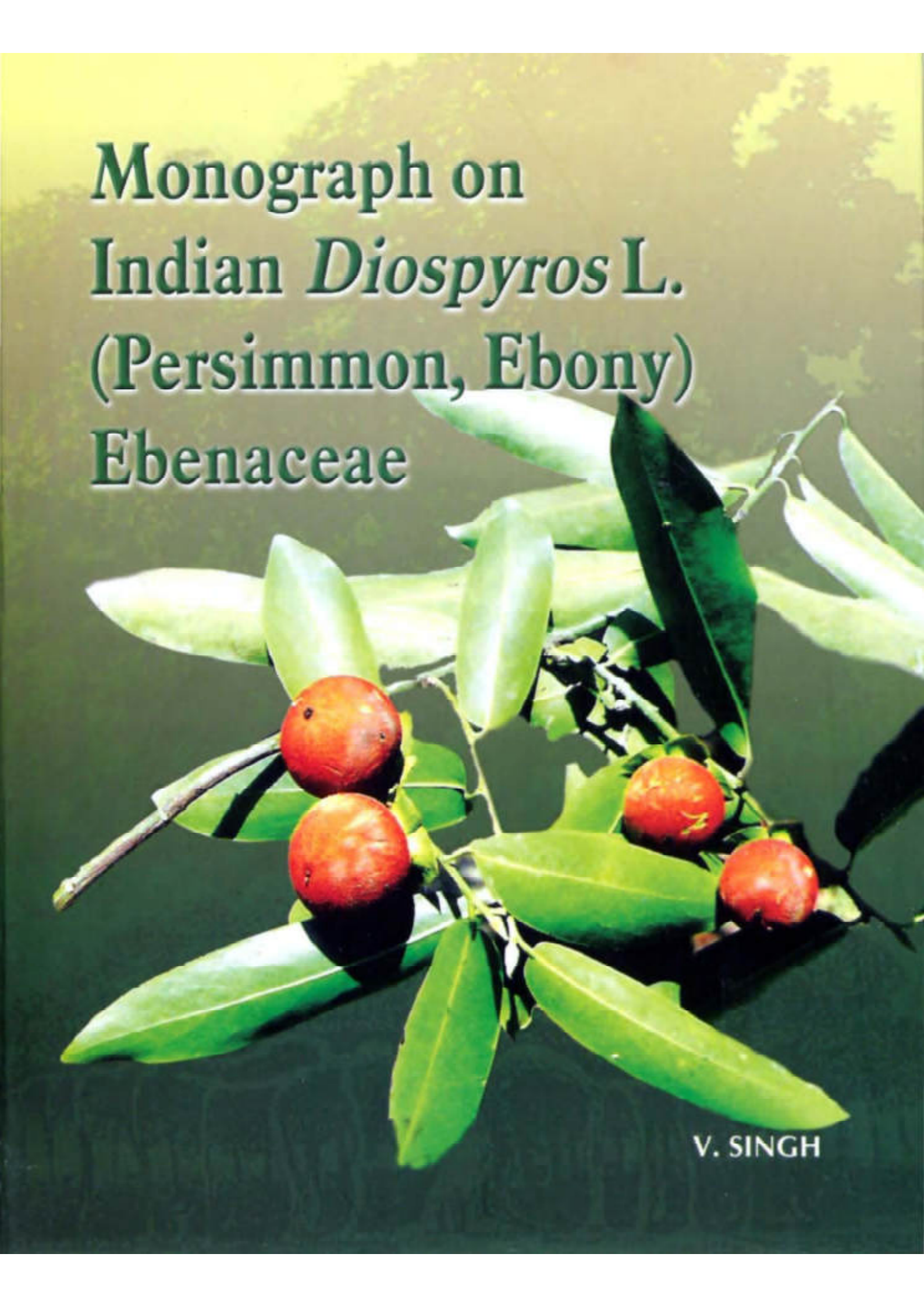
Monograph on Indian *Diospyros* L. (Persimmon, Ebony) Ebenaceae



V. SINGH

MONOGRAPH ON INDIAN *DIOSPYROS* L. (PERSIMMON, EBONY) EBENACEAE

V. SINGH

भारतीय वनस्पति सर्वेक्षण
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Foreword

The family *Ebenaceae* are represented by two genera viz. *Euclea* Murr. & *Diospyros* L., containing *ca* 600 species. The genus *Euclea* Murr. is rather small and represented by *ca* 20 species which are confined to Africa, Arabia and Comoro Islands. Rest of the species belong to the genus *Diospyros* L. and find rather wide distribution in the continents of Asia, Africa, Australia and North and South America. Members of this family show peculiar distribution pattern. Species distributed in one contitinent are not known to occur in other continents. Probably different continental groups of species have evolved independently. In India, Peninsular region, North-Eastern region and Andaman & Nicobar Islands are the major centres of diversity, speciation and evolution.

The genus *Diospyros* L., with mostly dioecious species, is highly polymorphic and individuals of a species show great range of morphological variation, which have resulted in misidentification, misinterpretation and recognition of several infra-generic and infra-specific taxa. Establishment of some new taxa based on the plants of one sex, male or female, has further increased taxonomic complexity in this group.

After the monumental works of A. De Candolle (1844) and Hiern (1873), selected taxonomic works have been done in different continents. In South-East Asia, after Bakhuizen's (1936-1955) monographic work, the contributions of Ng (1971, 1977, 1978b, 2001), Turner (1995), Lecomte (1930), Chen (1935), Shu-Gang *et al.* (1996) etc. from Indonesia-Malaysia region and Pacific Islands; Alston (1931) and Kostermans' (1977a, 1981) work on Sri Lankan *Ebenaceae* and Kress *et al.* (2003) contribution for Myanmar region after Kurz (1877) made significant contributions. In India, after Clarke's (1882) contribution to Flora of British India, no specific work has been done exclusively on *Ebenaceae*. However, attempts have been made to fill up the gap through regional and local floras. The genus *Diospyros* L. is represented by 66 taxa in India which show affinities to the Sri Lankan elements on one hand and to the Indo-Malayan elements on the other. A wide gap of knowledge also exists in other disciplines viz. embryology, cytology, palynology, phytochemistry, anatomy, reproductive biology etc on this group, particularly in Indian *Ebenaceae*.

The species of *Diospyros* L. are the source of several important products, viz. edible fruits, medicines and timber – generally called 'Ebony' Ebony timber is among those exotic materials that have been highly valued for carving, musical instruments, cabinets, furniture etc. Most species of the genus are rich in 'diospyrin' and have found reputed place in traditional systems of medicine, viz. Ayurvedic, Homeopathic and Unani systems. The drug obtained is called 'Tinduka or Visatinduka' The leaves of *Diospyros melanoxylon* Roxb. are valued for wrappers of cigarettes, called 'Bidi' which has been a good source of revenue for the nation.

Practically no taxonomic or monographic work has been done on such an economically important genus during recent years. There has also been a lacuna of infra-generic classification wherein the taxa from India may be accommodated. The classifications proposed for different continents (White, 1980, 1983; Hiern, 1873; Bakhuizen, 1936-1955 etc) are rather old to classify Indian species of *Diospyros* L.

The present monograph prepared by Dr. V. Singh is an outstanding contribution towards the advancement of Ebony systematics, particularly in Indian subcontinent. The author has described 66 taxa from Indian region, based on gross morphological characters and supplemented by findings of other workers in the field of anatomy, embryology, palynology, cytology, phytochemistry etc. The data from applied disciplines have also been used as an additional tool to solve certain taxonomic problems within the genus. Besides reviewing literature on different subjects and proposing a classification from family to infra species to accommodate Indian taxa based on constant suits of characters, the author has also discussed the phytogeographical aspects and phylogenetic and phenetic affinities to establish relationship and trace the path of evolution in *Ebenaceae*. The multidisciplinary approach has, thus, made the work more exhaustive. The beautiful illustrations, photographs and maps showing distribution pattern of taxa have further enhanced the authenticity and utility of the monograph. The nomenclatural part is upto date and has been authenticated by the citation of types.

Dr. V. Singh is an eminent scientist working in Botanical Survey of India, Ministry of Environment and Forests. He has done commendable work towards the advancement of Indian botany. The monographs play a vital role in the preparation of database from which centres of active evolution of the biodiversity may be identified and consequently preserved. After the publication of monographs on Indian subtribe *Cassinae* (*Caesalpiniaceae*) and Indian *Leucas* R. Br. (*Lamiaceae*), I congratulate Dr. Singh for bringing out another illustrated monograph on an economically important genus *Diospyros* L. (*Ebenaceae*).

Dated : 23rd November, 2004

M. Sanjappa
Director
Botanical Survey of India

Preface

In the increasing competitive global environment, developing agrarian nations are facing problems of over-exploitation of their natural resources and shrinking fiscal benefits therefrom. For maximizing the production from nature without eroding the resource base, there is an urgent need of exploration, inventorisation and documentation of plant resources and subsequent sustainable utilization, as emphasized in Biodiversity Convention. The species of *Diospyros* L. (*Ebenaceae*) are the source of several important products, particularly the timber which is generally called Ebony Ebony timber is among those exotic materials that have been highly valued since classic times. Besides edible fruits and Ayurvedic drug, called Tinduka or Visatinduka , obtained from *Diospyros* L., some species, viz. *D. melanoxylon* Roxb., fetch large revenue from its leaves used as wrappers in Bidi (Cigarette) industry.

The family *Ebenaceae*, particularly the genus *Diospyros* L., are more complicated taxonomically, as many of their components are not easily differentiated from closely related taxa due to great range of similarities. This usually leads to misidentification and misinterpretation of the components. The problems have been more critical in the genus *Diospyros* L. where individuals of a species themselves contain wide range of variations. The delimitation of the genera within *Ebenaceae* and species within the genus *Diospyros* L. have, therefore, been variously interpreted after Linnaeus (1753) and R. Brown (1810) by Don (1837), A. De Candolle (1844), Hiern (1873), Bakhuizen (1936-1955), White (1980, 1983) etc. The variable concepts regarding the status of taxa may be credited to inconsistency in morphological features, dioecious nature of family and gradual increase of knowledge in phenetic, phylogenetic and evolutionary aspects of this group.

The family *Ebenaceae* are represented by two genera, viz. *Euclea* Murr. and *Diospyros* L., according to recent concepts of White (1980, 1988) and Wallnofer (2001). Phytogeographically the genus *Euclea* Murr. is restricted to Africa, Arabia and Comoro Islands. On the other hand, the genus *Diospyros* L. finds rather wide distribution in the continents of Asia, Africa, Australia and North and South America. But, there has been an abrupt species – specific distributional demarcation between the components of the genus *Diospyros* L., as the species of these continents are confined to their geographical boundaries and do not encroach other regions. It indicates that continental groups of species have evolved and developed independently. As such, there have been no comprehensive recent global monographic or taxonomic works on *Ebenaceae* and continental work of one is not of much practical taxonomic value to the others.

In Asia, the limited taxonomic works done are on south-eastern regions from India and Sri Lanka eastwards to Pacific countries, which constitute chief zones of concentration of Ebenaceous components. The main centres of speciation in S. E. Asia are Indian subcontinent and Indonesia-Malaysia. In India,

the South India, North-East India and Andaman & Nicobar Islands are rich in diversity and constitute major centres of speciation and evolution (39 taxa). Inspite of diversity richness (66 taxa) and high level endemism (17 taxa), no specific taxonomic work has been done exclusively on *Ebenaceae* after Clarke (1882). However, scattered information on this group is available in recent regional and local floras published after Cooke (1904), Duthie (1911), Gamble (1922), Haines (1922), Kanjilal (1939) etc by various workers from different parts of the country. The works on other applied disciplines viz. cytology, palynology, embryology, anatomy, phytochemistry, reproductive biology etc are also very limited. As such, multidisciplinary approach to solve taxonomic problems through these tools has not been much effective for this group to understand variations, phylogenetic basis and evolution. Under above circumstances, the author undertook the task of revision of Indian *Ebenaceae* so as to add more evidences to understand evolutionary sequences and synthesis of new classification of Ebony family.

The present monograph on Indian *Ebenaceae* deals with 66 taxa. Besides adopting correct valid names for the Indian plants and providing full synonymy, the descriptions provided are based on personal observations of the author. Phenological data along with ecological notes have been provided to each taxon. Information regarding distribution of taxa in the World and in India in particular has also been provided to all taxa, along with migration aspects. Important findings of other workers on the phytochemistry, embryology, palynology, cytology, anatomy, reproductive biology etc have been used to supplement the description based on morphological characters and as an additional tool to solve taxonomic problems in this group. The keys based on persistent suits of characters have been provided from generic level to infra-specific level so as to provide a classification to delimit Indian taxa at different taxonomic levels/categories, authenticated by types. Besides phytogeographical and conservation aspects, the phenetic and phylogenetic affinities have been discussed in greater details. Vernacular names in different Indian languages and dialects and English names have been provided almost to all taxa along with economic uses and chemistry of organs used to make the monograph usable at grass root and global level. A number of beautiful photographs, detailed figures and distributional maps will help in easy determination of the taxa and their distributional aspects. Moreover, new additions to the science and changes in the status of some taxa will provide clear picture of the components of *Ebenaceae* in India. It is hoped that work will prove a milestone in the advancement of Ebony systematics, conservation of biodiversity and sustainable utilization of plant resources, particularly for Asia.

The author is very grateful to the present and former Directors of Botanical Survey of India for their ceaseless encouragement and facilities provided during the course of present study. He is also thankful to the authorities of various Indian and foreign herbaria, particularly Kew herbarium, for providing herbarium specimens on loan and donating photographs of plants. Thanks are also extended to the authorities of Indian and foreign scientific libraries, including Liaison officer of Botanical Survey of India, Kew, for supplying xerox copies of the literature at a very short notice. The author would also like to avail an opportunity to express his thanks to all his colleagues of Botanical Survey of India, Jodhpur, particularly Shri. P. J. Parmar, Deputy Director, Ms. Monika Singh, Ms. Anita Bana and Mr. A. K.

Shrivastava, Research fellows, for their help in various ways. Special thanks are extended to Shri R. S. Purohit, Artist of this office for preparing beautiful scientific illustrations, photographs and maps etc incorporated in this monograph. The contributions of Ms. Rinku Sharma are acknowledged for carrying out all computer work for this monograph.

The author gratefully acknowledges the invaluable suggestions from experts of this group which helped him in improvement of this monograph. Thanks are also extended to the Heads of offices of different Regional and Central offices of Botanical Survey of India who made available herbarium specimens, photographs and literature at various steps during the course of present study to make the work more exhaustive and authentic. It is also his pleasure to extend thanks to Shri. A. P. Jain, ex Librarian of this office who took keen interest in search of literature and its procurement while chairing the office. Dr. V. J. Nair, ex-Scientist, Botanical Survey of India, Coimbatore deserves thanks for providing latin translation for new taxa.

Lastly, the thanks are extended to Ms. Uma Jayaraman, ex Research fellow of this institution who initiated work on this group but couldn't continue. The publisher of this book who took the responsibility for wide circulation of this monograph in public interest also deserves thanks from the author.

The research do not stand still and has no end point, the author would welcome any suggestion from its readers that may be valuable in the future improvement of this book.

