees. Bark surface often fissured or flaky. Twigs glabrous or pubescent. Leaves entire or subrepand; petiole variable in size; stipules large, coriaceous and oersistent or minute and fueaceous. Flowers in terminal or axillary panicles. Sepals free or united at the base, the lobes unequal. Petals usually connate at the base. Stamens 15 to numerous; anthers subglobose to narrowly oblong, connective appendage subulate-cuspidate. Ovary glabrous or tomentose; style subulate; stigma entire or 3 toothed. Fruit closely surrounded by the bases of the accrescent calyx segments, 3 or more, rarely all of which are subequally enlarged(Ashton, 1977; Hooker, 1874; Kurz, 1877).

Wood

Vessels fairly large, scattered, open or filled with tyloses. Parenchyma abundant, sometimes vasicentric and diffuse. Rays distinctly heterogeneous. Resin canals irregularly distributed. Sapwood yellowish white, heartwood yellow to yellowish brown, heavy, coarse textured (Chowdhury & Ghosh, 1958; Gottwald & Parameswaran, 1966).

Uses

A general constructional timber and a valuable sleeper wood. Used also for a variety of purposes such as bridge construction, dug outs, ploughs, tool handles, etc.

Distribution 27 species : Bangladesh, Burma, India, Nepal and Sri Lanka.

SHOREA AFFINIS (Thw.) Ashton

Syn. *Doona affinis* Thw.

Common name

Sinh. – Beralia Dun.

A medium sized tree attaining a height of 35m and a girth of 2m with a straight cylindrical bole and derise umbrella shaped crown with many small ascending branches. Bark surface at first pale grey, becoming pale brown, longitudinally cracked and flaked; inner bark pale brown. Twigs slender, glabrous. Leaves 4.5 – 7.5cm by 2 – 3.5cm, lanceolate, caudate-acuminate, base broadly cuneate, subcoriaceous, margin revolute; lateral nerves 9 pairs, very slender, arched; petiole 0.7 – 0.8cm long, very slender; stipule minute, linear, fugaceous. Panicle 4.5cm long, axillary. Sepals oblong. Petals white, densely puberulent outside. Stamens yellow; appendage about $\frac{1}{2}$ the length of the anther. Fruit 1.8cm by lcm, ovoid, apiculate; the 3 larger fruit sepals 4cm by 0.8cm, tapering to thickened saccate base; the 2 shorter lobes 1.2cm by 0.8cm, ovate, acute, adpressed to the base of the fruit (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is commonly found in Sabaragamuwa, Western and Southern Provinces.

Forest Types and Floristics

This endemic species has a fairly wide distribution in the Lowland Wet Evergreen

Forest (Andrews, 1691) upto an altitude of 1000m. It is scattered with several other dipterocarps and prefers deep rich soil on the hill slopes.

Floristics

Sabargamuwa

Dipterocarpus zeylanicus, D. glandulosus, Shorea congestiflora, S. affinis, Palaquium petiolare, P. thwaitesii, Xylopia paruifolia. Mangifera zeylanica, Campnosperma zeylanicum, Canarium zeylanicum. Kurrimia zeylanica, Chaetocarpus castanocarpus, Gyrinops walla. Mesua thwaitesii, Symplocos coronata, Alseodaphne sp., *Evodia lunuankenda, Humboldtia laurifolia, Memecylon* spp.

Silviculture and Management

Phenology

Flowering in March-April and fruiting in May—June.

Being economically unimportant, the species has received no attention from the point of view of propagation.

It has no recognised end **use,** the bole being small and the wood rather light.

SHOREA ARGENTEA C.E.C. Fischer

A moderate sized tree attaining a height of 25m. Young twigs covered with minute, greyish fringed, peltate scales. Leaves 10 – 15cm by 4.5 – 6 5cm, oblong or ovate-oblong, bluntly acuminate, narrowed at the base, glabrous above, sparsely stellate hairy below; lateral nerves 9—10 pairs, slightly curved petiole 2 – 2.5cm long, channelled above, laterally compressed, dotted with fringed peltate scales and minute stellate hairs; stipule 0.6 – 0.7cm long, ovate, obtuse, densely covered with simple hairs, caducous. Panicle axillary or extra axillary, branchlets covered with fringed peltate scales, mixed with simple hairs. Sepals broadly ovate, subacute, the 3 outer 0.3cm long, the 2 inner slightly smaller, all densely silky tomentose without, glabrous within, ciliate. Petals spoon-shaped, the basal portion concave, 0 0.5 – 0 6cm in diameter, the apical portion ligulate, obtuse, about Icm long, 0.2 – 0.25cm wide, parallel veined, silky with adpressed hairs without, except at the base, thinly and shortly silvery silky hairy within. Stamens many; filaments flat tapering to a filiform apex; anthers oblong, base acute and slightly divergent. Connective produced into a setose curved awn nearly as long as the anther. Ovary ovate, slightly grooved at the base, narrowed gradually into the subulate stylopodium, densely grey hair; style short, glabrous, trigonous at apex (Fischer, 1926).

Distribution – Burma

Note: – The species is reported to occur in Burma (Fischer, 1926; Hundley and Chit **ko** ko, 1961). Details wanting.

SHOREA ASSAMICA Dyer

Common names

As. – Mekai
Bur. – Kyelan or Kyilan
Bur. –

A large tree attaining a height up to 50m and a girth of 6m with a straight clear bole of 30m. Bark light brown and has characteristically tessellated plates which are slightly raised on the lower portion. Young shoots puberulous or pubescent and lenticellate. Leaves 5 – 10cm by 2.7 – 5cm; broadly elliptic to elliptic-oblong or elliptic-obovate, shortly acuminate, base rounded, glabrous above, stellate pubescent beneath, midrib channelled above; lateral nerves 12 – 20 pairs, rather prominent and parallel; petiole up to 1cm long. Panicles terminal or from the axils of the uppermost leaves, up to 12cm long, thinly pubescent, the racemes bearing 2—5 secund flowers; bracteoles 0.8cm long, linear-lanceolate, silky, caducous. Calyx lobes lanceolate, grey pubescent, the three outer ones rather largei than the two inner ones. Petals white or cream-coloured, falcate-oblong, silky-pubescent on the portion exposed in bud. Stamens about 15, connective terminated by a fine awn about as long as the anther and filament put together. Ovary glabrous or almost so, ovoid, narrowed to a slender style. Fruit belly ovoid, about 2cm long by 1.2cm in diameter, the 3 larger calyx lobes upto 9cm by 1.8cm wide, linear to linear-obovate, rounded, 8 – 12 nerved, the shorter ones 4 – 5cm long and about 5 – 6 nerved (Hooker, 1874; Parkinson, 1937).

Distribution – Burma, India

In Burma the species is commonly found in moist valleys of Katha and Myitkyina (Upper Burma). In India it occurs in Assam, Arunachal Pradesh and Nagaland. It is found in the well-drained slopes of the Naga hills, Tuensang (Nagaland); Tirap and Lohit (Arunachal Pradesh) and Lakhimpur (Assam) up to elevations of about 950m (Chowdhury, 1960).

Forest Types and Floristics

In Burma the species occurs in the Northern Burma Tropical Evergreen Forest (Champion, 1936) characterised by the more or less high and evenly distributed rainfall. In India it is found in Assam Valley Tropical Wet Evergreen Forest (Champion and Seth, 1968), characterised in many places by the association with *Dipterocarpus macrocarpus*, and such association is termed generally as 'Hollong Mekai-forest'. These species generally stand over a closed evergreen canopy and find best expressions on the undulating alluvium of foot hills. The rainfall in the region is very high and exceptionally well distributed (Rowntree, 1954). The species is sporadic in most places but occasionally it is more or less gregarious in patches of varying extent, particularly in Arunachal Pradesh.

Floristics

(i) Myitkyina, Burma (Northern Burma Tropical Evergreen Forest)

I *Dipterocarpus turbinatus, D. macrocarpus, Shorea assamica*

I1 *Dysoxylum binectariferum,* Acro*carpus fraxinifolius, Michelia* spp., *Toona* sp., *Chukrassia* sp., *Syzygium* spp., *Quercus* spp., *Castanopsis* sp., *Mesua ferrea, Dendrocalamus hamiltonii, Cephalostachyum pergracile.*

In the third storey there is a dense growth of evergreen shrubs. Climbers and canes are abundant.

(ii) Lakhimpur, Assam (Assam Valley Tropical Wet Evergreen Forest)

I *Dipterocarpus macrocarpus, Shorea assamica, Mesua ferrea, Altingia excelsa, Dysoxylum procerum, Artocarpus chaplasha, Michelia* spp., *Stereospermum personatum, Canarium* sp., *Amoora* sp.

I1 *Vatica lanceaefolia, Syzygium* spp., *Garcinia cowa, Talauma* sp., *Myristica* spp., *Dendrocalamus hamiltonii, Bambusa pallida, Pseudostachyum polymorphum, Livistona jenkinsiana.*

I11 *Clerodendrurn* sp., *Ixora* spp., *Pinanga* sp., *Laportea* sp.

Silviculture and Management

Phenology

Flowering is from August to October and fruits ripen during January to February. Good seed years at intervals.

Silvicultural characters

A hygrophilous species which is essentially shade tolerant. Diffused light is, however, required for its growth from the sapling stage onwards.

Natural regeneration

The species is naturally regenerated with a great amount of success in India. As this species **is** associated with *Dipterocarpus macrocarpus,* a more or less common system of management is adopted to obtain good regeneration. The operations consist of preparation of the ground before seedfall by removing undergrowth, and removal of useless tree species in advance of the mainfelliings. Care is, however, taken to avoid large gaps which are liable to be invaded by *Mikania* in this region. After the seedlings establish themselves, the main fellings are carried out with adequate precaution to ensure that only diffused light is allowed. W Wherever regeneration is inadequate, it is supplemented by sowing freshly collected seeds. As the seeds have very low viability and are liable to be damaged by insects even before sepd-fall, it is essential to select healthy seeds and sow them immediately after collection. Supplementary operations consist of planting out nursery grown sredlings and coppicing saplings damaged during the main felling.

As a measure of aiding natural regeneration, the species is raised in nursery by sowing seeds under shaded beds. One year old seedlings are planted out 5m apart in areas where regeneration is inadequate. During the first and second year, frequent weedings are necessary. From the third year onwards weedings need be occasional.

This is one of the species which, along with *Dipterocarpus macrocarpus*, is regenerated over a wide area in Assam and Arunachal Pradesh. The rate of growth is rather slow and studies in Assam have shown that the species can attain the exploitable girth of 2.1m in about 84 years (Das, 1974).

Artificial regeneration

The species is generally not raised in plantations. However, attempts are being made in Assam to raise the species in containers in nursery and plant out the seedlings under shade in areas specially prepared for this purpose. The weed *Mikania* is a problem in such areas and therefore, frequent weedings are necessary.

Wood

Structure

Vessels large, mostly solitary; fairly evenly distributed, 4 – 9/mm^2 ; perforations simple. transverse.

Vessels large, mostly solitary; fairly evenly distributed, 4 – 9/mm^2; vessel segments 350 – 645/um long; perforations simple, transverse.

Tracheids abundant with numerous oval to elliptical pits.

Parenchyma paratracheal, paratracheal zonate, metatracheal and surrounding all resin canals; paratracheal parenchyma abundant; metatracheal parenchyma extremely spars?, parenchyma surrounding resin canals, 8—12 seriate; infiltration scanty in all types of parenchyma.

Fibres non septate, interfibre pits simple.

Rays medium to fine, rather distant, 4 – 6/mm, 1—5 seriate, heterogeneous, infiltration scanty.

Resin canals sporadic, longitudinal, in uniseriate tangential rows at distant and irregular intervals; contents white.

Properties

Sapwood dirty white to grey, heartwood pale brown, fairly straight grained, coarse textured, moderately heavy, sp. gr. 0.49 to 0.68. Weight at 12 percent moisture content 577Kg/m^3.

Shrinkage percentage green to oven dry

Radial	3.1
Tangential	7.1
Volumetric	10.8

Modulus of rupture (Kg/cm^2)

Green	533.9
Air dry	660.7

Modulus of elasticity (Kg/cm^2)

Green	92,700
Air dry	110,000

Maximum crushing stress (Kg/cm^2)

Green	284.5
Air dry	407.7

Wood can he seasoned easily and it dries out fairly quickly without undue degrading. It is not a durable timber; graveyard tests at Dehra Dun having indicated a life of less than 60 months. Easy to saw and work and can he brought to a fairly smooth surface.

Uses

A constructional timber, used *as* beams, scantlings and planks. A well known species for commercial plywood and extensively used in eastern India for tea-chests.

SHOREA CONGESTIFLORA (Thw.) Ashton

Syn. *Doona congestiflora* Thw.

Common name

Sinh. – Tiniya.

A large tree reaching a height of 40m and a girth of 2m Bark surface purplish brown to greyish mottled, vertically fissured and becoming patchily flaked towards the base in old tides; inner bark reddish, fibrous. Young parts tawny pubescent. Leaves 6.5 – 12.5cm by 2.5 – 6cm, narrowly elliptic ovate, shortly acuminate, obtuse to narrowly subcordate at base, coriaceous lateral nerves 11 – 15 pairs, slender, arched, elevated on both surfaces, though more so below, midrib slender but prominent below, obscurely depressed above; petiole 0.8 – 1.2cm long; stipule 1.2cm by 0.6cm, ovate, subacute, fugaceous. Panicle axillary and terminal, 5cm long, pubescent, relatively stout with short branchlets; flowers shortly pedicelled. Sepals glabrous, oblong, obtuse. Petals truncate, obtuse, pale pink. Fruit lcm by 0.8cm, narrowly ovoid, apiculale; the 3 larger fruit sepals 4.7cm by lcm, thickened at base; the 2 shorter sepals 1.7cm by 0.8cm, ovate, caudate (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

The species is found in Pasdum Korale, Kanneliya, Hellepef, Hiniduma, Sinharaja, Deniyaya, Dediyagala, Pelmadulla, Gilimale and Ratnapura.

Fokst Types and Floristics

This endemic species is an important component of the Lowland Wet Evergreen Forest (Andrews, 1961). Typically it is in gregarious groups along moist hill sides, sometimes forming characteristically extensive patches. More often, it is scattered with other dipterocarps characteristic of this forest type.

Floristics

Kanneliya

I *Dipterocarpus zeylantcus, D. hispidus, D. glandulosus, Shorea trapezifolia* S. *congestiflora, Vatica* sp, *Hopea* sp., *Palaquium petiolare, P rubignosum P. grande, P. th it esii, Xylopia parvifolia, Vitex pinnata, Pygeum zeylanicum.*

I1 *Mesua ferrea, Chaetocarpus castunocarpus,* C. *coriuceous,* C. *pubescens. Callo phyllum bracteatum.* C. *tomentosum,* C. *soulattri, Kurrimia zeylanica, Myristica dactyloides.*

111 *Semecarpus nigro-viridis.* S. *gurdeneri, S. subpeltutu, Aporosa* sp. *Wormia triquetru. Gyrinops walla, Dillenia retusa, Acronychia pedunculata, Humboldtiu laurifolia, Diospyros insignis.*

IV *Mallotus* spp., *Memecylon* spp., *Polyalthiu acuminata, Bragantia wallichii, Symplocos minor.*

Silviculture and Management

Phenology

Unlike the majority of dipterocarps of this Island, the species is in flower during August—September. The fruiting is during September—November.

Both in the scattered and gregarious habitat, regeneration is satisfactory. No organised system to obtain regeneration and subsequent establishment is in vogue. As the forest floor is generally devoid of a thick layer of leaf litter, the freshly fallen seeds have a good germination bed. Being shade tolerant, further growth is not impeded.

Wood

Structure

Wood diffuse porous. Vessels numerous, 26/mm^2, moderately small, mostly solitary, occasionally in pairs; perforations simple, oblique; tyloses absent.

Parenchyma scanty.

Fibres non-septate.

Rays very fine, uniseriate and multiseriate.

Resin canals very small, few, sometimes in tangential rows Jayamanne, 1978).

Properties

Wood reddish to pinkish brown, becoming pale on drying, close and straight grained, even textured, light and soft. Weight 512Kg/m^2 at 12 percent moisture content.

Wood seasons slow, not durable, not refractory to treatment. Easy to work and saw, finishes to a smooth glossy surface.

Uses

One of the important plywood species of the country, particularly for tea chests.

SHOREA CORDIFOLIA (Thw.) Ashton

Syn. *Doona nervosa* Thw.
D. cordifolia Thw.

Common name
Sinh. – Kotikan Beraliya

A moderate sized tree attaining a height of 30m and a girth of 2m with a frequently branching bole and a dense oblong to hemispherical crown. Bark surface chocolate brown, flaking in thin rectangular scales; inner bark pale brown. Young parts fugaceous puherulent. Leaves 8 – 15cm by 3 – 6cm, ovate-lanceolate to elliptic, caudate-acuminate, base broadly cuneate to obtuse, margin undulate; lateral nerves 8 – 11 pairs, very slender but prominent beneath, often with a few short slender intermediates; petiole 0.6 – lcm long; stipule fugaceous. Panicle 5cm long. with slender branches hearing 5 flowers; flower bud 0.5cm by 0.4cm, ellipsoid. Corolla l.lcm diameter, white. Anthers yellow. Fruit 1.6cm by lcm, ovoid apiculate, resinous; the 3 larger fruit sepals 3.8cm by 1.2cm, twisted, broadly spatulate, obtuse, tapering towards the base; the two smaller sepals 1.2cm by 0.8cm, ovate, acute (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found in Sabaragamuwa and the southern provinces.

Forest Types and Floristics

This endemic species is scattered in occurrence in the Lowland Wet Evergreen Forest (Andrews, 1961) along hill slopes below 1000m altitude. It is one of the top canopy species, seldom gregarious and found mixed with the common associates of this type of forest.

Silviculture and Management

Phenology

Flowering in March–April.

Regeneration is rather scanty. As the species is of limited economic importance, no steps have been taken to study the regeneration possibilities and potential.

Wood

Structure

Vessels few, small, mostly solitary; tyloses abundant.

Parenchyma scanty.

Rays fine.

Resin canals irregularly spaced in tangential rows.

Properties

Wood pale yellow, straight grained, fine textured and smooth, light but hard. Weight 640Kg/m^3.

Wood moderately durable in the open, durable under cover.

Uses

Because of its size, end use is limited. Sometimes used as constructional timber for ceiling, boards etc.

SHOREA DISTICHA (Thw.) Ashton

Syn. *Vateria disticha* Thw.
Vatica disticha (Thw.) A.DC.
Sunaptea disticha (Thw.) Trimen
Doona disticha (Thw.) Pierre
D. oblonga Thw.
Stemonoporus distichus (Thw.) Heirn

A small sized tree less than 25m in height and less than 2m in girth. Twigs densely tawny pubescent with prominent horizontal stipular scars. Leaves 9 – 17cm by 5 – Scm, ovate-oblong to elliptic, acuminate, base obtuse to subcordate, coriaceous, margin frequently narrowly revolute; lateral nerves 8 – 12 pairs, slender, arched, elevated on both surfaces, midrib slender, prominent below and depressed above; petiole 0.8 – 1.2cm long, puberulent. Flowers in short erect axillary panicles; tracts large, 0.5 – lcm long, ovate, distichous, tomentose. Fruit 1 2cm by 0.8cm, narrowly ovoid, apiculate; the 3 larger fruit sepals 4cm by lcm, saccate and thickened at base; the 2 smaller sepals 2cm by 0.8cm ovate-caudate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is highly restricted and found only in Lenegal Kande, although reported from Kanneliya and Gilimale.

Forest Types and Floristics

This endemic species is occasionally found in extremely restricted localities of the Lowland Wet Evergreen Forest (Andrews, 1961). It is a rare component of the forest type.

Silviculture and Management

Because of its small size and rarity, it is economically unimportant.

Wood

Structure

Vessels numerous 20-47/mm^2, medium sized mostly solitary; tyloses absent.

Parenchyma paratracheal and metatracheal.

Rays fine, uniseriate and multiseriate, heterogeneous; presence of dark brown substance common in ray cells.

Fibres non-septate and non-storeyed.

SHOREA DYERI Thw.

Syn. *Hopea discolor* sensu Worthington

Common name

Sinh. – YakahaluDun.

A very large tree attaining a height of 50m and a girth of 4m or more with a spreading hemispherical emergent crown. Bark surface yellowish-brown, irregularly thinly flaky. Young parts slightly puberulent. Leaves 5-13cm by 2.5 – 5cm, lanceolate-falcate, acuminate or subacute, rounded at base, thinly coriaceous; lateral nerves 11 – 14 paris, slender, pubescent on lower surface; petiole 0.8 – 1.5cm long, slender, thinly puberulent; stipule 0.7cm long, ellipsoid, subacute, fugaceous. Panicle terminal or axillary, branchlets short, bearing 4 secund flowers. Sepals subequal, ovate. Petals oblong-ovate, spreading, densely silky outside. Stamens about 60, unequal with densely setose appendage. Ovary tomentose, tapering into stylopodium and short glabrous style. Fruit lcm by 0.8cm, ovoid, apiculate; the 3 larger sepals 7.5cm by 1.2cm, narrowly spatulate, obtuse; the 2 shorter sepals 3.5cm by 0 . 5 (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lank?

This species occurs in Madulkella, Kegalle and Lunugala.

Forest Types and Floristics

This species which is endemic to the Island is fairly common in the Lowland Wet Evergreen Forest (Andrews, 1961), below 1000m altitude. It is generally scattered, but gregarious at intervals on tops and steep hill slopes, where the growth is retarded.

Floristics

Kegalle

Dipterocarpus hispidus, Shorea oblongifolia, S. congestiflora, S. dyeri, Palaquium petiolare, Xylopia parvifolia, Myristica dactyloides, Wormia triqketra, Gyrinops walla, Vitex pinnata, Symplocos coronata, Memecylon spp.

Silviculture and Management

Phenology

Flowering in January

Regeneration is fairly satisfactory, but mostly common in the sapling stage onwards. No regeneration operation is carried out to improve the stockings.

Wood

Dark brown, close grained and heavy. A general constructional timber of local importance.

SHOREA FARINOSA C.E.C. Fischer

Common name

Burm. – U-ban

A large tree, grows to a height of 45m Twigs slightly angular or compressed, dark-brown, glabrous. Leaves 8 – 16cm by 4.5 – 5cm oblong or oblong-lanceolate, rounded or acute, base rounded or truncate, glabrous above except the midrib, which is minutely pubescent; lateral nerves 15 – 18 pairs, slightly curved, anastomosing near the margin with small domatia in the axils; petiole 2 – 3.5cm long, terete, glabrous, slightly rugose. Inflorescence axillary and terminal. Sepals 0.5 – 0.65cm long, ovate, the outer 2 rounded at the apex, the inner 3 acute, all densely velvety with stellate hairs. Petals 1.3cm long, broadly ovate-oblong, obtuse, 15 veined, silky hairy on the portions exposed in bud. Stamens 22 – 25; filaments flat, ovate below and shortly filiform above; anthers linear-oblong, rounded at the base, connective awn 0.3 cm long. Ovary ellipsoid, narrowed into a subulate stylopodium, minutely hairy; style glabrous; stigma 3 lobed (Fischer, 1926).

Distribution -- Burma

Confined to Nagawun and Naunglawtek, South Tenasserim.

Note: – The species is little known. From herbarium specimens it appears that fruiting is in June (National Herbarium, Calcutta).

SHOREA GARDNERI (Thw.) Ashton

Syn. *Doona* ***gardneri*** Thw.

Common names

Sinh. Rata Dun
Tam – Koongli Maram

A large tree grows to a height of 45m and attains a girth of 3m with a characteristic dense hemispherical olive green crown. Bark surface purplish brown, flaky; inner bark orange brown, thick, fibrous. Twigs smooth, blackish. Leaves 4 – 9cm by 2 – 5 cm, ovate-acuminate, obtuse to cordate at base, margin subrevolute; midrib slender, prominent below hardly raised above, lateral nerves about 12 pairs, the basal pair sometimes with short lateral branchlets; petiole 1.2 – 2cm long, slender; stipule 1.5cm by 0.4cm, sparsely puberulent, lanceolate, acute, fugaceous. Panicle terminal or axillary, 7.5cm long; flowers very shortly pedicelled. Sepals ovate, obtuse, glabrous and shining. Petals pale pink, concave, pubescent outside. Stamens 15, in 3 subequal verticils. Ovary puberulent; style columnar. . Fruit ovoid, apiculate, 1.2cm by 0.8cm; the 3 larger fruit sepals 4cm by 1cm, thickened at the base; the 2 shorter sepals 0.7cm by 0.5cm, ovate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found from Raxawa, Dolosbage and Gampola southwards to the Mandapan Ella plains.

Forest Types and Floristics

This endemic species has a fairly wide distribution in the Highland Wet Evergreen Forest (Andrews, 1961) between 1000 to 1700m altitude. Sometimes it extends to the Tropical Montane Forest (Andrews, 1961) up to an elevation of 1800m but here the trees lose thrir magnificient form, although scattered, gregarious stands on hill slopes and ridges are sometimes seen. The species prefers deep well-drained soil, but can tolerate shallow poorly formed soil also.

Silviculture and Management

Phenology

Flowering between November and February. Sometimes extending to April. Fruiting from Febxuary to May.

Natural regeneration is satisfactory in hill slopes with deep well drained soil. But this type of soil is preferred for tea plantations and therefore perpetuation of the species in its favoured habitat is threatened. In poorer soils and steep slopes regeneration is scanty.

Wood

Structure

Vessels numerous, medium sized, mostly in groups of 3 or more; tyloses abundant.

Parenchyma aliform.

Resin canals solitary and in short tangential lines.

Properties

Sapwood dark yellow brown, heartwood orange brown, close grained, hard, heavy and strong. Weight 1057Kg/m^3 at 12 percent moisture content.

Wood fairly durable, works easily to a smooth surface and takes a good polish.

Uses

A well known timber for house building and bridge construction. Used for shingles and as railway sleepers. Cheap furniture is also made locally.

SHOREA GRATISSIMA Dyer

Syn. ***Hopea gratissima*** Wall.

Common name

Burm. U-ban-kaya

A large tree. Bark surface dark grey-brown, peeling off in irregular, thick oblong flakes; inner bark light orange brown and yellow, conspicuously laminated. Twigs slender, smooth, inconspicuously scurfy to - wards the end. Leaves 6 – 10cm by 3 – 4cm, oblong-lanceolate, shortly acuminate, acute at base, glabrous on both surfaces; lateral nerves about 14 pairs; petiole slender, about 2cm long. Panicle terminal and axillary, slightly puberulous. Calyx velvety, the lobes lanceolate. Petals oblong, velvety outside. Stamens 25; anthers oblong, the connective terminated by ***a*** long flexuous bristle. Style long, ***3*** cleft. Fruit belly ovate-oblong with a short sharp point, smooth; the 3 larger calyx lobes 6cm by 1.2cm; the 2 smaller lobes 2.5m by 0.6cm (Hooker, 1874; Kurz, 1877).

Distribution – Burma

Note: This species has been reported .from Burma (Hundley and *Chit* **ko ko,** 1961; Kurz, 1877) and confmed to Tenasserim. Details wanting.

SHOREA LISSOPHYLLA Thw.

Syn. ***Isoptera*** *lissophylla* (Thw) Livera

Common name

Sinh. – Malmora

A small tree attaining a height of 20m and a girth of 1m with crooked bole often branching from the base and with an irregular crown. Bark surface chocolate brown; coming away in small flakes. Young twigs densely greyish pubescent. Leaves 6 – 17cm by 4 – 10cm, very variable, broadly ovate, shortly acuminate, rounded or subcordate at base, thickly coriaceous, margin more or less revolute; lateral nerves **5** – 12 pairs; petiole 0.6 – 1.2cm long. stout, sparsely grey pubescent; stipule 0.8cm by 0.5cm, oblong, acute, fugaceous. Panicle terminal or axillary, the branches short, puberulent, bearing. 5 secund flowers. Sepals pubescent, the ***3*** outer acute, the 2 inner subacuminate. Petals linear-lanceolate, narrowly obtuse, cream coloured. Stamens many, connective appendage shorter than the anthers, but with **1** or 2 stout bristles. Ovary broadly ovoid, tomentose; style glabrous. Fruit 1cm in diameter, stylopodium distinct; fruit sepals subequal, 1cm by 0.7cm, ovate acuminate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found in Sinharaja, Karawita Yagirella and Beraliya.

Forest Types and Floristics

This endemic species is highly localized. It is generally gregarious in shallow poor soil and sometimes found over cliffs with a deformed branching system. Associates are mostly shrubs, as few tree species can survive in such habitat.

Silviculture and Management

Phenology

Flowering in April.

Regeneratiion is abundant. As the

species has no timber value, no importance is given to its propagation.

SHOREA MEGISTOPHYLLA Ashton

Syn. ***Doona macrophylla*** Thw

Common name

Sinh. – Monda Beraliya.

A large tree attaining a height of 40m and a girth of 3m with a dense hemispherical crown. Bark surface tawny brown, flaking in large oblong flakes leaving scallopedsurface beneath; inner bark pale brown. Twigs with prominent stipule scars. Leaves **13** – 23cm by 5 – 13cm, oblong-elliptic, acuminate, obtuse at base, thickly coriaceous, margin subrevolute; lateral nerves 13 – 18 pairs, slender, distinctly raised beneath; stipule 5cm by 1.5cm, narrowly elliptic, fleshy, with a prominent median sinuate nerve, fugaceous. Panicle 13cm long, erect, the branchlets 3cm long, bearing 6 flowers on short stout pedicels. Sepals obtuse, glabrous. Petals white, oblong, pubescent outside. Stamens 15; anthers yellow. Fruit 3cm by 2cm ovoid, prominently apiculate; the 3 larger fruit sepals 6cm by Zcm, broadly spatulate, obtuse, saccate and thickened at the base; the *2* shorter sepals 1.5cm by lcm, ovate, subacuminate (Ashton, 1977; Trimen, 1893).

Distribution – **Sri** Lanka

The species is localised in Mandegala, Mukulana, Hewesse, Kanneliya, Naunkita, Udugama, Beraliya, Gilimale, Ratnapura 2nd Kukul Korale.

Forest Types **and** Floristics

This endemic species is semigregarious in restricted localities in the Lowland Wet Evergreen Forest (Andrews, 1961). It is commonly found on undulating land where the soil **is** moderately deep.

Floristics

Kanneliya

Dipterocarpus glandulosus, Shorea megistophylla, Calophyllum inophyllm, Litsea glutinosa, *Nothopegia* ***beddomei,*** *Campnosperma zeylanica, Artocarpus nobilis, Mansifera zeylanica. Garcinia combogia.*

Silviculture **and** Management

Phenology

Flowering between February and April.

Regeneration is not uniformly satisfactory as flowering is irregular. When seedfall is followed by monsoon during good seed years, regeneration is plentiful. As the conditions are not satisfied every year, regeneration is patchy and in isolated groups. No regeneration operations are carried out to encourage the establishment of the seedlings.

Wood

Structure

Vessels medium sized, moderately numerous, mostly solitary, but pairs and groups of ***3*** are often seen; tyloses present.

Parenchyma indistinct.

Rays fine.

Resin canals in wary tangential rows, irregularly .spaced.

P.roperties

Wood light brown, coarse textured, straight grained, hard and heavy. Weight 724Kg/m^3 at 12 percent moisture content.

Difficult to season, refractory to treatment, fairly durable. Saws easily and finishes to a fiarly smooth surface.

Uses

Mainly for light construction, usable for plywood.

Non wood products

The resin has ursolic acid, *2* Alpha, 3 Beta **dihydroxyurs-12-cn-28-oic** acid, asiatic acid and caryophyllene (Bandaranayake ***et al.,*** 1975.)

SHOREA OBLONGIFOLIA Thw.

Syn. ***Doona oblonga*** Sensu Worthington

Common name

Sinh. –

A large tree reaching a height of 40m and a girth up to 5m with an irregularly oblong to hemispherical crown. Bark surface tawny brown, irregularly flaky. Young twigs densely greyish pubescent. Leaves 10 – 19cm by 4.7cm, oblong, acuminate, cordate at base, margin revolute, glabrous above except for the midrib, greyish pubescent on the nerves below, lateral nerves 13 – 16 pairs, very prominent below; petiole 1 – 2cm long, stipule 0.6cm by 0.3cm, oblong, subacute, fugaceous. Panicle axillary, the branchlets 6 flowered. Sepals ovate, subacute, densely, puberulent. Petals pale yellow with a pinkish tinge at the base, lanceolate, narrowly obtuse, pubescent on the portions exposed in bud. Stamens many, subequal; connective appendage stout, shorter than the anther, with 3 terminal bristles. Ovary and stylopodium greyish pubescent, style glabrous. Fruit 2cm by 1.4cm, ovoid-ellipsoid, prominently apieulate; the **3** larger fruit sepals 6cm by 2cm, broadly spatulate, obtuse, base thickened; the 2 shorter ones 4cm by lcm, spatulate, obtuse (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

The species has a fairly wide distribution covering Sinharaja, Kohawatte, Gilimale, Kutapitya, Palmadulla, Beraliya, Hiniduma, Labugama Kande, Padukka, Pelwatte and Pasdun Korale.

Forest Types and Floristics

One of the more common endemic species of the genus found almost throughout the Lowland Wet Evergreen Forest (Andrews, 1961) up to 700m altitude. It is often abundant on moist hill slopes below 500m altitude and on alluvial soil along river banks.

Floristics

Kanneliya

I *Dipterocarpus hispidus, D. zeylanicus, D. glandulosus, Shorea trapezifolia, S. oblongifolia, S. worthingtoni, Palaquium petiolare, **P.** rubiginosum, Mangifera zeylanica.*

I1 *Calophyllum bracteatum, **C.** soulattri, Kurrimia zeylanica, Chaetocarpus castanocarpus, Mesua ferrea.*

111 *Semecarpus gardneri,* S. *subpeltata, Dillenia retusa. Acronychia pedunculata, Euodia lunu-ankenda, Symplocos spicata, Humboldtia laurifolia.*

Silviculture and Management

Phenology

Flowering in April—June.

Regeneration is rather scanty in many places. It should, however, be possible to establish satisfactory natural regeneration by proper treatment, but no systematic operations are carried out.

wood

Structure

Vessels numerous, medium sized, mostly in groups; tyloses common.

Paratracheal parenchyma aliform to confluent.

Rays fine.

Resin canals frequent in distinct tangential rows.

Properties

Wood pale reddish brown to dark reddish brown, smooth textured, straight grained, hard and heavy. Weight 865Kg/m^3 at 12 percent moisture content.

Seasons slowly, moderately durable, refractory to treatment, saws easily, finishes to a fairly smooth surface.

Uses

A constructional timber generally used as beams and joints. A good timber for shingles.

SHOREA OBTUSA Wall.

Syn. *Shorea leucobotrya* Miq.

A medium sized deciduous tree attaining a height of 25m with a clear bole of 15m and a girth of 2.5m. Bark dark grey, rough with deep irregular fissures. Young branches covered by fugaceous stellate tomentum. Leaves 10 – 15cm by 5 – 10cm, elliptic to elliptic-oblong, blunt or occasionally apiculate, rounded at base, entire, young leaves sprinkled with tufts of stellate hairs beneath, but usually glabrous when mature; lateral nerves 10 – 14 pairs; petiole 1.8cm long. Panicle axillary, tomentose; flowers yellow, almost sessile on short racemes. Calyx tomentose. Petals linear to linear-lanceolate, pubescent outside. Stamens 20 – 25; connective appendage hairy. Ovary pubescent; stylopodium large and hairy; style short, glabrous; stigma minute. Fruit pubescent; calyx lobes slightly puberulous, the 3 larger ones about 5cm long, somewhat oblanceolate, the **2** smaller ones about 1cm long, linear to linear-lanceolate (Hundley, 1961; Kurz, 1877).

Distribution – Burma

The species has a fairly wide distribution. It occurs in Ava, Prome, Martaban and Tenasserim. It is also reported from Upper Chindwin.

Forest Types and Floristics

This species is fairly common in the Dry Tropical Semi-Indaing and Indaing Scrub Forest (Champion, 1936). In the Semi-Indaing Forest, the stand is mixed, though more or less pure associates of some of the dipterocalps are occasionally seen. Bamboos are frequent. The forest has a leafless period up to 2 months. In the Indaing Scrub Forest the soil is shallow and rainfall is generally low. The composition of the forest **is** more or less similar to Indaing Forest but the growth of trees is lesser and clear, tall boles, typical of the dipterocarps, are rather uncommon. The canopy is irregular and light. Fore is a frequent phenomenon and it is claimed that the forest type is a result of the repeated occurrence of fire.

Floristics

(i) Allanmyo, Burma (Semi Indaing Forest)

I *Shorea siamensis, Shorea obtusa, Dipterocarpus tuberculatus, Terminalia sp., Tectona grandis, Xylia dolobriformis, Pterocarpus macrocarpus.*

I1 *Strychnos* sp., *Anogeissus acuminata.*

111 Bamboos and reeds.

(ii) Sittang (Indaing Scrub Forest)

I *Shorea siamensis. Shorea obtusa. Dipterocarpus tuberculatus, Buchanania* sp., *Diospyros burmanica, Aporosa macrophylla, Dillenia pulcherrima.*

I1 Bamboos

Silviculture and Management

Phenology

Leaves are shed in the early part of the not season, the tree remaining leafless for some time In moist localities the new leaves may appear very soon atter the fall of the old ones. Flowers appear in March – April, and fruits ripen in May -June (Troup, 1921).

Silvicultural characters .

The species is xerophilous. Unlike the majority of dipterocarps, it can survive even on poor soil and rocky areas. Often it is found gowing gregariously, although sometimes sporadic. It is a light demander. The species is a good coppicer (Troup, 1921).

Natural regeneration

The species regenerates satisfactorily where it is gregarious. As it is a light demander, no special operations are necessary except removal of congestion and lightening of overhead shade. It is, however, necessary to protect the area from excessive fire.

Natural regeneration bas been supplemented by planting out seedlings raised in nursery. *As* the viability is low freshly collected seeds, after screening out the ones attacked by insects, are sown in shaded nursery beds after clipping the wings. One year old seedlings are planted out with a ball of earth. Survival percentage has been reported to be 65 – 75. Stump planting has not been successful.

Wood

Structure

Vessels large to medium sized, the majority solitary or paired; vessel segments short, perforation simple, transverse, inter-vessel pits numerous, small, oval to orbicular, with wide border: tvloses abundant.

Tracheids sparse, with numerous small, oval or orbicular pits.

Parenchyma paratracheal, paratracheal-zonate, metatracheal, and surrounding all resin canals; paratracheal parenchyma and metatracheal parenchyma abundant; parenchyma surrounding resin canls forming 6—8 seriate, concentric hands which occur at irregular intervals, dark reddish brown infiltration copious.

Fibres filiform, non-septate, interfibre pits simple, minute, plugged with reddish brown infiltration.

Rays fine, 1—6 seriate, nearly homogeneous, reddish brown infiltration copious.

Resin canals solitary or 2-several contiguous, canal orifices rounded, contents white.

Properties

Sapwood pale brownish-white, narrow, perishable, heartwood brown, turning to dark brown or dark reddish brown, often with darker markings, dull, working quite smooth, interlocked grained and medium textured, very heavy; sp. gr. 1.05. Weight 961—1073 Kg/m^3 at 12% moisture content.

Seasoning is slow and difficult. Liable to surface cracking and end splitting. Durable in the open and in contact with water. It is reported that untreated sleepers have lasted for 15 years. Sawing and working difficult.

Uses

Primarily used for construction works, bridges, piles. A valuable sleeper wood. It is also used for a veriety of purposes such as boat building carts, tool handles, ploughs and rough furniture. Occasionally it is a host for lac insect.

SHOREA OVALIFOLIA (Thw.) Ashton

Syn. *Doona ovalifolia* Thw.

Common name

. Sinh. Pini-beraliya.

A moderate sized tree reaching a height of 35m and a girth of 3m with a fairly dense hemispherical crown. Bark surface dark brown, irregularly thinly flaking, leaving pale surfaces below; inner bark pale brown. Twigs glabrous. Leaves 4 – 6cm by **2** – 3.5cm, ovate, subcaudate acuminate, base cuneate to subcordate, thinly coriaceous lateral nelves 7 – 8 pairs, slender but distinct: ly elevated below, obscure above; petiole less than lcm long, stipule linear, fugaceous. Panicle subterminal axillary, 7cm long, branchlets bearing 2 flowers. Sepals glabrous. Petals pubescent outside, white. Stamens 15; anthers yellow. Fruit 1.3cm by lcm, ovoid, apiculate; the **3** larger fruit sepals 3.5cm by 0.6cm, narrowly spatulate, tapering towards the thickened and saccate base; the 2 smaller sepals 1.5cm long, ovate, acute (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

Confined to Western Sabaragamuwa and southern provinces.

Forest Types and Floristics

The species is common, although localised in the Lowland Wet Evergreen Forest (Andrews, 1961), but sometimes it extends to ridges and rocky places in the Highland Wet Evergreen Forest up to 1300m elevation. It is generally scattered, but on ridges a semigregarious habit is noticed.

Silviculture and Management

Phenology

Flowering in April-May. Flowers have been seen in some areas in December.

Regeneration is satisfactory in the Lowland Wet Evergreen Forest and it is abundant where the species is semigregarious with dense thickets of seedlings and saplings. However, no regular regeneration operations are carried out.

Wood

Structure

Vessels numerous, medium-sized, mostly solitary with few in groups of 3 or more; tyloses present. Paratracheal parenchyma aliform.

Resin canals mostly solitary and scattered.

Properties

Wood reddish brown, coarse textured, straight grained, hard and moderately heavy. Weight 243Kg/m^3.

Seasoning difficult as there is a tendency for splitting; moderately durable; refractory to treatment.

Uses

A general constructional timber.

SHOREA PALLESCENS Ashton

A large tree attaining a height of 45m and a girth of 3m with a large emergent hemispherical crown. Bark surface mauve-brown, deeply fissured. Young twigs and petiole pale puberulent. Leaves 7 – 13cm by 3.4 – 8cm, ovate fakate, acuminate, base cuneate, coriaceous; lateral nerves 8 – 9 pairs, slender and hardly elevated below petiole 1.5 – 2cm, slender. Panicle axillary or terminal, tomentose. Fruit 1.5cm by 2cm, ovoid, tapering into a prominent stylopodium; the **3** larger sepals in fruit 7cm by 2cm, spatulate, obtuse, tapering towards the thickened saccate base; the 2 shorter sepals 4cm by 0.4cm, lorate, acute (Ashton, 1977)

Distribution – Sri Lanka

Localised to Kegalle and the southern flaks of the Peak sanctuary.

Forest Types and Floristics

This endemic species is rather rare and reported to be found in the Lowland Wet Evergreen Forest (Andrews, 1961) Highly restricted on deep well drained oil along hill slopes. Not much is known about this species and even flowering specimens have not been collected.

SHOREA ROBUSTA Gaertn. f.

Common names

As.	–	Bolsal, Borsal, Hal, Sal.
Beng.	–	Gazari, Shal.
Hind.	–	Dieng-blei, Rinjal, Sakhu, Sakwa, Sal, Sala, Sarai.
Mal.	–	Malappumarutu.
Nep.	–	Sakwa, Sal.
Or.	–	**Sal,** Salwa, Sekwa, Soringhi
Tam.	–	Kungiliyam
Tel.	–	Guggilam, Saluva, Sarjakamu.

A large deciduous tree attaining a height of about 35m and a girth of 3.5m or more in favourahle localities. Bark thick, rough, dark brown, longitudinally fissured. Leaves 12 – 25cm by 10 – 15cm. ovate-oblong, acuminate, base cordate, glabrous when mature; lateral nerves 10 – 12 pairs petiole 2 – 2.5cm long, stipule 0.8cm long, falcate, pubescent. Panicle, axillary or terminal, pubescent; flowers shortly pedicelled. Calyx grey, tomentose outside, lobes short, triangular. Petals pale yellow, narrow-ohlong or lanceolate, softly grey tomentose. Stamens many; connective suhulate cuspidate. Ovary pubescent, style short, stigma ***3*** denticulate. Fruit belly 1 – 2cm long, ovoid; sepals in fruit enlarged, somewhat unequal, spatulate, narrowed at the base, with 10 – 12 straight parallel nerves (Gamble, 1915; Hooker, 1874).

Distribution – Bangladesh, India, Nepal

The species has the widest distribution amongst all dipterocarps, extending over an estimated area of 13 million hectares in India alone. Bangladesh and Nepal together have over one idlion hectares (Tran Van Nao, 1974). This is the only species of the family which is able to withstand frost and adapc itself to a variety of climatological, geological and soil characteristics.

In Bangladesh it has a fairly wide but interrupted distribution extending from Rangpur in the north to Mymensingh in the east and Dhaka in the south. It is reported that the Southern limit was Comilla or even the foot hills of Chittagong, but it is rarely found below Comilla now.

In India it has a very wide distribution and the sal forests have a facies of their own which is attributed to the undisputed predominance of this species. Planned forest management to favour this species, its resistance to burning and grazing as compared to its associates, etc., have helped in intensifying the dominance of this species. It occurs widely in northern and central India in two zones viz., the Sub Himalayan region (north of the Gangetic plain) and south of Ganga. In the Sub Himalayan region the north western limit is 31°N latitude in Punja, eastwards it extends to Assam through Uttar Pradesh, Bihar and West Bengal, spreading to Nepal and Bangladesh. The north eastern limit is Darrang in Assam. In the region south of Ganga, its western limit is Balaghat in Madhya Pradesh, spreading southwards to northern Andhra Pradesh and eastwards south of West Bengal and Bihar through Orissa. In Nepal it is mostly confined to Bhabar and the Terai regions, as well as the foot hills stretching from west to east as a more or less continuous belt.

The distribution of this species is of considerable interest as it represents the north western limit of the dipterocarps.

Forest Types and Floristics

The versatility of the distributional patiern of this species in Bangladesh, India and Nepal is a noteworthy feature, as it occurs in several forest types. Unlike other dipterocarps, which are mostly confined to Tropical Wet Evergreen and Tropical Semi-Evergreen Forests, this species is essentially a component of Tropical Moist Deciduous Forest, extending to the Tropical Dry Deciduous Forest (Champion, 1936; Champion and Seth, 1968).

In Bangladesh the general forest type in which this species occurs, is the Tropical Moist Deciduous Forest (Champion, 1936). In moist localities this is a predominant species, sometimes forming 90% of the natural stand. In drier areas its frequency decreases. A detailed classification of the sal forests of the country has not been attempted. It, however, conforms to the classification of Sal Forests in Eastern India.

In India, the species is primarily found in the Tropical Moist Deciduous Forest, extending *to* the Dry Tropical Forest. A detailed classification of the forests has been made to bring out the ecological variations by Champion and Seth (1968). In the Moist Tropical Forest, Sal is an important component in the North Indian Tropical Moist Deciduous Forest. Here, this species constitutes 60 to 90 percent of the top canopy, which is fairly dense. The middle canopy is light and even here, the constituent is often suppressed Sal. **A** shrubby undergrowth is usual, the shrubs being mostly semi evergreen. Climbers are few and bamboos are mostly absent. Rainfall is between 100 to 200cm. The soil is sandy or clayey, sal attaining its best development on well drained fermginous soil. The general floristics vary according to the locality factors. In the Dry Tropical Forest, this species is confined to the Northern Tropical Dry Deciduous Forest, which is characterised by an intermixture of small sized trees with a thin shrubby undergrowth. During hot weather, trees are leafless for two to three months. Rainfall is less than 100cm and the soil is typically shallow and rocky. The topography is mostly rugged. The various subtypes and their characteristic floristics are summarised below.

1 North Indian Moist Deciduous Forest

A) Very Moist Sal Bearing Forest

In this type of forest; sal is gregarious and dominant. The trees attain a height of over 40m on best sites and under 25m on poorer sites.

i) Eastern Hill Sat Forest

This type is characterised by the preponderance of *Dendrocalamus hamiltonii* and dense undergrowth, the main associates being *Schima wallichii, Dendrocalamus hamiltonii, Microstegium ciliaturn. Imperata arundinaceae.*

i a) Eastern Himalayan Sal

Here the sal is restricted to ridges with well drained soils on Nahan Sand Stone.

Floristics

Kurseong, West Bengal

I *Shorea robusta, Garuga pinnata, Terminalia belerica, T. alata, Schima wallichii, Lagerstroemia parviflora, Tetrameles nudiflora, Stereospermum personatum, Toona* sp., *Bauhinia purpurea.*

I1 *Mallotus philippensis, Callicarpa arborea, Litsea monopetala, Semecarpus anacardium, Symplocos laurina, Dendrocalamus hamiltonii.*

111 *Leea* sp., *Indigofera pulchella.*

i b) Khasi Hill Sal

This type occurs on the upper portions of the Khasi foot hills (Meghalaya) and Assam at an elevation of 150 – 650m. Here sal occurs in pure patches, but in ridges, with mixed deciduous species.

Floristics

Kamrup, Assam

I *Shorea robusta, Schima wallichii. Adina cordifolia, Gmelina arborea, Lagerstroemia parviflora, Dillenia pentagyna, Vitex peduncularis, Terminalia belerica.*

I1 *Emblica officinalis. Premna latifolia, Aporosa roxburghii, Aphanamixis polystachya, Dendrocalamus hamiltonii.*

I11 *Desmodium* spp., *Ziziphus mauritiana.*

ii) Eastern Bhaber Sal Forest

High quality sal is seen in this forest, the characteristic associates being *Schima wallichii, Lagerstroemia parviflora* and *Terminalia alata.*

ii a) East Himalayan Upper Bhabar Sal

This type occurs on alluvial, well drained soil with boulders.

Floristics

Buxa, West Bengal

I *Shorea robusta, Schima wallichii, Lagerstroemia parviflora, Dillenia pentagyna, Terminalia belerica, Sterculia villosa, Stereospermum personatum, Lannea coromandelica, Garuga pinnata, Gmelina arborea, Toona ciliata.*

II *Aphanamixis polystachya, Premna integrifolia, Mallotus philippensis. Syrygium* sp., *Machilus* sp., *Wrightia tomentosa, Careya arborea.*

ii b) **East** Himalayan Lower Bhabar Sal

This subtype differs from the upper Bhabar subtype in being decidedly damper with *Microstegium* spp., *Terminalia alata* and *Machilus* sp. It is a tall forest with high quality **sal.**

Floristics

Jalpaiguri, West Bengal

I *Shorea robusta, Terminalia belerica, T. alata, Dillenia pentagyna.*

I1 *Careya arborea, Premna bengalensis, Premna integrifolia, Amoora wallichii, Aphanamixis polystachya, Lagerstroemia parviflora, Aporosa dioica, Holarrhena antidysenterica, Mallotus roxburghii, Meliosma simplicifolia.*

111 *Coffea bengalensis, Clerodendrum viscosum.*

iii) Eastern Tarai Sal Forest

This subtype is characterised by the presence of canes and ferns, without bamboo, and occurs on dark alluvium. The characteristic associates are *Michelia champaca, Castanopsis* sp. and *Machilus* spp.

Floristics

Goalpara, Assam

I *Shorea robusta, Schima wallichii, Stereospermum personatum Dillenia pentagyna, Terminalia belerica, Lagerstroemia parviflora, Lannea coromandelica, Syzygium* sp., *Sterculia villosa, Toona ciliata, Albizzia procera, Salmalia* sp., *Litsea monopetala, Bridelia retusa, Amoora wallichii.*

11 *Turpinia cochinchinensis, Talauma hodgsoni, Machilus villosa.*

I11 *Morinda angustifolia, Leea indica.*

iv) Peninsular (coastal) Sal Forest

Much of the area at present occupied by this type is considered to be a stable subclimax type to semi-evergreen, conditioned by burning.

Floristics

I *Shorea robusta, Dillenia pentagyna, Terminalia alata, Bridelia retusa, Adina cordifolia.*

I1 *Syzygium cumini, Protium serratum, Polyalthia cerasoides, Cycas circinalis, Bambusa arundinacea, Dendrocalamus -strictus. Oxytenanthera sp.*

B) Moist Sal-Bearing Forest

This subtype is the most important and extensive sal forest in North India. It extends up to an elevation of about 1000m. Several subdivisions have been recognised based on the climatic and edaphic features.

i) Moist Siwalik Sal Forest

This subtype occurs on Nahan Sandstone with light soil. The typical associates are *Anogeissus latifolia, Terminalia alata, Dendrocalamus strictus, Colebrookea oppositifolia.*

Floristics

Siwalik Hills, Haldwani, U.P.

I *Shorea robusta, Anogeissus latifolia. Terminalia alata, Adina cordifolia, Pinus roxburghii, Lannea coromandelzca, Garuga pinnata. Terminalia belerica, Diospyros tomentosa.*

I1 *Ougeinia oojeinensis, Buchanania lanzan, Semecarpus anacardium. Bauhinia* spp., *Cassia fistula, Emblica officinalis, Olea glandulifera, Engelhardtia sp., Dendrocalamus strictus.*

IIl *Colebrookea oppositifolia, Murraya koenigii, Woodfordia fruticosa, Berberis asiatica, Indigofera pulchella.*

ii) Moist Bhabar Sal Forest

The characteristic associates are *Terminalia alata, Lagerstroemia parviflora, Mallotus philippensis, Clerodendrum viscosum.*

ii a) Bhabar-dun Sal Forest

Occurs on the dun and gentle bhahar slopes which are gravelly in nature with boulders underneath.

Floristics

Dehra Dun, Uttar Pradesh

I *Shorea robusta, Lagerstroemia* ***par****viflora. Adina cordifolia, Kydia calycina.*

I1 *Mallotus philippensis, Litsea glutinosa, Ehretia laevis, Syzygium cumini, Grewia elastica*

I11 *Clerodendrum viscosum, Glycosmis pentaphylla.*

ii b) Damar Sal Forest

Occurs on high alluvial river hanks. The species which are more characteristic of this subtype are *Adina cordifolia. Syzygium cumini, Sc hleichera oleosa.*

Floristics

North Kheri, Uttar Pradesh

I *Shorea robusta, Terminalia alata, Adina cordifolia, Lagerstroemia parvifora, Terminalia belerica, Stereospermum suaveolens, Kydia calycina.*

I1 *Syzygium cumini, Mallotus philippensis, Schleichera oleosa, Ougeinia oojeinensis.*

111 *Clerodendrum viscosum, Pogostemon plectranthoides, Maughania* sp., *Glycosmis pentaphylla, Ardisia solanacea, Phoenix acualis.*

iii) Moist Tarai Sal Forest

Th This subtype occurs on grey clayey alluvium with wet subsoil and is characterised by the presence of *Calamus.*

Floristics

Haldwani, Uttar Pradesh

I *Shorea robusta, Adina cordifolia, Trewia nudiflora, Syzygium cumini.*

I1 *Lagerstroemia parviflora, Litsea glutinosa. Elaeagnus latifolia, Alangium* sp., *Bambusa arundinacea.*

111 *Clausena pentaphylla, Ardisia solanacea, Calamus tenuis.*

iv) Moist Plains Sal Forest

This type also **is** subdivided into two subtypes according to the nature of the soil.

iv a) Western Light Alluvium Plains Sal

This type occurs on sandy alluvium with a dry subsoil. The characteristic associates are *Terminalia alata, T. belerica, Lagerstroemia parviflora* and *Mallotus philippensis.*

Floristics

North Kheri, Uttar Pradesh

I *Shorea robusta, Terminalia alata, T. belerica, Lagerstroemia parviflora, Adina cordifolia, Kydia calycina, Stereospermum suaveolens, Schleichera oleosa.*

I1 *Syzygium cumini, Miliusa velutina, Semecarpus anacardium. Bauhinia malabarica, Grewia* spp., *Mallotus philippensis, Butea monosperma, Holarrhena antidysenterica.*

I11 *Helicteres isora, Ardisia solanacea, Maughania* sp., *Clerodendrum viscosum, Murraya koenigii.*

iv h) Eastern Heavy Alluvium Plains Sal

Found on yellow clayey alluvium. The chai-acteristic associates are *Terminalia data, Dillenia pentagyna, Lagerstroemia parviflora, Croton oblongifolius, Maughania chappar.*

Floristics

Gorakpur, Utrar Pradesh

I *Shorea robusta, Terminalia alata, **T.** belerica, **T.** chebula, Adina cordifolia, Lagerstroemia parviflora, Dillenia pentagyna, Stereospermum suaveolens, Madhuca indica, Schleichera oleosa, Syzygium cumini, Pterocarpus marsupium.*

11 *Miliusa velutina, M. tomentosa, Mallotus philippensis.*

III *Croton oblongiyolins, Glycosmis pentaphylla, Clerodendrum viscosum. Ardisia solanacea. Maughania chappar.*

iv c) Kanirup Sal

The characteristic associates are *Dillenia pentagyna, Lagerstroemia parviflora, Schima wallichii, Careya arborea* and *Glochidion* spp.

Floristics

Kamrup, Assam

I *Shorea robusta, Dillenia pentagyna, Lagerstroemia paruiflora, Schima wallichii.*

I1 *Careya arborea, Gmelina arborea, Vitex peduncularis.*

v) Moist Peninsular Sal Forest

The rock is crystalline and the soil yellowish. Three subdivisions are recognised based on topography.

v a) Moist Peninsular High Level Sal

Here the sal extends up over the hills on laterite, trap and crystalline rocks. Regeneration is quite adequate but there **is** a risk of frost. Typical associates are *Syzygium cumini, Dendrocalamus strictus.* and *Phoenix acualis.*

Floristics

Kalahandi, Orissa

I&II *Shorea robusta, Syzygium cumini, Bauhinia* spp., *Albizzia chinensis, Toona ciliate, Xylia xylocarpa, Emblica officinalis, Callicarpa arborea, Careya* sp., *Dillenia* sp.

III *Alstonia venenata, Colebrookia sp., Boehmeria* sp., *Grewia* sp.

v b) Moist Peninsular Low level Sal

This subdivision is found on crystalline rocks with yellow loamy soils. There is a light shrub growth under the sal. Regeneration is satisfactory. The typical associates are *Pterocarpus marsupium, Terminalia alata* and *Emblica officinalis.*

Floristics

Angul, Orissa

I Shorea robusta, Terminalia alata, Adina cordifolia, Mitragyna parvifolia, Lager: stroemia parviflora, Anogeissus latifolia, Bridelia retusa. Albizzia procera, Pterocarpus marsupium, Salmalia malabarica, Gmelina arborea.

I1 *Cleistanthus collinus, Dalbergia latifolia, D. paniculata. Syzygium cumini, Dille-*

nia pentagyna. Careya arborea, Diospyros spp., *Mallotus phippensis, Dendrocalamus strictus.*

I11 *Cipadessa baccifera, Woodfordia fruticosa, Clerodendrum viscosum, Zizyphus oenoplea.*

v c) Moist Peninsular Valley Sal

Occurs on downwash from crystalline rocks giving a deep loamy soil which carries a moderate shrub growth. The characteristic associates are *Terminalia alata, Maughania chappar,* and *Indigofera pulchella.*

Floristics

Saranda, Bihar

I Shorea robusta, Terminalia alata, *Adina cordifolia, Mangifera indica, Syzygium cumini, Alstonia scholaris, Dillenia pentagyna, Diospyros peregrina, Twminalia belerica, Lagerstroemia parviflora. Anogeissus latifolia, Schleichera oleosa.*

I1 *Aphanamixis polystachya, Protium serratum Mallotus philippensis, Miliusa velutina, Ficus* spp., *Callicarpa arborea, Careya arborea, Canthium dicoccum. Grewia asiatica, Vitex peduncularis.*

I11 *Ardisia solanacea, Clerodendrum viscosum, Desmodium* sp., *Maughania* sp.

C) Moist Sal Savannah

Open Sal forest with heavy grass. Sal occurs in groups with other fire hardy species. Distributed throughout the Gangetic plains.

Floristics

Kamrup, Assam

I *Shorea robusta, Careya arborea, Emblica officinalis, Wrightia tomentosa.*

11 *Zyzyphus* sp., *Randia* **sp.**

2. Northern Tropical Dry Deciduous Forests

The upper canopy is light, and fairly even and continuous in the climax form. Rarely is an irregular broken canopy seen. Trees have relatively short boles and poor form.

i) Dry Sal-Bearing Forest

Here S. *robusta* of low quality predominates. It is often broken up into characteristically pure groups or mixed patches of varying extent. The canopy is irregular. *Anogeissus latifolia* and *Buchanania lanzan* are the most constant associates.

i a) Dry Siwalik Sal Forest

The soil is derived from Siwalik sand rock and conglomerates and is shallow, sandy and dry. Regeneration is deficient and very slow. Bamboos occur locally.

Floristics

Saharanpur, Uttar Pradesh

I *Shorea robusta. Anogeissus latifolia, Buchanania lanzan, Terminalia alata, Bauhinia variegata, Acacia* spp., *Pinus* ***rox**burghii.*

I1 *Emblica officinalis, Ougeinia oojeinensis, Cassia fistula. Dendrocalamus strictus.*

I11 *Woodfordia fruticosa, Indigofera pulchella. Colebrookea oppositifolia. Hetteropogon contortus, Bauhinia* sp.

i b) Dry Plains Sal Forest

This subtype is commonly seen on flat ground and in the vicinity of Moist Bhabar Sal and Moist Plains Sal. The top soil and sub soil are rather clayey. There is superficial water logging during rains, the surface drainage being sluggish.

Floristics

Ramnagar, Uttar Pradesh

I *Shorea robusta. Terminalia alata, T. belerica, Diospyros tomentosa,Anogeissus latifolia.*

I1 *Miliusa velutina, Buchanania lanzan. Semecarpus anacardium, Acacia catechu, Zizyphus* sp., *Mallotus philippensis, Aegle marmelos.*

I11 *Clerodendrum viscosum. Glycosmis pentaphylla.*

1 c) Dry Peninsular Sal Forest

Occurs on shallow soils derived usually from crystalline and metamorphic rocks. Characteristic associates are *Anogeissus latifolia, Boswellia serrata, Gardenia* sp., *Wendlandia tinctoria* and *Phoenix acualis.*

Floristics

Singhbhum, Bihar

I&II *Shorea robusta, Anogeissus latifolia, Boswellia serrata, Cochlospermum **religiosum**. Dillenia aurea, Ziryphus* sp., *Gardenia* sp.

111 *Woodfordia fruticosa, Wendlandia tinctoria, Grewia hirsuta, Phoenix acualis.*

As may be seen from the above typological description, edaphic features are mainly responsible for the compositional changes in the nature of sal forest, within the broad climatic zone. The data from analytical studies of typical soils of sal forests are given in the table adopted from Champion and Seth (1968).

In Nepal this species is found essentially in the Tropical Moist Deciduous Forest and occasionally Tropical Riverain Deciduous Forest and the Sub Tropical Deciduous Hill Forest (Statainton ,1972). These types correspond to the North Indian Tropical Moist Deciduous Forest described for India by Champion and Seth (1968). For descriptive purposes the following groupings can be made:

i Bhabar and Tarai Sal Forest

a) Purc Sal Forest
b) Mixed Sal Forest

ii Hill Sal Forest

In Bhabar and Tarai Sal Forest the species is gregarious, found in almost extensive pure patches. In the Mixed Sal Forest, this species is most common, forming 60 to 90% of the stand.

Floristics

Bhabar and Tarai Mixed Sal Forest

I S. *robusta, Lagerstroemia parviflora, Terminalia alata, T. myriocarpa, Syzygium cumini, Lannea coromandelica, Garuga pinnata, Amoora decandra, Buchanania lanzan.*

I1 *Mallotus philippensis, Cassia fistula, Wrightia tomentosa, Casearia tomentosa.*

111 *Clerodendrum viscosum. Pogostemon* sp., *Zyzyphus rugosa* (Nair, 1966).

In the Hill Sal Forest the species reaches on altitude of 1200m, though exceptionally it is found at 1750m. Trees are rather stunted in altitudes above 1000m. In some areas an interesting mixture of sal and pines is seen. Pine is scattered with Sal predominating.

Floristics

I *S. robusta, Lagerstroemia parviflora, Anogeissus latifolia, Adina cordifolia, Dillenia pentagyna.*

II *Nyctanthes arbortristis, Kydia calycina Leucomeris spectabilis, Glochidion velutinum.*

111 *Spermadictyon suaveolens, Phoenix humilis, Indigofera pulchella.*

Silviculture and Management

Phenology

As the species is spread over a large geographical area with varied pedological and climatological characteristics, there is considerable variation in the leaf shedding, flowering and fruiting periods. In moist localities, leaves turn yellow and fall between January and April. In drier localities, leaf 'shedding is earlier and the trees become completely leafless (Troup, 1921). New flush appears from February to May, depending upon the locality. Sometimes two separate flushes of new leaves appear in one season. Flowering is between January and May, depending upon the locality and season. In most of the areas it is during January – February, At the time of flowering, trees are partially leafless. When the trees are in full bloom, it is a striking sight to see the whole forest clothed in a mantle of white bloom, particularly in years of extensive and profuse flowering. The petals fall like snow covering the ground beneath (Troup, 1921).

Fruiting is from March to June, depending upon the locality. The young fruits are reddish to pale yellowish green and they give

Forest type	Locality	Altitude (metres)	Geology	Topography	Water table	Soil type	Depth (cm)	Mechanical composition: Coarse sand %	Fine sand %	Silt %	Clay %	Water holding capacity %	Moisture equivalent %	Nitrogen %	Organic matter %	pH	Fe_2O_3 %	Al_2O_3 %	Ca O %	MgO %	K_2O %	P_2O_2 %
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Moist siwalik sal	Betban, Saharampur, U.P.	457	Siwalik conglomerate	Hilly	Deep	Brown earth	0–28	35.5	47.6	9.6	1.6	31.1	27.4	0.08	2.21	6.2	1.2	4.6	0.23	0.12	0.62	0.11
							28–76	35.0	14.6	12.5	5.0	28.4	21.3	0.05	1.14	6.4	2.0	3.3	0.23	0.24	0.29	0.07
							76–128	79.0	13.7	2.5	25	28.4	16.2	0,03	0.55	66	1.8	19	0.25	0.10	0.31	0.06
							128–168	54.1	26.7	7.5	7.5	21.6	19.5	0.04	0.52	8.0	19	2.4	0.22	0.10	0.75	0.06
Moist bhabar sal	Lachhiwala, Dehra Dun, U.P.	6 III	Siwalik conglomerate slope	Gentle southern	Deep	Alluvial	0–15	5.75	25.3	56.6	10.5	40.7	35.7	0.14	2.86	6.2	1.5	10.7	0.14	0.111	0.49	0.07
							15–33	10.5	34.2	39.3	10.9	39.1	34.7	0.05	10	6.1	1.5	IJ.2	0.22	0.12	0.68	0.15
							33–84	5.9	37.7	33.6	15.0	37.0	32.5	0.04	0.45	5 9	1.3	12.2	0.21	0.20	0.77	0.07
							84–165	5.9	32.9	38.R	13.4	35.7	32.6	0.05	0.62	5.8	16	5.1	11.21	0.10	0.79	0.07
Moist plains sal (eastern heavy alluvium)	Dudhai, Gorakhpur, U.P.	152	Alluvium	Flat	Shallow	Alluvial	0–20	4.9	40.4	27.5	20.0	t6.4	31.1	0.10	2.1	6.3	1.6	li.7	0.25	0.30	0.94	0.11
							20–48	1.1	39.3	35.0	12.0	41.7	31.1	0.07	1.3	5.8	6.4	8.5	0.22	0.68	1.31	0.09
							48–167	4.6	24.7	27.5	27.5	38.0	31.2	0.07	1.2	5.9	4.4	10.2	0.20	0.46	1.47	0.10
							107–183	5.0	34.5	22.5	32.5	36.5	32.1	0.01	0.4	6.1	5.9	10.4	11.25	0.24	1.16	0.11
Moist plains sal (western light alluvium)	Chaltua, South Kheri, U.P	..	Alluvium	Flat	..	Alluvial	0–10	3.8	30.9	35.0	22.5			0.16	2.69			9.82	0.30	1.18	1.18	0.03
							10–311	3.6	36.7	32.5	25.0	40.4	27.9	0.09	1.66	72		111.00	0.28	1.19	1.22	0.07
							30–129	3.5	40.1	27.5	25.0	36.9	26.5	0.04	0.45	7.0		12.00	11.211	1.20	1.24	0.02
							129–175	3.4	38.8	35.0	17.5	41.4	31.2	0.03	0.21.	7.0		12.42	11.22	1.40	1.21	11.111
							175–19"	3.0	52.3	22.5	15.0	42.8	32.5	0.01	1.03	7.1		12.27.	0.25	1.65.	1.20	0.03
Moist peninsular sal	Korar, Kanker, M.P.	...	Laterite; Granite gneiss	.		Laterite	0–15	33.8	23.9	17.5	20.0	37.1	24.3	0.137	3.4	5.1	3.4	15.5	0.27	0.55	0.64	0.04
							15–30	43.3	12.0	17.5	27.5	32.7	23.6	11.067	1.8	5.6	6.9	11.7	0.08	11.21	11.21	0.04
							30–61	35.0	23.4	5.0	37.5	30.9	20.7	0.065	1.2	5.3	4.2	8.1	0.08	0.17	0.41	0.05
							61–122	46.1	13.0	12.5	27.5	33.6	18.9	0.038	0.9	5.6	6.9	14.1	0.06	0.26	0.64	0.04
							122–184	62.5	13.8	5.0	17.5	27.9	12.3	0.009	0.5	5.7	3.9	8.1	0.11	0.23	0.31	0.04
Dry plains sal	Motipur, Bahraich, U.P.	...	Alluvium	Flat		Alluvial	0–23	20.0	46.2	15.0	15.0	30.7	20.9	0.10	2.00	7 0		6.84	0.21	0.37	0.55	0.08
							23–61	19.0	44.9	12.5	20.0	27.6	19.6	0.05	0.93	7.3		8.08	0.17	0.38	0.61	0.14
							61–122	18.1	42.3	17.5	20.0	29.5	19.8	0.01	0.48	7.0		9.71	0.14	0.78	0.71	0.02
							122–183	25.2	42.4	10.0	20.0	28.9	18.1	0.05	0.62	7.0		8.90	0.16	0.61	0.92	0.07
Dry peninsular sal	Rambadevi, Deogarh, Orissa	350	Granite schist, quartzite	Plateau undulating	..	Black (stiff calcareous)	0–15	6.2	16.7	35.0	30.0	68.0	42.1	0.03	0.9	7.4	8.6	6.2	1.23	0.08	0.18	0.05
							15–58	8.7	14.7	32.5	27.5	75.7	43.5	0.03	0.6	7.7	9.1	8.2	2.52	11111	11.22	0.04
							58–92	19.3	13.0	32.5	27.5	69.2	41.5	0.01	0.6	7.8	9.6	14.5	1.63	0.08	0.19	0.06
							92–12?	48.3	13.4	12.5	12.5	54.5	30.2	0.01	0.3	7.5	10.6	4.8	1.96	0.08	0.12	0.04

a characteristic hue to those trees which bear them in quantity. They fall soon after ripening and disperasal is mainly by wind.

Silvicultural characters

The species is among the hardiest of dipterocarps capable of surviving under adverse conditions.' It is essentially a light demander hut can tolerate shade. It is frost tolerant and it is only when the frost is too severe that it succumbs to it. It can withstand fire and tolerate browsing to a remarkable extent. In view of these characteristics the species has been able to extend itself over a large area, unlike many other dipterocaqm

Though the species is basically a light demander, it is able to survive under shade. It attains the best development in complete overhead light from the earliest stages, provided frost is not too severe. In the moister sal forest, growth is inhibited as there is generally a fairly dense understorey of evergreen species. Saplings thus suppressed, recover by throwing out new shoots which are usually whippy. They continue in their whippy form and eventually die if light is not admitted. Once the canopy is broken, thick shoots emerge from each stool and establish themselves.

Normally the species has a stout tap root which penetrates the soil stratum with great ease (Troup, 1921). The lateral roots, as a rule, are near the surface in clayey soil, but in sandy soil they are profuse throughout. Shoots are sometimes produced on the stools just helow the ground level, which curve upwards and appear above ground a few centimetres away. They are often mistaken for root suckers.

The species coppices well. Shoots originate from the sides of the stool and seldom from the top. The number of shoots produced in a stool varies with age, as may he seen from the following data collected by Troup (1921).

Age in years	Average number of shoots per stool
1	2.2
2	1.7
3	1.8

Coppicing power is seriously affected when the vitality of the plant is seriously impaired by drought or frost. Experiments in Madhya Pradesh (India) have shown that the season of coppicing has a significant influence on the production of coppice shoots. The height at which the stools are cut also have an influence on the number and quality of coppice shoots. Usually stools cut a few centimetres above the ground level produce better shoots than those cut flush with the ground. The study of Osmaston (1911) have yielded the following results:

Sl. No.	Method of Cutting	Result
1	Cutting flush with the ground and trimming m the form of a convex cone.	Poor
2	Cutting 10 – 15cm above the ground level with similar trimming.	Most satisfactory
3	Cutting 10 – l5cm above the ground level without trimming.	Satisfactory

This is. one of the most frost resistant species. It has a remarkable habit of remaining quiescent which is referred to, as 'dying back' in forestry literature. During unfavourable seasons there is no obvious growth of the shoot, and new whippy shoots develop from or under the ground level. The process may continue for many years till favourable conditions are available. Once the conditions are favourable, an erect shoot develops and grows up.

The rate of growth of the seedling is quite fast in moister localities. It, however, differs according to site qualities and weather conditions (Homfray, 1935).

Age in years	Height in cm
1	22.5
2	75.0
3	130.0
4	282.5
5	360.0

The species withstands frost better than many of its associates, but in localities subjected to severe frost, it is exposed to injury resulting in the death of seedlings or coppice shoots. Abnormal frost years have done enormous damage to sal forests, particularly on low lying areas. Frost damaged saplings and poles are normally cut hack to obtain new healthy coppice shoots.

It is one of the most fire resistant species of the moist and dry deciduous forests. **It** can survive in regions exposed to frequent fire damage, where the majority of its associates are unable to survive. Damage by fire can, howeveer, be fatal in periods of severe drought.

Natural regeneration

The extent of natural regeneration varies in different localities. In moist deciduous forest it is comparatively better, but even here, uniform success has not been achieved. **In** many respects natural regeneration of this species has remained a problem despite concentrated efforts.

It was Hole (1921; 1941) who first made a systematic study of the ecology and regeneration of this species. According to him, bad soil aeration and inadequate moisture are chiefly responsible for unsatisfactory regeneration He challenged the unsubstantiated hut popular belief, that dying back was an inherent characteristic of sal, and showed that it was caused by heavy overhead shade, bad soil aeration and drought. To obviate these, he recommended the removal of overwood and hoeing of the soil. A perfect System of natural regeneration has still not been evolved, despite the painstaking studies OF Howard (1917; 1918), Champion (1933), Seth ***et** al* (1960), although standardised techniques have been worked out which are in vogue to a large extent.

According to Warren (1941) the principal factor determining the success of regeneration is the soil water regime. If regeneration is to be stimulated, competition for the existing water supply in the soil should be reduced by drastic openings in the canopy.

Griffith and Gupta (1947) found that the accumulation of organic matter was not detrimental to regeneration. They were of the view that bad soil aeration and inaequate moisture were the two inhibiting factors, which were responsible for poor regeneration. This was corroborated by further studies of Gupta (1954).

In the Sal symposium held in 1953 the problem of regeneration was considered with reference to the following factors

1. Fertility of seed
2. Climatic factors
3. Edaphic factors
4. Competition from weeds
5. Manipulation of overhead canopy

1. Fertility of seed

Fertility of seeds is not a problem even in unfavourable localities, as the seeds germinate without difficulty so long as the viability is not lost.

2. Climatic factors

A good seed year and timely rainfall are prerequisites for recruitment of sal (Majum. dar, 1960). Phenological studies through a period of 11 to 14 years (Pande, 1966), with particular reference to the effect of temperature, have revealed that high temperatures advanced the commencement of flowering and fruiting. Hence, in a drier forest with higher temperatures, seeds fall much earlier than the normal period (Pande, 1966). **As** the viability is limited to about 10 15 days only, if the seed fall is much earlier than the rains, the seeds fallen on the ground, even in a good seed year, may fail to germinate (Pande, 1966). The late arrival of the monsoon in a good seed year, thus spoils the chances of obtaining recruitment. A good seeding and timely break of rains are not likely to synchronise often to ensure continued recruitment to the desired extent. Even if such a synchronisation does take place, subsequent drought may result in considerable mortality. Thus, the climatic conditions significantly influence the extent of natural regeneration.

3. Edaphic factors

As 'die back' is essentially a result of the restricted development of the tap root, the main edaphic factor which inhibits establishment of regeneration is resistance to root penetration. Seth and Waheed Khan (1960) have observed that if soil working is done up to a depth of 30 – 45cm aeration improves in the zone of worked soil, and a more favourable moisture regime prevails in the 30 to 45cm and 45-67.5cm layers. Under such conditions seedlings may grow without 'dying back', provided overhead light conditons are adequate, and competition from weeds is minimal. Such conditions are obtained in sal ***taungya*** plantations, and seedlings grow without 'dying back'. They emphasized that 'dying back' is not an inherent gowth phenomenon, but only a result of unfavourable edaphic factors. Soil working not only improves the moisture regime, but also allows a rapid development of the tap root, thus ensuring the survival of the seedlings. Qureshi ***et al*** (1968) showed that weeding and soil working are beneficial for the growth and survival of seedlings.

Srivastava (1972) studied the competing effect of some common associates on the growth and nutrient uptake of seedlings. The studies indicated that different competing species influenced growth and nutrient uptake in different manners. They found that ***Maughania chappar*** and ***Murraya koenigii*** were not harmful as competitors, in addition to being good regeneration indicators. ***Clerodendrum viscosum*** and ***Syzygium cumini*** were found to be good site indicators, but bad associates of sal, **as** their presence resulted in the suppression of growth and nutrient up take of the latter. It has therefore been suggested by them that it would be beneficial to remove these species from good sites, once their indicator value has been made use of.

4. Competition from weeds

Establishment of sal natural regeneration is generally easier in irregular sal crops containing an adequate mixture of miscellaneous species of different age classes and with an undulating and occasionally broken canopy. Experience in **U.P.** has shown that the removal of miscellaneous species from the middle storey tends to increase the incidence of semi-evergreen weeds and shrubs, even under a close canopy of sal, which may interfere with the growth of young seedlings. On the other hand, miscellaneous species in the intermediate canopy help in obtaining regeneration probably by:

a) producing a mixed type of humus;
b) lightening the density of the undergrowth; and
c) allowing diffused light to reach the ground;

5. Manipulation of overhead'canopy.

Manipulation of the canopy for elimination of weeds and encouraging sal regeneration has not been very successful because of the inherent difficulties in getting the correct adjustment of the canopy, consistent with the requirements of economic exploitation. Hence, an irregular shelter wood system is being practised instead of a uniform system.

Thus, to summarise, natural regeneration of the species has remained a problem of serious magnitude in some of the important sal regions. In a few localities, the problem is quite desperate. In Uttar Pradesh the problem is confined to the Gangetic alluvium where seedlings are dying out and dying back year after year, due to poor soil aeration and water logging during heavy rains. The post monsoon drought is also one of the limiting factors in some areas. Large scale browsing is yet another potent problem. In Bihar, the problem is not so serious, not because recruitment and regeneration are easy, but due to the presence of profuse advance growth. Dying back is quite prevalent here also, particularly in areas with transported soil. In Madhya Pradesh too, the problem is serious in transported soil.

It is however to be added that the problem has been overcome to some extent by appropriate remedial measures. Soil working and weeding have greatly helped the establishment and survival of seedlings in the open as well as under partial shade. Measures like fencing for complete elimination of browsing, elimination of weed competition by timely weedings, manipulation of the top canopy and .middle storey to the extent possible, burning for improving soil structure etc. have already been tried and still the limiting factor appears to lie somewhere in the soil (Seth, 1967).

In Bangladesh and Nepal the same problem is encountered. Fairly successful regeneration has, however, been obtained by suitable remedial measures. In Bangladesh satisfactory natural regeneration is invariably found during the rains. **A** certain proportion of the seedlings survive when the canopy is sufficiently open. Most of the seedlings, however, die towards the beginning of the cold season, probably due to the rapid desiccation of the soil and overhead shade. During summer the forest is exposed to ground fire, when a large number of seedlings get burned. In the following rainy season, some of them come up and survive. When the canopy is opened they shoot up. Coppicing of saplings, removal of weed growth and manipulation of the canopy have resulted in overcoming the difficulties to some extent.

In Nepal the sal forests are generally irreguIar with most of the age classes represented. Regeneration **is** satisfactory in favourable localities, scanty or absent in areas to heavy browsing and repeated fires. The sal forests are managed under an irregular shelter wood system in a 15 year felling cycle. The problems of natural regeneration are similar to that in India. By remedial measures like soil working, weeding and manipulation of the canopy, a fair amount **of** success has been achieved.