Dated : 23rd November, 2004 **V. Singh**

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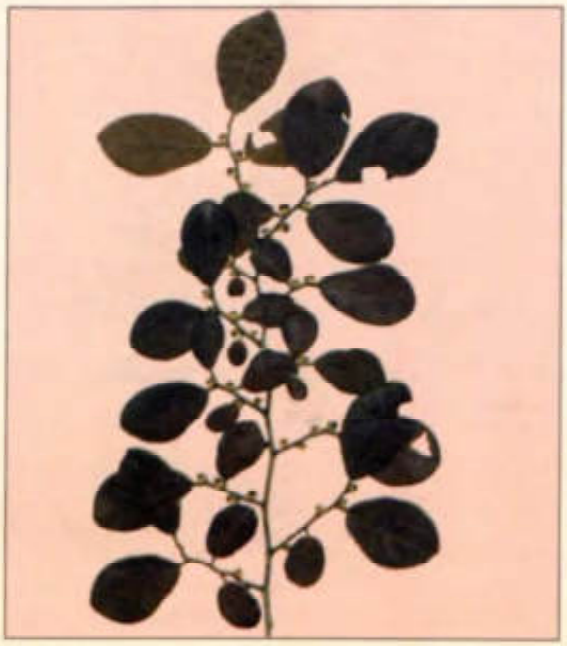

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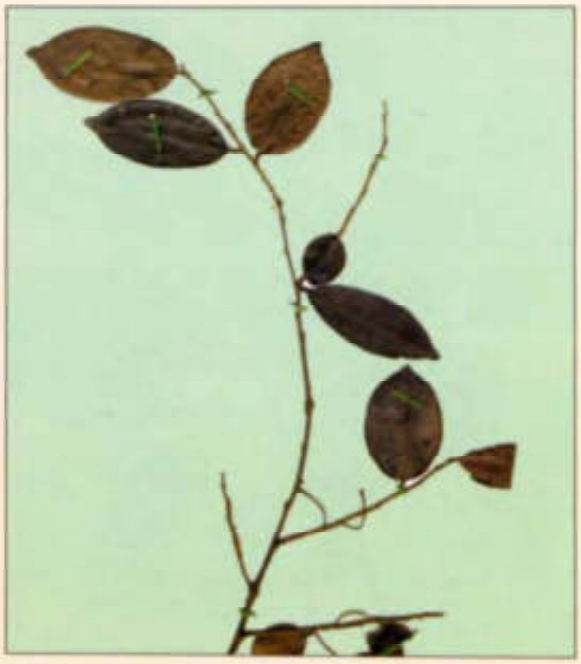

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Introduction

The family *Ebenaceae* are rather more complicated taxonomically than other allied families. Don (1837) and A. De Candolle (1844) recognized eight genera independently, classifying all taxa upto infra-specific level known at that time. Hiern (1873), however, followed the concept of A. De Candolle (1844), but reduced the number of genera to five and his concept found wide recognition throughout the World (Bentham & Hooker, 1876; Clarke, 1882; Gurke, 1891; Bailey, 1900; King & Gamble, 1905; Merrill, 1923; Lecomte, 1930, etc). Bakhuizen (1936-1955) further reduced the strength of the family to four genera by merging the genus *Maba* J. R. & G. Forster under *Diospyros* L. Recently White (1980, 1983) recognized only two genera viz. *Diospyros* L. and *Euclea* Murr. under *Ebenaceae* and merged the genera of earlier workers under the genus *Diospyros* L. The variable concepts regarding the status of genera in *Ebenaceae* may be credited to inconsistency in morphological features, the dioecious nature of the family and gradual better understanding of this group, particularly the phenetic and phylogenetic affinities of its components with the components of other related families. The dioecious habit of *Ebenaceae* has resulted in the creation of several taxa of infra-generic level, based on specimens of one sex and the counterpart opposite sex plants are not known even to date for some species, particularly in the genus *Diospyros* L. Further, there has been no base to establish relationship of such species with their counterparts if some plants of opposite sex are searched out subsequently, except foliage. It has resulted in considerable addition of new taxa to the family. The great range of variations and production of fertile fruits by female plants, for which male plants are not known, suggest free inter-specific hybridization, which is probably the main source for the origin and evolution of species at one end, and increase in complexity in this group on the other end. However, some such species described on carpellate or staminate plants only have failed to hold and develop fruits due to lack of plants of opposite sex to ensure pollination and fertilization. Such species are poorly represented in the field and herbaria viz. *D. kika* Debbarman & Biswas, *D. martabanica* Clarke var. *pellucido-punctata* (Hiern) Clarke, *D. saldanhae Kosterm.*, *D. sulcata* Bourd. etc. Such conditions have created taxonomic complexity within the family *Ebenaceae*. Several of the taxa which do not even belong to *Ebenaceae* have been included in this group viz. *Lissocarpa* Gurke, or new specific names have been given to already known taxa by earlier and present workers as is evident from lengthy synonymy under some *Diospyros* L. species. It has happened due to inadequate information and materials in the hands of workers while dealing with this group, great morphological variations within the taxa and individuals of a taxon, along with polynological and cytological consistency. The morphological variations are so extensive, particularly in *Diospyros* L., that no character of taxonomic value is constant in some species in vegetative and floral parts. Further, the inconsistency in phenotypic features increases with the range of distribution. As such, the workers have failed in laying hard and fast boundaries between the species

on natural principles. The classifications proposed sofar for infra-generic levels are highly unsatisfactory and artificial. For natural classification, particularly for establishing subsidiary groups viz. subgenera and sections, careful and critical examination of all species is necessary to evolve persistent suits of characters for delimiting categories at various taxonomic levels. Further, some species within a genus have no close relatives, while others form a small group of closely related species which are only distantly related to other groups. Therefore, there has been a necessity of judging the scientific value of the numberless species existing on the paper to avoid further confusion in the nomenclature, status and systematic position of the taxa. This goal may be better achieved by confining to monographic studies on *Ebenaceae* of limited regions to proceed further to the composition of synopsis of the species of the entire World.

In India, the family *Ebenaceae* are represented by single genus *Diospyros* L., containing about 66 species; of which about fifty per cent have originated in India and ca 45 per cent species of Indian origin are still endemic to India. The populations of *Diospyros* L. grow mainly in plains rather than on high altitudes, showing low adaptive ability to temperate zones. There has been great taxonomic confusion prevailing in Indian literature and herbaria through misidentification and misinterpretation of certain taxa due to great morphological variations in the components of *Diospyros* L. and inadequate constant morphological characters to delimit the taxa at specific and infra-specific levels. During present study, additional clues from other disciplines viz. anatomy, cytology, phytochemistry, embryology, palynology etc have been found very useful. But, unfortunately, such an important genus, which has high number of endemic taxa, has been greatly neglected in these fields in comparison to other allied groups like *Styracaceae, Polemoniaceae, Ternstroemiaceae, Myrsinaceae, Symplocaceae* etc. The supporting data from other disciplines, which may be used as a taxonomic tool, is available for those limited number of Indian species which show rather wide distribution in the country and World. However, I have made an attempt to use all available additional taxonomic clues at my disposal to provide a complete account of the genus *Diospyros* L. through multidisciplinary approach.

The genus *Diospyros* L. has also been considered as one of the important groups producing commercial timber, called "Ebony". Ebony differs in colour from jet black to brown-and-black variegated and has been acknowledged as an exotic material for centuries for carvings, musical instruments, cabinets, furniture etc. Most of the species of *Diospyros* L. provide edible fruits and a few of them are cultivated on commercial scale for this purpose. Many other species have medicinal potential and drug obtained is called "Tinduka or Visatinduka". This drug has found wide use in Ayurvedic, Homeopathic and Unani systems of medicine. It is also used as an ingredient in some other herbal preparations. The leaves of *D. melanoxylon* Roxb. are valued for wrappers of Cigarettes, called "Bidi", which have given recognition to the genus *Diospyros* L. in Indian population by the name of "Bidi Patta". In the States of Madhya Pradesh, Chhattisgarh and Orissa, Bidi Patta is one of the sources of revenue for the governments.

Practically no infra-generic classification has been evolved for such an economically important genus wherein all taxa from the World may be accommodated. The classifications proposed for different continental groups of species during recent years (White, 1980, 1983) or rather old classifications proposed by Hiern (1873), Bakhuizen (1936-1955) etc are not worth to classify Indian species of *Diospyros* L. with full satisfaction. As such, an attempt has also been made in this direction in this monograph to propose a more natural classification in the light of earlier recognized classifications.

REVIEW OF LITERATURE

Taxonomy : After the establishment of the genus *Diospyros* L. (1753), several workers have contributed to the taxonomy of this genus, and *Ebenaceae* as a whole. Among the old works, the contributions of Brown (1810), Don (1837), A. De Candolle (1844), Choisy (1855), Miquel (1859), Miers (1862), Boissier (1867), Hiern (1873, 1874, 1875, 1887), Brandis (1874), Bentham & Hooker (1876), Kurz (1877), Clarke (1882), Gurke (1891) etc need mention on the concepts of whom present taxonomic status of *Ebenaceae* is based.

During recent years, monumental monograph on the family *Ebenaceae* has been brought out by Bakhuizen (1936-1955). Subsequently, a number of workers have contributed to the family *Ebenaceae*, including the genus *Diospyros* L., all over the globe. The selected works on African *Ebenaceae* are those of White (1955, 1956, 1987) on central Africa, White (1988) and White & Verdcourt (1993, 1996) on tropical east Africa, White (1978a) on tropical west Africa, Winter (1963), Gordon (1974) and White (1983) on southern Africa, Letouzey & White (1970a) on Cameroon, Letouzey & White (1970b) on Gabon, Perrier de la Bathie (1952a, 1952b) on Madagascar and Comoros, Richardson (1981) on Mascarene Islands, Troupin (1985) on Rwanda, Berhaut (1975) on Senegal, Compton (1976) on Swaziland etc. The American *Ebenaceae* have been worked out by Wood & Channell (1960)-S. E. United States, Burkart (1979)-Argentina, Cavalcante (1963a, 1963b), Lopes (1998) and Ribeiro *et al.* (1999)-Brazil, Sauget & Liogier (1957-1963)-Cuba, Wallnofer & Mori (2002)-French Guiana, Standley & Williams (1966)-Guatemala, Standley (1920-1926) and Pacheco (1981)-Mexico, Pool (2001)-Nicaragua, White (1978b)-Panama, Macbride (1959)-Peru, White (1981) and Sothers & Berry (1998)-Guayana and Venezuela respectively, etc.

In the continents of Europe and Australia, very little taxonomic work has been done on this group. The works of Bailey (1900)-Queensland, Kostermans (1977b) and Harden (1990)-New South Wales may be recognized from Australia. In Europe, Grubov (1967) has contributed to USSR *Ebenaceae* and Tutin (1972) for rest Europe where this group is very poorly represented.

Maximum taxonomic work has been done on the *Ebenaceae* of S. E. Asia. Besides Bakhuizen's (1933, 1936-1955) monumental monographic works on Malaysian *Ebenaceae*, King & Gamble (1905) have contributed from Malayan peninsula, Ng (1971, 1977 1978b, 2001) from Malaysia-Indonesia and neighbouring peninsular and Pacific countries, Turner (1995) from Malaya, Lecomte (1930) from Indo-China (Laos, Cambodia and Vietnam), Chen (1935) and Shu-Gang *et al.* (1996) from China,

Merrill (1923) from Philippine, Phengklai (1972, 1981) and Utsunomiya *et al.* (1998) from Thailand and Wright (1904), Alston (1931) and Kostermans (1977a, 1981) from Sri Lanka. Recently, Kress *et al.* (2003) have provided a list of 47 species of *Diospyros* L. found in Myanmar, following Kurz (1877). In India, after Clarke's (1882) contribution to Flora of British India, no specific work has been done exclusively on *Ebenaceae*. However, this group has been described in almost all State level, regional and local floras during recent years, after Cooke (1904), Duthie (1911), Gamble (1922), Haines (1922), Kanjilal (1939) etc. For the economy of space, the literature citation of all works is not possible here, however, the important works are those of Maheshwari (1963), Balakrishnan (1981), Deb (1981), Matthew & Rani (1981), Sharma & Kachroo (1981), Manilal & Sivarajan (1982), Sharma *et al.* (1984), Saldanha & Ramesh (1984), Chowdhery (1984), Rao (1986), Bhargavan (1987), Haridasan & Rao (1987), Singh (1988), Singh (1991), Deshpande *et al.* (1993), Saxena & Brahmam (1995), Hanfi (1997), Pullaiah & Moulali (1997), Sinha (1999), Singh *et al.* (2001), Pradhan (2001) etc.

The other sporadic and scattered literature which was also found informative and useful in the preparation of this monograph includes Royal (1839), Bourdillon (1908), Rao (1914), Parkinson (1923), Fischer (1938), Benthall (1946), Nayar (1984), Sahni (1998) etc. Ghazanfar (1978) has contributed to the *Ebenaceae* of Pakistan. The Pacific areas, though, have been included by Bakhuizen (1936-1955) in his monumental work, yet, subsequently, Smith (1971)-Fizi, Samoa and Tonga, Kostermans (1977b)-all Pacific areas, St. John (1986)-Hawaii, White (1993a, 1993b)-New Caledonia and Yamazaki (1974) from far eastern regions of Micronesia have further added to our knowledge about the diversity in Pacific *Ebenaceae*. Heywood's (1978) work "Flowering plants of World" was also found taxonomically useful in the completion of present work.

Phenology & Pollination : Most species of *Diospyros* L. produce flowers and fruits between the months of February to November. However, a few species have been noticed in which flowering starts a little early i.e. in the month of January viz. *D. cordifolia* Roxb., *D. pilosiuscula* G. Don var. *pilosiuscula* and *D. saldanhae* Kosterm. The species like *D. ghatensis* Ramesh & Franceschi starts blooming in the month of September and produces mature fruits by May. *D. multibracteata* (Merr.) Bakh., however, blooms in December and fruit setting is over within a short period by May. It is interesting to record that the number of species which produce flowers and fruits round the year is very limited viz. *D. nilagirica* Bedd., *D. oocarpa* Thw., *D. ovalifolia* Wight, *D. ridleyi* Bakh. and *D. sulcata* Bourd.

The works on phenological studies are very limited (Rathore, 1970). The species of *Diospyros* L. require a definite drought period for flowering and probably this is one of the factors determining distribution of the species. It has been observed that a short dry period is sufficient for flowering of the species growing in wet areas. The species growing in the areas where wet and dry seasons are distinctly separated require a long drought period for flower initiation.

The pollinating agents for most species of *Diospyros* L. are bees, wasps, butterflies and beetles. The male flowers of most rain forest species reach to anthesis during the night and seem to be

nocturnal, the flowers then being shed the same night. However, in *D. kaki* Thunb. ex L. f., the male flowers open in the early morning, soon reaching anthesis, and are usually shed in the evening of same day (Hague, 1911; Namikawa *et al.*, 1932).

Ecology : *Ebenaceae* occur mainly in the low lands of the tropical and to a lesser extent in subtropical regions of the Old and New Worlds. The genus *Diospyros* L. is pantropical. Awasthi (1990) and Jayaraman (1992) have thrown some light on the distribution of the species of *Diospyros* L. Rathore (1969) has worked on the distributional pattern of male and female plants in *D. melanoxylon* Roxb. var. *melanoxylon*.

The species of *Diospyros* L. are usually small to medium-sized trees in the forest understorey, with an often remarkably low population density. Only few species penetrate the mountains and extra tropical warm temperate regions (*D. lotus* L. and *D. virginiana* L.), others are inhabitants of periodically inundated or permanently swampy areas or in the back of mangroves (*D. ferrea* (Willd.) Bakh.). Details have been discussed by Ambasht (1968), Chatha & Bir (1987) etc. Root system architecture in the species of *Diospyros* L. have been studied by Rathore (1971), Athaya *et al.* (1982), Prasad & Mishra (1984) etc. Further, Athaya (1985) has also studied the aspects of seed storage and viability of seeds. Awasthi (1986) has studied the sucker regeneration in *D. melanoxylon* Roxb. Troup (1921) has provided silvicultural data and Ghosh *et al.* (1976) have discussed problems of cultivation of *D. melanoxylon* Roxb. Horticultural aspects have also been highlighted by Yasui (1915), McDaniel (1973), Sharma (1977) and Srivastava (1979). George *et al.* (1996) have studied the effect of canopy on fruit set, quality and starch contents in the fruits. Kang *et al.* (1998) have worked on cold hardiness of buds and effect of temperature on seed dormancy in *Diospyros* L.

Modi *et al.* (1992) have studied the effect of pollution on *Diospyros* L. species and found that auto-exhaust pollution results in foliar injury. Williams *et al.* (1996) have also studied the effect of thermal power emissions on the species of this genus. Recently, Udgate (1997) has studied the effect of fertilizers on leaf production and found encouraging results.

Mani (1973) has worked on the plant galls developed on *Diospyros* L. species. Bhandari & Upadhyay (1986) and Kumar *et al.* (1989) have discussed pests of *Diospyros* L. Secoy & Smith (1983), Yang & Tang (1988) and Lester *et al.* (1995) have thrown light on the control and disinfestation of pests, particularly through plants. During recent years, the pathological studies have also received due considerations on this genus (Tandon & Lal Bihari, 1964; Naphade, 1970; Rao & Subramoniam, 1976; Roy *et al.*, 1983 etc). Mishra *et al.* (1986) have thrown light on microbial contamination in processed leaves for Biri.

Rathore (1976) has worked on quantitative morphology of leaf forms in *D. melanoxylon* Roxb. and Singh *et al.* (1982) on dry matter production in seedlings of *D. montana* Roxb. Rao *et al.* (1981) have carried out physiological studies on *Diospyros* L.

Cytology : The cytological studies in all groups have gained wide importance throughout the World. The number of chromosomes, their gross morphology, meiotic behaviour and karyotypic

differences provide good material for delimitation of taxa up to the level of family and to determine evolutionary sequences. In *Ebenaceae*, the chromosome number is very stable. An euploid series of 2n=30, 60, 90 and 135 allows inference of a basic number n=15. The notable contributions to the cytology of Indian species of *Ebenaceae*, especially to *Diospyros* L., include Namikawa & Higashi (1928), Pathak *et al.* (1949), Sobti & Singh (1961), Nanda (1962), Chatterji (1964), Fedorov (1974), Mehra (1976), Bir *et al.* (1979, 1980, 1984), Bedi *et al.* (1980), Goldblatt (1981, 1984, 1985, 1988), Bir & Chatha (1983, 1985), Ceschmedjiev (1983), Astanova (1984), Chen *et al.* (1985), Kumar & Subramaniam (1986), Solovyova & Omarav (1986), Goldblatt & Johnson (1990, 1991, 1994, 1996, 1998), Gill *et al.* (1990), Zhuang *et al.* (1990, 1992), Tamura *et al.* (1996), Sugiura *et al.* (2000) etc.

The basic information on chromosome numbers provides tool for molecular genetics. Most species of *Diospyros* L. are diploids; but *D. ebenum* Koenig has hexaploid populations (Franceschi, 1993; Yonemori *et al.*, 2000) and *D. virginiana* L. has tetra and hexaploids both (Baldwin & Culp, 1942). Yonemori *et al.* (2000) reported that *D. kaki* Thunb. ex L. f. has usually hexaploid populations and less frequently enneaploid and assumed to be an allopolyploid. The other notable works which need mention are of Yasui (1915), Namikawa *et al.* (1932), Delay (1947), Wood & Channell (1960), Mehra & Bawa (1969), Chatha & Bir (1987) and Tao *et al.* (1992). DNA restriction fragment length variability in *D. kaki* Thunb. ex L. f. has been studied by Nakamura & Kobayashi (1994).

Palynology : The pollen grains provide preservative constant characters to trace the evolutionary succession in any group (Polak, 1933). The pollen morphology, particularly the colporate numbers, shape of endocolpium, equatorial length and diameter of endocolpium, exine surface etc together provide index for the separation of taxa and suggest line of evolutionary sequences in *Ebenaceae*. Erdtman (1952) has defined pollen grains usually 3-colporate, prolate to spheroidal-prolate, with sexine as thick as nexine or thicker, psilate or nearly so or finely warty, with obscure (subreticulate) pattern or granular sculpturing pattern, and ora well defined, usually la-longate or sometimes with indistinct lateral ridges in *Ebenaceae*. Labouriau *et al.* (1969), Ayala-Nieto & Ludlow-Wiechers (1983), Roubik & Moreno (1991), Franceschi (1993), Jones *et al.* (1995), Wallnofer (2001) etc have also supported the findings of Erdtman (1952), with considerable additions of variations in pollen morphology. Sharma & Gupta (1979) have added to our knowledge regarding pollen morphology of *Ebenaceae* in relation to phylogeny. Recently, Nair & Kothari (1985) have carried out palynological studies on some species of *Diospyros* L. and recorded important evolutionary clues to suggest phylogenetic relationship among the species and to establish affinities with allied groups like *Sapotaceae* and *Styracaceae*. Accordingly, 3-colporoidate pollen bearing species viz. *D. montana* Roxb., *D. melanoxylon* Roxb. etc may be considered to form base in evolutionary succession in *Diospyros* L. From these species, 3-colporate grain bearing taxa have evolved in three independent lines viz. (i) with la-longate endocolpium – e.g. *D. oocarpa* Thw., (ii) with circular endocolpium – e.g. *D. exculpta* Buch.-Ham. (reduced to *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh in present work) and (iii) with la-longate endocolpium – e.g. most species of *Diospyros* L., especially *D. peregrina* (Gaertn.) Gurke, *D. sylvatica* Roxb., *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh, *D. buxifolia* (Bl.) Hiern., *D. cordifolia* Roxb.

and *D. ebenum* Koenig. In the last line the species may be arranged again along the line of evolutionary reduction on the basis of equatorial diameter of endocolpium starting from *D. peregrina* (Gaertn.) Gurke to *D. ebenum* Koenig.

Further, the uniform occurrence of 3-colporate forms within *Ebenaceae* as represented by *Diospyros* L. suggest its highly evolved position with no tendency of further variations. It is apparently different from allied family *Sapotaceae* in which there are also 4 and 5-colporate forms. Again, the lack of latex in *Ebenaceae* as against *Sapotaceae* further supports the view that the *Ebenaceae* is an independent family within Ebenales. The significance of palynological data in the modern taxonomy of vascular plants has been increasingly accepted in recent years. Spores and pollens offer a wide range of precisely definable morphological features which may be used to identify and classify the taxa with or in many cases without the reference of other morphological data. Mohl (1834, 1835), prior to Erdtman (1952), has stressed that based on palynology, trends of evolution may be recognized within plant groups as pollens offer stable and more conservative characters which are not altered by external influences and physiological status of individuals. Santos (1961, 1963), while working on the species of Apicolas, pointed out that the morphological evolution of pollen and spores not only provides a new base for a palynophylogenetic classification of the plant kingdom but also offers an elegant experimental material for genetics and plant breeding. But, unfortunately, very limited palynological work has been done on the family *Ebenaceae* and the genus *Diospyros* L. in particular. Some notable contributions which also need mention are of Guinet (1962) and Mukherjee (1969) on Indian species, Huang (1968, 1972) on Formosan and Taiwan species, Ikuse (1956) and Takeoka (1965) on Japanese, Labouriau (1973) and Labouriau *et al.* (1969) on the species of Cerrado, Selling (1947) on Hawaiian, Sladkov & Samoilovich (1954) on the species of tropical and subtropical parts of Russia, Sowunmi (1974) on Nigerian, Straka (1967) on Madagascar, Wang (1960) on Chinese, Ayala-Nieto & Ludlow-Wiechers (1983) on Veracruz, Roubik & Moreno (1991) on Barro Colorado island and Jones *et al.* (1995) on the species of S. E. United States.

Kapp (1969) has also emphasized on the significance of pollen morphology in taxonomy and phylogeny. Recent works on experimental control of breakdown and restoration of pollen plants by culturing pollen grains and protoplast culture from pollen grains for purpose of raising a wide spectrum of mutations etc have provided profound hope for developing homogynous lines needed in plant breeding, particularly for dioecious and monoecious taxa like *Ebenaceae*.

Anatomy : Anatomy of seedlings of *Ebenaceae*, especially development of phloem and xylem, lignification and differentiation of vascular elements, is discussed by Wright (1904). He reported that in the species with long-lived cotyledons, each cotyledon usually possesses 2 traces, and in the species with short-lived cotyledons, there are 3 traces. Studies of Wood & Channell (1960) revealed that in most species of *Diospyros* L., the nodes possess 1 trace from 1 gap; Watson & Dallwitz (2000) described them uni-lacunar or tri-lacunar. The petioles at distal end exhibit a solitary, crescent-shaped vascular strand in transverse section. Its form is species-specific and varies from open and slightly concave to

deep with strong incurved ends. The anatomical studies on young stem of *Diospyros* L. revealed that cork is usually formed immediately below the epidermis except in some species where it is of pericycle origin. The pericycle usually contains a composite and continuous ring of sclerenchyma, sometimes also with isolated strands of fibres. The secondary phloem is devoid of fibres, but stone cells are present in certain species. Secretary cells are abundant in the cortex, phloem, rays and pith of many species invariably or missing in some of these tissues in some species (Wright, 1904; Busch, 1913; Reinders & Stahel, 1948; Metcalfe & Chalk, 1950; Rao, 1951).

The characters of wood are remarkably constant throughout the family. The notable contributions on wood anatomy are those of Gamble (1881), Parker (1931), Metcalfe & Chalk (1950), Graaff & Baas (1974), Pearson & Brown (1981), Purkayastha (1982), Baas (2000) etc. They recorded that in *Diospyros* L. the vessels are solitary and in radial multiples of 2, 3, 4 or sporadically more, and with simple perforations. Pits between vessels and between vessels and ray cells or parenchyma are small. Nair & Mohan Ram (1989) have studied vesturated pits in rather details. Parenchyma is predominantly apotracheal, scattered and in numerous uniseriate lines, sometimes forming vasicentric sheaths round the vessels. Rays are 1 to 2-cells or rarely 3 to 4-cells wide, less than 1 mm high, heterogenous. Fibres possess small pits, and walls thinner than lumina. The xylem consists of a continuous cylinder only traversed by narrow rays. Growth rings are rather inconspicuous. Duke *et al.* (1981) and Ash (1983) have studied the growth rings in *Diospyros* L. in relation to rainfall. Former reported wide rings to correspond with high annual rainfall and narrow rings with adjacent low rainfall. Ash (1983), however, is of opinion that typical wide rings represent a normal growth season and the occasional narrow rings represent short additional growth period, trunk growth is not a simple function of climate as predicted by Duke *et al.* (1981). *D. cordifolia* Roxb. and *D. melanoxylon* Roxb. var. *melanoxylon* have helical thickenings on vessel element walls (Nair, 1987). Ray cells in wood in most species contain globular silica grains (Morton, 1994; Morton *et al.*, 1997).

In most species of *Diospyros* L., the sapwood is less hard, less heavy and less durable than the heartwood (Hillis & Soenardi, 1994); the latter is usually hard, heavy, fine-textured, close-grained, diffuse porous and coloured either dirty-white, greenish, yellowish, red, blackish or jet-black (ebonised). The ebonised wood may be uniformly jet-black or composed of succession of darker and lighter coloured, irregular streaks, giving it a variegated, banded or marbled appearance. Hillis & Soenardi (1994) found that ebonised zones are often associated with knots, branch stubs, decay, insect holes or injury and concluded that the black deposits are formed as a response to infection by fungi.

The structure of the mature wood is generally considered to be more conservative than the exomorphic features and, therefore, used in delimitation of families, genera and species and in establishing phylogenetic relationship. In woody groups, the structure of secondary xylem may provide aid in solving taxonomic problems. Bailey (1957) has stressed that if evidences from all parts and organs are used, the wood anatomy may be used as a more stronger taxonomic and phylogenetic tool. The anatomical features viz. presence of silica, crystals, different types of vessels, ray pitting, form of

apotracheal parenchyma are of diagnostic interest. Further, presence or absence of resin canals, scalariform and minute pitting, scalariform perforation plates etc are rather more important features of taxonomic interest in the identification of woods. Pearson & Brown (1981) have gainfully used micro anatomical features of the wood like diameter of vessels, width of rays, rays and vessels arrangement, diameter of fibres, lines of zonate parenchyma etc to separate some species of *Diospyros* L.

Leaf-anatomy has not received due attention in India. However, works of Elsler (1907), Stace (1965), Ng (1971) and Ditsch & Barthlott (1997) may be cited to understand the internal morphology of leaves. Accordingly, the cells of epidermis differ considerably in shape and size in different species. Their anticlinal walls are either straight, curved or undulated. Epidermal papillae occur on abaxial surface in several species of *Diospyros* L. All epidermal cells, except those bearing a hair, have a more or less centrally placed coronulated papilla. The papillae are connected by cuticular folds. In some species, however, papillae tend to be restricted to the cells around the sunken stomata which are confined to the abaxial leaf-surface. In *D. virginiana* L. stomata have also been found on adaxial side of leaves. The guard cells differ among species, usually being level with other epidermal cells or slightly protruding or sunken. The number of cells around each stoma varies from 3 to 9 and they are like other epidermal cells i.e. anomocytic condition or of ranunculaceous type. In some species, however, these subsidiary cells differ in shape, size and orientation and have straight anticlinal walls i.e. cyclocytic condition. The cuticular waxes are usually lacking in most *Diospyros* L. species. The hypodermis is usually absent. In majority of species, yellow, sclerified, pitted cells, either solitary or in clusters and sometimes branched are present in mesophyll and particularly in palisade tissue. The stone cells occur in parenchymatous portion of the veins of petioles. Secretary cells are found in abundance in cortical region and sometimes in the phloem of the petiole. Large solitary crystals and cluster of crystals (calcium oxalate) occur in idioblasts of the mesophyll of leaves (Wallnofer, 2001). Tomer *et al.* (1996) have carried out SEM studies on the trichomes in persimmon (*D. kaki* Thunb. ex L. f.) leaves. The seed morphology has been studied by Corner (1976).

Embryology : Very limited work has been done on the embryology of *Ebenaceae* and the genus *Diospyros* L. in particular. Scattered information regarding embryology, particularly embryogeny and organogenesis, is available in the works of Davis (1966), White (1983) and Johri *et al.* (1992). Recently, Yamazaki (1972) has contributed to the embryology of *Ebenaceae* in rather details. Studies of Yasui (1915) revealed non-fibrous endothecium in *D. kaki* Thunb. ex L. f. On the other hand, the studies of Hague (1911) and Anjaneyulu & Lakshminarayan (1989) on *D. virginiana* L. and *D. chloroxylon* Roxb. revealed fibrous endothecium in these species and a tapetum being dual in origin and dimorphic in nature. Yakovlev & Zhukova (1980) have studied the chlorophyll contents in the embryos of seeds. A perusal of studies carried out sofar revealed that in most species of *Diospyros* L. the anther wall comprises the epidermis, the endothecium, two middle layers and multinucleate tapetal cells. In microspore mother cells simultaneous cytokinesis follows meiosis and microspore tetrads are tetrahedral, isobilateral or decussate. The ovule is pendulous, anatropous, bitegmic, tenuinucellar, with raphe descending on the

outer side. The testa consists of the outer integument only. After fertilization, the inner integument disintegrates, except for its inner epidermis which persists and behaves as if it was the surface layer of embryo-sac. The archesporial cell functions as megaspore mother cell, undergoes meiotic divisions and produces a linear tetrad. The chalazal megaspore develops into a *Polygonum* – type of embryo-sac. Fusion of polar nuclei does not always occur, and the three antipodal cells are small and ephemeral. The endothelium is well developed. The development of endosperm is of cellular type. The embryogeny and organogenesis probably correspond to the polygonad type/chenopodiad variations or chenopodiad type (Wallnofer, 2001).

Phytochemistry : The family *Ebenaceae*, the genus *Diospyros* L. in particular, are very characteristic in having naphthoquinones, terpenoids, benzopyrones, polyphenols and tannins widely distributed among species and in different organs of the plants. Other compounds are steroids, naphthalene-based aromatics, hydrocarbons, lipids, amino acids, carotenoids and sugars (Hegnauer, 1966, 1989; Mallavadhani *et al.*, 1998, 2001). The derivatives and oxidative decomposition products of naphthoquinones are responsible for the dark brown to black coloured tissues of the bark, heartwood, fruits and leaves (Neuwinger, 1998). Idioblast containing tannins occur in various organs, including fruits (Utsunomiya *et al.*, 1998; Yonemori *et al.*, 2000). Kolbe & John (1980) have carried out serological comparisons among the members of *Ebenaceae*. The chemistry of different species of *Diospyros* L. has been carried out by a number of workers which have been gainfully compiled in "The Wealth of India, Vol. 3" (Anonymous, 1952). As such, many of the citation of references contained therein have been avoided in the present work due to the economy of space. However, the important contributions which need mention in the field of plant chemistry of *Diospyros* L. or *Ebenaceae* as a family whole are those of Loder *et al.* (1957), Kapil & Dhar (1961), Sundararamaiah & Row (1963), Gupta & Tiwari (1964), Ganguly & Govindachari (1966), Sidhu & Prasad (1967, 1970), Sidhu & Pardhasaradhi (1967a, 1967b), Yoshihira *et al.* (1967, 1970, 1971), Gupta & Mahadevan (1967 1968), Fallas & Thomson (1968), Dhar *et al.* (1968), Row *et al.* (1969), Gupta & Dhar (1969), Musgrave & Skoyles (1970) etc.

The studies on the distribution pattern of different chemical constituents in order to determine inter-relationship among species have received much attention during the decade of eighties. The important contributors are Misra *et al.* (1971), Bhakuni *et al.* (1971), Singh *et al.* (1971), Tezuka *et al.* (1973), Barclay & Earle (1974), Billore *et al.* (1976), Dhawan *et al.* (1977), Carter *et al.* (1978), Narayan *et al.* (1978), Matsuura & Iinuma (1978, 1985), Herath *et al.* (1978), Chauhan & Kumari (1978, 1980), Chauhan *et al.* (1979), Pardhasaradhi & Krishnakumari (1979), Srivastava & Omray (1979), Daniel *et al.* (1980), Srivastava & Kharya (1980) etc. It is interesting to note that several of the above cited works are pharmacology oriented and certain species have been found active against fungi, bacteria, viruses, insects, worms, termites, molluscs etc, having medicinal potential.