Artificial regeneration

The history of artificial regeneration of sal is almost as old as the problem of its natural regeneration (Srivastava, 1966). Though systematic attempts commenced in the early twenties of this century, records of much earlier plantations exist. **As** far as is known, the oldest plantation was raised in 1857 in a small patch situated in the compound of the club at Bareilly, Uttar Pradesh. Again, somewhere between 1876 and 1880, attempts were made in Ram Nagar (Uttar Pradesh) to afforest open grasslands with sal sown in ploughed lines. Most of the plants could not survive the severe frost. About this time, Schlich tried sowings of sal in Buxa (West Bengal). In 1887 or 1888 a small plantation of about 0.45 hectare was raised by transplanting young seedlings brought from the forest. Sowings on a cleared area along with a field crop (the practice now well established as the *taungya* method) can be traced to 1896 – 1899 plantations raised in Jalpaiguri (West Bengal). The afforestation of grassy tracts locally known as 'phantas' in the North Kheri forests of Uttar Pradesh commenced on an experimental scale in 1905 and sowings gave satisfactory results; but the supply of labour was insufficient for its cotinuance. Sowing in 1907 and 1909 in deserted fields in Ramnagar failed on account of severe frost and subsequent invasion by grass.

The problem of natural regeneration of sal had become so serious by 1910, as to necessitate systematic efforts to raise plantations.

A distinction should be made here between the earlier attempts for artificial regeneration which were mainly to introduce sal where it was not present viz.., grassy blanks, phantas, etc., and artificial regeneration in sal areas where natural reproduction failed, despite the efforts of foresters. Intetensive trials were undertaken for raising **sal** artificially. Patch sowings were attempted ***in** situ* in the forests of Gorakhpur (U.P.) in 1912, hut ended in failure. In 1913 nurseries were raised in Ramgarh (U.P.) with a fair amount of success. In 1913 sal was sown in the open and the results were encouraging. This success led to more extensive sowings in grass lands between 1914 and 1916, but the entire area was not ploughed. 'Mould' sowings and 'sod' soeings (a single clod of earth turned over with a hoe) were tried. At first, this innovation appeared to be a success, but the labour involved in keeping hack grass was very heavy, and plants died back in the subsequent hot weather. It was again in 1915, by a curious accident, that Bengal reverted to *taungya* cultivation, started earlier, and their method has been followed ever since.

The system of clearfelling and regeneration by coppice, supplemented by sowing and planting under the *taungya* method, was introduced in Gorakhpur (U.P.). Coppice regeneration was so poor, and *taungya* sowings so successful, that the whole area was given over to *taungya* cultivation and the coppice system given up.

The success of the taungya method of artificial regeneration was so well established by the end of the thirties, that it led to its adoption in other areas with different forest types. In the Gangetic Low level and Dry Gangetic Alluvial Sal Forests, where denovo natural regeneration failed, artificial regeneration by *taungya* was taken up in 1929. In Bihar and Orissa this system was adopted in 1933.

Much improvement has been made in the *taungya* technique and more or less a perfect method has been standardised. The areas earmarked for plantation are clear-felled by the end of April, and the cultivator collects the felling debris, digs out the old stumps and burns them for charcoal. The area is fenced. In the first year, agricultural crops like Maize or Paddy are raised. After reaping the harvest, soil preparation is undertaken by the cultivators and completed by the end of April of the second year. Soil preparation consists of digging trenches 45cm x 35cm, 3m apart. After the first monsoon showers the trenches are filled with excavated earth in such a way that the filled trenches are about 10 – 15cm above the ground level. Sal seeds are sown by the cultivators in two rows, 10cm apart. After sowing the seeds, the cultivators raise an agricultural crop. Three weedings are carried out during the monsoon. They maintain the sal crop along with the agricultural crop by proper weedings and cleaning for three years. They leave the, area in the fourth year by which time sal seedlings are ahout three years old. Further maintenance consists of cleaning and replacement of casualities.

There are regional variations in the general method described above to suit local conditions and the type of forest.

With the introduction of mechanisation, large scale mechanised plantations have been raised by ploughing the area **and** raising sal plantations with an agricultural crop. Even water logged areas and savannah have been successfully tackled in Uttar Pradesh (Srivastava, 1966). The success of large scale sal plantations depends upon the availability of adequate quantities of seeds every year. As every year is not a good seed year, this is a problem. Another factor is the variability in the ripening of fruits. Unless good ripe fruits are available in time, large scale sowings cannot he undertaken. To overcome this difficulty, planting stock is raised in nurseries for planting out in conjunction with sowing. Trials have been made with various kinds of planting stock like container plants, pre-sprouted stumps and transplants with a ball of earth. Container plants have given 80% success, transplants with a ball of earth **70%** and pre-sprouted stumps 40%. In West Bengal, however, a success of 90% has been reported in respect of pre-sprouted stumps (Roy Chowdhury, 1956; Chowdhuri, 1963). The regeneration of sal is an important forestry operation in Bangladesh, India and Nepal. Despite the problems encountered in natural regeneration, a large extent of the natural forest is regenerated annually. Where it is practically Impossible, techniques for artificial regeneration have been adopted with spectacular success.

Rate of growth

Several inventories have been prepared and experimental plots maintained to study the growth of this species. A summation of information for different quality classes is given in the table.

Crop age --- years	Site quality I Top height 36m – 30m at 80 years		Site quality 1/11 Top height 30m at 80 years		Site quality I1 Top height 30m – 24m at 80 years		Site quality II/III Top height 24m at 80 years		Site quality 111 Top height 24m – 18m at 80 years		Site quality III/IV Top height 18m at S0 years		Site quality IV Top height 18m – 12m at 80 years	
	Average dia. in cm	Average ht. in m	Average dia. in cm	Average ht. in m	Average dia. in cm	Average ht. in m	Average dia. in cm	Average ht. in m	Average dia. in cm	Average ht. in m	Average dia. in cm	Average ht. in m	Average dia in cm	Average ht. in m
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
10	8.0	8.8	7.2	8.1	6.8	7.5	6.3	3.6	5.8	5.7	5.3	4.8	4.5	3.9
20	14.0	14.7	13.0	13.8	12.0	12.6	11.0	11.4	10.0	9.9	8.7	8.4	7.5	6.9
40	24.2	22.5	22.5	20.7	22.7	18.6	19.0	16.8	17.2	14.7	15.0	12.9	13.7	11.1
60	33.0	28.5	30.5	25.8	28.5	23.1	26.3	21.0	24.0	18.6	21.8	16.5	19.5	14.1
80	40.5	33.0	38.0	30.0	35.3	27.0	33.0	24.0	30.2	21.3	27.5	18.9	25.2	16.2
100	47.5	36.3	44.7	33.0	42.0	29.7	39.0	26.4	35.7	23.4	31.1	20.4	29.0	17.4
120	54.0	39.0	51.0	35.4	47.8	31.8	44.0	28.2	40.5	24.9	36.5	21.6	32.7	18.0
140	60.0	41.1	57.0	37.2	53.2	33.6	49.2	29.7	44.7	26.1	40.2	22.2	35.7	18.6

Wood

Structure

Growth rings scarcely distinct. Vessels

large to medium sized, the majority solitary or paired, occasionally contiguous, evenly distributed, 5 – 9/mm2, perforation simple, transverse, intervessel pits numerous, small, oval to orifice; typloses present.

Tracheids sparse, with numerous small, oval or orbicular pits.

Parenchyma paratracheal, paratracheal zonate, metatracheal and surrounding all resin canals. Paratracheal parenchyma abundant metatracheal parenchyma sparse, scattered and in short tangential, usually uniseriate rows; parenchyma surrounding the resin canals forming 5 – 7 seriate concentric bands at irregular intervals, gummy infiltration copious, dark reddish brown; crystals occasional in the marginal cells of the paratracheal and metatracheal parenchyma.

Fibres libriform, fine, rounded in the transverse section, non-septate, interfibre pits simple, minute; reddish-brown gummy infiltration present.

Rays medium fine, close, 5 – 7/mm, 1–5 seriate, reddish-brown gummy infiltration copious.

Resin canals solitary or in groups of 2 – **3,** zonate in uniseriate tangential rows at irregular intervals (Chowdhury and Ghosh, 1958; Pearson & Brown, 1932).

Properties

Sapwood and heartwood usually distinct, sapwood when fresh, pale white, heartwood light brown to brown turning reddish brown on exposure, interlocked grained, often showing characteristic ribbon bands; medium to coarse textured, hard to very hard, heavy to very heavy, sp. gr. 0.62 – 1.00, air dry. Weight varies from 800 – 920Kg/m^3 at 12 percent moisture content.

Shrinkage percentage green to oven dry

Radial	3.6 – 5.1
Tangential	8.1 – 10.3
Volumetric	11.8 – 14.5

Modulus of rupture (Kg/cm^2)

Green	842.6 – 1064.1
Air dry	1061.4 – 1406.1

Modulus of elasticity (Kg/cm^2)

Green	126,700 – 150,200
Air dry	132,200 – 172,000

Maximum crushing stress (Kg/cm^2)

Green	423.1 – 571.7
Air dry	543.3 – 717.6

The timber seasons very slowly and is liable to split, warp and develop surface cracks. Heartwood very durable. Graveyard tests at Dehra Dun showed that timber remained in good condition even after 20 years in contact with the ground. **Sal** sleepers last for 16 – 18 years. Sapwood not durable and requires treatment before use. With proper treatment, a life of 25 – 40 years is possible for the sal poles. Heartwood refractory to treatment, side and end penetration practically impossible. There are many direct evidences to indicate that sal timber can last many years without deterioration. Wood excavated from Pataliputra, Samhalpur (Orissa), etc., which were 1000 to 2000 years otd, still remain in fairly good condition.

Rather difficult to saw and work. While working with machines, picking up of the fibres often takes place and it is difficult to obtain a smooth surface. For machining, cutters should not be ground too fine.

Uses

A widly used timber in Bangladesh, North India and Nepal for a variety of purposes. It is the most sought after timber for all types of constructional work where strength and durability are the main criteria. Used for beams, scantlings, rafters, floor boards, piles, bridges, electric posts, dug-outs, wheel hubs and railway sleepers. Also used for wagon flooring, turntables, buffers, brake blocks, ladders, etc.

It is a very good fuel wood. The calorific value of the sapwood is 5095 cals., 9173 Btu and that of the heartwood is 5433 cals., 9779 Btu. Sal lops and tops are used as pulp wood mixed. with bamboo pulp.

Non wood products

Bark

The bark, along with leaves and twigs, is a promising tanning material. The tannin content of the various parts is as follows:

Bark – 7.12%, young leaves – *20%*, twigs and leaves – 22% and powder dust – 12%. The aqueous extract of bark is of a pale reddish colour and the tannins are of the pyrogallol type. The extract is used locally for cheap tanning or in blend with .other tanning materials. Oleanolic acid (m.p- 305.306^{o}) has also been isolated from the bark (Karnik *et* a1.,1968). Bleached cellulose of good brightness has been obtained from the spent bark; the bleached cellulose contained 81.8% acellulose. A light greyish, somewhat granular cellulose gum has been prepared from it. This compares favourably with commercial grade technical gums. The cellulose from the spent hark has also been found suitable for making wrapping paper (Chowdhury and Ghosh, 1958; Karnik ***et al.*.** 1968: Narayanamurthy and Das,1949). Bark is oily, bitter, acrid and anthelmintic. It can cure ulcers and wounds and itches (Kirtikar and Basu, 1918). It is a useful raw material for fibre boards (Adarsh Kumar ***et*** al., 1971; 1972).

Oleoresin

The tree, on tapping, yields an oleoresin, known as Sal Danimar, 'Ral' or 'Lal' dhuma, which has been in use in India from time immemorial.

Method of tapping

3–5 narrow strips of bark are cut, 90 – 120cm, above the ground. When the tree is blazed the oleoresin oozes out as a whitish liquid and on exposure it hardens quickly and turns brown. The cut is freshened by scraping off the hardened resin. In about 12 days the grooves get filled with the resin. About 5Kgs of resin can be obtained annually from a good mature tree. Natural exudation also occurs from trees which are unhealthy or are injured by the heartwood borer. 'Ral' is known to occur in lumps at the base of the trees or even on the ground beneath the trees.

The crude method of tapping by making deep gashes into the wood was often found to cause permanent damage to the tree. Hence, tapping has been prohibited in reserved forests. A suitable economic method of commercial exploitation has yet to be evolved. Experimental results at the Forest Research Institute, Dehra Dun have shown that

a) Upper blazes yield more resin that the lower ones.

h) Maximum yield is obtained from September to November.

c) Fortnightly freshenings yield more resin than monthly freshenings.

Altogether 3 crops are obtained in July, October and January. In both quality and quantity, the first crop is the best.

Sal resin occurs in rough, stalactitic brittle pieces, 16 – 24cm in size, pale creamy yellow in colour, nearly opaque with a faint resinous balsamic odour. It has the following constants: sp. gr. 0.94 – 0.96; sap. Val. 35–37 and acid Val. 22-24.

The studies conducted on the anatomical responses due to successive blazing of the tree have shown that the structure of the newly formed wood has been greatly modified in the adjoining areas of the wound. There is an abundance of production of vessels which usually become smaller and more numerous per unit area. Parenchyma tissues also are developed in abundance. They are multilayered and filled up with profuse gum. Another after effect recorded is the absence of thick walled fibres which are responsible for the high density and good quality of wood. Hence, the wood formed after repeated tappings becomes more spongy, coarse textured and weak (Ghosh, 1958).

Sal dammar is widely used as anincense and as a disinfectant fumigant. Large quantities of dammar are used as an important ingredient of 'samagri' for cremation. It can also be used for hardening softer waxes for use in the manufacture of shoe – polishes, carbon papers, typewriter ribbon, etc. It is used in the inferior grades of paints and varnishes and for caulking boats. It has been used as a plastering medium for walls and roofs and as a cementing material for ply-wood, asbestos sheets, etc. The resin is used in the indigenous systems of medicine as an astringent and detergent. It is also used as an ingredient of ointments for skin diseases. It has curative properties against ear troubles, toothache, sore eyes, ulcers and wounds.

Seeds

Seeds are sometimes eaten after roasting. However, they are not very palatable. Decorticated seeds are used as poultry feed. An analysis of the dried seed meal gave the following values

moisture – 5.23%; protein – 6.16%, ether extractive – 16.77%, crude fibre – 4.81%, N. free extractive – 63.25%, calcium – 0.18%, total ash – 3.78% and acid insoluble ash – 0.95%

The fruit is sweet and cooling, aphrodisiac and astringent (Kirtikar and Basu, 1935).

Oil

Sal resin on dry distillation yields an essential oil, known as 'chua' oil. The yield of the oil has been found to .vary from 41 to 68% depending upon the sources of the

Estimated Annual Yield of Sal Seed Kanel,
Fat and Deoiled Meal in Selected States

Particular/Unit	States					Total
	Bihar	Madhya Pradesh	Orissa	Uttar Pradesh	West Bengal	
Exploitable sal forests (area in Sq. Km.)	16752.0	18841.0	14367.0	2884.0	2616.0	55.480.0
Estimated annual yield (thousand tonnes)						
1. In a good seed year						
(a) Kernel	826.2	929.2	708.6	142.2	129.0	2735.2
(b) Fat	115.7	130.1	99.2	18.9	L8.1	382.0
(c) Deoiled meal	649.0	780.6	595.2	119.5	108.4	2297.7
2. In a moderate seed year						
(a) Kernel	584.9	657.9	501.7	100.7	91.4	1936.6
(b) Fat	81.9	92.1	70.2	14.1	12.8	271.2
(c) Deoiled meal	491.4	552.7	421.4	84.6	76.7	1626.8
3. In a poor seed year						
(a) Kernel	186.9	210.2	160.3	32.2	29.2	618.8
(b) Fat	26.2	29.4	22.4	4.5	4.1	86.6
(c) Deoiled meal	157.0	176.6	134.7	27.0	24.5	519.8

Assumption:
1. The sal fruits consist of about 15% wings, 30% husk and 50% kernels. About 5% consists of losses in weighing and dust.
2. Yield of sal fat is 14% of the weight of kernels.
3. Yield of deoiled meal is about 84% of the weight of kernels.

Source: Various ledger files of the Minor Forest Products Branch, Forest Research Institute and Colleges, P.O. New Forest, Dehra Dun, Uttar Pradesh (India).

samples of the resin. The oil is light brownish yellow in colour and has an agreeable incense like odour. The oil has the following constants; sp. gr. 0.9420, acid val. 4.42, sap. val. 15.72 and sap. val. after acetylation – 39.49. It consists of 96.0% neutral, 3% and 1%phenolic and acidic fractions respectively. The oils from sal seeds have assumed great importance lately. The estimated annual yield of sal seed kernel, fat and deoiled meal in the principal sal areas in India is given in the table.

Apart from the use of the oil for converting fat into a substitute for cocoa-butter, it has a variety of local uses. It is used for cooking and lighting. It is suitable for soap making, after blending with other softer oils. The oil cake contains 10 – 12% protein and about 50% starch, and can be used as cattle and poultry feed. It is a fairly good fertilizer. It is a softening agent in textile sizing and a source of stearic aid. It is believed that a low pressure process has been developed in India to convert sal and other tree seed oils into petroleum fractions, which has immense potential. Analysis of the seed meal has shown the following constituents

Hcl insolublcs	–	1.96%
Calcium oxide	–	1.428%
Magnesium oxide	–	0.484%
P_2O_5	–	0.299%
K_2O	–	0.936%
Nitrogen	–	1.540%
Moisture	–	12.36%

In Orissa, Madhya Pradcsh and Bihar, the collection season usually starts about the middle of May and continues for about 4 weeks, The fruits have to be collected before the onset of the monsoon, as it is difficult to dry and decorticate the fruit collected during the rainy season. 'The dried fruits can be decorticated either by hand, or with suitable mechanised decorticators. 'The dewinging is done by hand. 'The dried fruits are spread on a hard surface to a thickncss of about 10cm, and debvinged by beating with sticks.

Several processes have been tried for the extraction of oil from decorticated seeds.

a) The kernel is powdered by mechanical means and slowly.boiled with water which is twice the volume of the powdered kernel. The oil floats on the surface of the water which on cooling solidifies, and it is then separated. This method gives only a low yield of fat.

b) The kernels are broken to small sized particles. The kernel powder is pressed through rolls, using varying degrees of temperature and moisture, and pressure. Practically no fat is secured by this process.

c) The solvent extraction of seed is carried out by adopting the flaking proccdure. The particle size of the kernel is reduced to 7 – 10 mesh, using fluted rolls and cooking .at 2.25Kg/sq. cm steam pressure with open steam injection to a limited extent, so as to adjust the moisture content of the meal going into the flaking rolls to about 15%. A steam jacketted flight screw kettle is most suitable for cooking the meal. 'The outcom. ing flakes, coming through the flaking rolls, are tempered. The flake thickness thus obtained is between 0.24 to 0.3mm with a moisture content of 8%. 'The flakes thus obtained do not show any sign of disintegration on solvent impact. 'This **is** due to the high starch content in the kernel. The studies conducted so far show that it is not possible to obtain a good yield of fat by expeller, even after proper conditioning of the kernels prior to expelling.

The fat is relined by a conventional method of alkali refining. Seeds yield 19 20% of a fatty oil. 'The fat obtaincd by skimming off the oil solidifies from a buttery consistency in cold wcather. 'The fat cotlrains various kinds of pigncnts wen after refining. After the extraction of fat from the kernel, about 84 – 85% of deoiled meal is left.

The chief apparent obstacle to the technical use of the fat is the comparatively small fat content (14%) of the kernels.

The probable glycerides content of the kernel fat is given in the following table:

Components	Fractions from acetone A	B	Whole fat
	(Increments % mol.)		(% mol.)
Glycerides	69.0	31.0	100.0
a) Component acids			
Palmitic	3.0	1.6	4.6
Stearic	37.2	7.0	44.2
Arachidic	5.0	1.3	6.3
'Oleic'	23.8	21.1	44.9
Groups of component glycerides:			
b) Palmitodi-C_{18}	8.9	4.9	13.8
Arachidodi-C_{18}	14.9	3.8	18.7
Tri-C_{18}	45.2	22.3	67.5
c) Fully saturated	1.5	–	1.5
Mono – 'oleo' – disaturated	63.5	–	63.5
Di – 'oleo' – mono-saturated	4.0	29.8	33.8
Tri – 'oleins'	–	1.2	1.2
Probable component glycerides Fully			
Saturated (1.5)		–	
Palmitodislearin	0.5	–	0.5
Arachidodistearin	1.0	–	1.0
Mono – 'oleo' disaturated (63.5)			
'oleo' palmitostearins	8.4	–	8.4
'oleo' distearin	41.2 – 45.2	–	41.2 45.2
'oleo' – arachido-stearins	13.9 – 9.9		13.9 – 9.9

	A	B	Whole fat
Di 'oleo' monosaturated			
Palmitodi 'olein'	–	4.9	4.9
Stearodi – 'olein'	4-nil	21.1	25.1 – 21.1
Arachidodi – 'olein'	Nil – 4.0	3.8	3.8 – 7.8
Tri – 'olein' (1.2)	–	1.2	1.2

SHOREA ROXBURGHII G. Don

Syn. *Shorea cochinchinensis* Pierre
S. *floribunda,* Wall. **ex** Kurz
S. *lacctfera* Heyne
S. *robusta* Roth.
S. *talura* Roxb.

Common names

Kan. Jhallamara, Jala
Mal. – Taluram
Tam. – Punnamaram, Talura
Tel. – Jalari.

A medium sized tree attaining a height of 25m and a girth of 2.5 – 3m. Bark grey with longitudinal fissures. Young branches glabrous. Leaves 6 – 13cm by 3.5 – 6cm, elliptic-ovate, obtuse, often emarginate, coriaceous, rounded at the base, glabrous; lateral nerves 12 – 16 pairs, petiole 1 – 2.5cm long. Panicle terminal or lateral from the axils of fallen leaves, flowers pinkish white, distinctly pedicelled, pedicel 1cm long. Calyx segments deltoid, linear, margins ciliate. Stamens 15; anthers ovate or oblong with a subulate extension from the connective. 0vary ovoid; style subulate; stigma minutely lobed. Fruit belly ovoid glabrous, ahout 2cm long; fruit calyx lobes elliptic-linear, obtuse, largest 7.5cm by 1.5cm, with 7 – 10 slender parallel veins (Brandis, 1906; Cooke, 1901; Gamble, 1915; Hooker, 1874; Talbot, 1909).

Distribution – Burma, India

In Burma the species *is* reported in Tavoy and Mergui in Tenasserim. In India the species is found in Nellore, Cuddapah and Chittoor (Andhra Pradesh); Shimoga, Bangalore, Mysore, Kolar and Coorg (Karnataka); Coimbatore, Salem and Madurai (Tamil Nadu); Calicut and Muvattupuzha (Kerala).

Forest Types and Floristics

In Burma the species is sporadic in the dry deciduous forest in the south. In India it occurs in the Southern Dry Deciduous Mixed Forest, occasionally extending even to the Dry Savannah Forest (Champion and Seth, 1968). These forest types are characterised by low rainfall and relatively shallow soil. The trees are rarely well formed and the leafless period extends to 2–4 months. The undergrowth consists of mostly thorny species. Bamboos are generally absent. The area is subjected to repeated fires. The ground is with hills of low or medium height and the flat-grounds have invariably been brought under cultivation. This is one of the few species of dipterocarps which is able to survive in unfavourable climatic and edaphic conditions.

Floristics

(i) South Cuddapah, Andhra Pradesh, India (Southern Dry Mixed Deciduous Forest)

I&II *Terminalia pallida, Shorea roxburghii, Shorea tumbuggaia, Syzygium alternifolium, Mangifera indica, Albizzia odoratissima.*

I11 *Phoenix acaulis.*

(ii) Chinglepet, Tamil Nadu (Dry Savannah Forest)

I&II *Shorea roxburghii, S. tumbuggaia, Pterocarpus marsupium, Anogeissus latifolia, Diospyros melanoxylon.*

III *Phoenix humils.*

IV *Cymbopogon* sp., *Themeda* sp., *Heteropogon contortus.*

Silviculture and Management

Phenology

In Burma flowering is from December to March and fruiting from March to May. In India the species sheds its leaves during February – March. Flowers appear from February to March, fruits ripen in April – May.

Silvicultural characters

A xerophilous species adapted to rather rigorous conditions.

Natural regeneration

In India the species regenerates fairly well, but establishment of the regeneration is subject to receipt of one or two showers following seedfall and protection from fire. As the viability of seeds is very low, unless seedfall is accompanied by a shower, the germination is poor. Soil working before seedfall has shown good results. As the commercial value of the species is limited, no systematic efforts have been made for regeneration.

Wood

Structure

Vessels large to medium sized, the majority solitary or paired, occasionally 3–4 contiguous, evenly distributed. 2 – 8/mm^2; perforations simple, transverse; tyloses sparse.

Tracheids abundant, with numerous small oval or orbicular pits.

Parenchyma paratracheal, metatracheal and surrounding resin canals; paratracheal parenchyma abundant, one to several seriate; metatracheal parenchyma abundant, 1-4 seriate; parenchyma surrounding the resin canals *7* – 9 seriate; pale yellow infiltration scanty.

Fibres essentially libriform, non-septate, interfibre pits simple, minute.

Rays 5 – 7/mm, 4–5 seriate, nearly homogeneous; infiltration sparse, lemon-yellow.

Resin canals present, solitary or 2-3 contiguous; contents white (Pearson & Brown, 1932).

Properties

Wood olive-yellow to yellowish brown, turning darker on exposure, fairly lustrous when first exposed but soon becoming dull; mostly interlocked grained. medium textured; moderately heavy, sp. gr. 0.76. Weight 769Kg/m^3 at 12 percent moisture content.

Seasoning fairly easy; not durable. Graveyard tests at Dehra Dun have shown a life of 50 – 60 months. It is very refractory to treatment. Sawing difficult, works to a smooth surface, but blunts tools quickly (Pearson & Brown, 1932).

Uses

The wood has localised usage, mostly for construction purposes, as beams and trusses. In India it is also used in bridge construction, for low grade furniture, tool handles and pit props.

Non wood products

The species is a valuable host of the lac insect ***(Laccifer lacca*** kern.) in South India and yields a good crop when innoculated with Deverbettakusum Variety in Karnataka. An essential oil is reported to be extracted from the flowers.

SHOREA SERICEIFLORA Fischer and Hut. chinson
Syn. ***Shorea*** *gratissima* Foxw.

Common names

Bum. – Kabanthangyin, Kaban-ywetthe, thingan-byu, thingan-wa.

A medium sized tree attaining a height of 30m and a girth of 2m, with a clear straight bole of about 14m. Bark dark grey to brown, with longitudinal furrows. Branchlets brown, pubescent when young, becoming glabrous or glabrescent when old. Leaves *7* – 13cm by 2.5 to 5cm, ovate-elliptic to ovate-lanceolate, acute to acuminate, base rounded, or some-what narrowed, coriaceous, glabrous; lateral nerves 16 – 20 pairs, parallel and curving towards the margin; petiole 1.5 – 2cm long, stellate pubescent when young, becoming glabrous later. Panicles terminal or axillary, thinly pubescent; flowers rather large, shortly pedicelled, 4-5 on racemes; bracteoles leafy, narrowly oblong, puberulous. Sepals unequal, 3 outer rather large, deltoid lanceolate, finely nerved, silky pubescent outside, the inner ones rather smaller. Petals white, ovate-oblong, falcate, veined and densely hairy outside on the portions exposed in bud. Stamens 20 – 30; filaments short; connective terminating in a hair like awn. Ovary nar-rowly conical, tapering upwards into a long narrow stylopodium which is crowned by minutely 3 lobed stigma. Fruit belly ovoid, pointed, 1.5cm long by about lcm in dia-meter; the larger fruit sepals 9 – 13cm by 1.2 – 1.5cm, linear, rounded at the apex and slightly narrowed at the base, about 11 – 12 nerved, glabrous to minutely pubescent, the shorter ones up to 7cm long and more pointed than the longer ones (Parkinson, 1937).

Distribution – Burma

Confined to Amherst and Tavoy of Tenasse-rim

Forest Type

The specie's has a highly restricted occurrence in the Southern Low Tropical

Evergreen Forest (Champion, 1936). Found scattered in a narrow range.

Silviculture and Management

Flowers appear from December to March and the fruits ripen during April – May.

Wood

Structure

Wood diffuse porous, vessels moderately large, majority radial or in partly oblique pairs, but less frequently aligned in tangential rows; tyloses scanty.

Resin canals irregularly spaced; white gummy infiltration copious (Chowdhury & Ghosh, 1958).

Properties

Sapwood fairly distinct, white or grey to light yellow, turning sometimes to a brownish grey shade; heartwood yellowish brown with pinkish tinge, slightly resinous, somewhat lustrous; usually interlocked grained, medium coarse textured, hard, moreratelv heavy, sp. gr. 0.73 to 0.79.

Difficult to season. A durable timber refractory to treatment. Sawing is difficult coarse textured, hard, moderately heavy, 1958).

Uses

Because of its restricted and sporadic occurrence the species is not known outside its habitat.

SHOREA SIAMENSIS Miq.

Syn. *Pentacme malayana* King
*P. **siamensis*** Kurz
P. *siamensis* (Miq.) Kurz
P. siamensis Var. *mekongensis* Craib
P. suavis A.DC.
P. tomentosa Craib

Common names
Bur. – Eng-kyn, Ingyin,
Thitya ingyin

A medium sized deciduous tree attaining a height of 18 – 27m with a clear bole of 12- 15m and a girth of 1 – Em. Bark surface blackish-grey, vertically and horizontally fissured in old trees. Young shoots covered by a fugaceous, greyish or whitish stellate tomentum. Leaves 10 – 15cm by 7 – 10cm, oblong or ovate-oblong obtuse or subacute, base truncate or cordate, glabrous on both sides; lateral nerves about 15 pairs; petiole 2 – 3.5cm long. Panicle axillary, scurfy tomentose; flowers small, yellowish, fragrant, almost sessile. Calyx lobes ovate-acuininate, glabrous, margin ciliate. Petals linear to linear-lanceolate, acuminate, velvety outside. Stamens 15; filaments very short; anther lobes slightly unequal, connective with a subulate prolongation which is bent outwards. Ovary ovoid; style filiform. Fruit belly ovoid, 'enclosed by the dilated and thickened bases of the enlarged calyx lobes; the ***3*** outer larger ones about 5cm long, the 2 inner ones 0.75 1.25cm long, linear-lanceolate (Hooker, 1874; Kurz, 1877).

Distribution – Burma

The species is seen throughout Upper Burma. Most frequent occurrence has been observed in Ava and Pome. It is also seen sporadically in Lower Burma (Hundley, 1962).

Forest Types and Floristics

The species occurs in a wide variety of forest types from normal *Indaing* Forest through various forms of *Semi-Indaing* to Dry Deciduous Mixed Forest (Hundley, 1961). It is occasionally found in fairly moist types of forest also. Here it is associated with *Dipterocarpus turbinatus* and *D. alatus* (Hundley, 1962). In the *Indaing* Forest the rainfall is below 110cm, the main factor influencing growth being soil. The best development is found on sandy alluvium in the river valleys. The *Indaing* Forest is characterised by the prevalence of *Dipterocarpus tuberculatus*. Bamboo is usually absent, the undergrowth is mainly grass, which gets burnt periodically. Large climbers are frequent. In the *Semi-Indaing* Forest rainfall is about 120cm or more and the soil is gravelly or sandy. Here the forest is more mixed and pure stands of this species are sometimes seen. Bamboos are present.

In the normal type of *Indaing* Forest *Shorea siamensis* and *Shorea obtusa* are the main associates of *Dipterocarpus tuberculatus,* which is the principal species. The relative proportion of these species varies considerably according to the site conditions, as on the ridges and other dry localities -Shorea *siamensis* and *shorea obtusa* are found without *Dipterocarpus tuberculatus.*

Floristics

(i) Burma (Indaing High Forest)

I *Dipterocarpus tuberculatus, Lagerstroemia parviflora, Terminalia* sp., *Tectona grandis.*

I1 *Shorea siamensis, Strychnos* sp., *Careya arborea, Gardneria crythroclada, Dillenia pulcherrima, Acacia catechu.*

I11 *Phoenix acualis, Cycas siamensis* (Champion, 1936).

(ii) Allanmyo, Burma (Semi Indaing Forest)

I *Shorea siamensis, Shorea obtusa, Dipterocarpus tuberculatus, Terminalia sp., Tectona grandis, Xylia dolabriformis, Pterocarpus macrocarpus, Lannea coromandelica, Anogeissus acuminata.*

I1 *Strychnos* sp.

I11 *Diospyros burmanica, Desmodium gyrans, Strobilanthes roseus.*

(iii) Upper Burma (Indaing Scrub Forest)

Dipterocarpus tuberculatus, Shorea obtusa. Shorea siamensis. Terminalia macrocarpa, Diospyros burmanica, Emblica officinalis, Acacia leucophloea, ***A.*** *catechu, Tectona hamiltoniana, Schleichera oleosa, Dalbergia paniculata.*

Silviculture and Management

Phenology

The species sheds its leaves towards the end of January or early February and remains leafless till April, when the new flush of leaves appears. Leaves turn reddish at the time of shedding. In moist localities the tree is leafless only for a short period (Hundley, 1962).

Flowers appear in March. Fruit ripens from May to June (Kurz, 1977).

Silvicultural characters

The species is typically xerophilous. It grows even in drier situations and on poor soil. It coppices well. Root suckers are produced occasionally (Hundley, 1962).

Natural regeneration

Usually the species regenerates freely but in dry situations heavy casualities occur due to drought. Successful germination depends largely on timely rains. The seed loses its viability quicklv and fails to germinante if it happens to fall on dry ground, particularly if exposed to the sun. Under natural conditions the seedlings take a long time to establish themselves. In areas subjected to frequent fires, the species acquires a straggling habit till the root system is vigorous enough' to send up a shoot, which rapidly develops .a thick rough, fire hardy bark at the base.

Natural reproduction is obtained without any special treatment. Uniformly successful regeneration is, however, uncommon due to the failure or delay of rains after seed-fall. In areas where regeneration fails freshly collected seeds are dibbled. This species being fire tender the removal of grasses and other undergrowth is necessary.

Wood

Strncture

Vessels large to medium sized, majority solitary or radially paired, occasionally in groups of ***3 – 5,*** generally radially aligned, evenly distributed, 4 – 9/mm^2; vessel segment evenly distributed,4–9/mm^2; tyloses abundant.

Tracheids abundant, pits numerous.

Parenchyma paratracheal, paratracheal zonate, metatracheal, and surrounding all resin canals; paratracheal parenchyma and metatracheal parenchyma abundant; brownish yellow infiltration scanty in all types of parenchyma.

Fibres libriform, non septate, pits simple, minute.

Rays fine, 6–8 per mm, mostly 4 senate, heterogeneous; the largest 60 – 70/um wide; brownish yellow gummy infiltration abundant; oxalate crystals present.

Resin canals solitary or 2–3 contiguous; contents white (Gottwald and Parameswaran, 1966, Pearson and Brown, 1932).

Properties

Sapwood and heartwood not clearly differentiated, sapwood dull grey to brown; heartwood brownish yellow turning to reddish brown or dark brown; interlocked-grained; medium coarse textured, very hard; heavy, sp. gr. 0.70 – 0.98. Weight at 12 per-cent moisture content 913Kg/m^3.

Shrinkage percentage green to oven dry

Radial	4.2
Tangential	9.8
Volumetric	14.3

Modulus of rupture (Kg/cm^2)

Green	902.0
Air dry	1029.6

Modulus of elasticity (Kg/cm^2)

Green	141,500
Air dry	164,100

Maximum crushing stress (Kg/cm^2)

Green	480.5
Air dry	561.7

In comparison to other dipterocarps the timber is quite durable; graveyard tests at Dehra Dun have indicated a life of over 270 months. Untreated sleepers have lasted 15 years (Pearson and Brown, 1932). Seasons slowly and surface cracking significant. Very refractory to treatment, rather difficult to work and saw. Takes a good polish on well finished surface.

Uses

A fine constructional timber, extensively used in Burma. An excellent sleeper wood. It is also used for a variety of purposes such as bridge construction, piles, dug-outs, ploughs, etc. Popularly used as mine shafts and in oil wells.

SHOREA STIPULARIS Thw.

Common names

Sinh. – Nawadun, Nawada, Hulan-Idda.

A large tree reaching a height of 45m and a girth of 4m with a large hemispherical crown. Bark surface chocolate brown, becoming irregularly fissured and flaking in thick flakes; inner bark reddish-brown and pale yellowish-brown, laminated, fibrous. Young shoots glabrous with conspicuous amplexicaul stipule scars. Leaves 6 – 15cm by 3 – llcm, variable in size, lanceolate to broadly oblong-ovate, acuminate to retuse, base broadly cuneate to obtuse, margins re-volute, coriaceous; lateral nerves 14-1 7 pairs, slender, distinctly elevated beneath, appla-nate above; petiole 1.5 – 3cm long; stipule 2.5cm by 1.5cm, persistent, ovate, subacute. Panicle axillary, lax, with spreading branches bearing 5 or less secund flowers; bracts sub-persistent. Petals adhering in a rosette, con-torted, forming an urceolate base. Stamens 15, connate with the petals; filament appla-nate, broad at base, tapering and filiform below the narrowly oblong anther; connective apicular, slender, 3 times as long as the an-ther. Fruit 3cm by 2cm, ovoid, tapering into a prominent slender apiculus; the 3 larger fruit sepals 13.5cm by 3.5cm, broadly spathu-late, obtuse, thickened at base; the two shor-ter sepals 9cm by 1.5cm (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs in Bambarabotuwa, Ratnapura, Kanneliya, Hiniduma, Yagirella and Labugama.

Forest Types and Floristics

This endemic species has a wide distribu-tion in the Lowland Wet Evergreen Forest

(Andrews, 1961) at an elevation of 1000m. In the Southern Provinces it extends to the margin of the Tropical Lowland Semi-Evergreen Rain Forest (Andrews, 1961). In the Lowland Wet Evergreen Forest, it is quite frequent and scattered.

Floristics

Kanneliya (Lowland Wet Evergreen Forest)

I *Dipterocarpus zeylanicus,* D. *hispidus. D. glandulosus, Shorea trapezifolia,* **S.** *stipularis, Mangifera zeylanica, Palaquium petiolare, P. grande, Pygeum zeylanicum.*

I1 *Kurrimia zeylanica, Myristica dactyloides. Calophyllum tomentosum, Mesua ferrea. Wormia triquetra, Mastixia tetrandra, Carallia brachiata.*

I11 *Symplocos spicata,* ***S.*** *cuneata, Aporosa latifolia,* ***A.*** *lindleyana, Semecarpus gardneri, Dillenia retusa, Garcinia morella.*

Silviculture and Management

Natural regeneration is satisfactory and even profuse. Seedlings come up in groups and with large attractive stipules they stand out in the forest. Being shade tolerant and with a sturdy root system, the seedlings are able to withstand unfavourable conditions and the survival percentage is quite high. No special operations are carried out to establish regeneration.

Wood

Structure

Vessels moderately numerous, 15 – 20/mm, medium sized, mostly solitary, sometimes in pairs, diffuse porous; tyloses present. Paratracheal parenchyma aliform, confluent.

Rays moderately fine, uniseriate and multiseriate, heterogeneous; dark brown infiltrations present.

Fibres non-septate.

Resin canals present; white crystalline substance frequent.

Properties

Wood pale in colour, coarse textured, moderately hard, light and siliceous. Wight 505Kg/m^3 at 12 percent moisture content. Seasons slowly without any distortion.

Uses

A good plywood species and used for tea chests. It is also used in the match and pencil industries.

Non wood products

The bark is used for arresting the fermentation of alcoholic beverages, especially toddy.

SHOREA TRAPEZIFOLIA (Thw.) Ashton

Syn. *Doona trapezifolia* Thw.

Common name
Sinh. – Yakahalu.

A large tree attaining a height of 45m and a girth of 5m with a cylindrical bole and a large hemispherical crown. Bark surface pale brown, irregularly fissured and flaking in rectangular flakes. Young twigs and petiole caducously tawny puberulent. Leaves 5 – 9cm by 1.8 – 4cm, lanceolate to elliptic-rhomboid, acuminate, base broadly cuneate to obtuse, thinly coriaceous; lateral nerves 11 – 14 pairs; petiole 0.8 – 1.2cm long, stipule 1.5cm by lcm, lanceolate, pubescent outside, fugaceous. Panicle terminal or axillary, branchlets 2.5cm long, bearing 5 flowers. Petals white. Stamens 15; anthers yellow. Fruit 2cm by lcm, ellipsoid-ovoid, apiculate; the **3** larger fruit sepals 4.5cm by 0 8cm, spatulate, obtuse, tapering towards the thickened base; the 2 shorter sepals 1.3cm by 0.8cm, ovate, cuspidate (Ashton, 1977; Trimen, 1983).

Distribution – Sri Lanka

The species occurs in Ambagamuwa, Pelmadulia, Sinharaja, Balangoda, Rakwana, Bambarabotuwa, Uluwinduwa and Deniyaya.

Forest Types and Floristics

This endemic species perhaps had a much wider distribution in the past in the Lowland Wet Evergreen Forest (Andrews, 1961). As the species prefers deep soil on gentle slopes, its habitat has been disturbed by plantations and now it is confined to localised patches in the Lowland Wet Evergreen Forest, occasionally into Highland Wet Evergreen Forest up to an elevation of 1200113 (Andrews, 1961). It is found in 'drifts' with its characteristic crown dominating the canopy. Mostly gregarious, interspersed in the dipterocarp forest with few associates.

Silviculture **and** Management

Phenology

Flowering in April and fruiting in August.

The species regenerates satisfactorily where it is gregarious but little attention has been paid for its propagation.

Wood

Structure

Vessels numerous, very small, almost exclusively solitary; tyloses common.

Paratracheal parenchyma aliform.

Rays very fine.

Resin canals present.

Properties

Wood golden brown to reddish brown, close grained and fine textured, hard and heavy. Weight 865Kg/m^3.

Uses

A constructional timber,' especially for flooring. It is accepted for cabinet work; a good plywood species.

SHOREA TUMBUGGAIA Roxb.

Syn. *Vatica tumbuggaia* W. & A

Common.names

Eng.	–	GreenDammer
Mal.	–	Thampakam
Tam.	–	Kongu,Karuppu dammer, Kungiliam
Tel.	–	Thamba, guggilamu, Nalla dammara

A small tree reaching a height of 12m and a girth of about 1.5m. Rarely, trees up to 18m in height and 2m in girth have been recorded. Young branches covered with minute stellate-tomentum. Bark dark brown, thick, longitudinally fissured. Leaves 9 – 20cm by 3.5 – 10.5cm, ovate or oblong, acuminate, base truncate or slightly cordate, glabrous on both surfaces; lateral nerves about 8 – 12 pairs, prominent beneath; petiole 3.5 – 5cm long, tomentose; stipule coriaceous. Panicle terminal, nearly glabrous; buds densely hoary; flowers shortly pedicelled, 1.5cm long, fragrant. Sepals united at the base into a short tube, the lobes imbricate, pubescent. Petals attenuate upwards, white, softly hoary tomentose outside, glabrous and yellow inside. Stamens many; filaments broad and dilated below and more or less united together at the base; connective terminating in a hairy bristle. Ovary ovate; style subulate; stigma 3 lobulate. Fruit belly 1.5cm long, ovoid, pubescent; fruit calyx lobes spatulate, obtuse, pubescent, unequal, the **3** larger ones 3.5 - 4.5cm long, 8–10 nerved (Gamble, 1915;Hooker, 1874).

Distribution – India

The species has a restricted distribution and is confined to Seshachalam and Villigunda hills of Cuddapah (Andhra Pradesh); North Arcot and Chinglepet (Tamil Nadu) and sparingly in the dry hills in Karnataka. It is reported that the species had a wider distribution in the past, but due to cultivation the area has shrunken considerably (Sharma, 1955;Troup, 1921).

Forest Types and Floristics

The species is adapted to survive in a dry climate with poor edaphic conditions. It is seen in the Dry Savannah Forest and in the Southern Dry Mixed Deciduous Forest (Champion and Seth, 1968). In its limited area of distribution the species is mostly gregarious forming patches of varying extent, chiefly on the upper slopes and crests of hills. On dry ridges, growth is stunted but on low slopes it teaches better dimensions.

Floristics

(i) South Cuddapah, Andhra Pradesh (Southern Dry Mixed Deciduous Forest)

I&II *Terminalia pallida, Shorea roxburghii, S. tumbuggaia, Syzygium alternifolium, Albizzia* spp.

I11 *Phoenix acaulis.*

(ii) Chinglepet, Tamil Nadu (Dry Savannah)

I&II *Shorea tumbuggaia, Bridelia* sp., *Anogeissus latifolia, Emblica officinalis, Diospyros melanoxylon, Phoenix humilis, Chloroxylon swietenia.*

I11 ***He****teropogon contortus, Themeda triandra.*

Silviculture and Management

Phenology

Flowers appear during March – April and the fruits ripen in June – July. Alternate years are good seed years (Sharma, 1955).

Silvicultural characters

A hardy, xerophilous species. It is fire hardy, it has the capacity to survive the effect of frequent burning. The seedlings and saplings axe, however, fire tender. Viability of the seed is very low.

Natural regeneration

The species has responded to natural regeneration operations fairly well. The method followed is to prepare the ground before seedfall by a light burning and hoeing of soil. As grass growth is heavy, it is necessary to free the seedlings by uprooting the grass.

Wood

Structure

Vessels medium sized, majority solitary or paired, occasionally in groups of 3 or more, evenly distributed, 2 – 10/mm^2;perforations segments 170 – 430/um long, the largest 150 – 200/um in diameter; perforations simple, transverse; tyloses abundant, occluding all vessels in the heartwood.

Tracheids abundant, with numerous small, oval or orbicular pits.

Parenchyma paratracheal, paratracheal zonate, metatracheal and parenchyma surrounding all resin canals; paratracheal parenchyma abundant forming a 1-several senate sheath; metatracheal parenchyma abundant, cells generally tangentially flattened; parenchyma surrounding the resin canals forming 9—12 seriate concentric bands; lemon yellow infiltration abundant.

Fibres libriform, medium fine, nonseptate, interfibre pits simple, minute.

Ray fine, 1—6 seriate, homogeneous; infiltration abundant, lemon yellow.

Resin canals present, solitary or **2** —3 contiguous; contents white (Pearson and Brown, 1932).

Properties

Wood light greyish-brown with slightly darker streaks, turning reddish brown with age, somewhat lustrous when first exposed but soon becoming dull, interlocked grained, medium textured, heavy to very heavy, sp. gr. approximately 0.94. Weight 981 Kg/m^3 at 12 percent moisture content (Chowdhury and Ghosh, 1958; Pearson and Brown, 1932).

Uses

A constructional timber for beams, posts and door frames. In rural areas, used as plough handles. Local artisans use the timber for turnery.

Non wood products

The species yields a resin which is used as an incense. It is also reported to be used in indigenous medicine (Kirtikar and Basu, 1918).

SHOREA WORTHINGTONI Ashton

Syn. *Doona venulosa* Thw.

A medium sized tree attaining a height of 30m and a girth of 2m Bark surface pale brown, with thin flakes; inner bark pale brown. Young twigs slender, rugulose, ***grey-***

yish brown, with short horizontal linear stipular scars. Leaves 4.5 – 9.5cm by 1.5 – 4cm, elliptic to ovate, subcaudate, acuminate, base cuneate, coriaceous, margin subrevolute; lateral nerves 6 – 9 pairs, ascending, slender, midrib slender but prominent below, narrowly depressed above; petiole 0.6 – 1.2cm long, slender, with adaxial furrow, stipules 1.6cm by 0.3cm, linear-lanceolate, acute, fugaceous. Panicle subterminal or axillary, 7cm long, slender, lax, with 5cm long branchlets bearing 4 flowers. Corolla 1.3cm, white as also the calyx, ovary and panicle; anthers yellow (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

This species is found in Udugama, Kanneliya, Sabragamuwa and Gilimale.

Forest Types and Floristics

This endemic species is confined to isolated localities in the Lowland Wet Evergreen Forest (Andrews, 1961). It prefers well drained soil on hill slopes and ridges. It is mostly scattered, but small gregarious patches are occasionally seen.

Floristics

Kanneliya

I *Dipterocarpus hispidus, D. zeylanicus, D. glandulosus. Shorea trapezifolia,* **S** *oblongifolia. S. worthingtoni, Palaquium petiolare, P. rubiginosum, Magifera* ***zey-*** *lanica*

I1 *Calophyllum bracteatum. C. soulattri, Kurrimia zeylanica, Chaetocarpus castanocarpus, Mesua ferrea.*

I11 *Semecarpus gardneri,* ***S.*** *subpeltata. Dillenia retusa. Acronychia pedunculata, Evoidia lunu-ankenda. Symplocos spicata, Humboldtia laurifolia.*

Silviculture and Management

Phenology

Flowering in April.

Regeneration is rather poor. Occasionally a few saplings are seen in the vicinity of the mother trees. Being a restricted species, no attention has been paid for its regeneration.

Wood

Structure

Vessels many, 36/mm^2, moderately small, mostly solitary, but occasionally in groups of 3, perforations simple, obleque; tyloses present.

Paratracheal parenchyma banded.

Rays moderateiy fine, uniseriate and multiseriate, heterogeneous;

Fibres nonseptate and nonstoried.

Resin canals present (Jayamanne, 1978).

Properties

Wood pale yellow.

Uses

This species has rio recognised end **use.**

SHOREA ZEYLANICA (Thw) Ashton

Syn. *Doona zeylanica* Thw.

A moderate sized to large tree reaching a height up to 45m and a girth of 4m with a somewhat sinuate bole and hemispherical crown with horizontal branches. Bark surface tawny brown. irregularly flaky; inner bark pale brown. Twigs very slender, glabrous. Leaves 3 – 9cm by 2.8cm, narrowly elliptic-lanceolate, caudate acuminate, base cuneate, revolute, coriaceous; lateral nerves about 8 pairs, ascending, arched, obscure; petiole 0.8 – 1.4cm long, very slender; stlpule fugaceous. Panicle axillary or terminal, 5cm long, lax, pedant, with 3cm long branchlets bearing 4 flowers. Sepals broadly ovate, acute, pubescent. Petals linear, acute, spreading, pubescent outside. Stamens many; anthers yellow. Fruit 0.7cm by 0.5cm, ovoid, apiculate; the 3 larger fruit sepals 2.8cm by 0.6cm, spatulate, obtuse, thickened and saccate at base, the 2 shorter sepals 0.7cm by 0.4cm, ovate (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs in Deltota, Kurulugala, Rasagala, Sinharaja and Deniyaya.

Forest Types and Floristics

This endemic species is localised to restricted areas in Lowland Wet Evergreen Forest and Highland Wet Evergreen Forest (Andrews, 1961). It is conspicuous on ridge tops, emerging out of the top canopy. It is reported that the species was once common in the Highland Wet Evergreen Forest.

Silviculture and Managemen

Phenology

Flowering from March to May. At infrequent intervals flowering is heavy.

Wood

Structure

Vessels moderately numerous, medium sized, mostly solitary with occasional multiple up to 3; tyloses present.

Paratracheal parenchyma vasicentric.

Rays fine.

Resin canals in tangential rows.

Properties

Wood pale yellow to light brown, fine textured, straight grained and hard. Weight 960Kg/m^3 at 12 percent moisture content.

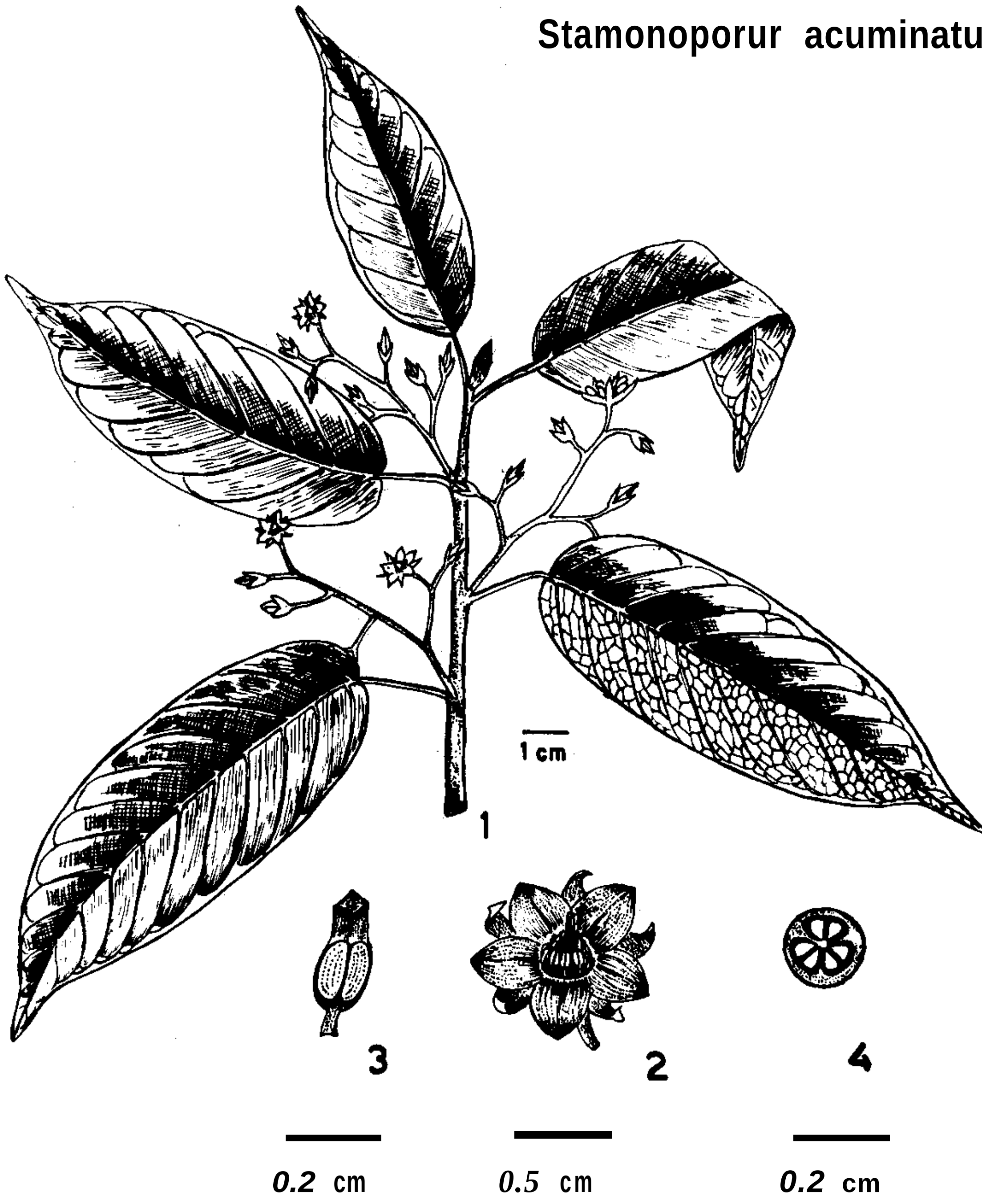
Seasons slowly with a tendency to split, fairly durable under cover, works easily and finishes to a smooth surface.

Uses

Used in building construction **as** joists, beams, planks for flooring and as shingles.

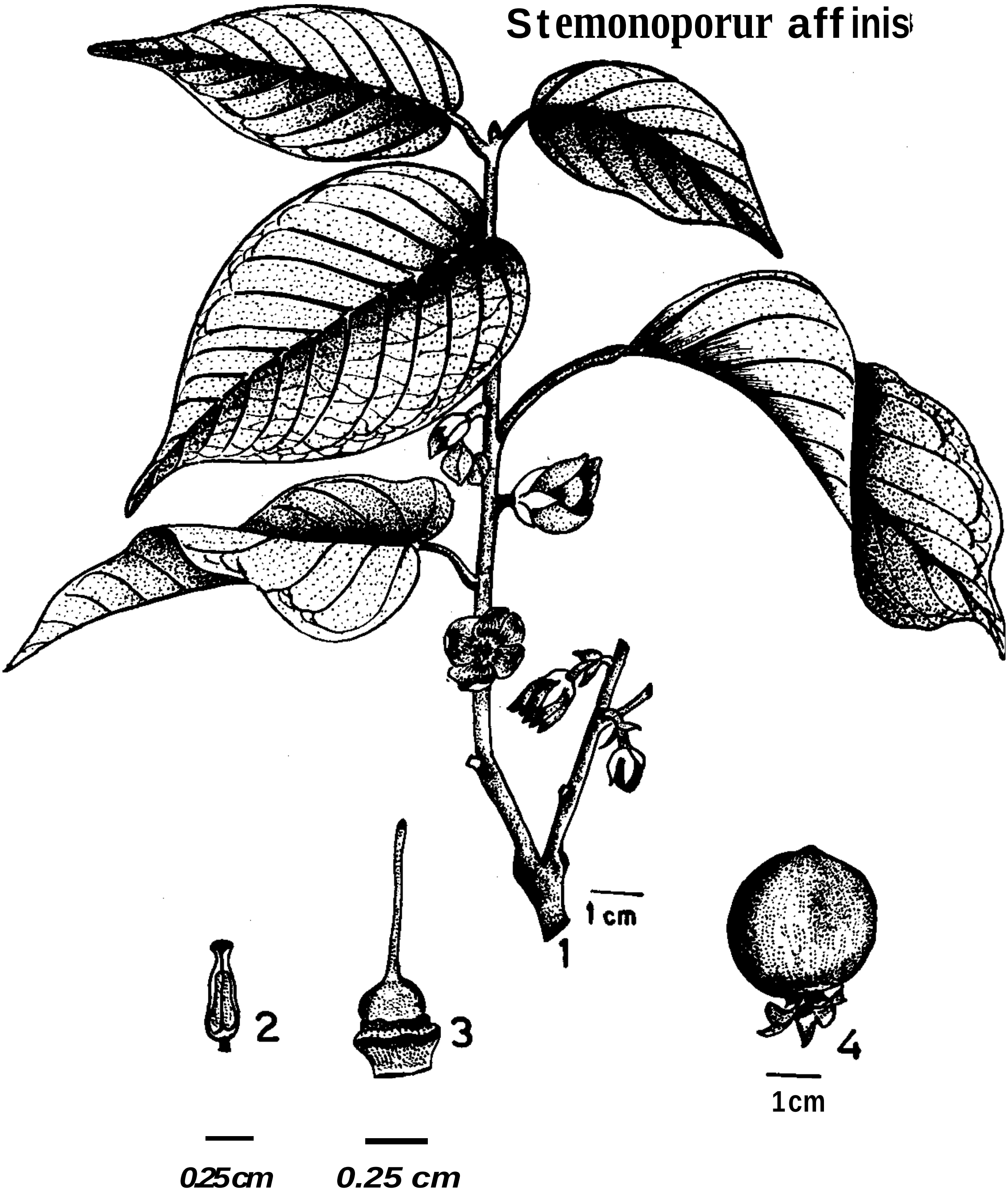
Stemonoporus

Stamonoporur acuminatus



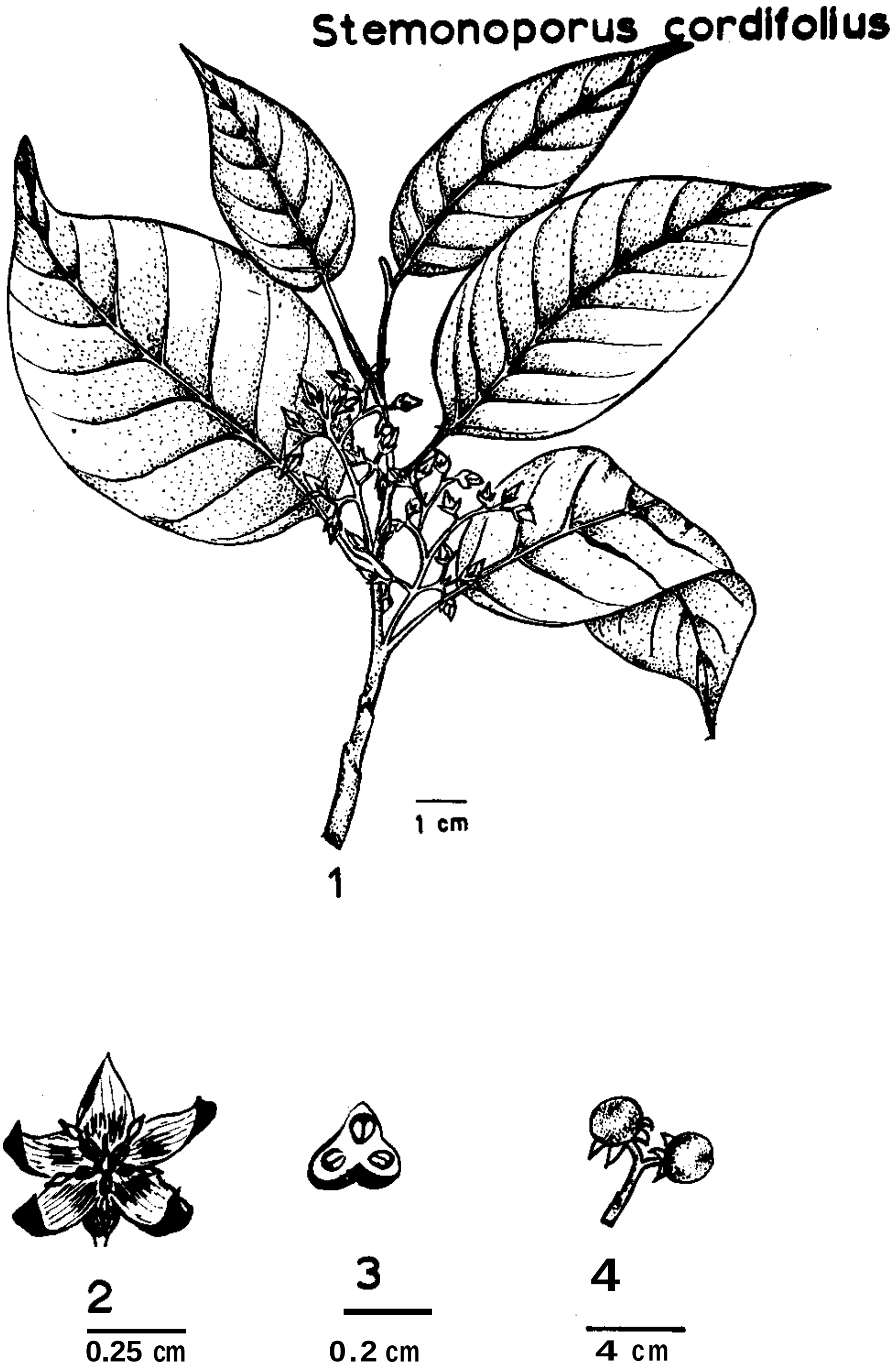
Stemonoporus **acuminatus**

1. **Flowering shoot**
2. **Flowerbud**
3. **Flower**
4. **T.S. of ovary**



Stemonoporus affinis

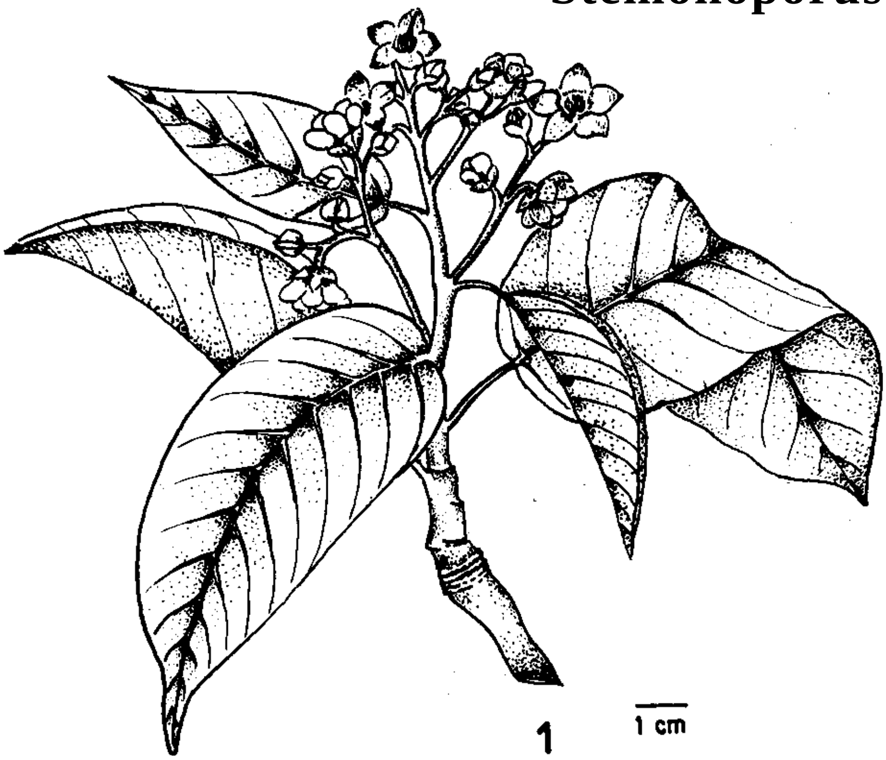
1. **Flowering shoot** 4. **Fruit**
2. **stamen**
3. **Pistil**

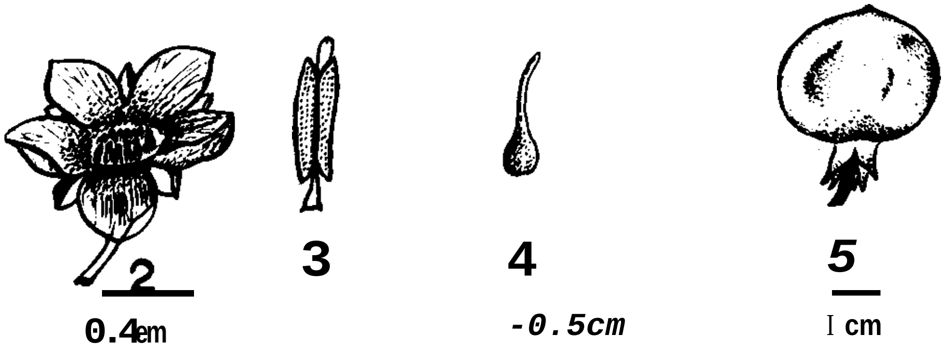


Stemonoporus **cordifolius**

1. **Flowering shoot**
2. **Flower**
3. **T.S. of ovary**
4. **Fruits**

Stemonoporus gardneri





Stemonoporus gardneri

1. **Flowering shoot**
2. **Flower**
3. **Stamen**
4. **Pistil**
5. **Fruit**

CHAPTER X

STEMONOPORUS Thw.

Very small to medium sized trees. Young parts typically densely puberulent. Twigs with very small obscure stipule scars. Leaves very variable in size and shape; petiole prominently geniculate; stipule minute, linear, fugaceous. Flowers in subterminal axillary racemes or panicles, or inflorescence more or less ramiflorus and reduced to a shortly pedunculate subcymose cluster or single flower. Sepals imbricate. Petals connate basally. Stamens 5 and equal or 10 or 15 and more or less unequal; filaments very short; anthers linear, tapering, the outer pair longer than the inner pair. Ovary 2—3 locular, ovoid, densely pubescent; style 2—3 times longer than the ovary, stigma obscure. Fruit globose to ovoid, with thick corky fibrous pericarp and distinct loculicidal sutures; fruit sepals short, equal, patent or reflexed (Ashton, 1977).

Wood

Vessels solitary or grouped. Parenchyma sparse. Rays heterogeneous with frequently enlarged marginal cells. Resin canals partly with tendency for tangential orientation (Gottwald and Parameswaran, 1966).

Distribution 15 species : Sri Lanka

STEMONOPORUS ACUMINATUS (Thw.) Bedd.

Syn. ***Vateria acuminata*** Thw.
Vateria jucunda Thw. ex trimen

Vesquella acuminata (Thw.) Heim
Sunapteopsis jucunda (Thw. ex Trim.) Heim

A medium sized tree reaching a height of 30m and a girth up to 3m. Young twigs pubescent. Leaves 6 – 16cm by 1.7 – 7cm, lanceolate-oblong, acuminate, base broadly cuneate to obtuse, glabrous; lateral nerves 10-12 pairs, slender, prominent below; petiole 1 – 2.7cm long, prominently genticulate. Inflorescence axillary racemes or panicles, pubescent; flowers distinctly pedicelled. Sepals linear-lanceolate, pubescent outside. Petals oblong, united slightly. Stamens 15 Ovary ovoid, densely pubescent; style filiform (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

In Ambagamuwa Badulla Rakwana, Kurulugala, Kiribatgala and Pelmadulla.

Forest Types and Floristics

This endemic species is gregarious in small patches in the Lowland Wet Evergreen Forest between elevation 600 to 1000m. It is also found in the Highland Wet Evergreen Forest up to an altitude of 1300m. It is conspicuouly seen exposed knolls.

Phenology

Flowering sporadically at all times.

The species **is** *of* little economic value and the timber has no distinct end use.

STEMONOPORUS AFFINIS Thw.

Syn. ***Vateria affinis*** Thw.
Vateria thwaitesii DC.

A small tree reaching a height of 15m

and a girth of 1m with an irregular hemispherical crown and twisted branches. Young parts glabrous. Leaves deflexed, 4.5 – 13cm by 2.7 – 7cm, broadly ovate, acuminate, cuneate at base, glabrous above and scabrous beneath; lateral nerves 9 – 11 pairs, arched, prominent below and more or less channelled above petiole 0.8 – 2.5cm long, slender. Inflorescence axillary, 1.5cm long, sparsely puberulent, few flowered Sepals oblong-Ianceolate, acute, puberulent at the base. Petals as twice as long as the sepals, orbicular, white. Stamens 15, slightly unequal. Ovary ovoid, pubescent; style slender. Fruit globose, 2.5cm in diameter; sepals in fruit 0.8cm by 0.4cm (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is confined to Hunasgiriya.

Forest Types and Floristics

This highly restricted species is semi-gregarious in the lower canopy of the Highland Wet Evergreen Forest (Andrews, 1961) between elevations 1100 – i600m

Phenology

Flowering sporadically throughout the year.

Being small in size and restricted in occurrence the species has no economic value.

STEMONOPORUS CANALICULATUS Thw.

Syn. ***Vateria canaliculata*** Thw.

A small tree 15m tall with a very slender stem with few branches. Young twigs tawny puberulent. Leaves 7cm by 2cm, elliptic lanceolate, acuminate, cuneate at base, coriaceous; lateral nerves 11 – 20 pairs, ascending, slender, prominent below and depressed above; petiole 1.5 – 6cm long, geniculate. Flowers solitary, pedicels very short. Sepals ovate, acute, pubescent. Stamens 15, subequal. Ovary ovoid, tomentose; style slender. Fruit depressed-globose to globose, smooth, 3cm in diameter; fruit sepals 0.8cm by 0.4cm (Ashton 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found in Kande, Kanneliya and Pasdun Korale.

Forest Types and Floristics

The species is gregarious in the understorey of the Lowland Wet Evergreen Forest (Andrews, 1961), but localized.

Phenology

Flowering in April and fruiting during May–June. An unimportant species of localised occurrence.

STEMONOPORUS CEYLANICUS (Wight) Alston

Syn. ***Vateria ceylanica*** Wight
V. wightii Thw
Stemonoporus wightii Thw

A medium sized monopodial tree reaching a height of 30m and a girth of L5m, with a dense oblong crown. The young twigs puberulent. Leaves 10 – 25cm by 8 – 14cm, oblong-elliptic, with obtuse base and obtuse to mucronate apex, coriaceous, glabrous above and slightly scabrous helow; lateral nerves 14 – 24 pairs, arched, prominent below, narrowly depressed above; petiole 2 – 7cm long, stout, prominently geniculate. Panicle axillary, puberulent, branchlets bear 6 flowers. Sepals ovate-oblong, obtuse, pubescent. Petals ovate, acute, white. Stamens 15, anthers unequal, yellow. Ovary densely puberulent; style linear. Fruit ovoid, subacute, prominently ribbed; sepals in fruits reflexed (Ashton, 1977 Trimen, 1893).

Distribution – Sri Lanka

Ratnapura, Sinharaja, Ellaboda Kande, Yatipora, Pelmadulla, Kuruwita, Nambapana and Lubugama.

Forest Types and Floristics

The species is scattered in the Lowland Wet Evergreen Forest (Andrews, 1961), more commonly on moist soil near streams.

Phenology

Flowering in April.

An economically unimportant species.

STEMONOPORUS CORDIFOLIUS (Thw.) Alston

Syn. ***Monoporandra*** *cordifolia* Thw.
Vateria cordifolia Thw.

A small tree attaining a height of 30m and a girth of 1m with a feathery spreading crown; the branches arise very low from the bole. Young twigs puberulous. Leaves 3.5 – 11cm by **2** – 6cm, ovate, caudate acuminate, base obtuse to subcordate, coriaceous. lustrous; lateral nerves 6 – 7 pairs, slender, prominent below, puberulent on the lower surface; petiole 1.2 – 2.5cm long, slender, geniculate. Panicle axillary; flowers small, pedicels pubescent. Sepals linear-lanceolate, acute, glabrous. Petals acute, dark lemon yellow. Stamens 5. Ovary puberulous; style filiform. Fruit globose, apiculate, 1.3cm in diameter; sepals in fruit 0.5cm by 0.2cm (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

In Ambagamuwa, Gabboda, Peak Sanctuary and Eastern Bambarabotuwa.

Forest Types and Floristics

Localized as a gregarious understorey species in the Lowland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowering in April.

An economically unimportant species.

STEMONOPORUS ELEGANS (Thw.) Alston

Syn. ***Monoporandra*** *elegans* Thw
Vateria &gum Thw.

A small tree reaching a height up to 20m and a girth less than Im with a feathery crown with descending branches. Young twigs glabrous. Leaves 4 – 7cm by **2** – 2.5cm, ovate to lanceolate, narrowly caudate acuminate, thinly coriaceous, margin at the base somewhat revolute; lateral nerves 6 – 7 pairs, with shorter intermediates; petiole 0.7 – 0.9cm long, slender. Racemes axillary **or** terminal. Sepals narrowly linear, very acute. Petals obtuse, dark lemon yellow. Stamens 5. Ovary globular, 2-celled; style linear; stigma minute. Fruit globular, apiculzte, 1.2m in diameter; fruit sepals 0.4m long, slender (Ashton, 1977; Trimen, 1893)

Distribution – Sri Lanka

The species is confined to the southern slopes of Adam's Peak

Forest Types and Floristics

A highly restricted understorey species occurring gregariously in the Highland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowering in April

Nonwood Products

A triterpene belonging to the Ursene **or** Oleanene series has been isolated from the bark and timber (Bandaranayake *et* a1.,1977).

A species of little economic importance.

STEMONOPORUS GARDNERI Thw.

Syn. *Vateria gardneri* Thw.

A small tree attaining a height of 20m and a girth of 2m with a dense spreading hemispherical crown. Young parts sparsely pale, tawny pubescent, fugaceous except at twig apex. Leaves 4.5 – 12cm by **2** – 7cm. Ovate **or** oblong-ovate, acuminate, obtuse rounded at base, glabrous; lateral nerves 9 – 13 pairs, slender but prominent beneath, applanate above; petiole 0.6 – 2.8cm long, slender, geniculate. Panicle lax, with 3cm long branchlets, each bearing 5 flowers. Sepals broadly ovate, acute, glabrous. Petals pale yellow. Stamens 15. Ovary tomentose; style slender. Fruit globose, 3.5cm in diameter, smooth; sepals in fruit 0.8cm by 0.4cm, sub-ovate (ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs in Rambodde, Adam's Peak, Maskeliya, Rakwana, Walan Kande and Eastern Sinharaja.

Forest Types and Floristics

A localised species found mostly in the upper reaches of the Highland Wet Evergreen Forest (Andrews, 1961), often touching the Tropical Montane Forest. In the higher reaches of the Highland Wet Evergreen Forest the species is often dominant with a semi gregarious habit.

Phenology

Flowering between January and March and fruiting from March to May.

A species of little economic importance.

STEMONOPORUS LANCEOLATUS Thw.

Syn. *Vateria lanceolata* Thw.

A very small tree reaching a height of 6m and a girth of 20cm. Petiole, and flower pedicel puberulent. Twigs terete, smooth. Leaves 7.5 – 19cm by 3.2 – 8cm, lanceolate to narrowly elliptic acuminate, obtuse to broadly cuneate at base, thinly coriaceous; lateral nerves 7 – 12 pairs, slender but prominent below and depressed above; petiole 1.2 – 2.5cm long, obscurely geniculate. Flowers solitary to ramiflorus on 0.5cm long slender pedicels. Sepals linear lanceolate. Stamens 15, anthers pubescent. Fruit 2.5cm in diameter, globose, sepals in fruits 0.5cm by 0.2cm, more or less reflexed (Ashton, 1977;Trimen, 1893).

Distribution – Sri Lanka

Kuruvita Korale, Eratne, Demanhandiya and Eknaligoda Kande.

Forest Typesand Floristics

This rare and restricted species is found in small gregarious groups on steep rocky hill slopes in the Lowland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowering in March.

A species of no recognized commercial value.

STEMONOPORUS LANCIFOLIUS (Thw.) Ashton

Syn. *Monoporandra lancifolia* Thw
Vateria lancifolia Thw
Stemonoporus nitidus spp. *lancifolius* Dyer
Stemonoporus nervosus Thw

A very small tree with a straight stem and slender branches. The leaves 5 – 14cm by 1.2 – 4.8cm, lanceolate, acuminate, broadly cuneate to obtuse at base; lateral nerves 8 – 12 pairs, slender, laxly reticulate; petiole 0.6 – 0.9cm long, slender. Flowers in groups of 3 on 1cm long slender axillary peduncles; pedicels 1.2cm long. Sepals linear acute. Corolla white, 1.2cm in diameter. Stamens 15. Ovary ovate, tomentose; style linear. Fruit globose, apiculate, 1.5cm in diameter; sepals in fruit 0.8cm by 0.2cm (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species occurs in Hellepel, Pasdum Korale, Kitugala and Hewesse.

Forest Types and Floristics

This species is semigregarious on hill slopes and river banks in the Lowland Wet Evergreen Forest (Andrews, 1961), confined to restricted localities.

Phenology

Flowering in May and fruits ripen during July – August.

Non wood products

A triterpene belonging to the Ursene or Oleanene series has been isolated from the bark and timber (Bandaranayake *et al.*, 1977).

The species is economically unimportant.

STEMONOPORUS NITIDUS Thw.

Syn. *Vateria nitida* Thw.

A medium sized to large tree, sometimes attaining'a height of 40m and a girth of 2.5m with an oblong or compact hemispherical crown. Leaves 5.5cm by 2.5 – 4cm, lanceolate or ovate-oval, caudate acuminate, broadly cuneate at base, coriaceous; lateral nerves 6 – 8 pairs, slender; petiole 0.5 – 1.6cm long, slender, geniculate. Flowers mostly solitary, axillary; pedicels very short, stout. Sepals lanceolate, acute, puberulous. Stamens 15. Fruit globose, apiculate. 1cm in diameter; sepals in fruit 0.5by 0.3cm, oblong (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is found in Gilimale, Hiniduma Korale, Sinharaja and Pasdun Korale.

Forest Types and Floristics

A restricted species localised in small groups on ridges in the Lowland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowering in April and fruits ripen in May—June.

Being of restricted occurrence, it has no recognized end use.

STEMONOPORUS OBLONGIFOLIUS Thw.

Syn. *Vateria oblongifolia* Thw.

A small tree, grows up to 20m in height and attains a girth of 1m with an irregularly shaped crown; bole usually crooked. Young twigs and buds densely puberulent. Leaves 4 – 12cm by 2.5 – 4.5~1,elliptic to oblanceolate, glabrous; lateral nerves 7 – 10 pairs, slender, somewhat sinuate, prominent on both surfaces; petiole 0.7 – 2.2cm long, shortly pubescent. Inflorescence terminal or axillary, 3cm long, pubescent; flower buds broadly ovoid. Sepals ovate, acute. Stamens 15. Fruit subglobose, 2.8cm in diameter, with **3** loculicidal shallow grooves; sepals in fruit 0.6cm by 0.3cm, reflexed (Ashton, 1977,Trimen, 1893).

Distribution – Sri Lanka

In Adam's Peak and Ambagamuwa.

Forest Types and Floristics

The species is of extremely restricted occurrence, found sporadically in the higher reaches of the Highland Wet Evergreen Forest (Andrews, 1961).

The species has no commercial value.

STEMONOPORUS PETIOLARIS Thw.

Syn. ***Vateria petiolaris*** Thw.

A small tree reaching a height of 20m and a girth of 1m. Leaves 8 – 30cm by 3.5 – 10cm, narrowly oblong, acuminate, obtuse to broadly cuneate at base, coriaceous; lateral nerves 10 – 19 pairs, arched, slender, coalesing with the margin to form a looped intramarginal vein; petiole **2** – 2.7cm long, slender, prominently geniculate. Flowers pale yellow, in groups of 5 in axillary or extraaxillary ramiflorus inflorescence; pedicels 0.3cm long, sepals ovate, acute, pubescent; corolla 1.4cm in diameter. Stamens 10 – 15 (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is confined to Kitulgala and Gilimale.

Forest Types and Floristics

A rare and restricted species occasionally found on well-drained deep soil in the Lowland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowers appear in May and fruits ripen in July.

The species has no economic importance.

Non wood products

A triterpene belonging to the Ursene or Oleanene series has been isolated from the bark and timber (Bandaranayake ***et*** *al.*, 1977).

STEMONOPORUS RETICULATUS Thw.

Syn. *Vateria reticulata* Thw.