The phytochemical data has been found useful not only in delimitation of taxa and establishing phylogenetic affinities, but may also be used in breeding programmes, particularly the protein and non-protein amino acid profiles. The data may also be gainfully used for socio-economic development of the

region by commercial exploitation of the species for specific compounds or products. The works of Sankaram *et al.* (1981), Bhaumik *et al.* (1981), Hazra *et al.* (1981, 1984), Lal & Ambasht (1981, 1982), Daulatabad & Ankalagi (1982), Jain & Srivastava (1984), Sankaram & Reddy (1984), Srivastava & Pitre (1985) etc need special mention. During the end of 20th century, Rastogi & Mehrotra (1993a, 1993b, 1993c) have produced a monumental work in this field by compiling the maximum available data and have opened a new era for herbal based medicines and other products for human welfare. The other notable works are those of Cutillas-Iturralde *et al.* (1993, 1998), Kang *et al.* (1994), Paknikar *et al.* (1996), Jain & Yadava (1996), Gondo *et al.* (1999), Kotani *et al.* (1999, 2000) and Umekawa *et al.* (1999) who have worked on inhibition of eukaryotic DNA polymerase by extract of *D. kaki* Thunb. ex L. f. and related polyphenols.

Paleobotany : The *Ebenaceae* are considered to have evolved in the Cretaceous era in Western Gondwana and have reached Eurasia and North America by Paleocene time. Fossils are known mainly from Tertiary, with only relatively few dating back to the Cretaceous (Berry, 1923; Wallnofer, 2001). Hiern (1873) has provided older paleobotanical literature in rather details. After Edwards (1931), during recent years, Franceschi (1993), Collinson *et al.* (1993), Mai (1995) etc have added to our paleobotanical knowledge, especially for *Diospyros* L. Awasthi (1974) has recorded fossils of *Diospyros* L. in Neogene angiospermous woods. Apart from *Diospyros* L. and *Euclea* Murr., *Diospyrocarpum, Diospyropsis, Diospyroxylon, Ebenoxylon* and *Tricolporopollenites miloni* fossil (extinct) form-genera belonging to *Ebenaceae* have been recorded. Further, Basinger & Christophel (1985) have recorded *Austrodiospyros cryptostoma* of Eocene time from Australia. Most of fossil records of *Ebenaceae* are based on wood and may need re-evaluation. The supporting evidences from leaves are lacking since the characters like extrafloral nectaries, coronullate papillae on abaxial leaf-surface etc have not been recorded for many taxa of *Ebenaceae*, especially in *Diospyros* L.

Economic uses : The *Ebenaceae* are the source of several important products, particularly the edible fruits and timber which is generally called "Ebony". Multiple uses of the species of *Diospyros* L. are available in the works of Watt (1890), Burkill (1935), Williams (1943), Sunderarajan & Balasubramanyam (1959), Maheshwari & Singh (1965), Nayar *et al.* (1989), Anonymous (1952), Jayaraman (1992) etc.

Ebony timber is among those exotic materials that have been highly valued since classical times. The ebony with dark streaked or jet black heartwood has wide demand in the World for musical instruments, carved works, cabinet making, as decorative veneer for furniture, interior decoration etc. The black materials are derivatives and decomposition products of naphthoquinones, filling the lumina. It has high content of carbon and properties characteristic of humic acid, giving durability and resistance to wood against fungi and insects. Details of timber and their multiple uses are given by Gamble (1881), Parker (1931), Agrawal (1970), Graaff & Baas (1974), Pearson & Brown (1981), Purkayastha (1982), Troup (1986) etc. Economically most important species in this respect are *D. assimilis* Bedd. (Malabar ebony), *D. chloroxylon* Roxb. (Coromandal ebony), *D. ebenum* Koenig (Ceylon ebony), *D. kurzii* Hiern (Andaman Zebra wood), *D. marmorata* Parker (Andaman Marble wood), *D. melanoxylon* Roxb. var.

melanoxylon (Coramandal wood), *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh (Nepal ebony) and *D. peregrina* (Gaertn.) Gurke (Bombay ebony).

Several species of *Diospyros* L. provide edible fruits rich in sugar, protein and minerals. As such, many of them are cultivated on commercial scale like *D. kaki* Thunb. ex L. f., *D. discolor* Willd., *D. lotus* L., *D. virginiana* L. etc. The fruits of many other species are of regional or local importance. Jayaraman & Singh (1987) have recorded about 18 species of *Diospyros* L. which provide edible fruits. The other works on food value of the fruits include Lewis (1934), Morton (1963), Singh & Arora (1978), Roy *et al.* (1998) etc. Certain fruits are astringent and not edible. Taira *et al.* (1992) have developed the methodology for the removal of astringency from the fruits. Laurie (1945) and Sen & Ray (1971) have discussed the fodder nutritive values of some species of *Diospyros* L.

The most species of *Diospyros* L. have medicinal potential, and the bark, leaves, wood, fruits and seeds are the main sources of medicines. Some species are valued for fish poison or ingredient for arrow-poison. The important works dealing exclusively with medicinal and poisonous aspects are those of Dymock *et al.* (1890-99), Chopra (1933), Kirtikar & Basu (1935), Chopra *et al.* (1956, 1958, 1969, 1984), Jain (1965), Jain & Tarafdar (1970), Kohli *et al.* (1972), Nadkarni (1976), Satyavati *et al.* (1976), Kapadia *et al.* (1977), Jayaweera (1980), Rao & Jamir (1982), Hemadri & Rao (1984), Yoganarasimhan *et al.* (1984), Jayaraman & Singh (1988), Pandey (1988), Agharkar (1991), Jain & Filipps (1991), Asolkar *et al.* (1992), Ahmed (1993), Joshi (1993), Singh (1993), Singh & Dhar (1993), Varier (1994), Srivastava & Rout (1994), Achiwa *et al.* (1997), Prajapati *et al.* (2003) etc. The Ayurvedic drug obtained from *Diospyros* L. is called 'Tinduka or Visatinduka'

Besides above, the information about the usefulness of taxa is also widely scattered on the herbarium sheets and with ethnic societies who have accrued considerable knowledge due to their long association with the forest environment. Part of such informations have been documented by Jain (1965, 1991a, 1991b), Dunn (1983), Maheshwari & Singh (1965), Jain *et al.* (1991), Rao & Henry (1996), Singh & Pandey (1998) etc.

The leaves of *D. melanoxylon* Roxb. var. *melanoxylon* and var. *tupru* (Buch.-Ham.) Singh (Tendu) are utilized on wide scale as wrappers for Cigarettes, called "Bidi". The States of Madhya Pradesh, Chhatisgarh and Orissa are the main producers of Tendu leaves. The important contributors on Tendu leaves and their trade are Desarkar (1963), Rathore (1972), Hunter (1981), Dhar *et al.* (1989), Lal & Dave (1991) etc. Fruits of *D. virginiana* L. are used to brew persimmon beer (Jayaraman, 1996). Many species are used for dying the fishing nets, umbrellas and polishing the base of boats for making them water proof.

Due to multiple uses of plant organs, some of the species are now heavily threatened by way of over-exploitation. As such, caryopreservation and *in-vitro* regeneration of new plants from leaf segments, hypocotyle segments, anthers, callus etc have been experimented in some species, particularly in *D. kaki*

Thunb. ex L. f. It may be hoped that in future, new techniques will be evolved for regeneration of other plant species through tissue culture. The notable contributions in this field are those of Yokoyama & Takeuchi (1976), Tao & Sugiura (1992), Tao *et al.* (1992), Nakamura *et al.* (1998), Choi *et al.* (2001), Matsumoto *et al.* (2001) etc.

SYNOPSIS OF THE PRESENT MONOGRAPH

The review of literature on the family *Ebenaceae* R. Br. revealed that this group has not only been neglected taxonomically, but also in the fields of applied disciplines viz. cytology, palynology, embryology, anatomy, phytochemistry etc. More serious is the fact that inspite of taxonomic confusion in certain infra-generic taxa of *Diospyros* L., no sincere efforts have been made to synthesize available data from other disciplines for solving the taxonomic problems upto the extent possible. Further, the present classifications provided for infra-generic taxa are inadequate to accommodate Indian species. In the present monograph, the author has made an attempt to collect additional clues of taxonomic interest from the available published literature on different subjects at author's disposal and has put them on record for providing a multidisciplinary description to the species in order to compare them with other related or unrelated taxa in different fields. As more data on different applied aspects would be explored in future, it would be possible to determine phylogenetic relationship between the taxa at different levels and path of evolution in the genus *Diospyros* L. The important salient features of the present work are as under :

i. Sixty six taxa (including varieties) of the genus *Diospyros* L. have been described as against 35 taxa of *Ebenaceae* reported by Clarke (1882) from present Indian territory.

ii. The herbarium specimens of the taxa included in the present work have been personally examined by the author and descriptions provided are original which fit on the Indian plants.

iii. Correct valid names have been adopted for the Indian plants and attempts have been made to provide complete synonymy under each taxon to avoid taxonomic confusion.

iv. The valid botanical names from the rank of family have been authenticated with the citation of types upto infra-specific level.

v. Lectotypes for eight species have been designated here.

vi. Phenological data along with ecological notes have been provided to each taxon.

vii. Distributional aspects of each species in India and other parts of globes have been discussed in details and indicated on maps to understand the routes of migration.

viii. Important findings of other workers on chemistry, anatomy, palynology, embryology, cytology etc have been incorporated to supplement the taxonomic description and are used as an additional tool to solve taxonomic problems in the delimitation of certain taxa. No such multidisciplinary approach has been made earlier in this genus.

ix. Besides phylogenetic affinities of *Ebenaceae*, the phenetic affinities within the infra-generic taxa of *Diospyros* L. have been discussed to understand evolutionary sequences.

x. A more natural classification has been provided upto infra-generic level and about 10 new sections have been established to accommodate Indian taxa. Keys have been provided upto infra-specific level based on morphological characters, supplemented with diagnostic data from other disciplines.

xi. One new variety has been described and two new combinations have been made, besides changing the taxonomic status and systematic position of several taxa.

xii. Economic uses have been provided along with vernacular and English names, wherever possible, so as to make easy the resource utilization.

xiii. Depleting and endemic taxa, cause of threat and conservation aspects have been discussed in details.

xiv. Detailed illustrations for 61 taxa and about 96 coloured photographs have been added for easy and perfect determination of taxa.

xv. Literature on taxonomy and other disciplines has been reviewed todate.

Thus, the present monograph on the genus *Diospyros* L. is authentic and more comprehensive. However, the author will welcome suggestions from the readers for future improvement.

ABBREVIATIONS

In the present monograph some abbreviations have been freely used to denote Indian languages and dialects, some herbaria and other pertinent and often used words. The abbreviations of various Indian herbaria are adopted from Index Herbariorum (1990) and other abbreviations used are in conformity with common internationally accepted usage in botanical taxonomy and International Code of Botanical Nomenclature (1994).

Andaman	And.
Assamese	Asm.
Bengali	Beng.
Bhojpuri	Bhoj.
Gujarati	Guj.
Hindi	Hindi
Kannada	Kan.
Kangri	Kang.
Khasi	Khas.
Malayalam	Mal.
Marathi	Mar.
Nagaland	Nag.

Nepali	Nep.
Oriya	Or.
Punjabi	Punj.
Rajasthani	Raj.
Sanskrit	Sans.
Tamil	Tam.
Telugu	Tel.
Urdu	Urdu
Chromosome Number	Chr. No.
Distribution	Distrib.
Ecology	Ecol.
Exsiccata	Exsicc.
Flowering and Fruiting (Phenology)	Fl. & Fr.
Herbarium Lugundo Batavum	HLB
Department of Botany, Andhra Pradesh University, Waltair	WALT

CLASSIFICATION

The family *Ebenaceae* were first established by Ventenat (1799), revised by Jussieu (1804) and finally assigned by R. Brown (1810) in its present form. Don (1837) enumerated about 83 species under the family *Ebenaceae* assigned to 8 genera. Among 8 genera, Don (1837) also included the genus *Diclidanthera* Mart. with 2 species. However, presently this genus has been placed under the family *Styracaceae*. Further, a new genus *Diplonema* G. Don described by him has also been merged with the genus *Euclea* Murr. by the subsequent workers. The species *Leucoxylum buxifolium* Bl., which other workers included in *Ebenaceae*, was placed by him in *Iliciniae*.

After Don (1837), A. De Candolle (1844) monographed the family *Ebenaceae* and described 8 genera viz. *Royena* L. (18 spp.), *Euclea* Murr. (15 spp.), *Gunisanthus* A. DC. (1 sp.), *Rospidios* A. DC. (1 sp.), *Macreightia* A. DC. (7 spp.), *Diospyros* L. (73 spp.), *Maba* J. R. & G. Forster (17 spp.) and *Cargillia* R. Br. (2 spp.). The genus *Euclea* Murr. was divided into two sections viz. *Rymia* A. DC. (7 spp.) and *Ortheuclea* A. DC. (8 spp.). Similarly, the genus *Diospyros* L. was divided into four sections viz. *Tetradiospyros* A. DC. (1 sp.), *Otogyne* A. DC. (5 spp.), *Eudiospyros* (L.)A. DC. (66 spp.) and *Amuxis* A. DC. (1 sp.). He dealt with 134 species and about 26 infra-specific taxa under these 8 genera but did not dealt with *Leucoxylum buxifolium* Bl. in his monograph on *Ebenaceae*.

Hiern (1873) proposed a rather more refined natural classification for the family *Ebenaceae* based on A. De Candolle's concept. He recognized only 5 genera under this family viz. *Royena* L. (13 spp.), *Euclea* Murr. (19 spp.), *Maba* J. R. & G. Forster (59 spp.), *Diospyros* L. (170 spp.) and one newly

described genus *Tetraclis* Hiern. (1 sp.). He dealt with about 262 species under these genera. The genus *Maba* J. R. & G. Forster was divided into six sections viz. *Ferreola* (Koeri. ex Roxb.) Hiern (24 spp.), *Macreightia* (A. DC.) Hiern (9 spp.), *Holochilus* (Dalz.) Hiern (6 spp.), *Rhipidostigma* (Hassk.) Hiern (9 spp.), *Barberia* Hiern (4 spp.) and sect. *Trichanthera* Hiern (7 spp.). Similarly, the genus *Diospyros* L. was also divided into 15 sections viz. *Melonia* Hiern (20 spp.), *Ebenus* Hiern (16 spp.), *Noltia* (Schum.) Hiern (9 spp.), *Gunisanthus* (A. DC.) Hiern (8 spp.), *Guaiacana* Hiern (6 spp.), *Cunalonia* Hiern (2 spp.), *Ermellinus* Hiern (18 spp.), *Patonia* Hiern (11 spp.), *Leucoxylum* (Bl.) Hiern (3 spp.), *Danzleria* Hiern (15 spp.), *Paralea* Hiern (19 spp.), *Cargillia* (Br.) Hiern (2 spp.), *Rospidios* (A. DC.) Hiern (15 spp.), *Cavanilloa* Hiern (8 spp.) and *Amuxis* A. DC. (1 sp.). He has reduced the genera *Macreightia* A. DC., *Holochilus* Dalz. and *Rhipidostigma* Hassk. as sections under the genus *Maba* J. R. & G. Forst. and the genera *Cargillia* R. Br., *Leucoxylum* Bl., *Noltia* Schum., *Gunisanthus* A. DC. and *Rospidios* A. DC. as sections under the genus *Diospyros* L.

Bentham & Hooker (1876) followed Hiern (1873) and provided a classification for *Ebenaceae* adding nothing new to the group. Gurke (1891) provided a synopsis of Asiatic species. Hiern's (1873) concept found wide recognition throughout the World till the middle of 20th century (Miquel, 1859; Clarke, 1882; Bailey, 1900; King & Gamble, 1905; Merrill, 1923; Lecomte, 1930 etc). In most of these works, the classification proposed by Hiern (1873) has been followed.