A medium sized tree attaining a height of 25m and a girth of 1.5m with an oblong dense crown. Young parts puberulent. Leaves 5 – 17cm by 2.5 – 9cm, ovate-lanceolate, acuminate, broadly cuneate to obtuse at base, margin subrevolute, thickly coriaceous, glabrous; lateral nerves 8 – 12 pairs, faintly prominent on both surfaces, petiole 1 – 1.5cm long, prominently geniculate. Flowers white, shortly pedicelled in groups of 5. Sepals lanceolate, acute, glabrous. Stamens 15. *Ovary* ovoid, subpersistently pale rufous puberulent. Fruit 5cm by 4cm, globular ovoid, subacute prominently ribbed; sepals in fruit lcm by 0.4cm, reflexed, with more or less impressed base (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is confined to Kanneliya and Hiniduma Korale.

Forest Types and Flonstics

An extremely localised species in the Lowland Wet Evergreen Forest (Andrews, 1961).

Phenology

Though flowers appear sporadically throughout the year, maximum flowers in September and fruits during October – November.

The species has little economic importance.

STEMONOPORUS REVOLUTUS Trimen ex Hook. f.

A small tree. Young parts fugaceous, puberulent. Leaves 4 – lOcm by 2 – 5cm, more or less, shallowly retuse, broadly cuneate at base, thickly coriaceous, prominently revolute; lateral nerves 8 – 14 pairs, slender; petiole 1 – 1.2cm long, stout. Flowers in groups of 5 in 3cm long axillary ramiflorous infloresscence. Stamens 15 (Ashton, 1977; Trimen 1893)

Distribution – Sri Lanka

The species occurs in Kiribatgale, Sinharaja and Kukul Korale.

Forest Types and Floristics

The species is of localised occurrence, confined mostly to ridges in the Highland Wet Evergreen Forest (Andrews, 1961).

Phenology

Flowering apparently sporadically at all times.

The species has no economic value.

STEMONOPORUS RIGIDUS Thw.

Syn. Vateria ***rigida*** Thw.

A small tree. Young parts puberulent, persistent on twig and petiole. Leaves 6 – 14cm by 3.5 – 5.5cm, narrowly elliptic to oblanceolate, with cuneate base and subacute to retuse acumen, thickly coriaceous; lateral nerves 7 – 11 pairs, ascending, rather straight, prominent beneath, depressed above; petiole 1.2 – 5cm long, more or less obscurely geniculate. Flowers shortly pedicelled in congested axillary to ramiflorus clusters. Sepals ovate-oblong, obtuse, puberulent. Petals oblong. Stamens 15. Ovary puberulent (Ashton, 1977 Trimen, 1893).

Distribution – Sri Lanka

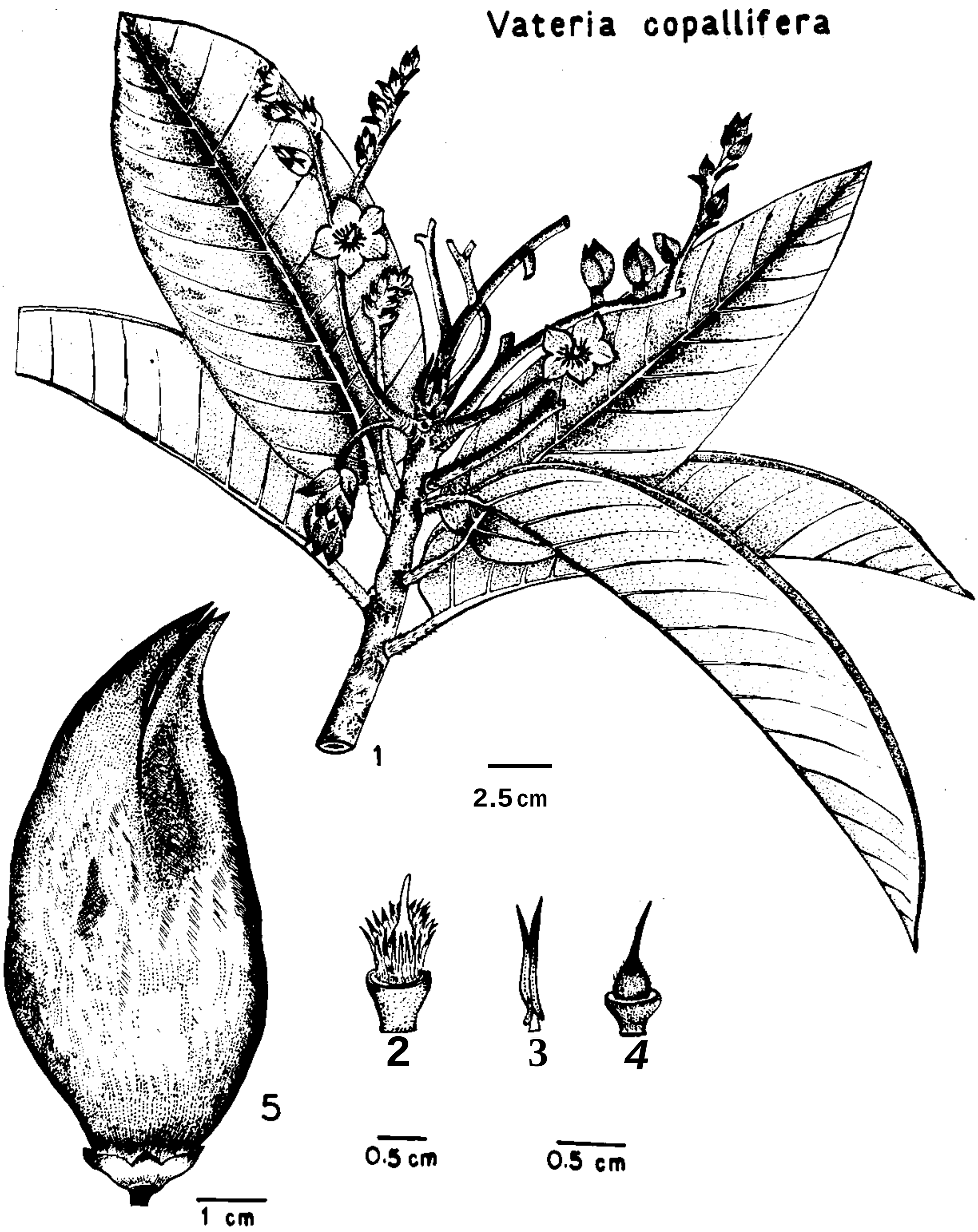
An extremely rare species reported from the Ambagamuwa region only.

Phenology

Flowering in April and fruits ripen in June–July.

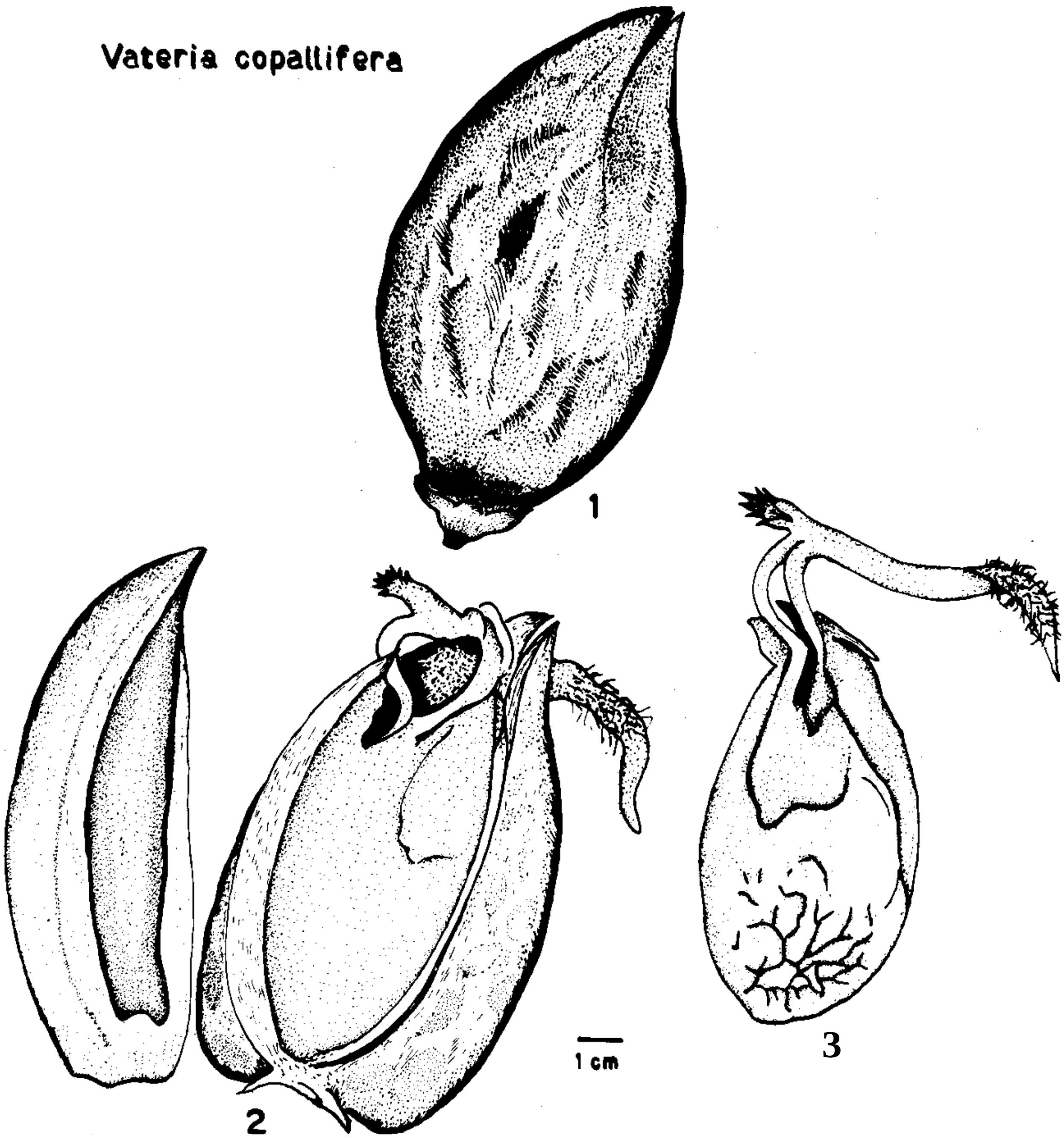
The species has no economic importaance.

Vateria



Vaterid **copallifera**

1.	**Flowering shoot**	**4.**	**Pistil**
2.	**Stamens and Pistil**	**5**	**Fruit**
3.	**Stamen**		

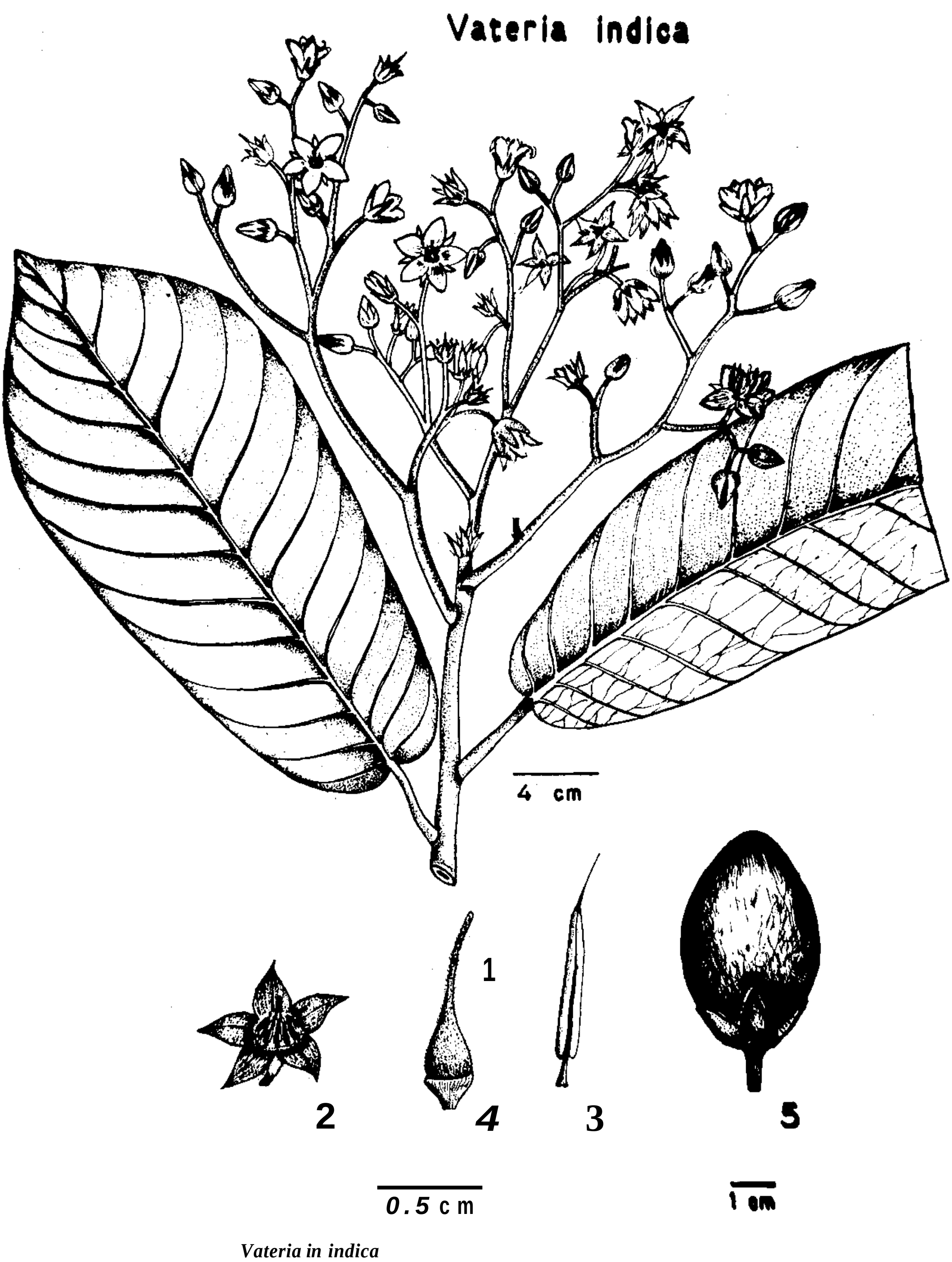


Vateria copallifera

1. . Frnit

2. & 3. Germination stages

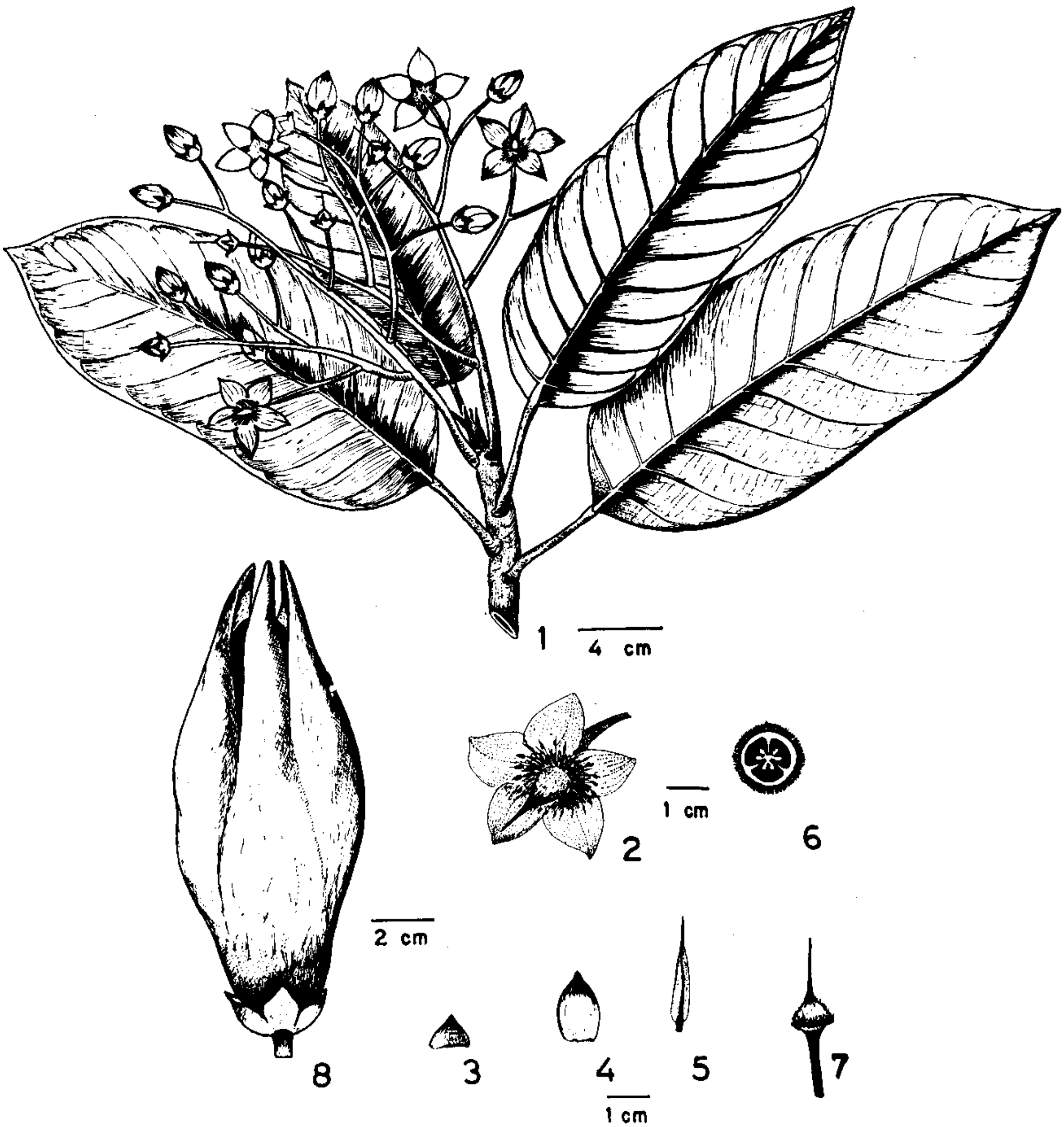
Vateria copallifera
(Cheracteristic Ascending Branches)
Kandy
(Photo KFRI)



Vateria in indica

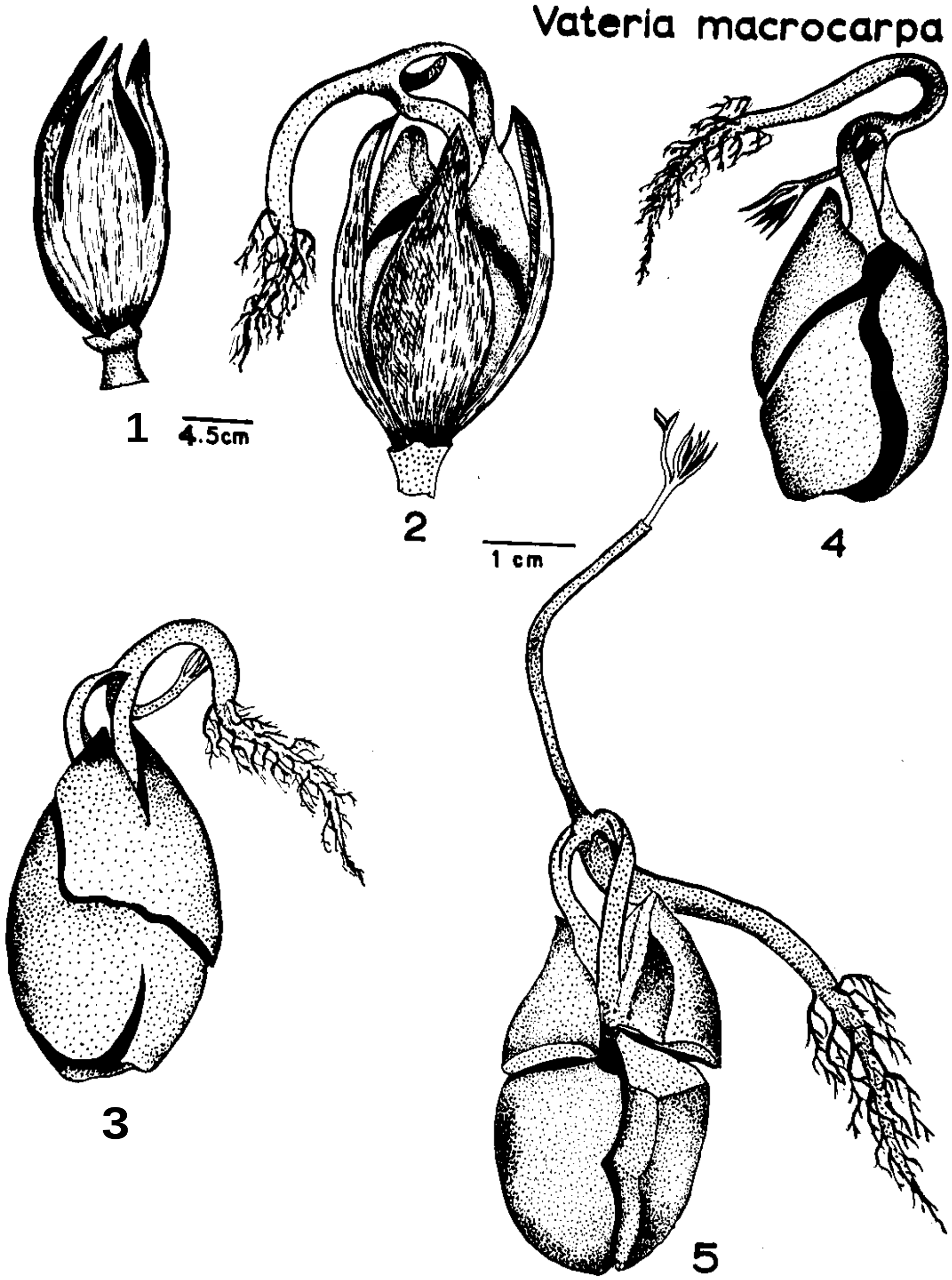
1. Flowering shoot	**4. pistil**
2. Flower	**5. Young fruit**
3. Stamen	

Vateria macrocarpa



Vateria macrocarpa

1. **Flowering shoot**
2. **Flower**
3. **Sepal**
4. petal
5. **Stamens**
6. **T.S. of ovary**
7. **Fruit**



***Vateria* macrocarpa Germination stages**

CHAPTER XI

VATERIA Linn.

Medium to large trees. Bark smooth, grey. Young twigs scabrous to tomentose. Leaves entire, usually coriaceous; petiole long, stout; stipule small, deciduous. Flowers in terminal or axillary racemose panicles. Sepals pubescent. Petals. white or cream coloured, often connate at the base. Stamens many; anthers linear; appendage to connective subulate, short or as long as the anther. Ovary densely tomentose; style subulate; stigma minute. Fruit ovate, oblong-obtuse or ovoid, sometimes beaked. Sepals in fruit equal, more or less reflexed (Ashton, 1977; Gamble, 1915;Hooker, 1877).

Wood

Vessels large to medium, often in pairs or clusters of 2-5. Parenchyma not profuse. Fibres straight to moderately alternating spiral. Rays distinct. Resin canals numerous. Wood white to yellowish to greyish brown, soft to moderately soft, moderately heavy, rather coarse textured (Chowdhury & Ghosh, 1958; Gottwald & Parameswaran, 1966).

Uses

Suitable for light construction work and commercial plywood.

Distribution **3** species. India and Sri Lanka

VATERIA COPALLIFERA (Retz.) Alston

Syn ***Elaeocarpus copalliferus*** Retz.
Vateria acuminata Heyne
(Stemonoporus acuminatus) – V. indica Sensu **Bl.**

Common name
Sinh. – Hal

A fairly large tree reaching a height of 40m and a girth of 4m with dense ascending branches. Bark surface smooth, pale grey, flaking irregularly, leaving scalloped surfaces below. Twigs densely tomentose. Leaves 12 – 15cm by 5 – 18cm, broadly to narrowly oblong, very shortly acuminate, obtuse to subcordate at base, thickly coriaceous, sparsely hairy on the lower surface; lateral nerves 18 – 25 pairs, spreading, prominent below; petiole 2 – 5.5cm long, tomentose. Panicle subterminal, densely tomentose; bracts 1cm long, concave, ovate, acute. Sepals subequal, hastate, subacute. Petals oblong, subacute, cream coloured. Stamens many; filaments very short, connective awn recurved. Ovary ovoid, tomentose; style slender, glabrous. Fruit ovoid, apiculate, 11cm by 7cm; sepals in fruit 1.5cm by 0.7cm lanceolate, subacute, reflexed.

Note: – Alston established this species i 1931. The above description is adopted from Ashton **(1977),** who has stated that he has not examined the type and relied on the identification of Alston and Fischer. **From** our observations it appears that the species **is** identical *to* ***Vateria macrocarpn*** Gupta **(1929),** which **is** endemic to India. More detailed studies are necessary to establish the taxonomic status.

Distribution Sri Lanka

The species is found in Ambagamuwa, Nawalapitiya, Kanneliya, Ratnapura, Gilimmale, Indikada and Mataka.

Forest Types and Floristics

The species is scattered over a wide area in the Lowland Wet Evergreen Forest (Andrews, 1961) on moist hill slopes and along the river hanks up to an elevation of 1000m. In some localities it is an important constituent of the top canopy.

Floristics

(i) Mataka

I *Euphoria longana, **Vitex** pinnata, Filicium decipiens, Terminalia parviflora, Alseodaphne semecarpifolia, Hydnocarpus venenata, Carallia brachiuta, Semecarpus coriacea. Vateria copallifera, Myristica dactyloides, Pterospermum canescens, Chukrassiu velutina. Mangifera zeylanica,. Gordonia* spp., *Ficus callosa. Homalium zeylanicum Calophyllum tomentosum.*

I1 *Neolitsea involucrata, Litsea* sp., *Maba buxifolia, Pavetta indica, Garcinia morella.*

111 *Calamus* spp., *Cippadessa baccifera, Ardisia elliptica, Phyllanthus* sp.

(ii) Kanneliya

Dipterocarpus zeylanicus, Artocarpus nobilis, Vateria copallifera, Shorea congestiflora, S. trapezifolia, Syzygiurn sp., *Lasiunthus apicalis, Palaguium* spp., *Wormia triquetra, Dillenia retusa, Prosorus indica, Mastixia tetrandru, Litsea glutinosa, Myristica dactyloides. Vitex pinnata, Gyrinops walla, Nothopegia beddomei, Meliosma simplicifolia, Cinnamomum multiflorum.*

Silviculture and Management

Phenology

Flowering commences about January–February and continues to April – May. The period of maximum flowering is generally March – April. Fruits ripen during Septemher to November.

Regeneration in the natural forest is satisfactory. Although the fruits are liable to he damaged by insects, germination is common and seedlings establish themselves easily. Germination is epigeal. The pencarp splits longitudinally from the apex downwards. The thick fleshy reddish cotyledons emerge out after the primary root establishes itself. No special methods have been adopted to regenerate the species.

Wood

Structure

Vessels numerous, medium to large, mostly solitary; tyloses absent.

Parenchyma indistinct.

Rays medium sized.

Resin canals in tangential rows.

Properties

Wood pale yellowish brown with narrow dark coloured streaks, moderately hard. Weight 640Kg/m^3 at 12 percent moisture content.

Timber is fairly durable under cover, but not durable in exposed conditions. Saws and works easily and finishes to a fairly smooth surface.

Uses

Suitable for light construction work as planks, used in plywood industry also.

Non wood products

The cotyledons are ground into a flour which is edible. The bark is used for arresting fermentation of toddy.

VATERIA INDICA Linn.

Syn. *Vateria malabarica* **Bl.**

Common names

Eng.		Indian Copal tree; Piney Varnish tree, White Dammer of southern India, White Dhup.
Kan.	–	Dhupa, Dhupa mara,

Illupathla.

Mal. – Paini-mara, Payini, Vellakundrikam, Vella pine.

Tam. – Dhup maram, Kondricam, Piney-maram, Valley kungiliam, Vellei-Kuntrikam.

Tel.. – Biliguggula, Dhupada, Guggula.

A medium to large evergreen tree attaining a height of 25m or more and a girth up to 5m. Bark surface smooth, grey. Young branches hoary stellate pubescent. Leaves 12 – 20cm by 6 – 9cm, oblong or elliptic-oblong, obtuse or minutely acuminate, base rounded or emarginate, glabrous on both surfaces, margin entire; lateral nerves about 14 pairs, very prominent below and depressed above; petiole stout, 2.5 – 3.5cm long; stipule lcm long, obliquely lanceolate, acute. Panicle terminal or lateral; flowers fragrant, pedicel about lcm long; bracts ovate, acute, caducous. Calyx lobes lanceolate, obtuse, hoary-pubemlous on both surfaces. Petals white, elliptic-oblong, obtuse. Stamens many; filament short; anther cells unequal, the outer being much larger; appendage as long as. the anther. Ovary ovate-oblong, pubescent; style filiform, glabrous. Fruit oblong-obtuse, 3-valved; fruit sepals not enlarged (Bourdillon, 1908; Cooke, 1901; Gamble, 1915).

Distribution – India

The species is confined to Western Ghats and its spurs, from North Kanara (Karnataka) to Tirunelveli (Tamil Nadu) through the Ghat Forests of Karnataka and Kerala.

Forest Types and Floristics

The species is chiefly found in the West Coast Tropical Evergreen Forest and to some extent in the West Coast Secondary Evergreen Dipterocarp Forest (Champion and Seth, 1968). The altitudinal range of the species is wido, extending from 65 to 1300m It is more frequent at higher levels in the West Coast Tropical Evergreen Forest. At low levels, although its frequency is less it attains better dimensions. It is generally not gregarious but a number of trees occur together interspersed with other species, thus giving an impression of a semi-gregarious habit. In Hassan Ghats (Karnataka) for example, it constitutes about 90 percent of the mature stand (Kadambi, 1957b). In moist localities, particularly along stream banks, it is occasionally gregarious.

Floristics

(i) Palghat, Kerala (West Coast Tropical Evergreen Forest – high level)

I *Cullenia exarillata, Machilus macrantha, Elaeocarpus tuberculatus, E. munrroii, Palaquium ellipticum. Mesua ferrea, Calophyllum elatum, Canarium strictum, Dysoxylum malabaricum, Vateria indica, Poeciloneuron indicum. Syzygium* sp., *Mangifera indica. Artocarpus heterophyllus, Polyalthia coffeoides, Cinnamomum zeylanicum. Holigarna arnottiana, H. grahamii, Hopea glabra, Litsea wightiana. Mastixia arborea, Dryptes elata.*

I1 *Myristica* sp., *Hydnocarpus pentandra, H. alpina. Euphoria longana, Lansium anamallayanum, Garcinia spicata, Elaeocarpus serratus, Gordonia obtusa, Syzygium* sp., *Baccaurea courtallensis, Glochidion malabaricum, Canthium dicoccum, Scolopia crenata, Xanthophyllum flavescens, Nothapodytes foetida, Actinodaphne hookeri.*

111 *Euonymus angulatus, Syzygum lineatum, Paramignya beddomei, Sauropus albicans, Leea indica, Saprosma fragrans, Webera* sp., *Clerodendrum viscosum, Macaranga roxburghii, Strobilanthes* sp., *Laportea crenulata. Olea dioica, Linociera malabarica, Callicarpa tomentosa, Pauetta* sp., *Vernonia arborea, Turpinia malabarica, Orophea uniflora, Sarcococca brevifolia, Croton scabiosus.*

(ii) Wynad (West Coast Tropical Evergreen – low level)

I *Vateria indica, Artocarpus hirsuta, Dysoxylum malabaricum. Artocarpus fraxinifolius. Hopea parviflora, Dipterocarpus indicus, Filicium decipiens, Kingiodendron pinnatum. Elaeocarpus* sp., *Bischofia javanica,* *Toona ciliata, Syzygium sp.*

I1 *Myristica* sp., *Litsea* sp., *Hydnocarpus pentandra, Pterygota alata, Vitex altissima, Schleichera oleosa. Cinnamomum* sp., *Pterospermum rubiginosum.*

111 *Leea indica, Strobilanthes* sp., *Calamus* sp.

(iii) Mangalore, Kamataka (West Coast Secondary Evergreen Dipterocarp Forest)

I *Hopea parviflora, H. wightiana, Vateria indica, Diospyros microphylla.*

I1 *Aporosa lindleyana. Olea dioica.*

I11 *Memecylon* sp., *Syzygium cayophyllatum*

Silviculture and Management

Phenology

Flowering is during January to March. Fruits ripen between May to July. Fruiting is not regular, one or two poor seed years alternate with one or two moderate seed s. years.

Natural regeneration

In good seed years, excellent regeneration is Seen below and around the mother trees. Fruits, being heavy, are not dispersed and regeneration is concentrated close to the mother trees. In the West Coast Tropical Evergreen Forest, where this species is a component at low levels, patches of seedlings are seen at frequent intervals during June —July. Survival of the seedlings depends upon adequacy of moisture and overhead shade. Failure of the monsoon and too liberal an opening of the top canopy can cause heavy mortality. Experiments in the Ghat Forest of Coorg (Karnataka) have shown that the r removal of unwanted species in the middle storey with retention of top canopy trees ensures faster growth of seedlings (Madras Silv. Res. Report 1927).

As natural regeneration is mostly concentrated in patches near the mother trees, it is a normal practice to supplement the same by artificial means. Sowing or dibbling fresh. ly collected seeds, planting out nursery grown seedlings with a ball of earth, planting out seedlings grown in containers, etc., have been tried with varying degrees of success. Good results have been obtained in direct sowing of freshly collected seeds in moist, well shaded forest areas after light soil working. Planting out seedlings grown in containers has given more reliable results with more than 70 percent survival. The containers should be fairly long (25 to 30cm) as the tap root grows rather rapidly (Rai, 1978). Germination commences in 2 – 3 days and is over in about 3 weeks. Germination percent is above 80. One year old seedlings are planted out in natural forest under overhead shade, in $30cm^3$ pits.

Artificial regeneration

Attempts have been made to underplant this species in Teak plantations and in open areas or strips in natural forest under shade crops like *Trema orientalis. Tephrosia candida*, etc., but with little success (Kadambi, 1957b).

Rate of Growth

A slow growing species., Statistics collected from Coorg have shown an annual girth increment of 1.9cm only (Somaiah, 1954).

Wood

Structure

Vessels large to medium, solitary or in clusters of 2 – 5 (usually-3), evenly distributed, 8-14/mm^2 ;perforations simple, transverse; tyloses present

Tracheids sparse.

Parenchyma paratracheal, metatracheal and surrounding resin canals; paratracheal parenchyma sparse; metatracheal parenchyma extremely sparse, restricted to solitary cells or short tangential rows; parenchyma surrounding resin canals sparse where the canals are solitary, abundant where the canals are zonate; pale lemon-yellow, infiltration present.

Fibres semi-libriform, medium fine, non-septate

Rays 3 – 7/mm, 5 - 9 seriate, heterogeneous; lemon yellow gummy infiltration abundant.

Resin canals longitudinal; contents white (Pearson and Brown, 1932).

Properties

Sapwood white with a tinge of grey and red; heartwood light yellow, turning light brown on exposure; lustrous when first exposed, often interlocked grained, medium coarse textured, sp. *gr.* about 0.60, moderately strong. Weight at 12 percent moisture content 576.67Kg/m^3.

Seasons without difficulty, both in the open and in the kiln. Sap stain common. Hence, conversion and seasoning immediately after felling advisable. Not durable. Heartwood refractory to treatment. Works and saws easily; peels well. Finishes to a good surface, takes good polish (Pearson and Brown, 1932).

Uses

A well known species for commercial plywood in South India. Mostly consumed by the plywood industry. **A** constructional timber of medium quality.

Non wood products

The tree yields an oleo-resin called 'White dammar' 'Indian copal' or Dhupa. Two methods of tapping are adopted to obtain the resin. In the first method, the barkj is wounded at the beginning of the dry season The resin will begin to ooze within 3 - 4 days and the flow will continue for 2 or 3 months. The second method is to light a fire around the base of the tree so as to scorch the bark, which then splits and the resin exudes.

The resin is in 3 forms.

1) Compact piney resin which is hard, in lumps of varying shapes, bright orange to dull yellow in colour, with a glossy fracture and resembling amber in appearance.

2) Cellular piney resin which occurs in shining masses, having balsamic odour and light green to yellow or white in colour.

3) Dark coloured piney resin from old trees.

The resin is a complex mixture of several triterpene hydrocarbons, ketones, alcohols and acids along with small amounts of sesquiterprenes. On distillation the oleo-resin gives an essential oil (76%) with a balsamic odour. The oil consists of phenolic constituents and azulenes, with the lattter predominating.

The essential oil has a marked antibacterial property against gram-negative and gram-positive microorganisms (Cbopra ***et*** *al.,* 1958, Howes, 1949).

The resin readily dissolves in turpentine and is used in the manufacture of varnishes. It is also used for torches or candles along with coconut oil in rural areas. Its solutions in chloroform can be used as a substitute for amber in photographer's varnish (Chopra ***et al.,*** 1958; Chandrasena, 1935). The resin is used to a large extent for making incense. It is also used in setting gold ornaments and for caulking boats (Trotter, 1940).

The resin has medicinal value. It is credited with tonic, carminative and expectorant properties and is used against throat troubles, chronic 'bronchitis, piles, diarrhoea, rheumatism, tubercular glands, etc. Mixed with gingly oil, it is used against gonorrhoea, with ghee and long-pepper for the treatment of ulcers. An ointment of the resin with the fat of *Garciniu indica* is said to be effective against carbuncles. It forms a good emollient for plasters and ointment bases (Chopra ***et*** *al.,* 1958; Kirtikar and Basu, 1935).

The kernels yield, by slovent extraction, about 22% fat known as Piney Tallow, Malabar Tallow or Dhupa Tallow It is commonly extracted by boiling the powdered kernels in water and allowing the extract *to* cool. The fat which floats on the surface is skimmed off. It is at first greenish-yellow, but is rapidly bleached by the air and has a slight, pleasant odour. The fat consists of glycerides of solid acids (53%) and liquid acids (Puntembaker and Krishna, 1932).

The tallow is edible after refining but not in common use. It is used in candle, soap manufacturing and for sizing cotton yarn in the place of animal tallow. It is reported to be used as a local application in rheumatism, etc. (Kirtikar and Basu, 1918).

The seed cake, though unpalatable to livestock,is useful as a manure, especially in coffee plantations.

The fruit wall contains 25 percent tannins. A glucoside, berginin, has hem isolated from the seeds and the bark.

The bark is an alexipharmic in the Ayurvedic preparations. The fruit is ground into a flour and eaten.

VATERIA MACROCARPA Gupta

Common name

Mal. – Vellapine

A medium sized tree with **a** dense crown, reaching a height of 20m and a girth of 3m or more. Bark surface dark grey, smooth. Young shoots covered with hoary stellate pubescence. Leaves 15 – 25cm by 6 – 12cm, elliptic-oblong or oblong-lanceolate, shortly acuminate, rounded or subcordate at base, coriaceous, glabrous on both surfaces, occasionally minutely hairy beneath the midrib towards the base; lateral nerves 16 – 20 pairs, parallel, prominent below; petiole 2.5 – 6cm long, swollen at the top, minutely pubescent; stipules deciduous. Panicle axillary, hoary stellate pubescent, flowers 3cm in diameter, distinctly pedicelled, pedicles ***1.5*** – 2cm long. Calyx lobes imbricate, triangular, acute, pubescent outside. Petals elliptic, minutely apiculate, coriaceous, glabrous. Stamens numerous; filaments short; anthers linear, connective produced into a subulate point. Ovary densely tomentose; style subulate; stigma minute. Fruit 9 – 14cm by 5 – 7cm, ovate, narrowed towards the apex, slightly curved; splitting from apex downwards at maturity; fruit sepals not enlarged, deflexed (Gupta, 1929).

Distribution – India

Highly restricted and seen at Bolampatty (Tamil Nadu), Muthikulam and Attappady (Kerala) only.

Forest Types and Floristics

This endemic species is highly localized in the West Coast Tropical Evergreen Forest (Champion and Seth, 1968). At Bolampetti (Tamil Nadu) it is seen up to an altitude of 1400m. The best growth is noticed at an elevation of 1200m here and it forms nearly pure patches. At this altitude the main associate is ***Cullenia*** *exarillata.* As the elevation increases, the trees are smaller in size. At an elevation of 1100m the distribution is very much dispersed.

Floristics

(i) Bolampetti, Tamil Nadu

Acrocarpus fraxinifolius, Vateria macrocarpa, Cullenia exarillata, Palaquium ellipticum, Artocarpus heterophyllus, Euphoria longana, Macaranga roxburghii, Actinodaphne hookeri (Jayaram, 1973).

(ii) Attappady, Kerala

Vateria macrocarpa, Cullenia exarillata, Elaeocarpus tuberculatus, Palaquium ellipticum. Mesua ***ferrea,*** *Dyxoxylum malabaricum, Bischofia jauanica, Chrysophyllum roxburghii, Artocarpus heterophyllus, Cinnamomum malabaricum, Meliosma microcarpa, Hopea glabra. Machilus macrantha. Polyalthia coffeoides* (Chand Basha, 1977).

Silviculture and Management

Phenology

Flowers in March, fruits ripen in June.

Natural regeneration

Satisfactory. Being a shade bearer, all stages of growth are seen in natural, undisturbed forests. It is a striking feature to see different stages of germination in the forest. Fruits are generally few in number and, due to their size and weight, fall below the tree and germinate. Germination is epigeal. The pericarp splits longitudinally from the apex downwards. The thick fleshy reddish cotyledons emerge out after the primary root establishes itself. No specific operations are carried out for propagation due to the localized occurrence.

wood

Structure

A diffuse porous wood; vessels moderately large to small, few to many *(5 – 25/* mm^2) in oblique groups; tyloses present.

Parenchyma, paratracheal and metatracheal.

Rays medium, rather widely spaced, often brownish in colour.

Resin canals small, uniformly scattered, mostly single, rarely in tangential rows; white gummy deposits common (Chowdhury and Ghosh, 1958).

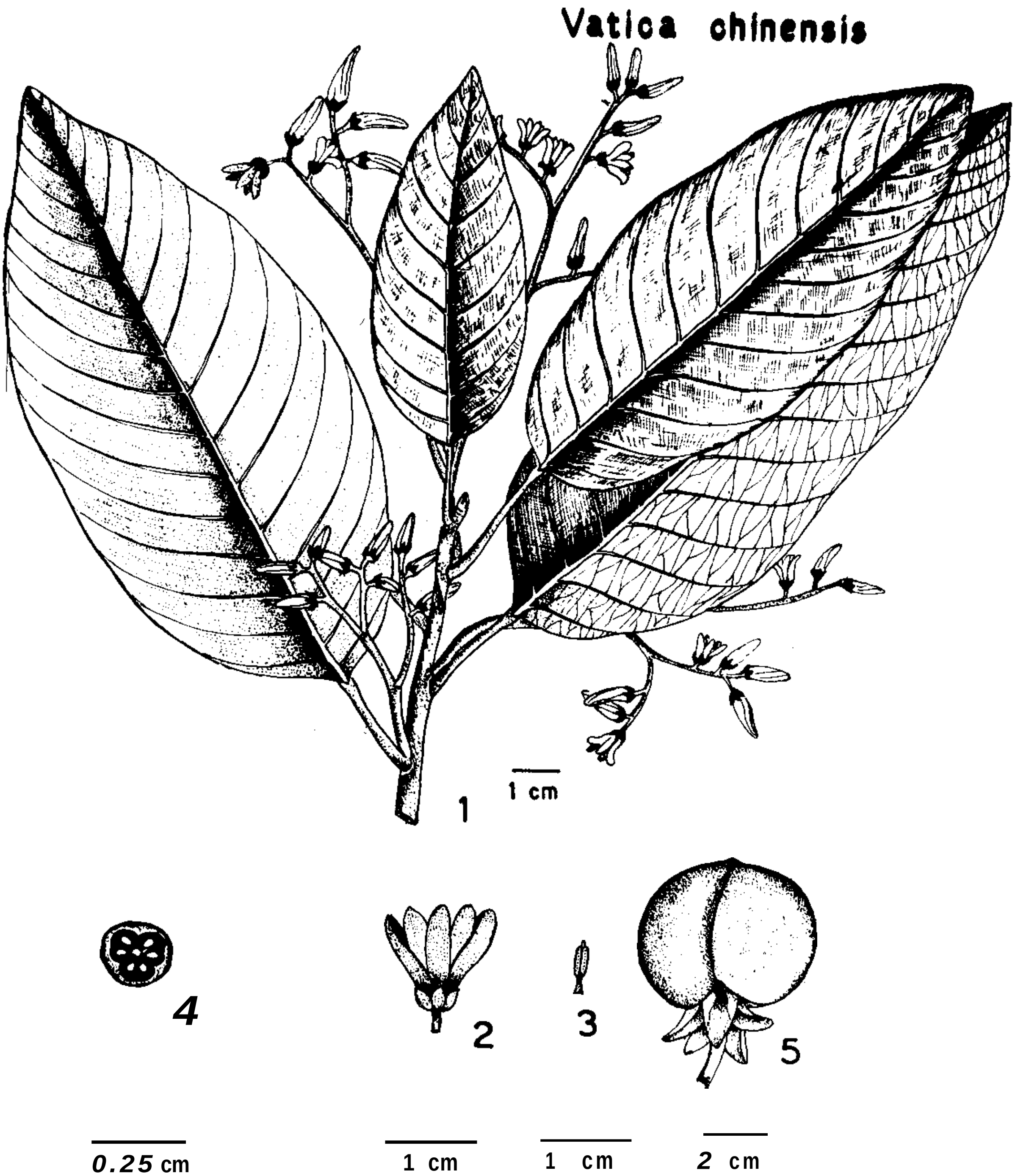
Properties

Sapwood usually white or creamy; heartwood whitish-grey or light yellowish turning brownish or pinkish on exposure; wood with resinous smell when fresh; often interlocked-grained in narrow bands; medium coarse and fairly smooth textured. Somewhat lustrous when firstly cut; moderately heavy, sp. gr. 0.53 – 0.68 (air dry). Seasons fairly well. Sap stain common. Hence quick conversion advisable. Not durable; easily susceptible to discolouration and decay. Refractory to treatment.

Uses

Due to restricted occurrence, it is not common in trade. **A** construction timber suitable as planks. Readily accepted by plywood industry for commercial grade plywood. Usable as match wood and for making oars.

Vatica

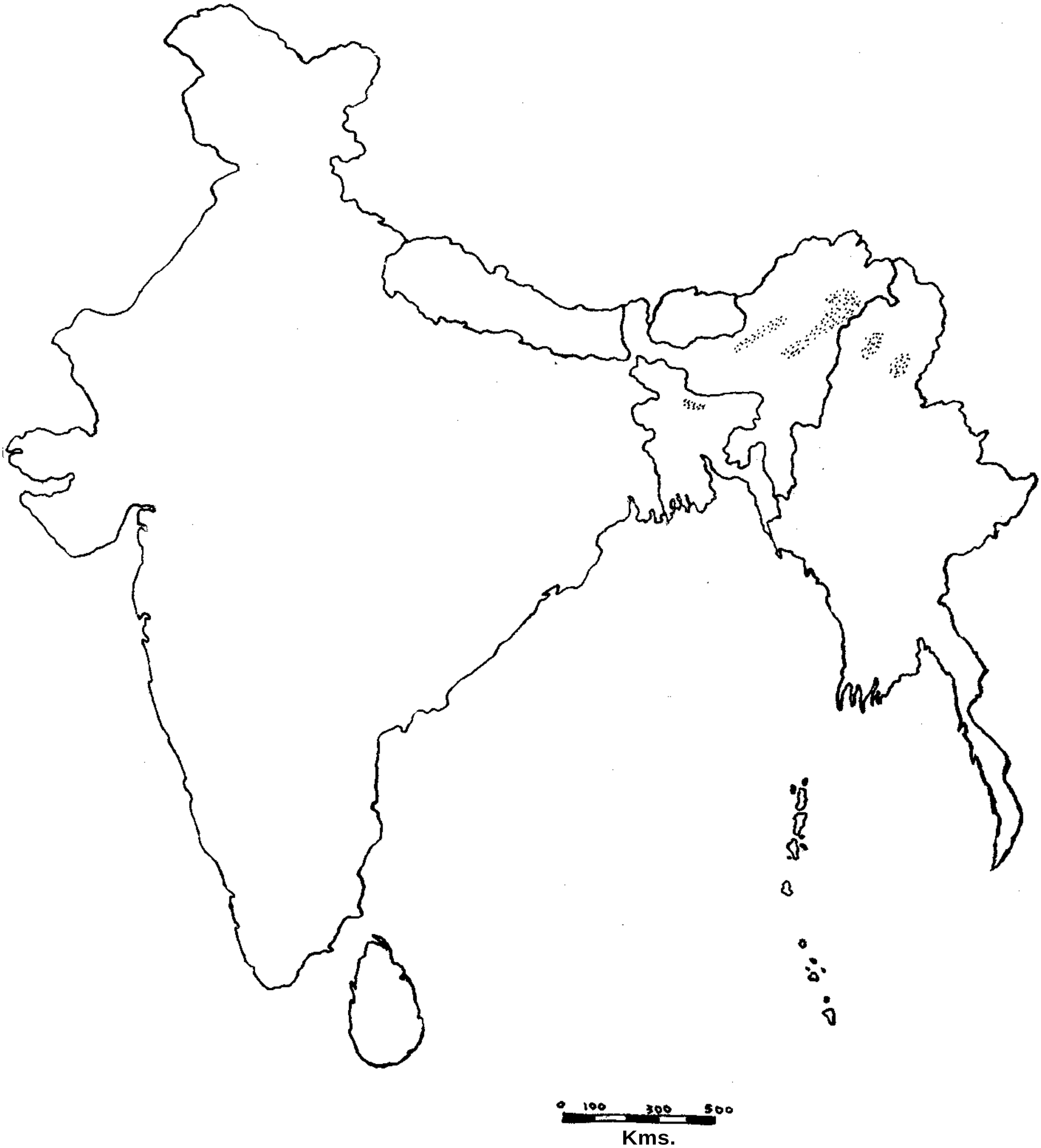


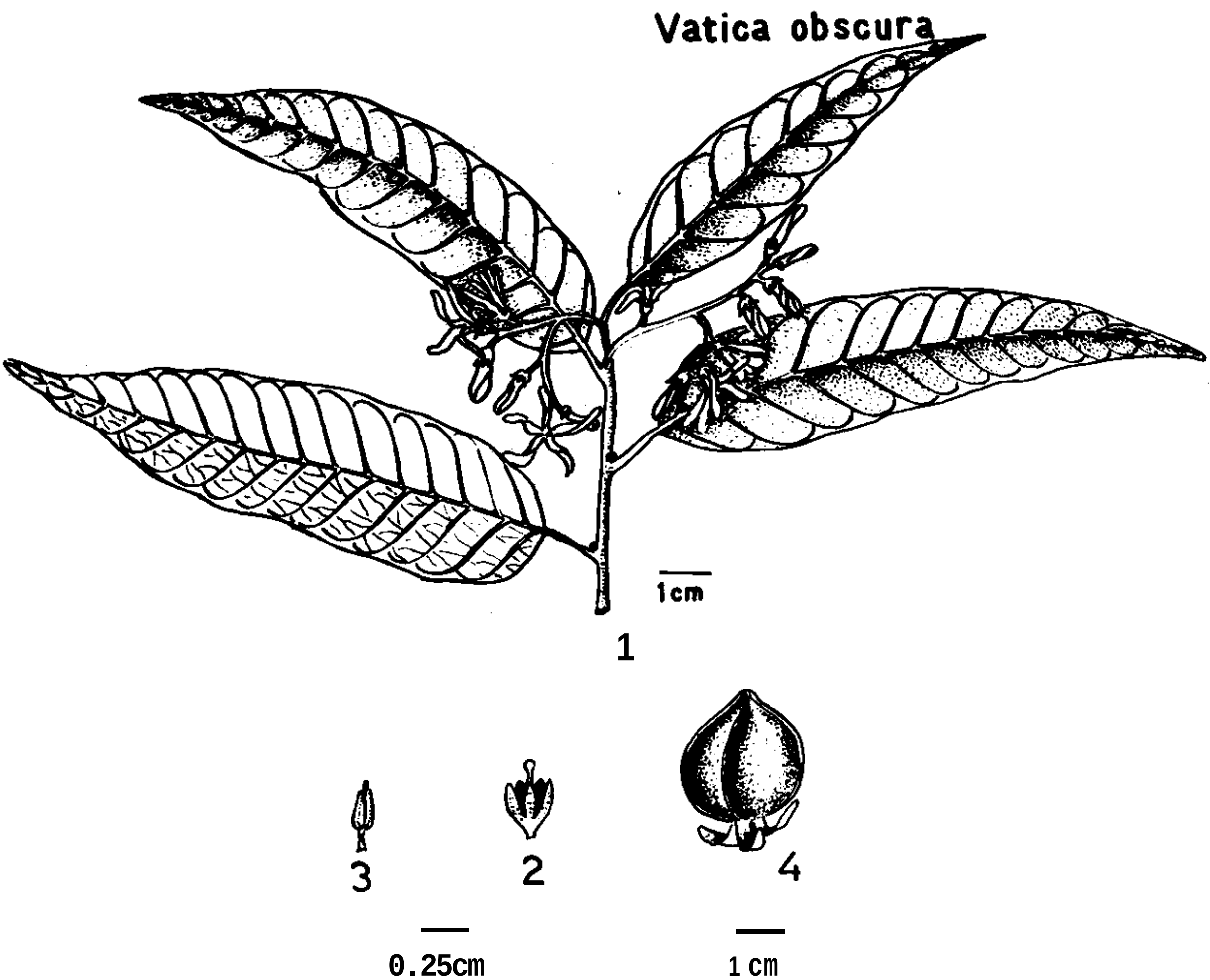
Vatica chinensis

1. **Flowering shoot**
2. **Flower**
3. **Stamen**
4. **T.S. of ovary**
5. **Fruit**

Vatica chinensis

Vatica lanceaefolia





Vatica obscura

1. **Flowering shoot**
2. **Calyx and Pistil**
3. ***stamen***
4. **Fruit**

CHAPTER XI1

VATICA Linn.

Small to medium sized trees. Bark smooth. Twigs pubescent or puberulous. Leaves entire, coriaceous; petiole stout; stipule small, fugaceous or inconspicuous. Flowers in axillary and terminal racemes or panicles, pubescent or tomentose. Sepals subequal. Petals narrowly oblong. Stamens 15; filaments short; anthers oblong; appendage to the connective short. Ovary ovoid, pubescent or puberulous; style short; stigma entire or minutely 3 lobed. Fruit ovoid to globose subtended by the unequal or subequal more or less recurved sepals (Ashton, 1977; Gamble, 1915; Hooker, 1874).

Wood

Vessels small, scattered. Parenchyma sparse or abundant. Rays fine to very fine, medium spaced. Resin canals small, usually solitary. Sapwood pale yellow, heartwood yellowish brown, straight to somewhat interlocked grained, rather fine textured, moderately heavy (Chowdhury & Ghosh, 1958, Gottwald & Parameswaran, 1966).

Uses

Occasionally used as constructional timber, and railway sleepers. Suitable for shuttles, bobbins and mathematical instruments.

Distribution 9 species: Bangladesh, Burma, India and Sri Lanka.

VATICA AFFINIS Thw

A moderate sized tree attaining a height of 35m and a girth of 2m with a hemispherical crown. Young shoots pubescent. Leaves **6** – 16cm by 2.5 – 6.5cm, lanceolate or linear-elliptic, subacute, base broadly cuneate, g1abrous;'lateral nerves **6** 8 pairs, prominent on both surfaces; petiole 1.3 – 2.5cm long, geniculate; stipule fugaceous. Panicle axillary and terminal, subpersistently pubescent. Sepals lanceolate, acute, finely pubescent. Petals **3** times as long as the sepals, pubescent. Stamens 15; filaments dilated at the base, appendage short, filiform; anthers broadly oblong. Ovary densely pubescent; style glabrous; stigma 3 lobed. Fruit 2.5cm by 2cm, ovoid, obtuse, with 3 indistinct loculicidal grooves; fruit sepals subequal, nearly 1cm long, oblong, obtuse (Ashton, 1977, Trimen, 1893).

Distribution – Sri Lanka

Found in Botaloogodda, Pasdun Korale, Nelum Keliya, Sinharaja, Kalutara and Hewesse.

Forest Types and Floristics

This endemic species is localised in the Lowland Wet Evergreen Forest (Andrews, 1961) on deep well drained soil and along stream banks. It is scattered in occurrence and the frequency is low.

Silviculture and Management

Phenology

Flowering in March.

The species regenerates well, but no special treatment is in vogue.

Wood

Structure

Vessels numerous, small, mostly solitary; tyloses absent.

Paratracheal parenchyma vasicentric.

Rays fine to medium.

Resin canals solitary and scattered.

Properties

Wood reddish brown, smooth textured, close grained, hard and fairly heavy. Weight 840Kg/m^3 at 12 percent moisture content.

Uses

Used in light construction, as railway sleepers and as piles.

VATICA CHINENSIS Linn.

Syn. *Vatica roxburghiana* BI.
Vateria roxburghiana Wt. et Arn.
Isauxis roxburghiana Thw.

Common names
Mal. – Cherupiney, Adakkapayin
Sinh. – Mandora

A medium sized tree reaching a height of 20 – 30m and a girth of 2m, with a spreading oblong dense crown. Young shoot and petiole pubescent. Bark pale grey, smooth. Leaves 9 – 25cm by 4 – 11cm, narrowly ovate, acute, with rounded base, coriaceous, glabrous, lateral nerves 10 – 14 pairs, arched, prominent on both surfaces; petiole 2.5-5cm long, puberulous; stipule small, pubescent outside, fugaceous. Panicle axillary. Sepals ovate, acute, pubescent. Petals oblong, white. Stamens 15; filaments short, flattened at the base; anthers oblong apiculate. Ovary ovoid puberulent, style short, glabrous; stigma minutely 3 lobed; fruit 2.5cm in diameter, subglobose, puberulous, with 3 loculicidal furrows; sepals in fruit ovate, subacute, recurved and more or less adpressed to the base of the fruit (Bourdillon, 1980; Gamble, 1915; Ashton 1977).

(Bourdillon, 1980; Camble 1915; Ashton 1977)

Distribution – India, Sri Lanka

In India the species is confined to western ghats, from South Kanara (Kamataka) to Southern Kerala. In Sri Lanka it is found frcm Colombo, Southwards to Kdutra.

Forest Types and Floristics

In India the species is found scattered and localised in the West Coast Semi-Evergreen Forest (Champion and Seth, 1968). It is more common at low elevations on the banks of rivers. In Sri Lanka it is seen more or less gregariously along river banks and in the vicinity of fresh water swamps in the Lowland Wet Evergreen Forest (Andrews, 1961).

Floristics

(i) Kolathupuzha – Kerala, India

I *Artocarpus hirsuta, Adina cordifolia. Terminalia alata, Holoptelia integrifolia, Machilus macrantha.*

I1 *Polyalthia fragrans, Vatica chinensis, Aporosa lindleyana. Cinnamomum zeylanicum, Bridelia retusa.*

111 Bamboos and reeds.

IV *Glycosmis pentaphylla, Butea* sp., *Strychnos* sp.

(ii) Kalutara, Sri Lanka

I *Dipterocarpus zeylanicus, Shorea congestiflora. Vatica chinensis, Hopea* sp., *Palaquium petiolare, P. grande, Xylopia parvifolia, Vitex pinnata, Pygeum reylanicum.*

I1 *Mesua* ***ferrea,*** *Chaetocarpus castanocarpus, C. pubescens, Myristica dactyloides, Kurrimia zeylanica, Campnosperma zeylanica, Carallia brachiata.*

111 *Aporosa latifolia, Semecarpus gardneri, Axinandra lanceolata, Wormia* ***tri****quetra. Achronychia pedunculata, Euodia lunu-ankanda, Humboldtia laurifolia, Diospyros insignis.*

IV *Polyalthia acuminata, Memecylon* spp., *Symplocos minor, Ochlandra stridula.*

Silviculture and Management

Phenology

In India flowering is in February – March and fruiting is in June. In Sri Lanka flowering is mostly in early May.

In India the region in which the species occurs is greatly altered by biotic influences. No specific efforts have been made for regeneration. In Sri Lanka also no attempts have been made for reproduction.

Wood

Structure

Wood diffuse porous, vessels small evenly distributed, often solitary; tyloses present.

Parenchyma mostly paratracheal.

Rays fine to very fine, medium spaced

Resin canals minute; white gummy deposits present (Chowdhury and Ghosh, 1958).

Properties

Sapwood and heartwood generally distinct, sapwood pale-yellow, heartwood light brown, darkening on exposure to reddish brown, straight to somewhat interlocked grained, rather fine textured, heavy; weight $956 Kg/m^3$ at 12 percent moisture content.

Wood is moderately durable, difficult to saw and work (Chowdhury and Ghosh, 1958).

Uses

In India uses are limited and localised. It is sometimes used in constructional works. In Sri Lanka it is a constructional timber, usuable as railway sleepers also.

VATICA LANCEAEFOLIA B1.

Syn. ***Vateria lunceaefolia*** Roxb.
Vateria lanceoluta Wt. et Arn.

Common names

As. – Dieng-soh-kaina, kalang, Asing, Keyoasing, Kham-Khor, Khirkha-champa, Makruk, Moral.
Bur. – Panthitya

A moderate sized tree reaching a height of 25m. Bark thin, grey to greenish grey, smooth. Young parts mealy puberulous, soon becoming glabrous. Leaves 18 – 22cm by 5 – 6cm, elliptic-lariceolate, acuminate, narrowed at base, glabrous above and more or less glaucous beneath; lateral nerves about **15** pairs; petiole 1 – 1.3cm long. Panicle axillary and terminal, tawny puberulous; flowers large, shortly pedicelled. Calyx tube short, the lobes ovate, acute, pubescent. Petals white, cuneate, tawny velvety outside. Stamens 15; anthers ovate-oblong, the cells with a blunt beak at the base; appendage of the connective cylindric. Ovary pubescent; style cylindric; stigma clavate, 3-toothed. Fruit ovoid, the calyx lobes nearly equally enlarged, shorter than the calyx itself (Hooker, 1874; Kurz, 1877).

Distribution – Bangladesh, Burma, India

In Bangladesh and Burma the species is extremely localised. In India, also of restricted distribution, confined to Assam, Arunachal Pradesh and Nagaland.

Forest Types and Floristics

In eastern India the species is found in Assam Valley Tropical Wet Evergreen Forest, Cachar Tropical Evergreen Forest and Assam Valley Tropical Semi-Evergreen Forest (Champion and Seth, 1968). Thus the (Champion and Seth, 1968). Thus, the species occurs in different types of forests in conditions. It grows even in swampy areas where the height is less than 10m (Rowntree, 1954). In all these forest types the species is in the second storey, mostly scattered but occasionally forming gregarious patches of understorey.

Floristics

(i) Lakhimpur, Assam (Assam Valley Tropical Wet Evergreen Forest)

I *Dipterocarpus macrocarpus, Shorea assamica, Mesua ferrea. Altingia excelsa, Dysoxylum procerum. Artocurpus chaplasha,* *Michelia* spp., *Canarium* spp., *Amoora wallichii.*

I1 *Vatica laleceoefolia. Syzygium* spp.., *Garcinia cowa. Talauma* sp., *Myristica* spp.

I11 *Clerodendrum* sp., *Ixora* sp., *Pinanga* sp., *Laportea* sp.

(ii) Brahmaputra Valley, Assam (Upper Assam Valley Tropical Evergreen Forest)

I *Mesua ferrea, Ailanthus grandis, Echinocarpus* sp., *Michelia* sp., *Quercus lamellosa, Tetrameles nudiflora. Dysoxylum hamiltonii, Altingia excelsa.*

I1 *Aphanamyxis polystachya, Beilschmiedia* sp., *Gynocardia odorata. Sapium baccatum. Vatica lanceaefolia.*

I11 *Garcinia cowa, Pandanus furcatus, Miliusa* sp., *Leea* sp.

(iii) Cachar, Assam (Cachar Tropical Evergreen Forest)

I&II *Palaquium* sp., *Diospyros* sp., *Cynometra polyandra, Dipterocarpus turbinatus, Mesua ferrea, Syzygium* spp., *Euphoria longana, Sapium baccatum. Vatica lanceaefolia, Canarium* spp.. *Hydnocarpus kurzii, Heritiera acuminata. Persea owdenii, Kayea floribunda.*

(iv) Aka Hills, Assam (Assam Valley Tropical Semi-Evergreen Forest)

I *Phoebe* spp., *Beilschmiedia* spp., *Cinnamomum cecicodaphne, Persea* sp., *Alseodaphne* sp., *Amoora* spp., *Dysoxylum* spp., *Toona* spp., *Canarium* sp.. *Michelia* spp., *Castanopsis* sp., *Tetrameles nudiflora, Ailanthes grandis, Altingia excelsa.*

I1 *Quercus* spp., *Litsea* spp., *Vatica lanceaefolia, Talauma* sp., *Meliosma* sp., *Artocarpus* sp.

111 *Strobilanthes* spp., *Psychotria* spp., *Laportea* sp.

Silviculture and Management

Phenology

Flowers appear in May and fruiting is during July – August.

Silvicultural characters

A hygrophilous species, shade tolerant in all stages of growth. It is hardy and capable of surviving in poor site conditions, including swampy areas.

Natural regeneration

In areas where the species is associated with *Dipterocarpus macrocarpus* and *Shorea assamica*, regeneration operations are aimed at promotion of these two latter species. Being comparatively less valuable as timber, *Vatica lanceaefolia* is retained only when it does not interfere with the regeneration of its more important associates. After the preliminary regeneration operations are completed, this species is encouraged by carrying out weeding, climber cutting, etc., so that it continues in the second storey.

Wood

Structure

Wood diffuse porous, vessels small, moderately numerous, 13 – 37/mm^2, round to oval; occasionally filled with tyloses.

Parenchyma abundant. Paratracheal parenchyma forming an incomplete sheath round the vessels or vessel groups; metatracheal parenchyma scanty; parenchyma surrounding the resin canals indistinct.

Rays fine to very fine, medium spaced.

Resin canals small, irregularly distributed, mostly single, occasionally in groups of 2–3 and rarely in tangential rows (Chowdhury and Ghosh, 1958).

Properties

Sapwood light-yellowish brown, heartwood yellowish brown, straight to somewhat interlocked grained, moderately hard, heavy, sp. gr. 0.601. Weight 673Kg/m^3 at 12 percent moisture content.

Modulus of rupture (Kg/cm^2)
at 12% moisture content 979.9

Modulus of elasticity (Kg/cm^2)
at 12% moisture content 143,500

Maximum crushing stress (Kg/cm^2)
at 12%m moisture content 544.3

Seasons slowly and liable to cupping and surface cracking. Not durable, graveyard tests at Dehra Dun indicated a life less than 24 months. Moderately refractory to trcatrnent, penetration of preservatives being partially successful. Easy to saw and work with tools (Chowdhury and Ghosh, 1958).

Uses

A constructional timber of local importance in eastern India. Usable as planks and house posts. Wood with finer texture and straight grain are suitable for shuttles, bobbins and mathematical instruments. Extensively used *as* firewood and for making charcoals.

Non wood products

The species yields a clean, white, aromatic oleoresin. On hardening it turns light amber in colour. Used *as* incense. When distilled, a scented balsam is obtained which is known as 'chua' and is used to flavour tobacco for chewing with betel leaves. It also yields a strong smelling balsam the 'ghund', used in religious ceremonies (Kurz, 1877).

VATICA OBSCURA Trimen

Common names

Sinh. – Dunmala
Tam. – Tunpalai

A medium sized tree reaching a height up to 30m and a girth of 1.5 – 2m. Young shoots densely pubescent. Bark surface pale brown, smooth. Leaves 7 – 15cm by 1.5 – 35cm, narrowly lanceolate, subacute, broadly cuneate at base, thinly coriaceous; lateral nerves 11 – 15 pairs, slender; petiole 0.7 – 1.8cm long. Panicle axillary, tomentose; flowers fragrant, pedicels articulated. Sepals very small, ovate-lanceolate, subacute, tomentose. Petals 5 – 6 times as long as the sepals, oblong, base concave. Stamens 15, very small; filaments dilated at base; anthers shortly apiculate. Ovary ovoid, densely pubescent; style glabrous; stigma **3** lobed. Fruit 2.5cm in diameter, broadly ovoid, with **3** obscure loculicidal furrows; sepals in fruit lcm by 0.5cm, oblong-elliptic, obtuse, with 3 Faint veins (Ashton, 1977; Trimen, 1893).

Distribution – Sri Lanka

The species is seen in Bintenne, Batticaloa, Nuwaragala and Galodai.

Forest Types and Floristics

This endemic species is found in Tropical Lowland Semi-Evergreen Forest (Andrews, 1961) and mostly confined to river banks and permanent water courses. Along river banks it is sometimes semi gregarious, but mostly scattered in the second storey.

Floristics

Bintenne

I *Alstonia scholaris, Trewia nudiflora, Canarium zeylanicum*

I1 *Diospyros ebenum,* ***D.*** *oocarpa, Vatica obscura. Manilkara hexandra, Alseodaphne semecarpifolia, Mangifera zeylanica, Syzygium* spp., *Litsea involucrata, Hydnocarpus venenata, Gleniea zeylanica, Chloroxylon swietenia, Vitex pinnata, Berreya cordifolia, Nephelium longana, Gyrocarpus jacquini, Adina cordifolia.*

I11 *Acronychia Qedunculata, Polyalthia acuminata, Aphania bifoliatus.*

Silviculture and Management

Phenology

Flowering in May—July.

9 Regeneration is satisfactory. No special method has been adopted for its propagation.

Wood

Structure

Vessels numerous, very small, almost exclusively solitary; tyloses common.

Paratracheal parenchyma vasicentric.

Rays fine.

Resin canals solitary, diffuse and scattered.

Properties

Wood brownish, with characteristic odour, close grained, fairly smooth textured, hard and heavy. Weight 1000Kg/m^3 at 12 percent moisture content.

Seasons slowly, fairly durable, non-refractory to treatment.

Uses

A constructional timber, mostly used as beams. It is also used as railway sleepers after treatment.

Non wood products

A gummy exudation from the tree is used for caulking boats.

VATICA ODORATA (Griff.) Sym.

Syn. *Anisoptera odorata* (Griff.) Kurz
Hopea faginea Wall.
Shorea pinangiana Wall.
Synaptea odorata Griff.
Vatica astrotricha Hance
V. curtisii King
V. *dyeri* Pierre ex laness
V. grandiflora Dyer
V. *faginea* Dyer

A small tree reaching a height of 15m. Bark surface smooth, thin. Twigs and bud densely clothed with fulvous or rusty-pink stellate tomentum when young. Leaves 7 – 12cm by 3 – 6cm, ovate-oblong, subacute, base rounded or subcuneate, both surfaces quite glabrous; lateral nerves 9 – 15 pairs; petiole 0.5 – 1.2cm long, usually stellate-tomentose. Racemes axillary, pubescent, few flowered. Calyx lobes unequal, the 2 larger narrowly oblong, obtuse; the 3 shorter lanceolate-acuminate. Petals elliptic, slightly oblique, glabrous except the pubescent edge. Stamens 15; anthers oblong; connective apiculate. Ovary subglobose; style short; stigma 3 toothed. Fruit globose, crowned by the cylindrical style, 0.7cm in diameter, the lower half united with the calyx tube; the 2 larger calyx lobes 4 – 6cm by 1.5cm, oblong-lanceolate, usually obtuse, rarely subacute, 5 nerved, the 3 smaller lobes 1 – 1.5cm long (King, 1893; Symington, 1943).

Distribution – Burma

CHAPTER XI11

PESTS AND DISEASES

Pests and diseases are discussed under 1. Insect pests, 2. Marine borers of timber, 3. Fungal diseases and 4. Angiospermic parasites.

1. INSECT PESTS

Insects recorded from living trees as well *as* felled timber of forest trees were listed systematically by Mathur and Singh (1960 – 1969). This list, based mainly on information contained in the ledger files of the Forest Research Institute, Dehra Dun, India, is the chief source of information on insects attacking dipterocarps in the region. A large group of insects are associated with dipterocarps; for example, over 350 species are knownto attack *Shorea robusta* alone. However, only a few of these can be counted as actual or potential economic pests. The scope of the present discussion is limited to the more important species. Information on the biology and ecology of many dipterocarp pests may be found in Beeson's (1941) monumental work on insects of the Indian subcontinent. Browne (1968) gave an annotated list of insect pests of the living sal tree *(Shorea robusta)*. Several reports puhlished as Indian Forest Bulletins or Records contain detailed information on specific dipterocarp insects. In addition, information is also available in 'Working Plans' for specific forest areas.

The insgct pests are discussed under pests of seeds, pests of living trees and pests of timber. Pests of timber constitute the great majority of insects reported from dipterocarps; pests of living trees are of minor importance, except for *Shorea robusta*. Most dipterocarps in South Asia exist at present in natural or semi-natural associations with other p!ant and animal communities and this explains the small number of economic pests. Indeed, a vast number of insects are associated with, and draw their sustenance from various dipterocarps, but most of them remain at low population levels and do not impair the growth and regeneration of the species. It is interesting to note that most insects which have attained pest status have been reported from species for which plantations have been raised, e.g., *Hopea parviflora, Shorea robusta* and *S. roxburghii*.

Among the pests of trees leaf-feeding insects are the most numerous. Although the sal stem-borer, *Hoplocerambyx spinicornis* Newman, is the most notorious among pests of dipterocarps, generally few stem-boring insects are known. This may be attributed to production of a resinous exudate by most dipterocarps in response to stem injury, which offers resistance to the establishrnent of young larvae.

Pests of Seeds

Seeds of most dipterocarps are damaged by several species of beetles and moths. Most insects feed on the cotyledons, often completely hollowing out the seed. Little quantitative information is available on the damage caused, hut it is generally believed that the destruction of seeds by insects adversely affects natural regeneration of many dipterocarps, especially *Dipterocarpus indicus, D. turbinatus, Hopea pamiflora* and *Shorea robusta*. To raise seedlings for artificial regeneration, it is generally recommended that the ground under mother trees he cleared and fallen seeds collected daily, in order to prevent insect damage. In Karnataka (India) ripe fruits of *Hopea parviflora* are usually collected by lopping branches, as an insurance against insect damage of fallen seeds (Rai, S.N., unpublished notes, Kamataka Forest Department).

The seeds of *Dipterocarpus* spp. are attacked by the beetles *Sitophilus rugicollis* Casey., *Alcidodes* spp. (Syn. *Alcides), Lyctus africanus* Lesne and *Thamnurgides* spp., and the moths *Blastobasis spermologa* Meyr., *Laspeyresia pulverula* Meyr. (Syn. *Enarmonia pulverula)* and *Lyonetia eratopa* Meyr. (Mathur *et al.*, 1958). According to Beeson (1941) larvae of the weevil, *Alcidodes crassus* Pascoe (Fig.) which feed in the fruits of *Dipterocarpus grandiflorus, D. gracilis* and *D. turbinatus*, destroy seeds so extensively as to affect regeneration.

Fruits or seeds of *Vatenu indica* are attacked by six species of beetles; these are the curculionid, *Sitophilus vateriae* (Syn. *Calandra vateriae)* and the scolytids, *Coccotrypes borassi, Thamnurgides cardamomi, T. indicus, T. variabilis* and *T. vateriae* (Mathur *et al.*, 1958). *Coccotrypes*, as well as most species of *Thamnurgides*, confine their feeding to the fleshy pericarp; therefore, even attacked fruits produce viable seedlings. One species, *Thamnurgides cardamomi*, however, bores through the hard shell of the seed after the soft outer parts have been destroyed by other organisms and feed on the plumule (Beeson, 1941).

Seeds of *Shorea siamensis* are attacked by the beetle *Araecerus fasciculatus* De Geer. (Anthribidae), which is a widely distributed pest of stored seeds of various trees, particularly of Leguminosae. This beetle lays eggs in ripe fruits and the newly hatched larvae bore into the seed. Infestation usually occurs while the fruit is still on the tree (Beeson, 1941). Other seed pests include *Alcidodes dipterocarpi, Pammene therestis* and *Dichocrocis leptalis.*

Seeds of *Shorea robusta* are attacked by six species of beetles and twelve species of moths (Mathur *et al.*, 1958). The beetles are *Sitophilus rugicollis, Diplophyes shoreae* (Curculionidae); *Coccotrypes integer* (Scolytidae); *Alphitobius laevigatus, Gonocepbalum planatum* (injurious to sown seeds) and *Mesomorphus striolatus* (Tenehrionidae). Seed borers among the moths are *Blastobasis crassifica, B. molinda, B. ochromorpha, B. spermologa* (Blastohasidae); *Brachmia resoluta, Brachyacma palpigera* (Gelechiidae); *Lyonetia eratopa* (Lyonetidae), *Dichocrocis leptalis, Ephestia* sp., *Lamoria adaptella* (Pyralidae); and *Laspeyresia pulverula* and *Pammene therestis* (Tortricidae). The most important pest is the tortricid *P. therestis.* It damages seedlings and tender shoots of saplings also. In the sal forests of Dehra Dun (Uttar Pradesh, India) *P. therestis* may have seven generations per year – 2 to *3* in seeds and *3* to 4 in seedlings (Chatterjee and Thapa, 1970a). Each year, the last generation larvae which thrive in seedling$ enter hihernation by November and the adults emerge in March—April, the following year. These insects pass through two to three generations in older saplings before seeds become available. From June to August, the period between seed fall and seed germination, the seeds are used as host. The insects then switch over to fresh seedlings from August onwards. Seeds attacked are hollowed out completely. In seedlings, part of the stem and tap root are tunnelled and eaten up, causing death of the seedling. In saplings, the leading shoots are often killed back. Beeson (1941) estimated that in the submontane belt of Uttar Pradesh and in Madhya Pradesh, more than half of the regeneration seedlings are killed by this insect. At Dehra Dun, Chatterjee and Thapa (1970a) found the rate of infestation of seedlings to be 10 to 30 per cent in January—February and 40 to 80 per cent in late May. However, because of profuse seed production, these authors do not consider the damage by ***P.***

therestis serious enough to adversely affect natural sal regeneration.

Pests of Living Trees

Insects injurious to *Dipterocarpus. Hopea, Shorea* and *Vateria* are dealt with separately. Only one pest each is known from *Parashorea stellata* and *Vatica lancaefolia.* These are the beetle, *Hoplocerambyx spinicornis,* (well known in India as a serious pest of sal trees) which attacks dying trees of *Parashorea stellata* in Burma and a coccid, *Aonida crenulata* Green, which feeds on the sap of leaves of *Vatica lancaefolia.*

Among beneficial insects associated with dipterocarps are the lac insect, *Laccifer lacca* Kerr., which feeds on *Dipterocarpus tuberculatus, Shorea obtusa,* **S.** *robusta,* **S.** *roxburghii,* and the wild tassar silk worm, *Antheraea mylitta* (Drury) which feeds on *Shorea robusta. Shorea roxburghii* is used in India for commercial production of Mysore stick lac. Wild tassar silk worms fed on *Shorea robusta* are reported to produce cocoons 2 to 3 times superior in silk yield over those fed on the common commercial tree hosts, *Terminalia arjuna* and *T. tomentosa* uolly *et al.,* 1968).

DIPTEROCARPUS

Although more than a dozen species of insects have been recorded from healthy standing trees of *Dipterocarpus,* (most from *D. tuberculatus)* (Mathur and Singh, 1969), the majority are minor pests of little economic significance. Most are polyphagous caterpillars which feed on the foliage. These are *Arhopala asopia* (Syn. *Amblypodia asopia)* and *Poritia hewistoni* (Lycaenidae); *Dasychira cerigoides* and *Dasychira mendosa* Hb. (Lymantriidae); *Hemiscopis suffusalis* Scop. (Pyralidae); *Cypa decolor decolor, Oxyambulyx canescens,* and *O. substrigilis substrigilis* (Sphingidae); and *Cyclosia papilionaris* (Zygaenidae). Of these, only *Dasychira cerigoides* has been noted in epidemic form A serious outbreak of this insect occurred in northern Burma in the years 1938 and 1939 resulting in complete defoliation of *Dipterocarpus tuberculatus* and *D. turbinatus* forests in extensive areas (Beeson, 1941). Successive generations of this insect occur in May—July and August-November. The life cycle lasts about 75 days. Unburnt areas are reported to suffer more damage than burnt areas. Unlike *Dasychira mendosa,* which is a general leaf feeder attacking a variety of trees and cultivated plants including castor, coffee and maize, *D. cerigoides* appears to have some preference for *Dipterocarpus* forests.

Other types of insect damage include the following. **A** small pyralid caterpillar, *Cateremma tuberculosa* Meyr., feeds from within galls produced in the leaves of *D. tuberculatus;* this insect is more prevalent in the monsoon season. Leaf galls are produced in ***D.*** *alatus* by the thrips (Thysanoptera), ***Cor****yphothrips trochiceps* Karny and *Gynaikothrips siamensis* Karny. A coccid (Homoptera), *Beesonia dipterocarpi* Green, feeds on the sap of *D. tuberculatus* from within galls made at the extremeties of small green shoots. The gall resembles a chrysanthemum flower (Fig.) but is of a woody texture. The insect is described by Beeson (1941); it is not a major pest.