Recently, Bakhuizen (1936-1955) has proposed a revised classification for *Ebenaceae*, particularly for Pacific and S. E. Asian taxa. He recognized four genera under this family viz. *Tetraclis* Hiern, *Royena* L., *Euclea* Murr. (1 sp.) and *Diospyros* L. (181 spp.). His classification differs from the classification proposed by Hiern (1873) in a fundamental point that he merged the genus *Maba* J. R. & G. Forster under *Diospyros* L., since the characters like trimerous flowers and 3 or 6-celled ovary used to distinguish the genus *Maba* J. R. & G. Forster from *Diospyros* L. don't hold good as there have been specimens with 4 to 20-celled ovary and trimerous flowers. Contrary to above, both genera have more characters in common e.g. flowers 3 to 7-merous, calyx often accrescent, corolla with contorted aestivation, inflorescence cymose or 1-flowered, staminodes usually present in female flowers, ovary 2-20 locular, locules 1 to 2-ovulate and seeds oblong or ellipsoid. These characters are good enough to isolate other genera of *Ebenaceae* from *Diospyros* L. except *Maba* J. R. & G. Forster at global level. Bakhuizen (1936-1955) has also merged the genus *Macreightia* A. DC., *Rospidios* A. DC., *Cargillia* Br., and *Gunisanthus* A. DC. under the genus *Diospyros* L. He divided the genus *Diospyros* L. into 5 subgenera viz. *Cargillia* (Br.) Bakh. (2 spp.), *Eudiospyros* (L.) Bakh. (161 spp.), *Hierniodendron* Bakh. (3 spp.), *Maba* (J. R. & G. Forst.) Bakh. (14 spp.) and *Mabacea* Bakh. (1 sp.). The subgenus *Eudiospyros* (L.) Bakh. was divided into 32 sections viz. *Acanthebenus* Bakh. (1 sp.), *Asterocalix* Bakh. (1 sp.), *Basithrix* Bakh. (13 spp.), *Brachycylix* Bakh. (32 spp.), *Campanulata* Bakh. (8 spp.), *Cavanilleastrum* Bakh. (3 spp.), *Caudifera* Bakh. (2 spp.), *Cladantha* Bakh. (2 spp.), *Confertiflora* Bakh. (3 spp.), *Didymanthera* Bakh. (5 spp.), *Ebenaster* Bakh. (8 spp.), *Ebenopsis* Bakh. (6 spp.), *Ebenus* Bakh. (5 spp.), *Eriantha* Bakh. (5 spp.), *Eucarpon* Bakh. (7 spp.), *Glutinosa* Bakh. (6 spp.), *Kurzella* Bakh. (5 spp.), *Liophylla*

Bakh. (4 spp.), *Lotus* Bakh. (1 sp.), *Nesindica* Bakh. (11 spp.), *Pachycylix* Bakh. (1 sp.), *Phyllosepala* Bakh. (2 spp.), *Podophora* Bakh. (3 spp.), *Ptychocylix* Bakh. (7 spp.), *Reflexocalix* Bakh. (2 spp.), *Rigidophylla* Bakh. (4 spp.), *Saccocalix* Bakh. (4 spp.), *Sapotanigra* Bakh. (1 sp.), *Stelechantha* Bakh. (1 sp.), *Trisantha* Bakh. (2 spp.), *Truncicalix* Bakh. (4 spp.) and *Verruculosa* Bakh. (2 spp.). The subgenus *Maba* (J. R. & G. Forst.) Bakh. has been divided into 4 sections viz. *Cupulifera* Fosb. (3 spp.), *Ferreola* (Koen. ex Roxb.) Fosb. (2 spp.), *Rhipidostigma* (Hassk.) Bakh. (4 spp.) and *Miquelia* Bakh. (5 spp.).

Recently, White (1980, 1983), while dealing with African *Ebenaceae* proposed a new classification. He has recognized only two genera viz. *Diospyros* L. (91 spp.) and *Euclea* Murr. (12 spp.). Rest of the genera viz. *Cargillia* R. Br., *Gunisanthus* A. DC., *Maba* J. R. & G. Forster, *Macreightia* A. DC., *Rospidios* A. DC., *Royena* L. and *Tetraclis* Hiern have been merged under the genus *Diospyros* L. The latter genus has been divided into 18 sections viz. *Asteropetala* White (1 sp.), *Brevistyla* White (8 spp.), *Brevituba* White (13 spp.), *Calvitiella* White (10 spp.), *Dodonium* White (2 spp.), *Entia* White (1 sp.), *Erikesi* White (2 spp.), *Forbesia* White (8 spp.), *Forsteria* White (2 spp.), *Katula* White (1 sp.), *Lagenaria* White (1 sp.), *Latibulum* White (4 spp.), *Marsupium* White (1 sp.), *Myrmecophila* White (1 sp.), *Noltia* (Schum.) White (7 spp.), *Rhaphidanthe* White (1 sp.), *Royena* (L.) White (18 spp.) and *Tabonaca* White (10 spp.).

Further, the systematic position of the genus *Lissocarpa* Gurke, having *ca* 5 species, is also debatable. Gurke (1891) placed it in the family *Lissocarpaceae*, Savolainen *et al.* (2000) considered it a member of *Rutaceae* in Sapindales and recently Berry *et al.* (2001) have argued to place it in *Ebenaceae* as a sister group of *Diospyros* L., based on plastid rbcL sequence data, following the concept of Heywood (1978), Willis (1985) and Vasques (1993). For latter concept, evidences from wood anatomy and plastid rbcL sequences have been taken into account, besides morphological similarities in having sympetalous flowers, biovulate carpels, pendulous ovules, fleshy fruits and seeds with bony endosperm. Contrary to above, I support the concept of Ng (1971), Franceschi (1993) and Wallnofer (2001) to consider *Lissocarpaceae* as a monogeneric family having phylogenetic close affinities with *Ebenaceae*, since the genus *Lissocarpa* Gurke differs from *Ebenaceae* in several morphological characters viz. bisexual flowers, flowers consistently 4-merous, inferior ovary, tubular and 8-lobed corona, seeds with vascular system of 6-12 branches that form prominent longitudinal ridges etc. Further, the vessels in *Lissocarpa* Gurke have both simple and scalariform perforation plates, whereas in *Diospyros* L. and *Euclea* Murr. (*Ebenaceae*) only simple perforation plates occur. Scalariform perforation plates are considered plesiomorphic wood character in angiosperms as compared to simple ones. In the end, it may be concluded that *Ebenaceae* have only two genera viz. *Diospyros* L. and *Euclea* Murr. as per present status of knowledge. The genus *Euclea* Murr. is not represented in India. As such, Indian *Ebenaceae* is monogeneric and I shall deal only with the genus *Diospyros* L. as represented in India in the present monograph. The Indian *Ebenaceae* though show rather close affinity with Malayan region in comparison to Africa and New World, yet, I will prefer to follow White's (1980, 1983) concept to classify Indian

Table 1 : Comparison of infra-familiar and infra-generic classification of *Ebenaceae* as proposed by four most important monographers. The number of species accepted by the authors is given in parenthesis

CANDOLLE (1844)	HIERN (1873)	BAKHUIZEN (1936-1955)	WHITE (1980, 1983)	SINGH (proposed here)
Cargillia (2)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
Diospyros (ca 73)	*Diospyros* (ca 170)	*Diospyros* (ca 181)	*Diospyros* (ca 91)	*Diospyros* (ca 66)
sect. *Amuxis* (1)	sect. *Amuxis* (1)	subgen. *Cargillia* (2)	sect. *Asteropetala* (1)	sect. *Acanthebenus*(3)
sect. *Eudiospyros* (66)	sect. *Cargillia* (2)	subgen.*Eudiospyros*(161)	sect. *Brevistyla* (8)	sect. *Assimilis* (2)
sect. *Otogyne* (5)	sect. *Cavanillea* (8)	sect. *Acanthebenus* (1)	sect. *Brevituba* (13)	sect. *Atrata* (1)
sect. *Tetradiospyros*(1)	sect. *Cunalonia* (2)	sect. *Asterocalix* (1)	sect. *Calvitiella* (10)	sect. *Barberi* (1)
	sect. *Danzleria* (15)	sect. *Basithrix* (13)	sect. *Dodonium* (2)	sect. *Basithrix* (3)
	sect. *Ebenus* (16)	sect. *Brachycylix* (32)	sect. *Entia* (1)	sect. *Brachycylix* (2)
	sect. *Ermellinus* (18)	sect. *Campanulata* (8)	sect. *Erikesi* (2)	sect. *Candolleana* (2)
	sect. *Guaiacana* (6)	sect. *Cavanilleastrum*(3)	sect. *Forbesia* (ca 8)	sect. *Campanulata*(5)
	sect. *Gunisanthus* (8)	sect. *Caudifera* (2)	sect. *Forsteria* (2)	sect. *Confertiflora* (1)
	sect. *Leucoxylum* (3)	sect. *Cladantha* (2)	sect. *Katula* (1)	sect. *Crumenata* (3)
	sect. *Melonia* (20)	sect. *Confertiflora* (3)	sect. *Lagenaria* (1)	sect. *Ebenaster* (2)
	sect. *Noltia* (9)	sect. *Didymanthera* (5)	sect. *Latibulum* (4)	sect. *Ebenopsis* (1)
	sect. *Paralea* (19)	sect. *Ebenaster* (8)	sect. *Marsupium* (1)	sect. *Ebenus* (3)
	sect. *Patonia* (11)	sect. *Ebenopsis* (6)	sect. *Myrmecophila* (1)	sect. *Eucarpon* (1)
	sect. *Rospidios* (15)	sect. *Ebenus* (5)	sect. *Noltia* (7)	sect. *Hirsuta* (1)
		sect. *Eriantha* (5)	sect. *Rhaphidanthe* (1)	sect. *Insignis* (1)
		sect. *Eucarpon* (7)	sect. *Royena* (18)	sect. *Kaki* (2)
		sect. *Glutinosa* (6)	sect. *Tabonaca* (10)	sect. *Kurzella* (1)
		sect. *Kurzella* (5)		sect. *Liophylla* (1)
		sect. *Liophylla* (4)		sect. *Lotus* (4)
		sect. *Lotus* (1)		sect. *Maba* (10)
		sect. *Nesindica* (11)		sect. *Nesindica* (4)
		sect. *Pachycylix* (1)		sect. *Ptychocylix* (2)
		sect. *Phyllosepala* (2)		sect.*Pyrrhocarpoides*(1)
		sect. *Podophora* (3)		sect. *Stelechantha* (4)
		sect. *Ptychocylix* (7)		sect. *Sylvatica* (3)
		sect. *Reflexocalix* (2)		sect. *Trichophylla* (2)

Contd.

CANDOLLE (1844)	HIERN (1873)	BAKHUIZEN (1936-1955)	WHITE (1980, 1983)	SINGH (proposed here)
		sect. *Rigidophylla* (4) sect. *Saccocalix* (4) sect. *Sapotanigra* (1) sect. *Stelechantha* (1) sect. *Trisantha* (2) sect. *Truncicalix* (4) sect. *Verruculosa* (2) subgen. *Hiemiodendron* (3) subgen. *Maba* (14) sect. *Cupulifera* (3) sect. *Ferreola* (2) sect. *Rhipidostigma* (4) sect. *Miquelia* (5) subgen. *Mabacea* (1)		
Euclea (15) sect. *Rymia* (7) sect. *Orthreuclea* (8)	***Euclea*** (19)	***Euclea*** (-)	***Euclea*** (ca 12)	***Euclea*** (-)
Gunisanthus (1)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
Maba (17)	***Maba*** (59) sect. *Barberia* (4) sect. *Ferreola* (24) sect. *Holochilus* (6) sect. *Macreightia* (9) sect. *Rhipidostigma* (9) sect. *Trichanthera* (7)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
Macreightia (7)	(incl. in *Maba*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
Raspidios (1)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
Royena (18)	***Royena*** (13)	***Royena*** (-)	(incl. in *Diospyros*)	(incl. in *Diospyros*)
	Tetraclis (1)	***Tetraclis*** (-)	(incl. in *Diospyros*)	(incl. in *Diospyros*)

Ebenaceae upto generic level. For lower categories, the concepts of Bakhuizen (1936-1955) will be taken into account with necessary additions and amendments in characters and circumscription of the sections proposed by Bakhuizen (1936-1955), since Bakhuizen's (1936-1955) treatment is out of date now, several of his species do not even belong to *Ebenaceae*, many others have had to be merged and the characters used by him to separate certain sections overlap and do not hold good.

EBENACEAE

Vent. Tab. Regne Veg. t. 443. An VIII. 1799; R. Br. Prodr. ed. 1 524. 1810; Gurke in Engl. & Prantl, Nat. Pflanzenfam. 4 (1) : 153. 1891, *nom. cons. Diospyraceae* Voigt, Hort. Suburb. Cal. 343. 1845. ***Type*** : *Ebenus* Kuntze, non L.

Dioecious, rarely monoecious or polygamous, evergreen or deciduous trees, shrubs or geoxylic undershrubs, rarely with spinous branches. Bark smooth or deeply scored longitudinally and transversely, often black, charcoal-like and brittle; latex absent. Trichomes generally unicellular, simple or 2-armed, one arm usually very short; sometimes club-shaped multicellular glandular hairs conspicuous in some species, rarely with peltate hairs. Leaves simple, usually alternate or spirally arranged, often distichous or with an angular divergence of 2/5^{ths}, rarely opposite or subopposite to pseudo-verticillate in whorls of 3, entire or somewhat sinuous and minutely crenulate, often revolute-margined, coriaceous and opaque, rarely membranous or chartaceous, sometimes with extra-floral nectaries on abaxial surface near the base, pubescent at least when young, subsequently glabrous above or bothsides, epidermal papillae often present on abaxial surface, elliptic or oblong, sometimes of other shapes, obtuse to acuminate at apex; midrib usually depressed on the upper surface; secondary veins pinnately arranged, remote, arching within the margin and anastomosing; tertiary veins obscure or manifest, often transverse to the midrib or in various directions; stipules absent, rarely solitary and sheath-like enclosing buds and soon caducous; petioles usually short. Male inflorescence usually few-flowered cymose, fasciculate or pseudo-racemose or paniculate, peduncled or sessile, multibracteate, mostly pubescent or tomentose to ferruginous, usually in the axils of the young leaves or rarely extra-axillary, sometimes with solitary flower or occasionally lateral and cauliflorous. Female inflorescence of solitary flowers in the axils of leaves, rarely fasciculate or few-flowered cymose, multibracteate; pedicels articulated at the apex; bracts and bracteoles imbricate, usually glabrous inside, sometimes tomentose on both sides. Flowers unisexual, sometimes structurally or functionally hermaphrodite, regular, usually tri to tetra or pentamerous, rarely 6 or 7-merous, rarely condition of phyllomania occurs in which imbricated bracts give the appearance of flower-buds or florepleno condition occurs in which male flowers become double by conversion of stamens into petaloid organs; male flowers usually with a rudimentary ovary; female flowers usually thicker and larger than males, with few barren staminodes on the receptacle or epipetalous, arranged in a single row or staminodes altogether absent. Disc absent or well developed and fleshy, fimbriate or undulate. Calyx usually companulate, lobed to various depths or indistinctly lobed or truncate and entire, sometimes tearing irregularly, less frequently chorisepalous; lobes often accrescent and either erect, spreading or reflexed and sometimes plicate in the fruit, aestivation valvate, imbricate or contorted. Corolla usually

isomerous with calyx but exceeding the latter, hypocrateriform, tubular, campanulate, urceolate or globose, white, cream-coloured, yellow, pink or reddish, throat narrow or wide open, often hirsute, sericeous or otherwise pubescent on both or outerside, subcoriaceous or fleshy, deciduous or marcescent; lobes usually sinistrorsely contorted. Stamens in male flowers all fertile, hypogynous or more commonly inserted at or near the base of the corolla-tube or exceptionally about at the middle, often in two rows, free or combined by their filaments in pairs or otherwise, the inner ones usually shorter or subequal, hidden within the corolla-tube, rarely exserted; anthers lanceolate, linear or oblong, rarely ovate, hairy or glabrous, erect, apiculate or sometimes obtuse, basifixed, 2-celled, outer ones introrse, inner ones extrorse, dehiscing by longitudinal slits or by apical pores; connectives usually produced at the apex beyond the anthers; filaments usually flattened, free or united in pairs, triads or fascicles, shorter than anthers, glabrous or hairy. Ovary rudimentary, non or reduced to a bunch of hairs in male flowers. Ovary in female flowers superior, sessile, 2 to 8-carpellate, subglobose, ovoid or conical, with or without a disc, hairy or glabrous, 2 to 16-celled but septa sometimes incomplete in the lower part; cells 1 to 2-ovuled, placentation apical-axile; ovules pendulous, oblong, anatropous; styles 1, quite short, branches as many as carpels and longer than style, usually branches are counted as styles; stigmas often bifid at apex or variously lobed. Fruits usually a berry, fleshy or semi-woody, globose, ovoid, oblong or conical, usually indehiscent or rarely splitting in valvate manner from the apex; pericarp 2 to 3-layered, coriaceous or in the edible species thin and membranous; mesocarp thick, fleshy, spongy or fibrous, adhering to the seeds. Seeds 1-16, pendulous, usually wedge-shaped, oblong and laterally compressed; testa smooth, thin or coriaceous; albumen equable or cartilaginous ruminated; embryo axile or slightly oblique; cotyledons 2, equal, foliaceous; radicle superior, cylindrical. Fruiting calyx-tube cup-shaped or flattened; lobes enlarged and thickened or not, patent, reflexed or pointing downwards or enrolled, lateral margins of lobes reflexed or not, space between the lobes sagging often forming large marginal marsupial sacs.

The family is represented by 2 genera as per latest concept (White, 1980, 1983; Wallnofer, 2001). They may be segregated as under :

KEY TO THE GENERA

1a. Leaves usually alternate, rarely opposite to subopposite, entire-margined. Inflorescence cymose or fasciculate in males; female flowers usually solitary. Calyx accrescent in fruit. Fruits usually more than 1-seeded, very rarely 1-seeded. Seeds elongated and usually flattened laterally, sometimes circular in cross section or somewhat irregular in shape, usually with a persistent, distinctly raised, straight and sometimes branched vascular strand longitudinally encircling it in a loop; embryo straight or slightly curved in its own plane. *Diospyros* L.

1b. Leaves alternate, opposite to subopposite or in pseudo-whorls of three, entire-margined or margins finely crenulate. Inflorescence a simple or branched pseudo-raceme, sometimes 1-flowered. Calyx not accrescent in fruit. Fruits usually 1-seeded, rarely few-seeded. Seeds subglobose, with 3 lines radiating from apex, one consisting of a shallow, vertical groove (impression on the dislocated fruit-axis), and the other two of

the distal parts of the curved vascular loop; cotyledons strongly flexed out from the embryo-plane in direction to the dislocated fruit axis ***Euclea*** Murr.

The genus *Euclea* Murr. is confined to Africa, Arabia, Socotra and the Comoro Islands. In India, the family *Ebenaceae* contain only the genus *Diospyros* L., which otherwise finds pantropical distribution.

DIOSPYROS L.

Sp. Pl. ed. 1. 1057. 1753. ***Type :*** *D. lotus* L.

Trees, shrubs or undershrubs, usually dioecious, rarely monoecious or polygamous, usually evergreen or less frequently deciduous, few species with spine-tipped branchlets. Leaves usually alternate, very rarely opposite to subopposite in few species, entire-margined. Inflorescence axillary, usually cymose or fasciculate in males, rarely solitary; female flowers usually axillary, solitary, rarely fasciculate or cymose. Flowers usually borne on young branches or less frequently cauliflorous, usually dimorphic in size and shape, males usually smaller than females. Calyx persistent and usually accrescent in fruit, very variable, usually 3 to 8-lobed, less frequently cup-shaped and unlobbed or polysepalous (chorisepalous). Corolla 3 to 8-lobed, very variable. Stamens 2 to *ca* 100 in males; anthers dehiscing by longitudinal slits. Pistillode variable, from well developed to absent in male flowers. Staminodes present or absent, often well developed in female flowers. Disc well developed or not, sometimes fimbriate. Ovary in female flowers globose, ovoid or conoidal, glabrous or hairy, 2 to 8-carpellate; 2, 3 or 4-loculed, rarely unilocular, usually each locule 2-ovuled, rarely due to false septum originating from carpellary wall opposite the placenta bisect each locule, making each locule 1-ovulate, number of uniovulate locules per ovary varies as 4, 6, 8, 10, 12, 14 or 16; style branches 2-8. Fruit a 1 to 16-seeded berry. Seeds usually flattened laterally, but sometimes circular in cross section or somewhat irregular in shape, longitudinally encircled by a persistent, distinctly raised, straight, and sometimes branched vascular strand in a sort of loop; albumen equable or ruminated, rumination in few species forms a shallow ingrowth around the distal part of the radicle; embryo straight or slightly curved in its own plane; surface of cotyledons usually oriented parallel to the median radial plane of the fruit, rarely at right angle to it.

The genus *Diospyros* L. is represented by *ca* 600 species (Wallnofer, 2001), of which *ca* 300 species occur in Asia and the Pacific area, 98 species in Madagascar and the Comoro Islands, 94 species in African mainland, *ca* 100 species in America and 15 species in Australia. The genus is rather poorly represented in Europe. In India, the genus *Diospyros* L. is represented by about 66 taxa (species and varieties). The Indian taxa belonging to *Diospyros* L. may be classified into following sections.

KEY TO THE SECTIONS

1a. Calyx and corolla usually 3-lobed. Calyx-lobes valvate. Ovary 3-carpellary, 1 to 6-celled; septa between the cells incomplete if more than 3-celled; cells 1 to 2-ovuled.
sect. ***Maba*** (J. R. & G. Forst.) Singh comb. stat. nov.
(spp. 2, 10, 21, 22, 23, 36, 41, 42, 44, 57)

1b. Calyx and corolla 4 or more-lobed. Calyx-lobes valvate, imbricate or contorted. Ovary 4 or more carpellary, 4 to many-celled; septa complete between the cells; cells 1-ovuled. 2

2a. Calyx-lobes imbricate or contorted in both sexes or atleast in females. 3

2b. Calyx-lobes valvate in both sexes. 10

3a. Calyx-lobes valvate in males, contorted or imbricate in females. 4

3b. Calyx-lobes imbricate or contorted in both sexes. 5

4a. Fruiting-calyx enlarged, upto as long as fruit, 1.8-6 cm across; lobes ovate or ovate-lanceolate, foliaceous, erect, spreading or reflexed. sect. ***Lotus*** Bakh.
(spp. 24, 35, 40, 47)

4b. Fruiting-calyx much shorter than fruit, 6-7 mm across; lobes linear, reflexed. sect. ***Confertiflora*** Bakh.
(sp. 16)

5a. Calyx-lobes contorted in both sexes. 6

5b. Calyx-lobes imbricate in both sexes. 7

6a. Trunk and branches armed with spines. Stamens 16. Staminodes 7-12. Ovary 8-celled.
sect. ***Acanthebenus*** Bakh.
(spp. 13, 14, 15)

6b. Truncus et rami inermes. Stamina 24-36. Staminodia 4 vel absentia. Ovarium 4- vel 6-cellulare. Trunk and branches unarmed. Stamens 24-36. Staminodes 4 or absent. Ovary 4 or 6-celled.
sect. ***Assimilis*** Singh sect. nov.
Type : *D. assimilis* Bedd. (spp. 4, 58)

7a. Fruiting-calyx flat, disciform, not enclosing the fruit. 8

7b. Fruiting-calyx cup or bowl-shaped, enclosing lower part of fruit. sect. ***Ebenus*** Bakh.
(spp. 19, 28, 46)

8a. Staminodes absent. sect. ***Brachycylix*** Bakh.
(spp. 9, 59)

8b. Staminodes upto 10. 9

9a. Fruit 5-10 cm in diameter. Ovary 8-celled. sect. ***Ebenaster*** Bakh.
(spp. 18, 65)

9b. Fruits upto 3 cm in diameter. Ovary 4, 6 or 10-celled, not 8-celled. sect. ***Stelechantha*** Bakh.
(spp. 12, 45, 51, 60)

10a. Corolla urceolate or campanulate. 11

10b. Corolla tubular or hypocrateriform. 15

11a. Calyces fructuum in parem inferam cupulati. Ovarium 8-cellulare, rare 6-cellulare. Fruiting-calyx cup or bowl-shaped, encircling lower part of fruit. Ovary 8-celled, rarely 6-celled. sect. ***Sylvatica*** Singh sect. nov.
Type : *D. sylvatica* Roxb. (spp. 26, 31, 61)

11b. Fruiting-calyx flat, not encircling the fruit. Ovary 4, 6, 8 or 10-celled. 12

12a. Stamens seated on torus. Ovary 4 or 6-celled. sect. ***Eucarpon*** Bakh. (sp. 54)

12b. Stamens inserted at the base of corolla-tube. Ovary 4, 8 or 10-celled. 13

13a. Albumen ruminatum Calyx eandem plantam 4-, 5- vel 6-lobatus. Ovarium 8-cellulare Albumen ruminate. Calyx 4, 5 or 6-lobed on same plant. Ovary 8 celled. sect. ***Candolleana*** Singh sect. nov.
Type : *D. candolleana* Wight (spp. 11, 20)

13b. Albumen equable. Calyx strictly 4-lobed. Ovary 4, 8 or 10-celled. 14

14a. Male cymes 5 to 15-flowered. Female cymes 3-flowered. Staminodes 4. Ovary 4-celled. Fruit upto 2 cm in diameter. sect. ***Kurzella*** Bakh. (sp. 33)

14b. Cymae marium 3 floratae. Flores feminei solitari, axillares. Staminodia 8 vel absentia. Ovarium 8- vel 10-cellulare. Fructus 3-7 cm in diam. Male cymes 3-flowered. Female flowers solitary, axillary. Staminodes 8 or absent, never 4. Ovary 8 or 10-celled. Fruit 3-7 cm in diameter. sect. ***Kaki*** Singh sect. nov.
Type : *D. kaki* Thunb. ex L.f. (spp. 30, 32)

15a. Corolla glabrous bothsides. 16

15b. Corolla pubescent or hairy on one or bothsides, completely or partially. 18

16a. Stamens inserted on corolla-tube. Ovary 8-celled. Calyx-mouth truncate; teeth small. sect. ***Ebenopsis*** Bakh. (sp. 63)

16b. Stamens seated on torus. Ovary 4-celled. Calyx divided about half way down or more. 17

17a. Calyces fructuum cupulati; lobi foliacei, multum amplificati, lobi fructis aequantes vel longiores, erecti, fructis occultis. Fruiting-calyx cup-shaped; lobes foliaceous, much enlarged, as long as fruit or longer, erect, concealing the fruit. sect. ***Barberi*** Singh sect. nov.
Type : *D. barberi* Ramas. (sp. 6)

17b. Calyx fructi planus, disciformis; lobi foliacei, patulus vel reflexus, parvus quam fructus, fructus non absconditus. Fruiting-calyx flat, disciform; lobes foliaceous, spreading or reflexed, not enclosing the fruit, smaller than fruit. sect. ***Trichophylla*** Singh sect. nov.
Type : *D. trichophylla* Alston (spp. 7, 62)

18a. Calyx hairy outside, glabrous within. 19

18b. Calyx hairy bothsides. 21

19a. Stamens inserted at the base of corolla-tube. 20

19b. Stamina in toros insidentia. Stamens seated on torus. sect. ***Crumenata*** Singh sect. nov.
Type : *D. crumenata* Thw. (spp. 17, 49, 50)

20a. Calyces fructuum in inferam cupulati. Albumen ruminatum. Fruiting-calyx cup or bowl-shaped, enclosing lower part of fruit. Albumen ruminate. sect. ***Insignis*** Singh sect. nov.
Type : *D. insignis* Thw. (sp. 29)

20b. Fruiting-calyx flat, disciform, not enclosing the fruit. Albumen equable. sect. ***Basithrix*** Bakh. (spp. 3, 25, 66)

21a. Stamens seated on torus. 22

21b. Stamens inserted at the base of corolla-tube. 25

22a. Calyx and corolla 4-lobed. sect. ***Campanulata*** Bakh. (spp. 1, 38, 39, 52, 56)

22b. Calyx and corolla 5 or 6-lobed. 23

23a. Fruiting-calyx cup or bowl-shaped, enclosing lower part of fruit. sect. ***Ptychocylix*** Bakh. (spp. 8, 48)

23b. Fruiting-calyx flat, disciform, not enclosing the fruit. 24

24a. Stamina 20, anthera glabra. Flores feminei solitari. Staminodia 5. Ovarium 4-cellulare. Fructus ad 3 cm in diam. Stamens 20; anthers glabrous. Female flowers solitary. Staminodes 5. Ovary 4-celled. Fruit upto 3 cm in diameter. sect. ***Pyrrhocarpoides*** Singh sect. nov.
Type : *D. pyrrhocarpoides* Ramesh & Franceschi (sp. 53)

24b. Stamens 16; anthers pubescent. Female flowers in fascicles. Staminodes 10-12. Ovary 10 to 12-celled. Fruit 6-7.5 cm in diameter. sect. ***Liophylla*** Bakh. (sp. 55)

25a. Calyx et corolla 5-lobata. Stamina 5-8. Ovarium 10-cellulare. Albumen ruminatum. Calyx and corolla 5-lobed. Stamens 5-8. Ovary 10-celled. Albumen ruminate. sect. ***Hirsuta*** Singh sect. nov.
Type : *D. hirsuta* L.f. (sp. 27)

25b. Calyx and corolla 4-lobed. Stamens 10-22. Ovary 6 to 8-celled. Albumen equable. 26

26a. Marium et feminei inflorescentia et calyces ater pubescentia. Fructus ad 6-7 cm in diam. Calyces fructuum ad 4-6 cm in diam.; lobi foliacei, amplificati, ovatus, basis subcordatus. Male and female inflorescences and calyx distinctly black pubescent or hairy. Fruit 6-7 cm in diameter. Fruiting-calyx 4-6 cm in diameter; lobes ovate, subcordate at base, enlarged, foliaceous. sect. ***Atrata*** Singh sect. nov.
Type : *D. atrata* (Thw.) Alston (sp. 5)

26b. Male and female inflorescences if pubescent or hairy, not black. Fruit upto 3.5 cm in diameter. Fruiting-calyx upto 3 cm in diameter; lobes oblong-lanceolate, neither subcordate at base nor much enlarged. sect. ***Nesindica*** Bakh. (spp. 34, 37, 43, 64)

In the present infra-generic classification attempts have been made to accommodate Indian taxa under the sections proposed by Bakhuizen (1936-1955), as far as possible, with necessary emendments in circumscription of sections based on constant diagnostic characters. However, use of constant diagnostic characters has resulted in wide segregation of certain taxa from one section to another and creation of several new sections to accommodate Indian elements for more natural and practical classification. In the present work, the subgenus *Maba* (J. R & G. Forst.) Bakh. has been reduced to the rank of section under the genus *Diospyros* L., keeping in view the present generic concept in *Ebenaceae* (White, 1980, 1983). *D. montana* Roxb. from sect. *Acanthebenus* Bakh. has been transferred to the sect. *Lotus* Bakh. Similarly, *D. peregrina* (Gaertn.) Gurke has also been brought under the sect. *Lotus* Bakh. from sect. *Glutinosa* Bakh. However, *D. kaki* Thunb. ex L. f. has been removed from the sect. *Lotus* Bakh. and placed under new sect. *Kaki* Singh (type species *D. kaki* Thunb. ex L. f.) along with an Indian endemic and closely allied taxon *D. kika* Debb. & Biswas. Bakhuizen (1936-1955) considered *D. virginiana* L. and *D. ehretioides* Wall. ex G. Don close to his sect. *Lotus* Bakh. However, in the present classification the former taxon falls close to the sect. *Basithrix* Bakh. and latter has been accommodated under the new sect. *Candolleana* Singh (type species *D. candolleana* Wight). Similarly, *D. paniculata* Dalz. may be better placed under the sect. *Ebenus* Bakh. rather than *Phyllosepala* Bakh., contrary to what proposed by Bakhuizen. *D. atrata* (Thw.) Alston, which is considered as a forma of *D. malabarica* (Desr.) Kostel. and placed under the sect. *Glutinosa* Bakh. by Bakhuizen (1936-1955), has been accommodated in new sect. *Atrata* Singh (type species *D. atrata* (Thw.) Alston).

Again, contrary to Bakhuizen's (1936-1955) concept for accommodating the taxa *D. pilosiuscula* G. Don and *D. pruriens* Dalz. in the sect. *Basithrix* Bakh. has been found unsatisfactory. As such, the latter species has been placed under the sect. *Stelechantha* Bakh. and former taxon under new sect. *Crumenata* Singh (type species *D. crumenata* Thw.). For those species which could not be accommodated in existing system, new sections have been created to make the classification natural, simple and practicable, based on broad constant characters. As such, apparently allied species look widely placed and vice verse. The infra-generic classification in *Diospyros* L. has been a very stupendous task due to high degree of variability within the individuals of a species. As such, either we have to opt such a broadly circumscribed classification or have to go further down dividing sections into series, subseries etc, ultimately ending into individual species or individual specimens due to high degree of variability at different levels.