No insect is known to damage the wood of standing healthy trees.

HOPEA

Among the *Hopea* species, more is known about the pests of ***H.*** *parviflora,* the only species raised in plantation scale.

The most economically important pest of *H. parviflora* is the beetle, *Massicus venustus* (Cerambycidae). The larvae make large galleries, first in the sapwood, and then in the heartwood, where they pupate. Generallv, the attack is confined to dead wood and fire-scorched or overmature trees. However, like the sal borer, *Hoplocerambyx spinicornis* (see under *Shorea)* it is able to establish successfully in living trees when their resistance is lowered by various causes. Mass attacks produce a girdling effect and the trees are killed. Life cycle **is** apparently annual with adults emerging in both the southwest and north-east monsoon seasons in southern

India (Beeson, 1941).

Seedlings and saplings of *Hopea parviflora* are damaged by several insect pests, of which the following are the most important. A chrysomelid beetle, *Hyperacis malabarica,* bites off the leading shoot of seedling in September—October (Beeson, 1941). The adult female of a small weevil, *Rhynchitis contristatus,* girdles the succulent young shoots by biting a ring of punctures, the distal part withers and curls over but remains attached to the plant until broken off by wind or other agencies. Eggs are laid in punctured holes in the withered portion. The larvaetunnel in the killed shoot or in the soil and may take three to seven months to complete development. Pupation takes place in the dry shoot or in the soil. Adults emerge in most months except January to March, and attack fresh plants. This insect is not conffined to *Hopea pamiflora;* shoots of various dicotyledonous trees and shrubs are also attacked (Beeson, 1941; Browne, 1968). A scolytid beetle, *Xylosandrus compactus* (Syn. *Xyleborus morstatti, Xyleborus compactus)* attacks seedlings or trees up to **3** years old, and small twigs. It makes a hole, about a millimeter in diameter, leading to a circular brood gallery which girdles the stem and causes death (Beeson, 1930). This species, which also attacks coffee plants, among several others, is generally known as a shot hole borer of coffee and is quite common throughout the range of *Hopea pamiflora* in southern India. In south Managalore (Karnataka, India) another scolytid, *Sphaerotrypes* sp., is reported to enter the stem of seedlings and tunnel down to the root, killing the plant (Kadambi, 1954b). This report needs confirmation as most species of *Sphaerotypes* have a gallery system confined to the bark-sapwood region.

Several insects feed on the foliage of *Hopea* spp., but none is considered to be a serious pest. Apart from unidentified grasshoppers, caterpillars are the major leaf-feedders. These are the lycaenids, *Arhopala bazalus,* ***A.*** *canaratca,* ***A.*** *centaurus* and *Rathinda amor,* recorded from *H. helferi;* the lymantriids, *Leucoma flavescens, Orgyia postica* and *Redoa* sp., and the noctuid, *Lophoptera illucida.* recorded from *H. parviflora.* **A** small caterpillar, *Microcolona* sp. (Cosmopterygidae) mines the leaves of *H. wightiana.*

SHOREA

Over 125 species of insects are known to feed on healthy standing trees of *Shorea.* Most of these have been recorded from S. *robusta.* the most valuable and the best investigated of all dipterocarps in South Asia. Insects associated with S. *robusta* are dealt with first.

Shorea robusta

About 115 species cause primary damage to living trees of *S. robusta.* These include 93 species of Lepidoptera, 16 of Coleoptera, 4 of Hemiptera and 1 each of Ephemeroptera and Isoptera (Mathur and Singh, 1961). Based on the type of damage caused, the sal pests are grouped and discussed under **(1)** the sal borer, *Hoplocerambyx spinicornis.* **(2)** other borers, including, secondary borers of standing moribund trees, and **(3)** leaf feeding and sap sucking insects. A few minor pests do not fall into any of the above categories; they include larvae of several scarabaeid beetles which feed on roots of seedlings, a cricket *(Gryllus* sp.) which feeds on the inner bark and sapwood of branches, and two buprestid beetles, *Psiloptera cupreosplendens* and *P. fatuosa* (Fig.), which gnaw the bark of thin twigs in strips and ragged patches.

(1) The sal borer, *Hoplocerambyx spinicornis*

The sal borer, *Hoplocerambyx spinicornis* Newman (Cerambycidae, Coleoptera), is the most devastating pest of sal. It is so well known in the sal forests of India that it is often referred to simply as *Hoplo.* A species normally breeding in felled and dying trees, it is capable of killing large numbers of healthy standing trees when an outbreak occurs.

Since the year 1897 when it was first recorded as a pest of sal (by Stebbing, from Bihar), a series of bad epidemics have been reported from the various northern states of India. These include the epidemics in 1913—24, 1958 and 1965 in Uttar Pradesh (Beeson and Chatterjee, 1925; Mathur, 1962; Chatterjee and Thapa, 1970), in 1924—27 and 1963 in Madhya Pradesh (Watt, 1928; Beeson and Bhatia, 1939; Chatterjee and Thapa, 1964), in 1931—34 in Bengal (Ahmad, 1935), and in 1961 in Assam (Mathur, 1962). Most of the recent epidemics occurred in spite of attempting routine preventive measures (vide infra). According to Beeson (1941), in India the average annual economic loss resulting from sal borer attack is not less than Rs. 0.25 million (1941 estimate); in epidemic years the loss may be enormous. For example, in an epidemic over 12 Km^2 of forests in Uttar Pradesh, about 45,000 trees (amounting to nearly a million cubic meters of wood) were killed over a period of four years (1916 to 1919) before control measures were adopted (Beeson, 1924).

Nature of damage The beetle larvae feed and tunnel in the trunk of the tree; when large numbers of larvae attack a tree, the tree dies. In epidemics, healthy trees of all dimensions, except those below 30cm and above 200cm. in girth, in general (Chatterjee and Thapa, 1964, Roonwal, 1976) are attacked and killed. Young larvae feed at first beneath the bark, later in the sapwood, and finally bore deeply into the heartwood where they pupate. A full-grown larva (Fig.) may measure up to 9cm in length. Severely attacked trees start dying off from the crown downward; by a sudden withering of the foliage. Profuse exudation of resin may be‘ seen at points where the young larvae bore into the bark. A big sal-tree may harbour up to 300 larvae and in the late stages of attack, the dust falling on the ground may often accumulate to a height of one meter (Beeson, 1941). Healthy trees are attacked only in epidemics; at other times, the attack is confined to trees which are dead, felled or otherwise damaged.

Life history and *ecology:* The life history of *H. spinicornis* on sal has been worked out in detail by several investigators in India. The life cycle is annual. Beetles begin to emerge from infested trees as soon as the south-west monsoon rains start, the peaks of emergence closely following the peaks of rainfall. The beetles feed on the bark of sal, particularly when the inner bark is exposed due to some cause or other. They are attracted to newly exposed inner bark and sapwood over considerable distances, up to 400 meters upwind according to Beeson (1941). This behaviour is taken advantage of in trapping beetles for control of epidemics. The beetles live for 3 to 4 weeks and lay 100 to 300 eggs per female. The eggs are laid singly in cracks and crevices in the bark and the larvae hatch out in 3 to 7 days. In a healthy tree, the newly hatched larvae that bore into the living bark are often trapped in the flow of resin and killed. But in an epidemic, several hundreds of eggs may be laid on a single tree (as many as 1,378 larvae have been recorded from a single tree) so that the rate and quantity of resin produced is insufficient to kill the larvae. Thus, when the primary infestation is heavy, many or most larvae may establish themselves successfully. The liability of a healthy tree to attack by *H. spinicornis* therefore depends on the abundance of the insect. This density-dependent susceptibility to attack explains the apparent paradox – “A perfectly healthy sal tree is able to resist the attack of Hoplocerambyx, yet *Hoplo*-cerambyx is able to kill a perfectly healthy sal tree” (Beeson, 1941).

Generally the larva is fully grown by November. Pupation takes place within the tunnel and the beetles emerge with the onset of the monsoon in June—July and a new genertion starts.

Control measures: When not more than one per cent of the growing stock is attacked by the insect, the infestation is considered to be below the economic threshold (Beeson, 1941). To keep damage to a tolerable level and prevent the outbreak of epidemics, certain preventive measures are recommended as part of the normal silvicultural operations in sal forests. These include (1) felling trees as soon as they become exploitable, thereby preventing the build-up of potential breeding material for the insect, such as and unsound trees (2) confining fellings to the period October to March, and removing or debarking all felling refuse before the following rains, and (3) carrying out regular patrolling of the forest during the cold weather to locate trees which are dead or dying due to borer attack and arranging the disposal of such trees. In addition, remedial measures are carried out as soon as there is evidence of an incipient outbreak. In brief, they consist of (1) enumeration of attacked trees to determine the area of attack and the intensity of incidence, (2) extraction, conversion on the spot, or disposal by burning, of severely attacked trees, and (3) collection and killing of beetles by setting up trap-trees during the monsoon months. To set up traps, unsound or injured trees 75cm to 125cm girth (these are the most attractive) are selected and felled at the rate of 3 to 5 trees per hectare (depending on the severity of infestation). These trap trees are cut into 3m logs, bark near the cut ends beaten to make it more attractive to beetles, and the logs distributed in small heaps in the affected area. Beetles which settle on these trap logs are collected and destroyed daily. At intervals, these logs are again cut into smaller logs and billets to expose fresh sap. When the beetle yield falls off, the trap materials are debarked and burned. By this method as many as 1,000 beetles have been caught per trap tree in 24 hours (Beeson, 1941). During mic over 85 Km^2 of sal forests in northern India, 650 beetles were trapped per Km^2 of forest in the year 1951 (Roonwal, 1976). For further details of the trap-tree method, see Beeson (1941), Mathur (1962) and Chatterjee and Thapa (1964). These authors also describe several instances of successful control of sal borer outbreaks by the trap-tree method. The control measures devised for H. *spinicornis* are probably the most effective, ecologically the most acceptable, and the best tested of all insect control operations in Indian forests.

(2) Other borers, including secondary borers of standing moribund trees

Other borers of the living sal tree, mentioned below, are of minor importance. Larvae of a cerambycid beetle, *Celosterna scabrator,* occurring more usually as a pest of *Acacia,* bore into the stem and root of saplings, often killing the plant; the adult beetle feeds on the bark of young living shoots. Larvae of a moth, *Gerontha captiosella* (Tineidae) bore into the branches and stems of trees. Another moth larva, *Inderbella tetraonis* (Indarbellidae) bores a short shelter tunnel in living trees and feed on the green bark. A drywood termite, *Neotermes qreeni,* often gains entry through dead patches in the living tree and tunnels into the heartwood.

Some borers which do not attack healthy standing trees, attack moribund trees and called secondary borers. Possibly, they cause death to occur a year or two earlier than would happen in their absence (Beeson, 1941). The secondary borer fauna varies considerably in its species composition in different localities and among individual trees within a locality. They generally comprise larvae and adults of beetles of the families Bostrychidae, Buprestidae, Cerambycidae, Platypodidae and Scolytidae.

Characteristic borers present in dried out crowns are *Acmaeodera stictipennis* (Fig.) and *Chysobothris beesoni* (Buprestidae); *Sinoxylon anale* and *Xylodectus ornatus* (Bostrychidae); and *Xylotrechus smei* (Cerambycidae) (Fig). Typical borers in the larger branches and boles of such trees are the cerambycid beetle, *Aeolesthes holosericea* (Fig.), *Coptops aedificator* and *Diorthus cinereus.* In high rainfall areas, the characteristic secondary borers include *Dialeges pauper* and *Xylotrechus bouqueti* (Cerambycidae); *Crossotarsus saundersi* and *Diacavus furtivus* (Platypodidae); and many *Xyleborus* sp. (Fig.) (Scolytidae). *Aeolesthes holoseri-*

(Cerambycidae) needs special mention as it closely resembles *Hoplocerambyx* and may be easily confused with it in all stages. It is a polyphagous timber borer widely distributed in the Oriental region. The large larval galleries, deep in the trunk, ruin the timber. Although found occasionally in unhealthy standing trees, it is essentially a pest of felled trees and is not known to attack healthy trees.

(3) Leaf-feeding and sap-sucking insects

Over 80 species of caterpillars and about a dozen species of beetles feed on the foliage of *S. robusta*. The more numerous among the caterpillars are lymantriids (25 spp.), noctuids (12 spp.), pyralids (10 spp.) and geometrids (9 spp.). Among the beetles, scarabaeids (6 spp.) and curculionids (4 spp.) constitute the majority. In addition, some species of grasshoppers feed on sal foliage; they are particularly injurious to seedlings in nurseries and regeneration areas. Mathur and Singh (1961) give a complete list of these insects. only the more important species are mentioned below. Most of the leaf-feeding insects are polyphagous and occur usually in small numbers. Except when an outbreak occurs, their impact on the growth and survival of sal is negligible. Only the following species are known to cause significant defoliation:

Ascotis selenaria *(Geometridae):* The sub-species ***A.*** *imparata* Walker, is distributed throughout India and sometimes causes wholesale defoliation of new flushes of foliage. In 1974, it caused complete defoliation of about 2 Km^2 of sal forests in Dehra. Dun, Utttar Pradesh, India (Sen-Sarma, Pers. Commom.).

Dasychira grotei *Moore (Lymantriidae)* (Fig.). This species occurs in the plains as well as up to 2,300 meters e1evation in the Himalayas. Frequently, it appears in epidemics extending over hundreds of square kilometres of sal forests, particularly in Assam, where epidemics were recorded in the years 1897, 1907, 1914. 1922 and 1936. Epidemics also occurred over 300 Km^2 of forests north of Brahmaputra in 1884, in Bengal in 1899 and in Madhya Pradesh in 1909. Defoliation is most e in August—October. Trees of all ages are attacked and the whole leaf, except ribs, is eaten. Trees may be killed if two or three defoliations occur in succession (Beeson, 1941).

Euproctis latifascia *Walker (Lymantriidae)* Larvae of this moth are active during the South-West monsoon and cause severe defoliation, particularly of young plants, often leading to the death of many plants.

Lymantria bivittata ***Moore*** *(Lymantriidae):* This insect caused large scale defoliation of sal in Darjeeling (West Bengal, India) in the summer of 1961 (Rudra, 1961).

Lymantria mathura ***Moore*** *(Lymantriidae):* This species is one of the principal defoliators of sal in Assam, West Bengal and the Sub-Himalayan regions of India. Localized epidemics, usually during leaf fall period, have been reported (Beeson, 1941; Roonwal, 1953; Chowdhury, 1962).

Maurilia iconica *Walker (Noctuidae);* In the sal forests of Bengal, India, this insect often causes severe defoliation.

Paectes subapicalis *Walker (Syn.* lngura subapicalis) *(Noctuidae):* Outbreaks of this caterpillar (Fig.) frequently occur in the sal Forests of Uttar Pradesh and Madhya Pradesh in India. Tender foliage in particular is eaten up and in bad epidemics the trees may be completely stripped (Beeson, 1941).

Selepa celtis Moore *(Noctuidae):* This insect, widespread in central and northern India, occasionally causes complete defoliation of various tree species, including sal.

Suana concolor *Walker (Lasiocampidae):* This species, which has two generations per year, regularly causes some defoliation of sal in India but epidemics have not occurred.

Trabala vishnu *Lef. (Lasiocampidae):* This species which passes through four or five species, which passes through four or five generations per year, is a sporadic defoliator and Madhya Pradesh (India).

In Bangladesh, the leaf-feeding caterpillars, *Dasychira horsfieldi* and *Antheraea paphia*, do considerable damage to young coppice shoots of sal. Sometimes the leading shoots are also damaged. On recovery, the coppice shoots grow like tea bushes (Ahamed, 1958).

Of the sap-sucking insects, a coccid, *Drosicha stebbingii*, occurs throughout the sal forests of northern India and periodically breaks out in epidemics. In epidemics, twigs and branches of trees dry up as a result of insect feeding. Leading shoots of young saplings may be killed. Other less important sap-sucking insects include a cicadid, *Platypleura capitata.* a mealy bug, *Pedronopsis beesoni* and the lac insect, *Laccifer lacca.*

Other Shorea species.

Shorea roxburghii, whose distribution is confined to southern India, is attacked by the cerambycid borer, *Massicus uenustus.* Other pests recorded from *S. roxburghii* are the lac insect, *Laccifer lacca* and several caterpillars. A tortricid caterpillar, *Platypeplus aprobola* (Syn. *Argyroploce aprobola)* feeds on both young leaves and flowers. Other leaf-feeding caterpillars are *Gelasma* sp. and *Hyposidra talaca* (Geometridae); *Lycaenopsis puspa gisca* (Lycaenidae); *Dasychira mendosa* (Lymantriidae); *Anua triphaenoides* and *Lophotera* spp. (Noctuidae); *Chalcidoptera straminalis*, *Lamida* sp. and *Orthaga euadrusalis* (Pyralidae); *Striglina seitaria* (Thyrididae); and *Cacoesia* spp. and *Homona coffearia* (Tortricidae) Mathur and Singh, 1961). However, none of these is known to cause wide-spread defoliation.

A cerambyecid beetle, *Cyriopalus wallaci,* is an important pest of *Shorea siamenisi* in Burma. The reddish brown beetles, about 4 to 5 cm long, show a preference to timber of about 50-90cm girth and attack green, healthy trees. The larvae make long ramifying tunnels, 4-5cm in diamater, running vertically up and down the trunk of the tree. One larva can damage upto one meter of timber. The tree is not necessarily killed, but tunnelling by a few larvae is sufficient to make the timber useless for constructional work. In large trees, the attack is confined to branches, and stalactites of solidified resin up to 9Ocm long may be seen hanging from the branches (Beeson, 1941).

The sal borer, *Hoplocerambyx spinicornis* is known to attack *Shorea assamica,* S. *obtusa* and *S. siamensis,* but large-scale epidemics have not been reported. A lymantriid caterpillar, *Dasychira thwaitesi* has also been recorded from S. *assamica.*

VATERIA

Only two pests have been reported from living trees of *Vateria,* both from *V. indica. Massicus uenustus* attacks stumps as well as fire-scorched and over-mature trees. *A* drywood termite, *Neotermes* sp., attacks standing trees and makes its nest in it, riddling the heart-wood (Sen-Sarma *et al.,* 1975).

Pests of Timber

The timber of dipterocarps, like that of other trees, is damaged by a large number of insects. They fall under two major groups – beetles and termites.

WOOD DESTROYING BEETLES

From the time trees are felled, throughout the course of processing and utilization, different groups of beetles cause damage to timber. The resulting wastage is believed to be enormous but no estimate of the economic loss has been attempted. The total number of species of beetles known to attack dipterocarp timbers is very large; for example, about 130 species have been recorded as pests of sal timber alone. A complefe list of insect borers of several species of dipterocarp timbers is given by Mathur and Singh (1960-69). Unlike many pests of living trees which attack only a narrow range of hosts, the timber borers, in general, attack a large variety of timber species. The borer complex of a particular species of timber, therefore varies from place to place.

The sapwood of all dipterocarps **is** attacked by different kinds of borers, but the heartwood of some, such as *Shorea* and *Hopea,* is comparatively more resistant to borer damage. Based on the type of damage caused, economically important borers of terocarp timbers can be conveniently cassed into three major groups – (1) large sapwood and heartwood borers (2) powder-post beetles and (3) Pin-hole borers.

(1) Large sapwood and heartwood borers

This group consists chiefly of beetles of the family, Cerambycidae. They are usually large, conspicuous insects. Most of them attack only freshly. felled or unseasoned timber. The eggs are laid in cracks in the bark and the newly hatched larvae tunnel into sapwood initially, eventually entering the heartwood. Usually the life cycle is annual. It is the larva that causes damage; beetles seldom bore into the wood. Because of the large size of the insects, the tunnels made are large and the timber is ruined for most purposes.

Over *60* species of cerambycid beetles have been recorded as pests of dipterocarp timbers. Those attacking more than one dipterocarp genus include *.4eoleothes holosericea, Chlorophorus hederatus. Dialeges pauper, Euryphaqus lundi. Dihammus grissoplagiatus, Hoplocerambyx spinicornis, Massicus venustus* and *Mesocacia assamensis.*

Aeolesthes holosericea (Fig.), *Hoplocerambyx spinicornis* (Fig.), *Xylotrechus smei* (Fig.) and *Stromatium barbatum* are the most important borers of *Shorea robusta* (Bhatia, 1950; Mathur et al., 1970). Important borers of *Dipterocarpus* are A. *holosericea* and *M. venustus (Khan, 1947).* of *Vateria, M. venustus* (Khan, 1947), and of *Hopea, Remphan hopei* (Beeson and Bhatia, 1939). As these beetles lay eggs only when bark is present, sawn and seasoned timber are not attacked. Damage to logs in storage can be prevented by debarking the logs soon after felling. Stromatium barbatum, *however,* can attack debarked timber also (Mathur *et al.,* 1970).

(2) Powder-post beetles

Mostinsects of this group belong to the families, Bostrychidae and Lyctidae. These comparatively small insects reduce the wood to powder by repeated tunnelling and feeding of successive generations of the insect in the same piece of wood. Most species confine their attack to softwoods or sapwood of hardwoods. They are of great economic importance due to the damage caused to stored logs and manufactured articles.

Over 30 species of powder-post beetles have been recorded as pests of dipterocarp timbers (Mathur and Singh, 1961—69). Generally, they show little discrimination between timber species. For example, *Minthea rugicollis* is known to attack 120 timber species and *Lyctes africanus* may attack 90 (Beeson, 1941). Those recorded from more than one dipterocarp genus include *Dinoderus minutus*, two species of *Heterobostrychus* (Fig.), *Lyctus africanus,* three species of *Sinoxylon, Trogoxylon spinifrons, Xylodectes ornatus* (Fig.), *Xylothrips flavipes* (Fig.) and *Minthea rugicollis.* Borers of stored sal poles causing economic damage are *Heterobostrychus aequalis* (Fig.), *Schistocerus anobioides, Sinoxylon anale, Xylodectes ornatus* (Fig.) and *Xylothrips flavipes* (Fig.) (Bhatia, 1950;Mathur*et al.,* 1970).

Attack by powder-post beetles is a limiting factor in the full utilization of wood. For logs in storage, the damage is generally confined to about 5cm depth in the sapwood, which will be usually eliminated as slabs when converted in saw mills. But the loss in significant in those dipterocarps which are peeled. As the debarking of logs exposes the sapwood, the liability to attack by powder-post beetles increases. Yet, debarking is necessary to prevent attack by cerambyicd beetles. Application of insecticides to debarked timber has therefore been recommended for protection of stored logs (Mathur *et al.,* 1970; Chatterjee and Thapa, 1971).

(3) Pin-hole borers

The pin-hole borers chiefly belong to the family Platypodidae, with some representatives of Scolytidae.They are small beetles, 3 to 6mm in length, which produce small holes (pin-holes) in timber by tunnelling. The tunnels, (Fig.) bored by the adult beetles, are usualIy at right to the axis of the bole and typically free of wood dust. The tunnel walls of some beetles (Amobrosia beetles) are stained black, due to growth of a fungus on which the insects feed. This group of beetles attack only unseasoned wood with a high moisture content. Logs held in storage and freshly sawn timber are usually attacked. Unless the pin-holes are numerous they do not impair the strength of the wood. Generally, they only mar the appearance of the timber, the damage being considered a blemish rather than a defect.

Like the powder-post beetles, pin-hole borers are highly polyphagous. An exception is *Diacaves furtivus,* which is known to attack only *Shorea robusta*. Over 100 species have been recorded from dipterocarp timbers (Mathur and Singh, 1961-69), but the damage is not considered economically serious. Common genera attacking dipterocarps are *Crossotarsus. Diapus, Platypus, Webbia* and *Xyleborus* (Fig.).

Accumulated felling and logging refuse offers a favourable habitat for the build-up of large populations of pin-hole borers and increases the danger of attack. Prompt removal of logs from the forest and rapid conversion are generally recommended as preventive measures.

TERMITES

Termites are an important group of wood-destroying insects. Generally, most timber species are attacked by termites; the sapwood of all timbers is highly susceptible, but the heartwood of some is more resistant than others.

The natural resistance of several dipterocarp timbers were reported by Pearson and Brown (1932), Dover andMathur (1934), Kamesan (1936), Purushotham *et al.* (1953, 1968), Das *et al.* (1965), Sen-Sarma (1963) and Sen-Sarma *et al.* (1975). Resistance to termites is usually determined from two types ot tests. In 'grave-yard tests', samples of timber of a standard size are partially buried in soil under outdoor conditions and observations on deterioration made over a few years. In these tests, in addition to termites, fungi and other soil micro organisms and climatic factors contribute to. deterioration. Timber infested by certain groups of fungi are known to become more attractive to some species of termites (Sands, 1969). The 'grave-yard test', therefore, gives reliable information on termite resistance under natural conditions of use of timber in the open, in contact with soil. In 'accelerated laboratory tests' small pieces of timber are exposed to laboratory cultures of termites. These tests have been conducted with only some species of termites, for which methods of laboratory culture have been developed. As the susceptibility of timber may vary with the species of termite used, these results may not be of general validity; in addition, possi. ble pre-conditioning factors are excluded in this type of tests.

The results show that the natural durability of timbers varies, depending on the place where it was tested, in grave yard tests (Purushotham *et. al.,* 1968) and depending on the species of termites used, in accelerated laboratory tests (Sen-Sarma *et al.,* 1975). For a given species of timber, significant within-tree and between-tree variations have also been found. In general, the outer heartwood is more resistant than the inner heartwood, as was reported for *Shorea robusta* (Sen-Sarma *et al.,* 1975). Significant variation also exists between samples of the same timber species originating from different geographical regions (Purushotham *et al.,* 1953). However, termite resistance is predominently a species characteristic.

The information from grave yard tests has been given under each species. However, their comparative resistance as worked out by different investigators is shown in table below, along with results from accelerated laboratory tests. In spite of differences in the results obtained by different workers, the following general conclusions may he drawn. Of the dipterocarps tested, the heartwood of *Hopea paruiflora. H. cordifolia, Shorea robusta, S. obtusa* and *S. siamensis,* possess a high degree of resistance. However, in laboratory tests with the subterranean termites, *Heterotermes indicola* and *Microcerotermes beesoni, Hopea parviflora* was only moderately resistant (Table). It must also be noted that in *Shorea* and *Hopea,* the more resistant of the dipterocarp genera, the resistance varies considerably among the species. All species of *Dipterocarpus* and *Vateria* are susceptible to termite attack. On an average, highly resistant timbers like *Hopea parviflora* and *Shorea robusta* have a useful service life of over 10 years under outdoor conditions.

Termite Resistance of Dipterocarp Woods (Heartwood)

Timber species tested	Kamesam (1936) Grave yard test Res. classes I to IV[a]	Purushotham *et al.* (1953) Grave yard test Res. classes I to VI	Das *et al.* (1965) Grave yard test Res. classes I to III	Sen-Sarma (1963) Lab. tests with *Heterotermes* Res. classes I to VI	Sen–Sarma (1975) Lab. tests with *Microcerotermes beesoni* Res. classes I to V
Dipterocarpus alatus	II	V	III	–	–
D. grandiflorus	III	V, VI	III	–	–
D. indicus	II	IV	II		
D. kerii	III	V	111	–	–
D. macrocarpus	III	V	III	–	–
D. obtusifolius	III	V	111	–	–
D. tuberculatus	II	V	111		–
D. turbinatus	I11	V	I11		–
D. zeylanicus	III	V	I1		
Hopea cordifolia	II	I	J		
H. glabra	III	I1	I	–	–
H. odorata	II	IV	11	–	–
H. parviflora	I	I	I	III	III
Parashorea stellata	I1	IV	I1	–	–
Shorea assamica	I1	V	III	–	–
S. obtusa	I	–	I	–	–
S. robusta	I	I	I	I	II[b], IV[c]
S. roxburghii	I1	IV	I1	–	–
S. siamensis	I1	I	J	–	–
Vateria indica	IV	V	III	V	V

a The most resistant timber is assigned to class I and the least to class IV. Note that the least resistant is assigned to class IV, V or VI by different authors, depending on the number of ciasses to which resistance has been divided.

h. Outer heartwood.

c Inner heartwood.

In general, the resistance of timbers to termite attack is attributable to the presence of chemical substances that are toxic or repellent to termites. They are usually present in greater quantities in the heartwood, especially in the outer layers. The hardness of the also play a role; if there is a choice, termites prefer lighter wood species, although they are able to destroy very hard woods also.

2. MARINE BORERS OF TIMBER

Some dipterocarps are valuable timbers for marine works. All these are subject to damage by a number of marine organisms which bore into the wood either for food or shelter. In contrast to their resistance to land pests, the resistance of most timbers to marine borers is spectacularly low. For example, *Shorea robusta*, which has a service life of about 20 years on land, hardly lasts ***3%*** years in sea water (Purushotham and Rao, 1971).

The marine borers cause considerable economic damage to timbers in the South Asian coast because the tropical waters provide a favourable environment for these organisms. More than 35 species of borers have been recorded. Most of them attack a variety of timber species and do not exhibit preferences for particular species of timber. A brief account of the principal groups of marine borers in the South Asian coast is given here. An excellent review of the work carried out in India during the period 1953 to 1970, on the biology, ecology and control of marine wood borers is given by Purushotham and Rao (1971).

The marine wood borers fall into two major groups – molluscans and crustaceans.

Molluscan Borers

The most destructive of the marine wood borers are the highly specialized bivalve molluscs known as shipworms (Teredinidae). About 21 species of shipworms have been reported from the region. *Teredo*, *Bankia* and *Nausitora* are the common genera. Thousands of these shipworms often attack the same object, completely ruining the wood with their closely drilled tunnels. Their presence is not easily detected because they leave only small, pin-sized openings to the outside. Shipworms specifically recorded from dipterocarp timbers include *Teredo furcifera, Lyrodes pedicellatus, Bankia bipalmulata* and *B. indica* in *Shorea robusta;* and *B. indica* in *Hopea* sp. (Nair, 1965; Purusho: tham and Rao, 1971).

Another group of molluscan borers are piddocks (Pholadidae), of which about 6 genera occur in the region. *Martesia* is the most important genus. ***M.*** *striata* is the most destructive of all marine borers in the Indian Coast. It can tolerate wide ranges of salinity and therefore extends its range to estuarine regions. The damage caused by this group of borers is restricted to the superficial layers of timber up to 25mm to 35mm in depth.

Crustacean Borers

Important crustacean borers in the region belong to 2 genera – *Limnona* and *Sphaeroma;* the latter is the most dangerous. Although their attack is confined to the surface of the wood, because of the high density of settlement and rapid rate of reproduction, the surface id honey-combed and destroyed in a short time. Sphaeromids also occur in estuarine waters; they are especially abundant in the estuarian waters of Kerala in the south western coast of India.

Studies in four harbours in India, viz., Cochin, Vizhakhapatnam, Madras and Bombay, showed that the species composition of the borer fauna and their seasonal abundance varied considerably among the harbours (Purushotham and Rao, 1971). Detailed investigations have not been carried out on the resistance of dipterocarp woods to marine borers. Based on limited tests, Purushotham and Rao (1971) tentatively classified 25 timber species into three categories which showed good, .moderate and poor resistance to marine borers in Indian harbours. Of the two dipterocarp species included in these tests, *Dipterocarpus indicus* showed good resistance and *Shorea robusta* moderate resistance.

Ascu and creosote – coal tar *(70:30* or 60:40) are generally 'considered to be effective preservatives against marine borers. However, the effectiveness of different preservatives may differ for different borer species.

3. FUNGAL DISEASES

Fungal diseases of woody plants, often lead to a substantial reduction in the potential yield of utilizable timber. Amongst dipterocarps, diseases of sal received maximum attention from investigators. In a field survey of sal in Dehra Dun Forest Division (India) it was found that over 70 per cent of the trees had heart-rot infection. This was estimated to result in the loss of 10 per cent of the total merchantable volume of timber (Bakshi, 1963). Although a few diseases have also been reported from other dipterocarps, they have seldom caused serious economic problems and have not been thoroughly investigated.

Fungi may attack the root, the stem, the foliage or the felled timber, as primary or secondary parasites, thereby causing various diseases. Heart-rot diseases in standing trees are economically most important. Fungal decay of felled wood and timber, is also a serious problem for most dipterocarps. Many fungi which cause deterioration of felled timber during storage, often enter the tree during its growth. A heterogenous assemblage of fungi attacking dead wood, either in combination or in succession, bring about changes in colour, loss of strength and weight. The heartwoods of some dipterocarps possess a high degree of natural resistance due to the presence of toxic chemicals; partly based on this resistance to fungal decay, timbers are usually classified into natural durability classes. Indications about the natural durability of various dipterocarp timbers have already been given. The timber decaying fungi reported from various dipterocarps are species of *Daedalea, Fomes, Ganoderma, Lentinus, Lenzites. Polyporous, Polystictus. Stereum* and *Trameters* (Chow+hury and Ghosh, 1958).

Diseases of Shorea robusta

About 150 species of pathogenic fungi have been recorded from sal tree and timber. A check list and brief accounts of the most important fungi are given by Bagchee (1953), Browne (1968) and Bakshi (1976). Detailed accounts of most diseases and the causative fungi were published in a series of articles by Bagchee (1953, 1954, 1957, 1958 and 1961), who did pioneering work on diseases of sal. Diseases include root and stem rots and foliar diseases. The most important are the different types of rots caused by various genera of Basidiomycetes. Some fungi degrade only the heartwood, some only the sapwood, while others affect both sap and heart wood. They may also be distinguished into 'brown' and 'white' rots. In 'brown-rot', mainly the cellulose is attacked by fungi while lignin remains mostly unaffected, and in 'white-rot', all components of cell wall material, including lignin which imparts the normal brown colour to the wood, are generally degraded by the fungi. Rots are often known after the external appearance of the rotted wood, for example, honeycombed rot, fibrous feathery rot, ochraceous pocket rot, mottled sap rot, yellow sap rot, etc. Some confusion in the common names of different 'rots' exists because different authors have used different names for diseases caused by the same organism. For the sake of convenience, the rot diseases of sal are grouped into major and minor rots, based on economic importance.

MAJOR ROT DISEASES

Root rots

Root rot caused by the fungus, *Polyporus shoreae,* **is** one of the major mortality factors of sal in India. Other fungi which also cause root rot will be described under minor rot diseases.

Polyporus ***shoreae*** Wakef.: This fungus causes a serious root disease throughout the sal forests of U.P., Assam and North Bengal (India). In some parts of Assam, the extent of dying and dead trees due to this fungus was estimated at 10 to 20 per cent. In Golpara (Assam) alone, about 2000 hectares of sal were affected (Rajkhowa, 1958, cited in Bakshi, 1976). The fungus appears to be widespread but is of greater economic significance in forests of the wet type. The disease, commonly known as 'partridge rot', results in top drying and the death of trees (Bagchee, 1957; Bakshi and Boyce, 1959).

In the roots, the fungus develops light yellow mycelial felts in small patches on the bark. The bark and sapwood exhibit 'pocket-rot'. The 'pockets' are variable in size and are filled with a white fibrous mass which gradually turns light brown. The heartwood is not affected. Above the ground no symptoms are noticeable till the disease is in an advanced stage with about 80 per cent of the root system decayed. The few healthy surviving roots cannot meet the water requirements of the tree and top drying of the infected trees sets in, which extends downwards till the whole tree dries up in a few years or is wind-thrown.

Infection takes place through healthy or injured roots. The fungus may also spread 'to the adjoining trees by root contacts. Primary infection normally occurs in the distal end of the roots. The disease then progresses up the roots to the collar, where it gets restricted and does not usually advance into the stem.

The fruit bodies of the fungus develop at the base of the diseased tree or on the exposed roots of fallen trees. They are large, bucket-shaped, brown or brownish black on the upper surface and contain many pores on the lower surface. In the pores, basidiospores develop which are wind-borne.

*Heart **rots***

Heart rot usually refers to the rotting of the heartwood of trees by various pathogenic fungi. Although the heartwood of sal is one of the most naturally durable dipterocarp timbers, the living tree is susceptible to many fungi which cause heart wood decay. The more serious among them are caused by the species, *Fomes caryophylli*, ***F.** fatuosus*, *Hymenochaete rubiginosa. Trametes cubensis* and ***T.** incerta* (Bagchee, 1958; Baskshi, 1976).

In general, trees of all ages are liable to infection by heart rot fungi. Infection takes place through wounds or openings in the trunk caused by various physical and biological factors. The pathogen may establish itself in the tree even before the heartwood velops and will eventually attack the heartwood. In coppice forests, the fungi usually establish themselves in the stools first and then migrate to the heartwood of the coppice shoots.

Common symptoms of heartwood decay in sal are the formation of sporophores, 'punk knots', decaying wounds, swollen bole and dead branches. Of these, the sporophores are sure indicators of decay. 'Punk knots', ***a*** characteristic symptom of attack by *Fomes caryophylli*, consist of cylindrical cores of decayed woody tissues, embedded in the sapwood up to different depths and opening up on the bark as round or oval hard structures (Fig.). In advanced stages of decay, in most cases, portions of the stem swell up perceptibly, giving a spindle or bottle-shaped appearance to the bole. In many cases of heartwood decay, however, the affected trees appear healthy and vigorous for many years, although the heartwood inside is being progressively destroyed by the fungus.

Fomes caryophylli (Rac.) Bres.: This fungus is present in almost all types of sal forests, but is more common in the frost-affected forests of northern India (Hoshiarpur Siwaliks in Punjab, along the foot hills of the Himalayas in Uttar Pradesh, and in the plateaus of Chhota Nagpur), Bagchee (1961). Sal trees of all ages are susceptible to this fungus, but the incidence is usually high when they are young, as they are more prone to frost damage. This fungus may account for over 25 per cent of the total decay of sal (Bakshi, 1976). lhe disease is commonly known as 'ankhya-rot' or 'gauj', which refers to the punk knots which appear in the form of eyes or pox-marks on the surface of the bole (Fig.). The disease is described in detail by Bagchee (1958, 1961), Bakshi (1957, 1976) and Bakshi *et **al.*** (1963).

There are no definite symptoms in the initial stages of the disease. Most trees in which the fungus is established do not produce strong lateral branches; instead, a large number of bushy epicormic shoots are thrown out from almost every whorl, resulting in a phenomenon known as ‘feathering out’ (Fig.). But this character is not of diagnostic value as it many also be produced under the influence of other conditions. ‘Punk knots’ (Fig.) is a characteristic symptom when the fungus is well established in the heartwood. In later stages, the elegant tapering shape of the bole, so characteristic of sal, is deformed. In the early stages of decay, the wood is stained dark brown. Later, white rot is produced and the wood becomes spongy. Yellow mycelial mat may develop in decayed wood. Decay may also occur as circular rings associated with punk knots.

The sporophores are small, woody and have a brownish black upper surface. In nortliern India, typical sporophores are produced during the wet season in areas subject to frost. In dry forests, sporophores are rarely produced, and the fungus usually propagates vegetatively.

F. fatuosus (Lev.) Cooke: It is widely distributed in the sal forests of Bangladesh, India and Nepal. Normally it causes stump decay and occurs as a saprophyte on grounded logs, it may also attack the living sal trees of coppice origin. In the deciduous and semideciduous forests of northern India, where sal is the major species, it usually attacks sal. Only poorer classes of sal are usually attacked; immature and vigorous trees are not susceptible. The fungus does not extend to dry zone forests with an annual rainfall fo less than about 70cm. It is also rare in the wet evergreen forests (Bagchee, 1954). As a common slash decay, this fungus is prevalent in northern India, extending from Hoshiarpur Siwaliks to Assam along the foot hills of the Himalayas.

Rot caused by ***F.*** fatuosus in sal is characteristically different from other white pocket-rots caused by Polyporus. In the initial stages of attack, the wood is bleached in patches to a light brown, where decay pockets develop in the later stages. The pockets are filled with white decaying fibres which disintegrate in course of time and the pockets become empty. Light brown, reflexed, sessile, woody, large sporophores appear near the base of the affected tree.

Hymenochaete rubiginosa (Schred.) Lev.: This fungus, which causes a ‘white pocket rot’ or ‘spongy pocket rot’, is widely distributed in Bangladesh, India and Nepal. It is a common saprophyte of felling slash, stumps and timber but also attacks standing sal trees. In the forests where sal is the major crop, the fungus generally restricts itself to sal, although it is capable of attacking the hardwood associates of *sal.* Also, in timber yards where sal is stored with other hardwoods, sal is the preferred host.

The only external symptom of heart rot is a knotted appearance of the stem, accompanied by slight swelling. In the advanced stage, however, the initial symptoms of canker appear, such as discolouration and cracking of the bark and sapwood. Sometimes there is more than one bulge on the stem, signifying multiple foci of infection. With the increase of pressure caused by the fungal mycelia, the bark splits up, exposing the rot. On exposed rots, sessile, corky sporophores appear in large numbers, usually in closely imbricate clusters (Bagchee, 1954, 1958; Bakshi, 1957 and Bakshi *et al.*, 1963).

Tramates cubensis (Mont.) Sacc.: This fungus is usually a saprophyte of slash and stump. In India and Nepal it is almost ubiquitous on decaying slash and stumps in the sal forests of the terai and bhabar regions. It is also found in Bangladesh and the states of Assam, Bengal, Bihar, Orissa and Madhya Pradesh in India (Bagchee,‘ 1954). As a parasite of living trees it is not considered to be of much econotnic importance. Sporophores are usually sessile, produced singly or in clusters. The upper surface of the sporophore is white to light brown, turning black at the base (Bakshi, 1971).

T. incerta (Curry) Cooke: It occurs a wound parasite and *as* a saprophyte of slash and causes a white pocket rot of sapwood as well as heartwood. Generally young crops of sal in low quality sites in the drier parts are attacked. In India, it is known to cause high mortality in sal saplings and poles in the Singhbhoom area of Bihar and some parts of Madhya Pradesh and Orissa (Bagchee, 1958). In the wet sal forests it is usually found as a secondary parasite of over-mature trees and as a saprophyte of fallen logs.

In young saplings no characteristic symptoms occur in the initial stages. With the formation of heartwood in the pole stage, indication of heart rot is marked by deformed branches and knotted stems. White pocket rots produced in the sapwood and heartwood are filled with fungal mycelia intermingled with wood fibres bleached to brownish grey and white. Sporophores are sessile, woody, with a dirty white upper surface which turns black with age (Basshi, 1971).

MINOR ROT DISEASES

Most of these fungi primarily attack slash and stumps and are not considered to be of much economic importance.

Fomes albomarginatus (Lev.) Cooke: This species is a secondary wound parasite and causes a pocket rot of roots and stems, often in association with *Polyporus shoreae* and *Phellinus lamaoensis.* Decay occurs in both sapwood and heartwood. Infection may spread through root contacts. Although not a virulent pathogen, it may be active in dense groups of trees (Bagchee, 1954). It is also prevalent in stumps and dead trees in the valley of Sitanadi, South Raipur Division and in the valley of Indravati, North Bastar Division (Madhya Pradesb). Leathery and semicircular sporophores, when fresh, are attractively coloured.

F. durissimus Lloyd: It is a wound parasite of the stem, usually attacking trees at the base, often at the ground level, but rarely the uranches. It is both a sap and heart rot fungus and may cause minor damage to the living trees. It also occurs as a saprophyte of logs and stumps. It has been recorded in the sal forests of Uttar Pradesh. Old mature sporophores are woody, sessile and dark brown (Bagchee, 1954).

***F.** lividus* Kalchber.: In the sal forests of north and central India, it is one of the common fungi causing decay of slash (Bagchee, 1954). The fungus also occurs in living trees as a secondary parasite of wounds. A high rate of infection is often noticed in coppice shoots. Sporophores are brownish when mature and occur in small to large patches.

F. melanoporus Mont.: This species attacks living trees of sal, usually near the base of the stem, causing decay of both sapwood and heartwood. It also attacks girdled trees, stumps and stored timbers, in India (Bagchee, 1954). Mature sporophores are large, jet black in colour and woody in texture.

F. ribis (Schum. ex Fries) Gill: In the Terai region of India, this fungus is found at the base of the living trees of sal. The initial stage of attack is characterised by the formation of cankers, with discolouration and roting of the bark and the collapse of the sapwood cells. Young infected trees often die due to infection. Sporophores are large, sessile, thin but rigid and tusty brown in colour (Bagchee, 1954).

F. tricolor (Murr.) Bres.: This fungus is a wound parasite found mainly on old trees, decaying bark and sapwood. It appears to be exclusively associated with sal. It is widespread in the sal forests of north, north-west and central India. Large, flat and black coloured sporophores are usually produced on the stems of standing rees (Bagchee, 1954).

Hexagoniu sulcata Berk. **:** Decaying stumps and logs of sal in moist localities are the common habitats of this fungus. It also occurs as a wound parasite on unhealthy trees growing in poor quality sites. It is widespread in the moist sal forests of the Terai along the foot hills of the Himalays. Sporophores formed on dead wood are sessile and semicircular, with hexagonal pores on the under surface (Bagchee, 1954).

Inonotus tabacinus (Mont.) Karst. (Syn. Polystichus tahacinus Mont.). This usually *a* saprophytic fungus, hut can also occur as a secondary wound parasite of sal. Young sal trees are attacked initially through the collar region or surface roots. Sometimes it causes the formation of deep cankers. Infected trees often show 'die-back' of the crown. A slashdecaying agent, it is widely distributed in India. Sessile and leathery sporophores are usually clustered and brown in colour (Bagchee, 1954).

Lentinus praerigidus Berk.: This fungus is normally a saprophyte causing the decay of wood in contact with wet ground. It also attacks the sapwood and heartwood of living trees but causes only minor damage. Timbers of all categories are attacked, causing white rot. The fungus establishes itself along the growth rings, forming large white streaks due to the decay of wood in the vertical direction. Sporophores are with short stems, imbricated in groups and with gills of unequal length (Bagchee, 1954).

L. subnudus Berk.: The fungus is found principally in humid forests at the base of the living trees, attacking exposed and injured surface roots and causing white rot. In Uttar Pradesh and Madhya Pradesh (India), it is also reported as a secondary parasite of frost injured sal. Sporophores are solitary or in clusters, stalked and whitish in colour (Bagchee, 1954).

Phellinus lamaoenis (Murr.) Heim. (Syn. *Fomes lamaoensis* Murr.): It is a saprophyte causing the decay of slash or logs under moist conditions. It has also been reported to cause active root and stem rot, killing young and'immature sal trees growing in lowlying marshy areas (Bagchee, 1954). Sporophores are stalked, funnel shaped with the upper surface dark brown to black.

Although this species has been much cited as a wound parasite causing a destructive brown root rot of various dicotyledonous trees, it is now believed to be totally saprophytic (Foster as cited by Brown, 1968).

Polyporus anebus Berk.: This species is usually saprophytic, but also occurs as a wound parasite of sal. It prqduces a fibrous rot of sapwood and a pocket rot of heartwood. It is prevalent in moist, deciduous sal forests. Sporophores appear close to the ground when the trees are almost dead. They are leathery and semicircular (Bagchee, 1954).

P. weberianus Bres. and P. Henn.: This fungus is a wound parasite of sal causing sapwood decay. Infection usually occurs through the tunnels of insect borers, particularly of *Hoplocerambyx spinicornis*.

Its distribution is limited to moist valleys of the Siwaliks and the foot hills of the Himalayas, in India. Sporophores, which often emerge through the insect tunnels, are spongy, semicircular, with an undulated margin (Bagchee, 1954).

Schizophyllum commune Fr.: This species, a common saprophyte of slashes, can also attack saplings of sal and several other hardwood trees. Under favourable conditions, it attacks sapwood and kills the saplings by girdling them. In frost pocket areas in India it causes minor damage to the regenerating sal. Sporophores are greyish and finely pubescent, fan-shaped and often with a black margin. Gills on the lower surface characteritically split longitudinally on drying (Bagchee, 1954).

Trametes straminea (Pat.) Lloyd: It is usually associated with slash decay or as a wound parasite, in the moist deciduous forests of north and central India. Through wounds it establishes itself in the heartwood of standing trees, where decay progresses rapidly and the tree is finally reduced to an outer shell of sapwood which may snap with the weight of the crown. On decaying timber, the fungus remains active for a long time and produces sporophores till the wood is destroyed completely. Sporophores are soft and spongy when fresh, cork-like in texture and light-buff in colour when dry (Bagchee, 1954).

Hypoxylon mediterraneum (de Not.) Miller: This fungus is generally associated with dying and dead sal trees. .It is a weak parasite in the dry sal forests of Bihar, Uttar Pradesh, Assam and Orissa (Bakshi, 1963). Fruit bodies appear on the bases of the trees as black in wide patches.

Control of various fungal rot diseases

The incidence of rot diseases can substantially be reduced by management practices and silviculture. As most of these fungi enter the tree through wounds, control measures are aimed at minimising injuries. Major factors causing injury and measures for their amelioration are discussed as follows:

Frost: The severity of frost is reduced by adjustment of the canopy. In the 'Uniform System' of management, this is possible by adjusting the successive fellings in the final periodic blocks, while in the 'Selection System', the canopy is not opened out too wide for obtaining regeneration.

Fire: Fire protection methods are carried out where accidental fires are of common occurrence. Early control burning to minimise the risk of severe fire is a practice commonly advocated. In wet sal forests where the incidence of root diseases caused by *Polyporus shorea* is high, this practice may help to bring the disease under control to some extent by reducing the soil moisture content.

Suppression: Suppressed trees which tend to develop dead branches, branch stubs and knots, constitute an infection hazard and may act as sources of the fungal infection. At the time of regeneration fellings, it is useful to eliminate as many suppressed trees as possible.

Damage during felling operations: Care is to be taken to prevent injury to the residual stock during felling and logging operations. Lopping of thick lateral branches prior to felling may be helpful. It has been suggested that all injured trees and trees exhibiting symptoms of decay, like sporophores and punk knots, should be removed during cultural operations. In places where the decay hazard is high, a 'pathological rotation age' has been practised to obtain the maximum yield of sound wood before the stock is destroyed by rots.

FOLIAR DISEASES

Foliar diseases reported from sal are leaf spots, sooty moulds and thread blights. Except for the blight caused by *Corticium repens,* which occasionally results in the 'die-back' of seedlings and young sapling, none of the foliar diseases appear to be of much economic significance.

Leaf spots: An unidentified species of *Cercospora* infests leaves of young sal and produces diffused grey coloured leaf spots. The disease is common in spring in Uttar Pradesh and Bihar. Usually the necrotic portions (spots) of the leaf tissue fall off after it has rained, producing a 'shot-hole' symptom.

Another leaf spot disease of sal caused by a sphaerospidales, has been reported from over-crowded, unthinned forests of the Terai region in Uttar Pradesh. Leaf spots are produced in November-December, which are at first pinkish, later turning to greyish-brown. These spots give rise to dead oval patches (Bagchee, 1953).

Sooty moulds: Three species of fungi are known to thrive on the leaf surface of sal and produce a black sooty coating of mycelia. *Asterina* sp. occurs on the leaves of young sal in moist zones produces a sooty mould on both surfaces of the leaf. *Capnodium* sp. appears in spring and becomes vigorous by mid-summer, covering almost the entire .upper surface of the leaves with a black crust. Fungal hyphae do not penetrate the epidermis and the black crust either falls off in summer or is washed away by the rains. *Meliola* sp. usually appears from March to June in dense sal forests in the Terai region from North Kheri to Dehra Dun in Uttar Pradesh. The symptoms are similar to those produced by *Capnodium* and the hyphae do not penetrate into the living cells under the cuticle.

Blights: *Corticium repens* Berk. causes a white thread blight of seedlings and young saplings of sal. It forms white mycelial strands on the bark which spread upwards to the smaller branches, twigs and leaf axils, resulting in defoliation and the death of young terminal shoots (Browne, 1968; Bakshi, 1976). *Marasmius cupressiformis* Berk. is reported to cause a black thread blight and *M. gordiceps* a horse-hair blight (Bagchee, 1953; Bagchee and Singh, 1954).

Stem Canker: *Macrophoma shorea* infects smaller branches of sal trees. Prominent cankers, knotted twigs and the formation of "Witches' broom" are typical symptoms of the disease. It has been noticed sporadically in South Kheri and Dehra Dun Forest Divisions in Uttar Pradesh and in Mandla and Bilaspur Forest Divisions in Madhya Pradesh (Bagchee, 1953). The disease has also been reproduced successfully by artificial inoculations.

Diseases of other Dipterocarps

There are some diseases also reported from other dipterocaps but the damage caused by them is not very significant.

Dipterocarpus alatus and *D. turbinatus* are attacked by the root parasite, *Fomes albomarginatus* (Bagchee, 1954). *Ganoderma applanatum* (Syn. *F. applanatus)* is known to cause a white sap and heart rot in *D. macrocarpus* (Puri, 1960). In *Hopea parviflora, Trametes straminea* and *Inonotus tabacinus* cause some minor rots (Bagchee, 1954; Butler and Bishy, 1960).

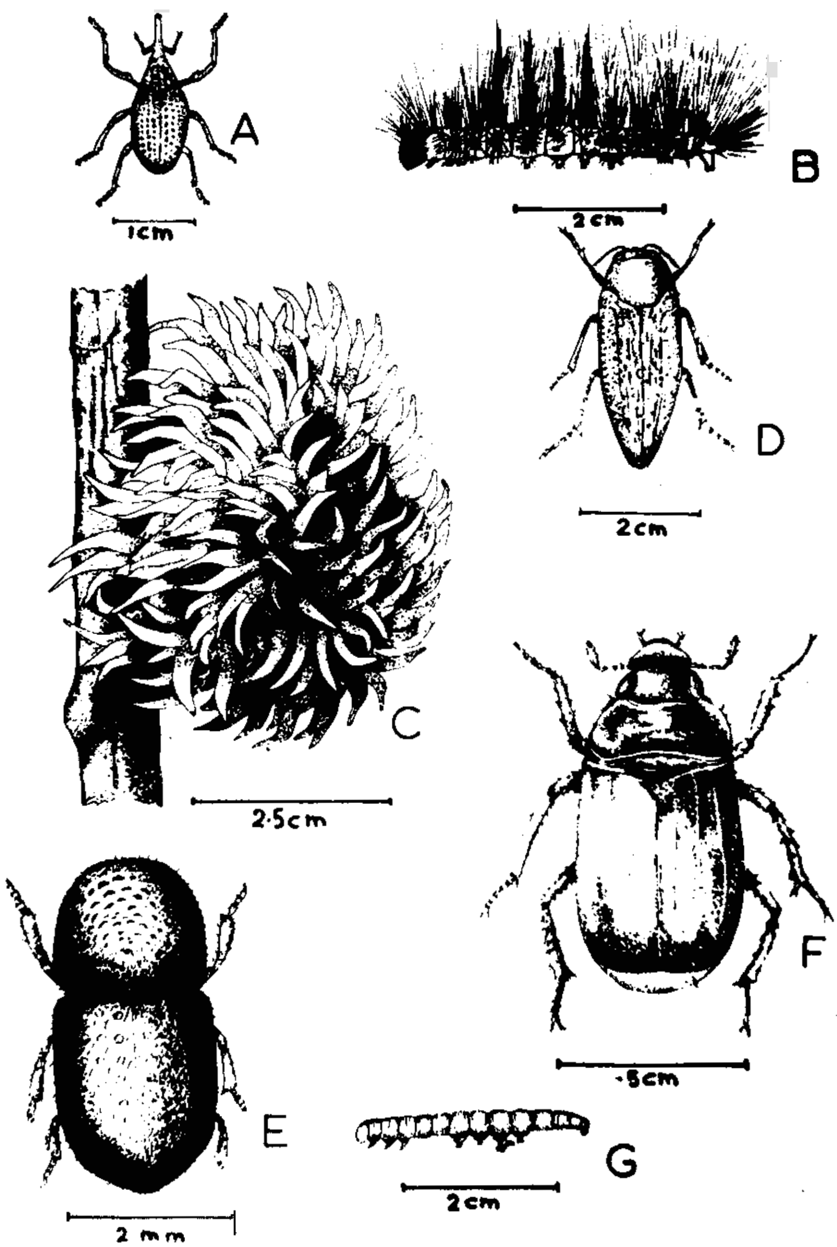
4. ANGIOSPERMIC PARASITES

Angiospermic stem parasites recorded on dipterocarp are mostly Loranthaceous plants including *Helixanthera parasitica. Loranthus scurrula, Dendrophthoe falcata* and *Macrosolen cochinchinensis* (Davidson, 1945; Browne, 1968).

Different fruit eating birds help the dispersal of these parasitic plants (Davidson, 1945). The seeds germinate and produce seedlings, which establish themselves on the host by drawing part of their nourishment through the haustoria. As a consequence, on continuous depletion of nourishment from the branches of the host plants, the branches get dried up. These parasites are particularly injurious to saplings, which become suppressed and sometimes permanently stunted, while in bigger trees the growth rate may be retarded. There is no record of sal trees dying due to an attack of angiospermic parasites.

De (1941a) and Davidson (1945) reported that the lopping and pruning of infected branches considerably reduced the infestation of these parasites in sal forests in India. In those days they found the cost of cutting out clumps of the parasites was quite nominal. Kuijt (1955), however, recommends this practice for small areas or individual plants.

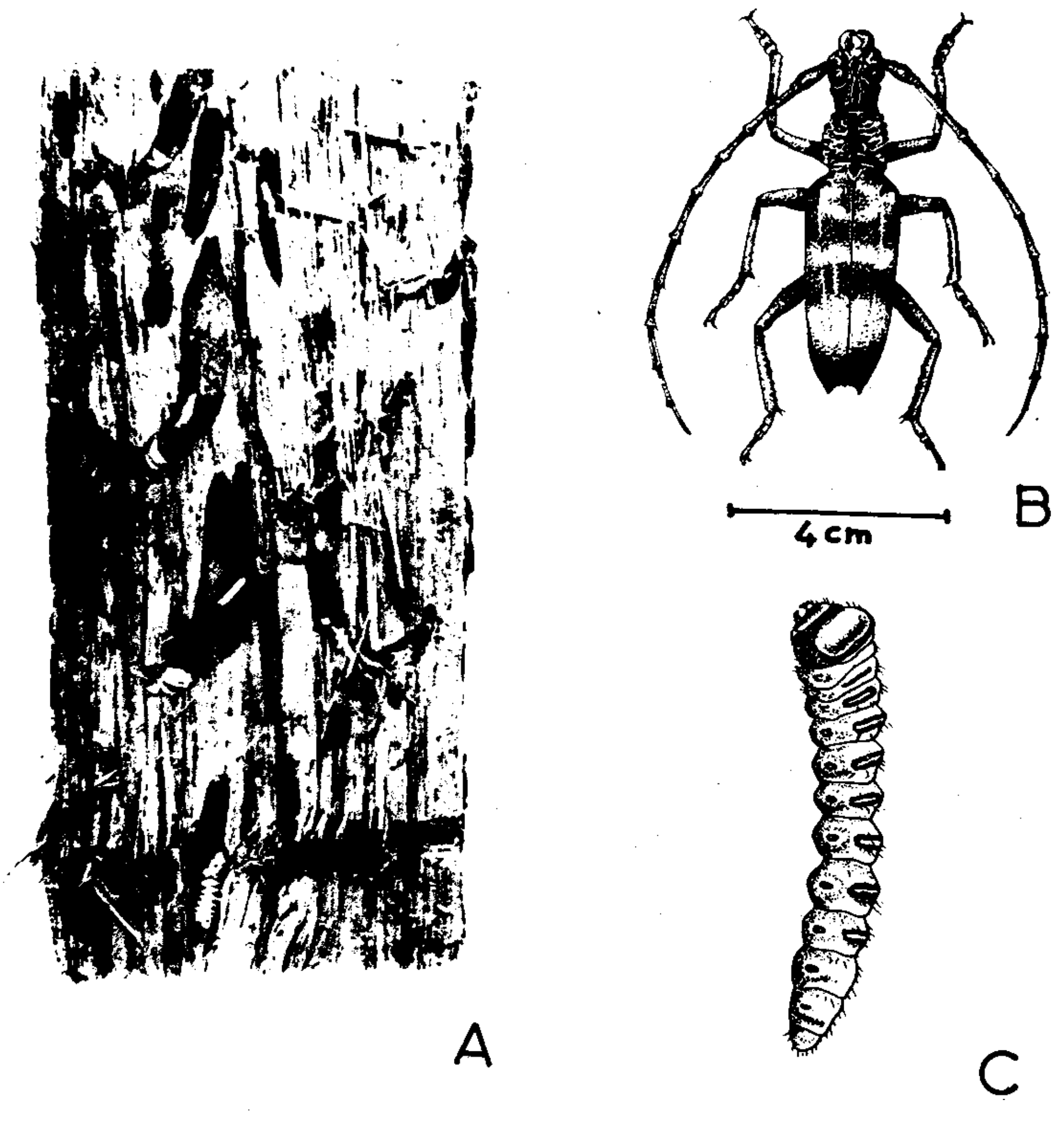
Though partial control of these parasitic plants in various host plants has been claimed by spraying or trunk injection of toxic chemicals or hormones (Kadambi, 1954d; Seth, no large scale trials have been tried due to practical limitations.



Pests of living trees

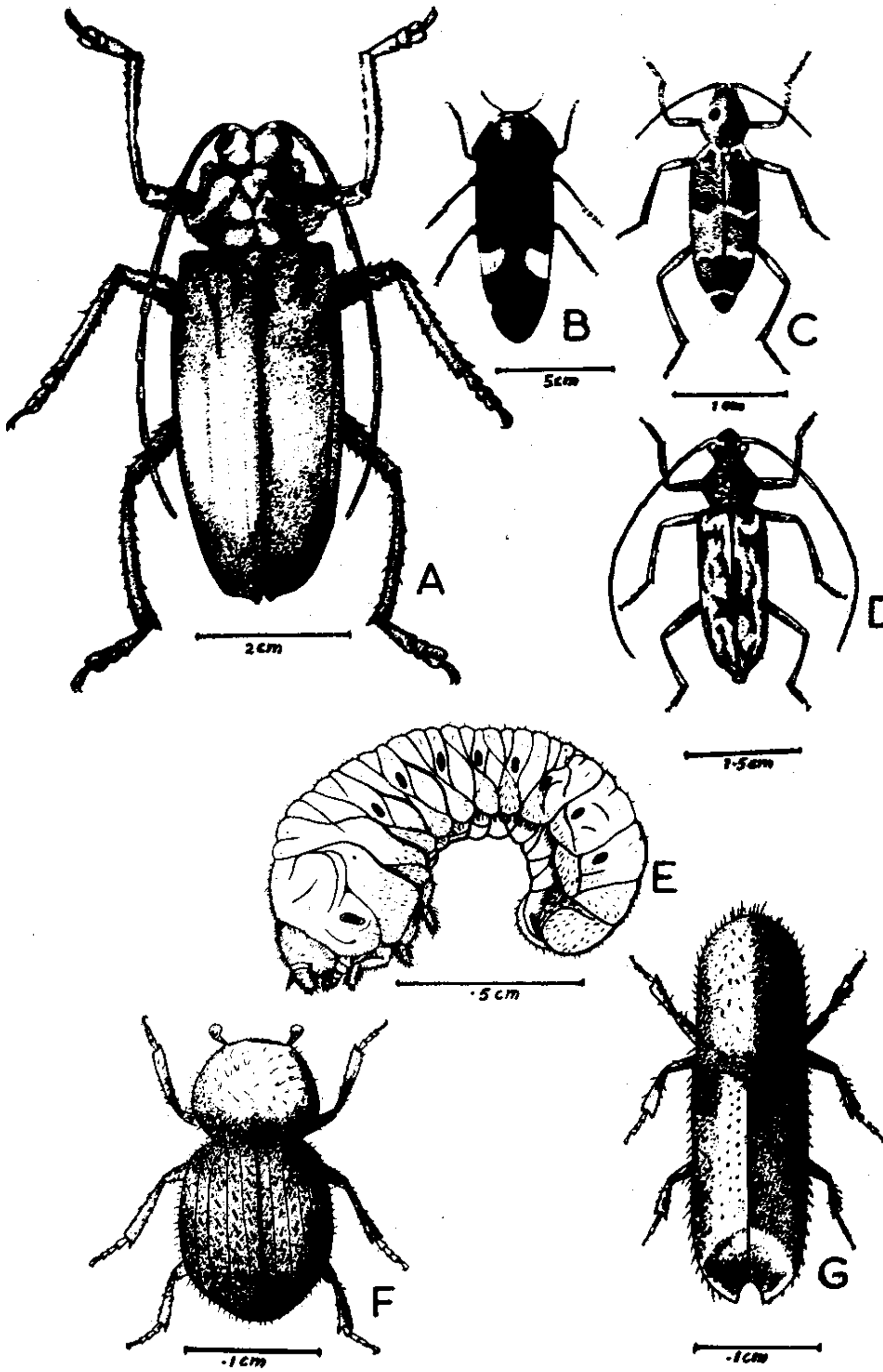
A. *Alcidodes crassus*
B. *Daychira grotei*
C. Gall produced by *Beesonia dipterocarpi* in *Dipterocarpus tuberculatus*
D. *Psiloptera fatuosa*
E. *Xylosandrus compactus*
F. *Adoretus caliginosus*
G. *Paectes subapicalis*

(All figures except E, redrawn after Beeson, 1941)



The sal borer *Hoplocerambyx spinicornis*

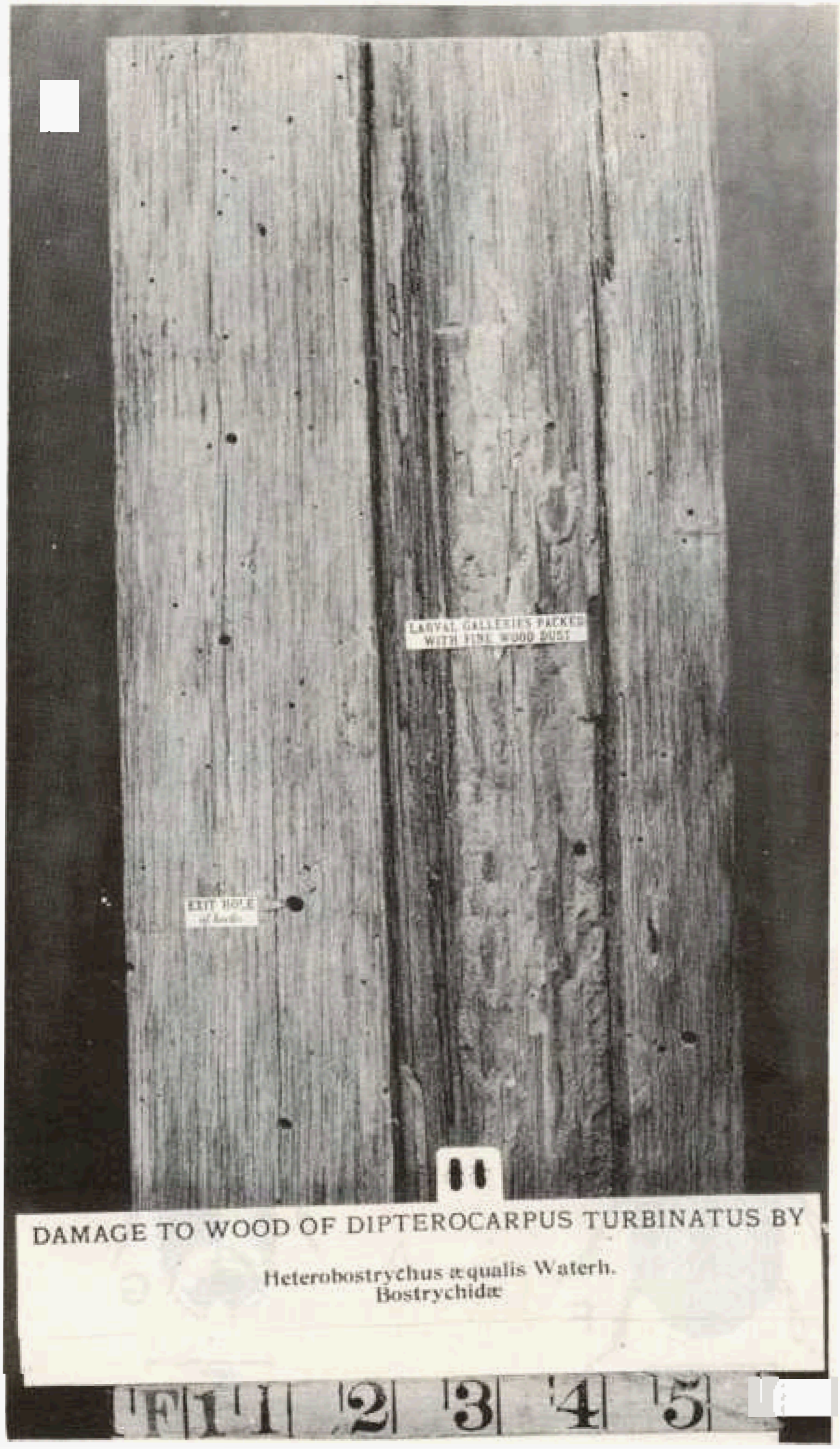
A. Longitudinally split log of *Shorea robusta* showing the insects and their tunnels. (Photo FRI)
B. Adult male
C. Full-grown larva



Timbar pests

A. *Remphan hopei*
B. *Acmacodera stictipennis*
C. *Xylotrechus smei*
D. *Aeolesthes holosericea*
E. Larva of *Heterobostrychus acqualis*
F. *Xyleborus semigranosus*
G. *Xyleborus shoreae*

(Redrawn after Stebbing. 1914 and Beeson, 1941)

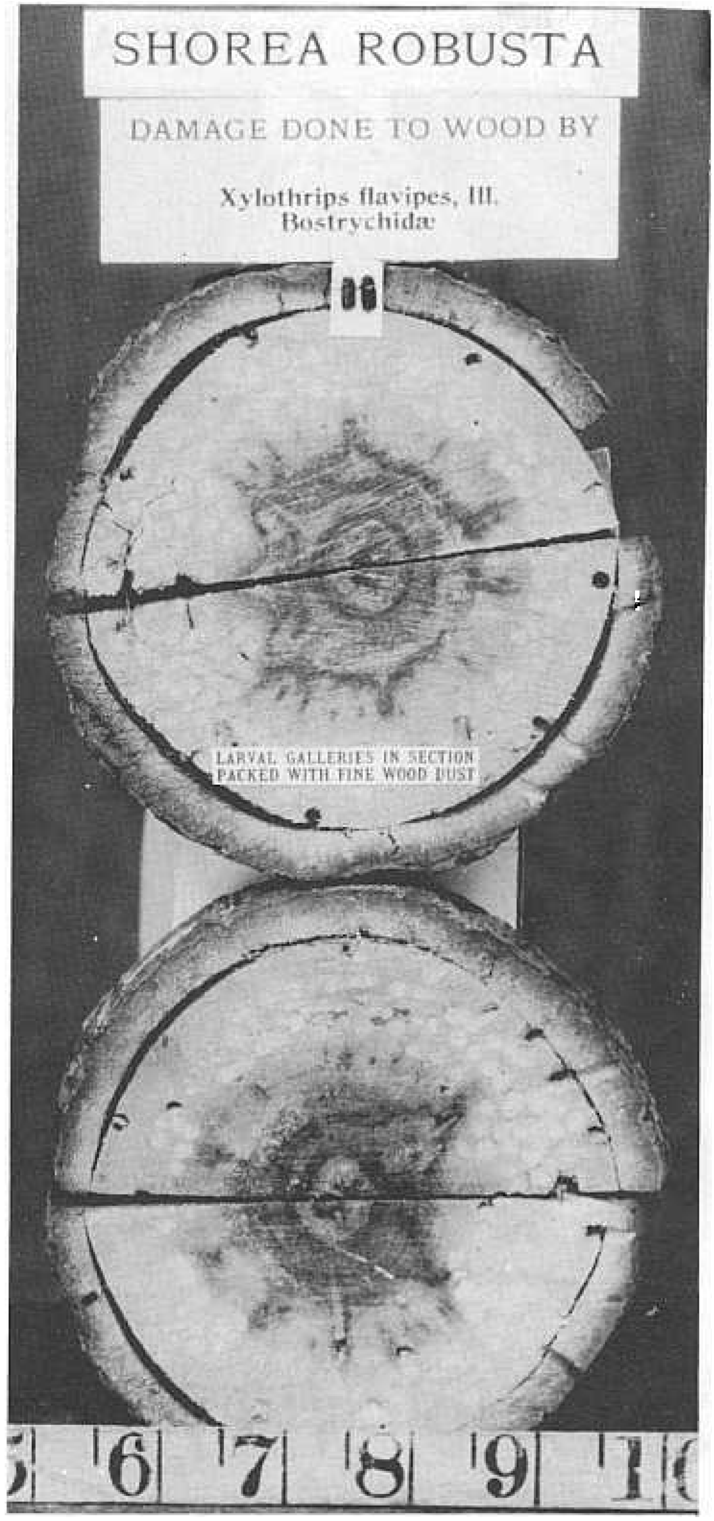


Wood of *Dipterocarpus turbinatus* showing damage caused by the powder-post beetle, *Heterobostrychus aequalis*

(Photo FRI)

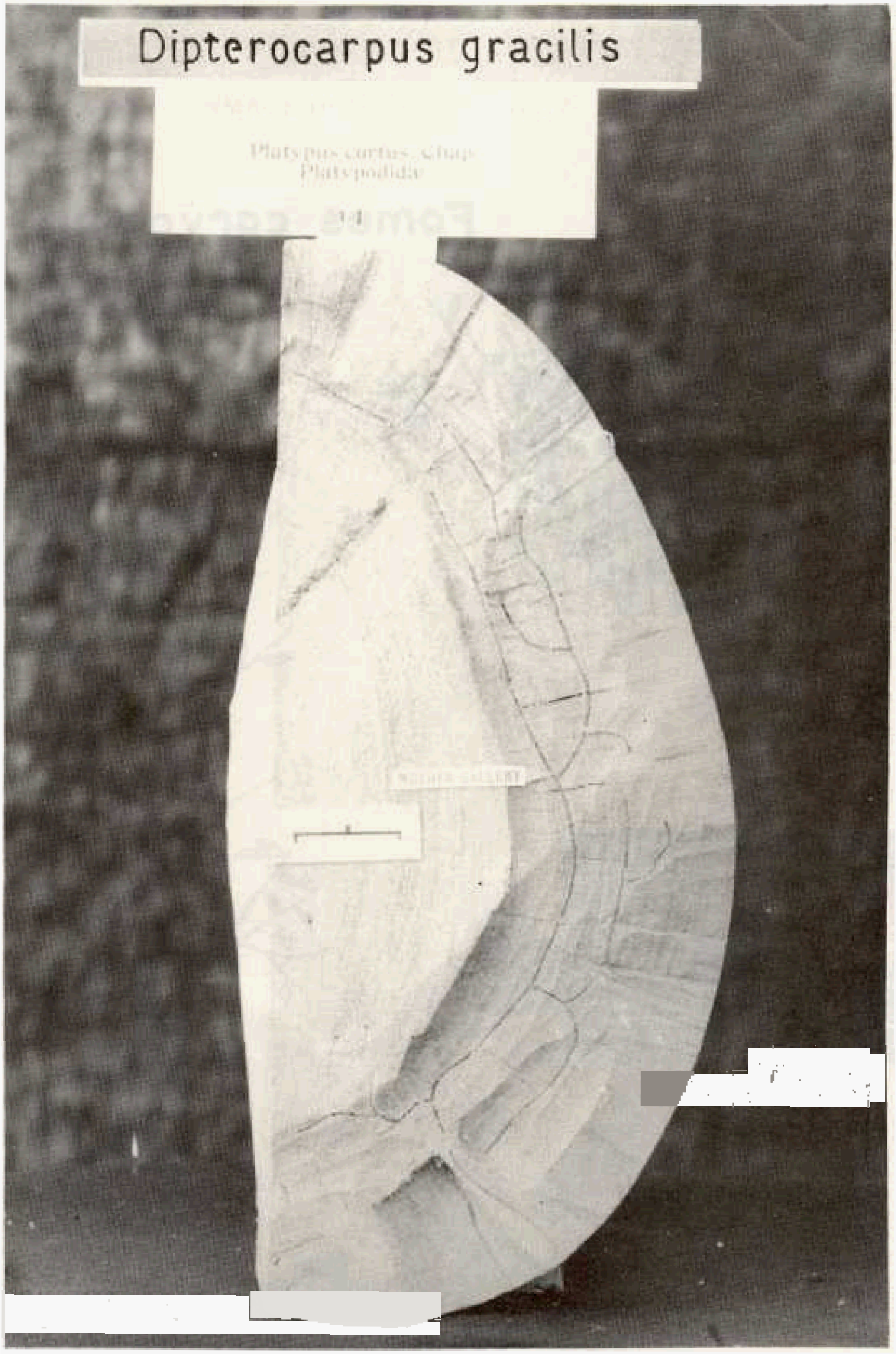
Larval galleries of the powder-post beetle, *Xylodectes ornatus*, packed with wood dust, running longitudinally on the surface of the sapwood of *Shorea robusta* (below) and the same in cross section (above)

(Photo FRI)



Log of *Shorea robusta* attacked by the powder-post beetle, *Xylothrios flavipes,* showing larval tunnels in cross-section packed with wood dust. Note that the tunnels are confined to sapwood.

(Photo



Cross-section of part of a log of *Dipterocarpus gracilis* showing gallery system of the pin-hole borer, *Platypus curtus.*

(Photo FRI)

Fomes caryophylli

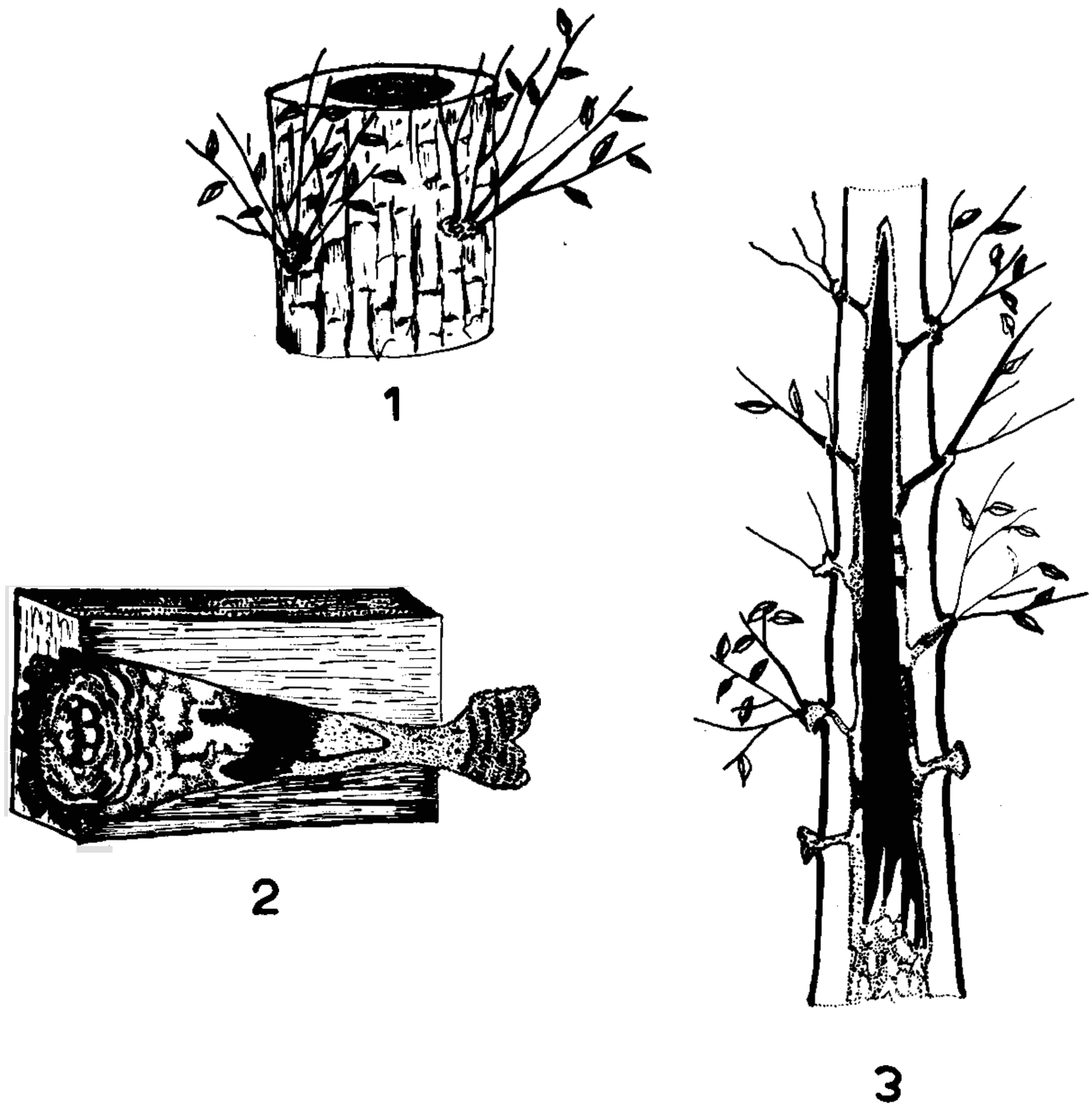


Diagram showing damage to *Shorea robusta* by the fungus, *Fomes caryophylli*

1. & 3. A diseased tree showing feathery branchlets on trunk

2. Section of wood showing punk knot

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