ARTIFICIAL KEY TO THE SPECIES

1a. Calyx and corolla 3-lobed. 2
1b. Calyx and corolla 4 to 5 or more-lobed. 16
2a. Corolla urceolate, glabrous bothsides. 3
2b. Corolla tubular or salver-shaped, hairy on one or both sides, completely or partially. 5
3a Petioles canaliculate above. Male flowers in 10 to 25-flowered, axillary cymose fascicles. Stamens 8-18. Ovary 3-celled and cells 2-ovuled or 6-celled and cells 1-ovuled due to incomplete partitions. **22. *D. fasciculosa***
3b. Petioles flat above, terete or 4-gonous, not canaliculate. Male flowers in 3 to 5-flowered, axillary clusters or in 7 to 15-flowered, lax, dichasial cymes. Stamens 12-22. Ovary 6 or 8-celled, partitions complete and cells 1-ovuled. 4
4a. Petioles 4-gonous. Male flowers in 3 to 5-flowered, axillary clusters. Stamens 12-14. Staminodes 6. Fruits cylindric-oblong, less than 1 cm in diameter. **57. *D. sahayadryensis***
4b. Petioles terete or flat above. Male flowers in 7 to 15-flowered, axillary, dichasial cymes. Stamens 13-22. Staminodes 4. Fruits globose, upto 2 cm in diameter. **61. *D. sylvatica***
5a. Calyx hairy or pubescent bothsides. 6
5b. Calyx hairy or pubescent outside, glabrous within. 7
6a. Leaves 9-16 x 4-6 cm, oblong-ovate, subcordate at base. Stamens 8-9 or rarely 12, some connate by filaments and rest free; anthers apiculate due to produced connectives. Ovary glabrous, 6-celled; cells 1-ovuled. Fruits 3-4 x 1.5 cm, much longer than broad, elliptic-oblong, 3 to 4-seeded. **2. *D. andamanica***
6b. Leaves 2-7.5 x 1-3 cm, elliptic-lanceolate, cuneate at base. Stamens 9-12, free, not united by filaments; anthers obtusely narrowed at apex, not apiculate. Ovary hairy, 1 to 3-celled; cells 2-ovuled. Fruits almost globose, 5-7 mm in diam., 1 to 3-seeded. **42. *D. neilgerrensis***
7a. Anthers glabrous throughout. Ovary hairy or glabrous. 8
7b. Anthers hairy on sutures, connectives or at tip. Ovary hairy or glabrous. 11
8a. Ovary 6-celled, sometimes 3 to 5-celled; cells 1-ovuled. Staminodes present. Male flowers in more than 3-flowered axillary cymes or clusters. 9
8b. Ovary 3-celled; cells 2-ovuled. Staminodes absent. Male flowers in 1 to 3-flowered, axillary cymes. The roots contain crusgallin chemical. **23. *D. ferrea***
9a. Ovary 3 to 5-celled. Staminodes 12-20. Bracts several, linear-lanceolate, 9-12 mm long. Fruiting-calyx flat, not clasping the fruit. Roots have no crusgallin chemical. **41. *D. multibracteata***
9b. Ovary 6-celled. Staminodes upto 6. Bracts few, ovate-oblong or linear to ovate-lanceolate, 3-6 mm long Fruiting-calyx cup-shaped, clasping lower part of fruit. 10
10a. Male-cymes axillary, 9 to 12-flowered. Stamens 6-12. Female flowers in 8 to 25-flowered racemes from old wood. Staminodes 3. Ovary hairy. **10. *D. cacharensis***
10b. Male flowers in axillary, 3 to 5-flowered clusters. Stamens 12-14. Female flowers axillary, solitary Staminodes 6. Ovary glabrous. **57. *D. sahayadryensis***
11a. Stamens seated on the torus. Ovary hairy. 12
11b. Stamens inserted on corolla-tube, epipetalous. Ovary hairy or glabrous. 13

17a. Male flowers in 9 to 12-flowered, axillary cymes. Female flowers in 8 to 25-flowered racemes on old wood; racemes solitary or fascicled. Calyx divided upto middle in both sexes; lobes 3, distinct. **10. *D. cacharensis***

12b. Male flowers in 3 to 7-flowered, axillary cymes. Female flowers axillary, solitary or 1 to 3-together on young branches. Calyx almost truncate; teeth 3-4, indistinct. **44. *D. oocarpa***

13a. Male flowers in 3 to 12-flowered, axillary cymes. Pistillode densely hairy, conspicuous. Ovary hairy. Albumen equable. 14

13b Male flowers in 3 to 4-flowered, axillary cymes. Pistillode rudimentary or absent. Ovary glabrous. Albumen ruminate. **36. *D. marmorata***

14a. Calyx almost truncate; teeth 3 or 4, small. Stamens 9-14. **44. *D. oocarpa***

14b. Calyx divided upto middle or below; lobes 3, well developed. Stamens 5-12. 15

15a. Leaves subsessile, long caudate-acuminate at apex; petioles *ca* 2 mm long, terete. Stamens 5-10. **21. *D. elegans***

15b. Leaves long-petioled, shortly acuminate at apex; petioles 2-3 cm long, canaliculate above. Stamens 12, rarely 6-9. **10. *D. cacharensis***

16a. Calyx-lobes imbricate or contorted. 17

16b. Calyx-lobes valvate. 43

17a. Corolla urceolate, campanulate or bell-shaped. 18

17b. Corolla tubular or hypocrateriform. 33

18a. Corolla completely glabrous bothsides; lobes ciliate or not. 19

18b. Corolla hairy or pubescent on one or bothsides, completely or partially; lobes ciliate or not. 26

19a. Stamens 24-64. Staminodes 5, sometimes upto 12 or absent; in latter case, ovary 6-celled. 20

19b. Stamens upto 20. Staminodes usually 8-12, rarely 4 or totally absent; in latter two cases, ovary 4-celled or 8-celled. 21

20a. Calyx-lobes contorted. Anthers glabrous. Ovary 6-celled. Staminodes absent. Fruits upto 2 cm in diameter. Fruiting-calyx-lobes not foliaceous, reflexed, margins out-rolled. **4. *D. assimilis***

20b. Calyx-lobes valvate or imbricate. Anthers hairy. Ovary 8-celled. Staminodes usually 5 or rarely upto 12. Fruits 4-6 cm in diameter. Fruiting-calyx-lobes foliaceous, erect or spreading, clasping base of fruit, margins flat. **47. *D. peregrina***

21a. Stamens seated on the torus. Pedicels of female flowers 1.5-2.5 cm long. Staminodes absent. Ovary 4-celled. **24. *D. foliolosa***

21b Stamens inserted on corolla-tube, epipetalous. Pedicels of female flowers upto 8 mm long. Staminodes 4-12. Ovary 4 or 8-celled. 22

22a. Ovary 4-celled. Stamens 10-12, rarely 16-20; anthers obtuse. **16. *D. courtallumensis***

22b. Ovary 8-celled. Stamens 16; anthers apiculate or obtuse. 23

23a. Calyx glabrous bothsides or hairy or pubescent one side only; lobes imbricate or valvate. Anthers glabrous or hairy, apiculate. 25

23b. Calyx pubescent or hairy bothsides; lobes contorted. Anthers glabrous, obtuse or apiculate. 24

24a. Leaves oval-oblong or lanceolate-oblong, with rounded or cuneate base. Fertile anthers and staminodes apiculate. Staminodes 4. Fruiting-calyx-lobes broadly ovate, margins flat, not reflexed. Mesocolpium distance in pollens *ca* 20 μm. **40. *D. montana***

24b. Leaves ovate-lanceolate, with rounded or subcordate base. Fertile anthers and staminodes obtuse at apex or slightly narrowed but not apiculate. Staminodes 8-12. Fruiting-calyx-lobes rather narrow, reflexed, margins out-rolled. Mesocolpium distance in pollens ca 12 µm. **15. *D. cordifolia***

25a. Male flowers in 1 to 3-flowered, axillary cymes. Anthers hairy. Fruits upto 2.5 cm in diameter. **35. *D. lotus***

25b. Male flowers in axillary, many-flowered, racemose panicles. Anthers glabrous. Fruits ca 5 cm in diameter. **65. *D. variegata***

26a. Calyx and corolla 5-lobed. Stamens 10-12. Staminodes 5. Ovary 10-celled. Fruit a truncate cone. **60. *D. sulcata***

26b. Calyx and corolla 4 or 5-lobed; when 5-lobed, the stamens always more than 12 and ovary less than 10-celled. Stamens usually more than 12; if 12 or less, the leaves distichous and staminodes absent. Staminodes usually more than 5 or absent; if 5 or less, ovary upto 8-celled. Ovary 4, 6 or 8-celled. Fruits globose, ovoid, oblong or cylindric. 27

27a. Plants armed with spines. Calyx-lobes contorted. Fertile anthers apiculate or obtuse, glabrous. Staminodes present, 7-12. Ovary glabrous, 8 celled. 28

27b. Plants unarmed. Calyx-lobes imbricate. Fertile anthers apiculate or obtuse, glabrous or hairy. Staminodes present or absent. Ovary 4 to 8-celled. 30

28a. Fruits 2-3 cm in diameter. Fruiting-calyx-lobes up to 1 cm long, reflexed, margins often out-rolled. Male flowers in 3-flowered axillary cymes. Anthers obtuse. **15. *D. cordifolia***

28b. Fruits up to 1 cm in diameter. Fruiting-calyx-lobes less than 1 cm long, spreading horizontally, margins not reflexed. Male flowers in 4 to 10-flowered, axillary, cymose clusters. 29

29a. Fruits 7-10 mm in diameter. Fruiting-calyx flat, disciform, with spreading lobes not touching or enclosing the fruit. **13. *D. chloroxylon* var. *chloroxylon***

29b. Fruits 5-7 mm in diameter. Fruiting-calyx cup-shaped, with erect lobes enclosing lower part of fruit. **14. *D. chloroxylon* var. *cupulosa***

30a. Stamens 24-64. Fruits 4-6 cm in diameter. ***47. D. peregrina***

30b. Stamens up to 20. Fruits up to 3 cm in diameter. 31

31a. Fertile anthers obtuse, glabrous.Staminodes 4, rarely 1-7. Ovary 4 to 6-celled. ***45. D. ovalifolia***

31b. Fertile anthers apiculate, glabrous or hairy. Staminodes 8-10 or totally absent. Ovary 4 to 6-celled. 32

32a. Female flowers in racemose panicles on old wood Staminodes 8-10. Fruits 1.5-1.8 cm in diam., ovoid-globose. Fruiting-calyx flat; lobes reflexed. Fertile anthers hairy. **12. *D. cauliflora***

32b. Female flowers axillary, solitary. Staminodes absent. Fruits 4-8 mm in diam., cylindric or oblong. Fruiting-calyx flat; lobes spreading. Fertile anthers glabrous. ***9. D. buxifolia***

33a. Calyx and corolla 5-lobed. 34

33b. Calyx and corolla 4-lobed. 36

34a. Stamens 10-12. Staminodes 5. Ovary 10-celled. Fruiting-calyx flat, not enclosing the fruit. **60. *D. sulcata***

34b. Stamens 15-20. Staminodes more than 5 or totally absent. Ovary 4 or 6-celled. Fruiting-calyx cup-shaped, enclosing lower part of fruit. 35

35a. Ovary 6-celled. Staminodes 11. Stamens 16, inserted at the base of corolla-tube, epipetalous; anthers hairy. **28. *D. haleana***

35b. Ovary 4-celled. Staminodes absent. Stamens 15 or 20, seated on the torus or at the base of the corolla-tube; anthers glabrous. **46. *D. paniculata***

36a. Leaf-base distinctly subcordate. Staminodes 4. 37

36b. Leaf-base rounded, obtuse or cuneate. Staminodes 4 or more or even absent. 38

37a. Calyx-lobes imbricate in bud in both sexes, distinctly nerved particularly in female plants. Pedicels of female flowers 8-12 mm long. Seeds oblong. Corolla pubescent within in female plants, glabrous in males, hairy outside in both sexes. Medullary rays 2 or 3 cells in tangential width. **51. *D. pruriens***

37b Calyx-lobes contorted in bud in both sexes, not nerved. Pedicels of female flowers upto 4 mm long. Seeds pear-shaped. Corolla glabrous within, hairy outside in both sexes. Medullary rays one cell in tangential width. **58. *D. saldanhae***

38a Male cymes 3 to 4-flowered, borne directly in the axils of leaves. Stamens inserted at the base of corolla-tube, epipetalous. Ovary 6 or 8-celled. Fruits up to 3 cm in diameter. 39

38b. Male cymes 1 to 3-flowered, borne subspicately or racemosely on a common axillary peduncle. Stamens seated on the torus and/or at base of corolla-tube. Ovary 4-celled and fruits up to 2.5 cm in diam. or 8-celled and fruits 5-10 cm in diameter. 41

39a. Anthers hairy. Ovary 6-celled, hairy. **28. *D. holeana***

39b. Anthers glabrous. Ovary 6 or 8-celled, glabrous. 40

40a. Calyx pubescent outsides, glabrous within; lobes contorted. Staminodes absent. Ovary 6-celled. Fruiting-calyx flat, not enclosing fruit. **4. *D. assimilis***

40b. Calyx glabrous bothsides or hairy within in lower half; lobes imbricate. Staminodes 8-16. Ovary 8-celled. Fruiting-calyx cup-shaped, enclosing lower part of fruit. **19. *D. ebenum***

41a Male cymes 3-flowered, arranged in racemes on upto 17.5 cm long peduncles. Stamens 24-48; anthers apiculate. Ovary 8-celled, hairy. Fruits 5-10 cm in diameter. **18. *D. discolor***

41b. Male cymes 1 to 3-flowered, arranged racemosely or subspicately on up to 5 cm long peduncles. Stamens 13-16; anthers acute, not apiculate. Ovary 4-celled. Fruits up to 2.5 cm in diameter. 42

42a. Calyx-lobes distinctly nerved. Corolla-lobes imbricate in males, contorted in females. Male inflorescence 1 or 2-flowered, flowers borne racemosely on a common axillary, 3-5 cm long peduncle. Stamens 13-14, seated on torus. Ovary hairy. Fruiting calyx more than 1.5 cm in diameter. Medullary rays with 2 or 3 cell in tangential width. **51. *D. pruriens***

42b. Calyx-lobes not veined. Corolla-lobes contorted in both sexes. Male flowers in 1 to 3-flowered cymose clusters arranged subspicately on a common axillary, 5-7 mm long peduncle. Stamens 16 or rarely 14, in two rows, one row seated on torus and other one on corolla-base. Ovary glabrous. Fruiting-calyx 8-10 mm in diameter. Medullary rays one cell in tangential width. **59. *D. stricta***

43a. Corolla urceolate or somewhat tubular-urceolate or campanulate. 44

43b. Corolla clearly tubular, salver-shaped or hypocrateriform. 62

44a. Corolla glabrous bothsides. 45

44b. Corolla hairy or pubescent bothsides or one side, completely or partially. 52

45a. Calyx pubescent or hairy on one side, either outside or within. Ovary glabrous, except at apex or base. 46

45b. Calyx either glabrous or pubescent to hairy bothsides. Ovary hairy or glabrous. 50

46a. Stamens seated on torus. Staminodes 4 or absent; if 4, the ovary 3-celled or 6 to 8-celled, never 4-celled. 47

46b. Stamens inserted on corolla-tube, epipetalous. Staminodes 4-12, if 4, the ovary 4-celled, otherwise 8-celled. 48

47a. Petioles canaliculate above. Male flowers in 10 to 20-flowered, axillary, cymose fascicles. Stamens 8-18. Ovary usually 3-celled and cells 2-ovuled; sometimes ovary 6-celled and cells 1-ovuled due to incomplete partitions. Amb of pollens almost triangular. 22. *D. fasciculosa*

47b. Petioles flat above, not canaliculate. Male flowers in 7 to 15-flowered, lax, dichasial cymes. Stamens 18-20, rarely 13-22. Ovary 6 or 8-celled, partitions complete and cells 1-ovuled. Amb of pollens subcircular. 61. *D. sylvatica*

48a. Ovary 4-celled. Staminodes 4. Fruiting-calyx 6-7 mm across, flat, disciform, with spreading or reflexed lobes, not enclosing the fruit. Stamens usually 10-12, sometimes 16-20; anthers obtuse, glabrous. 16. *D. courtallumensis*

48b. Ovary 8-celled. Staminodes 5-12. Fruiting-calyx 1-6 cm across. Stamens 16-64; anthers apiculate, hairy. 49

49a. Fruits 1.4-2.5 cm in diameter. Fruiting-calyx flat, 1-1.8 cm across; lobes foliaceous, not clasping the fruit. Male cymes 3-flowered. Male calyx pubescent within, glabrous outside. Stamens 16 35. *D. lotus*

49b. Fruits and fruiting-calyx 4-6 cm in diam.; lobes of latter foliaceous, clasping lower part of fruit. Male cymes 3 to 7-flowered. Male calyx pubescent outside, glabrous within. Stamens 24-64. 47 *D. peregrina*

50a. Female calyx-lobes imbricate. Ovary 4-celled, hairy. Staminodes absent. Stamens seated on torus 24. *D. foliolosa*

50b. Female calyx-lobes contorted or imbricate. Ovary 8-celled, hairy or glabrous. Staminodes 4 or 8. Stamens inserted at the base of corolla-tube, epipetalous. 51

51a. Plants often armed with spines. Calyx-lobes contorted in female flowers, valvate in males. Staminodes 4. Fertile anthers glabrous. Growth rings indistinct. 40. *D. montana*

51b. Plants unarmed. Calyx-lobes imbricate in female flowers, valvate in males. Staminodes 8. Fertile anthers hairy. Growth rings demarcated by dark-coloured latewood fibres. 35. *D. lotus*

52a. Calyx and corolla 5-lobed. Staminodes 5. Ovary 4 or 10-celled, hairy throughout. 53

52b. Calyx and corolla 4-lobed; sometimes calyx 5 or 6-lobed, but corolla 4-lobed. Ovary 4 or 8-celled, hairy or glabrous; sometimes ovary 10-celled but glabrous. Staminodes more than 5; if 5 or less, the ovary glabrous throughout or hairy at apex or base only. 54

53a. Leaves hairy beneath. Calyx divided up to middle. Ovary 4-celled. Wood diffuse porous. 11. *D. candolleana*

53b. Leaves glabrous bothsides. Calyx deeply divided below the middle. Ovary 10-celled. Wood with numerous pores in radial lines. 60. *D. sulcata*

54a. Anthers glabrous. Fruiting-calyx flat or cup-shaped. 55

54b. Anthers hairy. Fruiting-calyx flat or cup-shaped. 58

55a. Stamens 12-16. Ovary 4 or 8-celled, glabrous or hairy at apex only. Albumen equable. 56

55b. Stamens more than 16. Ovary 4 to 6-celled, hairy throughout and albumen equable; if 8-celled and glabrous, the albumen ruminate. 57

56a. Male cymes 5 to 15-flowered. Ovary 4-celled. Calyx-lobes not nerved in both sexes. Fruiting calyx flat, not enclosing the fruit; lobes foliaceous. 33. *D. kurzii*

56b. Male cymes 3-flowered. Ovary 8-celled. Calyx-lobes distinctly nerved. Fruiting-calyx cup-shaped, enclosing lower part of fruit; lobes not foliaceous. **31. *D. kanjilali***

57a Stamens seated on torus. Ovary hairy, 4 to 6-celled. Albumen equable. Medullary rays 2 or 3 cells in tangential width. **54. *D. racemosa***

57b Stamens inserted on corolla-tube, epipetalous. Ovary glabrous, 8-celled. Albumen ruminate. Medullary rays 1 cell in tangential width. **20. *D. ehretioides***

58a. Stamens inserted on corolla-tube, epipetalous Ovary glabrous except at base sometimes Fruiting-calyx flat or cup-shaped; lobes foliaceous or not, acute or subacuminate. 59

58b. Stamens seated on torus. Ovary hairy. Fruiting-calyx cup-shaped, enclosing lower part of fruit; lobes foliaceous, long-acuminate. **26. *D. glandulosa***

59a. Staminodes 5, rarely up to 12. Ovary 8-celled, glabrous or with a basal ring of hairs. Fruiting-calyx flat; lobes foliaceous, acute or obtuse, become erect and clasping lower part of fruit. Male cymes 3 to 7-flowered. Stamens 24-64, usually 40. ***47. D. peregrina***

59b. Staminodes 8. Ovary 8 to 10-celled, glabrous. Fruiting-calyx enclosing lower part of fruit or not; in former case, the calyx is cup-shaped, but not as in *D. peregrina*. Male cymes 3-flowered. Stamens 16-24. 60

60a. Calyx-lobes palmately 5 to 7-nerved, nerves converging towards apex. Fruits up to 2.5 cm in diameter. Fruiting-calyx cup-shaped, enclosing lower part of fruit. **31. *D. kanjilali***

60b. Calyx-lobes not nerved. Fruits 3-7 cm in diameter. Fruiting-calyx flat, not enclosing the fruit. 61

61a. Leaves 10-15 x 3-10 cm; petioles 0.5-2 cm long. Male calyx pubescent outside, glabrous within. Staminodes 8. Ovary 8-celled. Fruiting-calyx 2.5-5 cm in diam., flat, not enclosing fruit. **30. *D. kaki***

61b. Leaves 2.5-9.5 x 1-2 cm; petioles 3-5 mm long. Male calyx tomentose bothsides. Female plants not known. **32. *D. kika***

62a. Corolla glabrous bothsides. 63

62b. Corolla pubescent or hairy bothsides or one side, completely or partially. 66

63a. Stamens seated on torus. Staminodes 4. Ovary 4-celled, pubescent or hairy. 65

63b. Stamens inserted on corolla-tube, epipetalous. Staminodes 8-16. Ovary 6 or 8-celled, glabrous. 64

64a. Staminodes 8-10. Ovary 8-celled. Calyx glabrous bothsides; mouth truncate, teeth small. **63. *D. truncata***

64b. Staminodes 16. Ovary 6-celled. Calyx hairy bothsides, divided half way down. **64. *D. undulata***

65a. Male cymes 2 to 3-flowered. Male calyx-mouth almost truncate; teeth much smaller than tube. Anthers apiculate. Fruiting-calyx cup-shaped, much enlarged, completely enclosing the fruit or larger; tube distinct; lobes foliaceous, erect or spreading. ***6. D. barberi***

65b. Male cymes 3 to 6-flowered. Male calyx divided half way down; lobes about as long as tube. Anthers obtuse or acute, not apiculate. Fruiting-calyx flat, not enclosing fruit; lobes foliaceous, reflexed. ***7. D. benghalensis***

66a. Calyx glabrous bothsides or hairy outside only, ciliate or not. 67

66b. Calyx hairy or pubescent bothsides, ciliate or not. 81

67a. Calyx hairy or pubescent outside, glabrous within; margins of lobes ciliate or not. 68

67b. Calyx glabrous bothsides; margins of lobes ciliate. **62. *D. trichophylla***

68a. Stamens inserted on corolla-tube, epipetalous; anthers glabrous or hairy. Ovary hairy or glabrous. 69

68b. Stamens seated on torus; anthers glabrous or hairy. Ovary hairy. 76

69a. Ovary glabrous, 4-celled. Fertile anthers obtuse, acute or apiculate. 70

69b. Ovary hairy or pubescent, particularly when young, 4, 6 or 8-celled. Fertile anthers subacute, obtuse or apiculate. 71

70a. Midrib of leaves flat above, not canaliculate. Stamens 16-17; anthers obtuse or acute. Female flowers axillary, solitary. Staminodes more than 4 or absent. Fruits *ca* 2.5 cm in diameter. **25. *D. ghatensis***

70b. Midrib of leaves canaliculate above. Stamens 12-16; anthers apiculate. Female flowers in 3-flowered, axillary cymes. Staminodes 4. Fruits upto 2 cm in diameter. **33. *D. kurzii***

71a. Ovary 4-celled. Staminodes 6 or more. Fruiting-calyx flat, not clasping the fruit. Albumen equable. Stamens 6-7, sometimes 12; anthers subacute or obtuse. **3. *D. apiculata***

71b. Ovary 4, 6 or 8-celled. Staminodes 3-5. Fruiting-calyx flat or cup-shaped. Albumen equable or ruminate. Stamens 9-20; anthers apiculate. 72

72a. Male cymes 1 to 3-flowered. Fruits with 4 depressed lines running down from apex. **66. *D. virginiana***

72b. Male cymes or clusters 3 to 20-flowered. Fruits without depressed visible lines. 73

73a. Ovary 4-celled. Male cymes 3 to 20-flowered. Anthers glabrous. 74

73b. Ovary 6 or 8-celled. Male cymes 3 to 7-flowered, with anthers hairy, or the male cymes 3 to 20-flowered and anthers glabrous. 75

74a. Leaves 7-35 x 2.5-15 cm; petioles 5-20 mm long. Male flowers in 3 to 20-flowered, sessile, axillary clusters. Stamens 14-20. Female flowers in 1 to 6-flowered, axillary, sessile clusters. Ovary pubescent throughout.Fruits 3-4 cm in diameter. Fruiting-calyx cup-shaped, enclosing lower part of fruit. Albumen ruminate. Medullary rays 2-3 cells in tangential width. **29. *D. insignis***

74b. Leaves 4.5-9 x 1.8-3.5 cm; petioles up to 5 mm long. Male flowers in 5 to 15-flowered, axillary, dichasial, pedunculate cymes up to 1.5 cm long. Stamens 12-16. Female flowers in 3-flowered, pedunculate, axillary cymes. Ovary hairy at apex only. Fruits 1.5-1.8 cm in diameter. Fruiting-calyx flat, not enclosing the fruit. Albumen equable. Medullary rays 1 cell in tangential width. **33. *D. kurzii***

75a. Calyx almost truncate at mouth; teeth small. Male cymes axillary, 3 to 7-flowered. Stamens 9-14; anthers hairy at tip. Staminodes 3. Fruits ovoid-oblong, *ca* 3.5 x 2.3 cm. Albumen equable. **44. *D. oocarpa***

75b. Calyx divided half way down; lobes about as long as tube. Male cymose clusters axillary, 3 to 20-flowered. Stamens 14-20; anthers glabrous. Staminodes 4-5. Fruits 3-4 cm in diameter. Albumen ruminate. **29. *D. insignis***

76a. Male flowers in 3 to 4-flowered, axillary racemes or cymes arranged in racemose manner on a common peduncle. Ovary 4-celled. 77

76b. Male flowers in 1 to 12-flowered, axillary cymes. Ovary 6 or 8-celled. 79

77a. Male flowers in 3 to 4-flowered, axillary racemes; pedicels 1-2 mm long. Staminodes 5 or more. Calyx deeply divided upto base, no tube; lobes glabrous bothsides, ciliate. Corolla hairy within. **62. *D. trichophylla***

77b. Male flowers in axillary, racemose cymes; pedicels 7-10 mm long. Staminodes absent. Calyx campanulate, tube distinct; tube and lobes pubescent outside, glabrous within. Corolla glabrous within. 78

78a. Young branches fulvous-pubescent. Leaves 8-17.5 x 1.5-4.5 cm; petioles 5-7 mm long Fruiting-pedicels 6-10 mm long. **49. *D. pilosiuscula* var. *pilosiuscula***

78b. Young branches pilose with long, fine, spreading hairs. Leaves 1.5-7 x 1.5-3 cm; petioles 2-5 mm long. Fruiting-pedicels 2-2.5 cm long. **50. *D. pilosiuscula* var. *andamanensis***

79a. Male cymes axillary, 1 to 3-flowered. Stamens 16. Fruiting-calyx flat, not enclosing fruit. Albumen equable. ***66. D. virginiana***

79b. Male cymes axillary, 3 to 7-flowered. Stamens 8-14. Fruiting-calyx flat or cup-shaped. Albumen equable or ruminate. 80

80a. Anthers ca 1.5 mm long, ovate, hastate or cordate at base, hairy at tip, glabrous or pubescent along connectives. Staminodes 3. Fruits 1-seeded. Fruiting-calyx cup-shaped, enclosing lower part of fruit. Albumen equable. Endocolpium of pollens lo-longate. Medullary rays one cell in tangential width. ***44. D. oocarpa***

80b. Anthers ca 3 mm long, linear, base rounded, totally glabrous. Staminodes 8-12. Fruits 6 to 8-seeded. Fruiting-calyx flat, not enclosing fruit. Albumen ruminate. Endocolpium of pollens lo-longate. Medullary rays 2 or 3-cells in tangential width. ***17. D. crumenata***

81a. Stamens seated on torus. Ovary 4 to 12-celled. 82

81b. Stamens inserted on corolla-tube, epipetalous. Ovary 4 to 12-celled. 100

82a. Calyx and corolla 4-lobed. 83

82b. Calyx and corolla 5 or 6-lobed. 90

83a. Anthers hairy. Ovary 4 to 10-celled. 84

83b. Anthers glabrous. Ovary 4 to 10-celled. 87

84a. Male flowers subsessile, in shortly pedunculate, axillary cymes. Stamens 12-15. Staminodes 4-5. Fruits 5-6 cm in diameter. Albumen equable. Corolla-lobes imbricate in males, contorted in females. ***52. D. pyrrhocarpa***

84b. Male flowers pedicelled, in axillary cymes. Stamens 8-16, rarely 18. Staminodes more than 5. Fruits up to 3 cm in diameter. Albumen ruminate. Corolla-lobes contorted in both sexes. 85

85a. Young branches glabrous or thinly puberulous. Male cymes glabrate. Stamens 12. Calyx distinctly veined, hairy with middle-fixed hairs in both sexes. Female flowers pedicelled. Ovary 6-celled, rarely 8-celled. ***1. D. affinis***

85b. Young branches ferruginous tomentose. Male cymes tomentose. Stamens 8, 12, 16 or 18. Calyx not veined, hairy with basifixed hairs in both sexes. Female flowers subsessile. Ovary 4 to 5 or 8-celled. 86

86a. Secondary veins and reticulation distinctly impressed on the upper surface of leaves, giving a wrinkled shape. Staminodes 6-9 or absent. Ovary 4 to 5-celled. Ectocolpium of pollens crustate. ***39. D. melanoxylon* var. *tupru***

86b. Secondary veins and reticulation raised or obscure on the upper surface of leaves, no wrinkled shape. Staminodes 8-10. Ovary 4 or 8-celled. Ectocolpium of pollens tenuimarginate. ***38. D. melanoxylon* var. *melanoxylon***

87a. Stamens 8-16. Ovary 4, 8 or 10-celled. Albumen ruminate. 88

87b. Stamens 18-33. Ovary 4 or 6-celled. Albumen equable. ***54. D. racemosa***

88a. Young branches and leaves glabrous. Male cymes up to 3-flowered or rarely 5 to 7-flowered; peduncles upto 5 mm long. Ovary 8 or 10-celled. 89

88b. Young branches tomentose. Leaves pubescent to tomentose. Male cymes dichasial, more than 3-flowered; peduncles ca 1.5 cm long. Ovary 4 or 8-celled. ***38. D. melanoxylon* var. *melanoxylon***

89a. Female flowers subsessile; pedicels 1-2 mm long. Fruits 5-8 cm in diameter. Fruiting –calyx 3-3.5 cm across, 5-8 mm thick, woody. Male calyx tomentose bothsides. Stamens 12; anthers acute or obtuse. Medullary rays one cell in tangential width. ***56. D. ridleyi***

89b. Female flowers pedicelled; pedicels 5-7 mm long. Fruits 3-5 cm in diameter. Fruiting-calyx *ca* 2.5 cm across, neither thick, nor woody. Male calyx tomentose outside, glabrous within. Stamens 8-14; anthers apiculate. Medullary rays 2 or 3-cells in tangential width. ***17. D. crumenata***

90a. Female flowers in compound cymes, panicles, racemes or fascicles of 2 or more flowers on old wood or in the axils of leaves. Anthers apiculate or obtuse, glabrous or hairy. 91

90b. Female flowers solitary, axillary or on old wood. Anthers apiculate or obtuse, glabrous or hairy. 94

91a. Male flowers in fascicles or in 1.5-2.5 cm long racemes on rather old, leafless, woody branches or sometimes in the axils of leaves. Stamens 16; anthers apiculate, hairy at tip. Fruits 6-7.5 cm in diameter. Albumen ruminate. ***55. D. ramiflora***

91b. Male flowers in axillary cymes or clusters. Stamens 10-18; anthers obtuse or apiculate. Fruits up to 5 cm in diameter. Albumen equable. 92

92a. Female flowers in compound cymes on old wood. Staminodes 10. Fruits subglobose, 7-7.5 x 3-5 cm. Anthers obtuse, glabrous. ***8. D. bourdilloni***

92b. Female flowers in fascicles of 2-5-flowers on old wood or in the axils of leaves, rarely solitary. Staminodes 4-6. Fruits upto 2.6 cm in diameter. Anthers apiculate, glabrous or hairy. 93

93a. Fruit a truncate cone, 0.8-0.9 x 2.3-2.6 cm. Fruiting-calyx flat, not enclosing the fruit; margins of lobes undulate. Stamens 10-12. No black heartwood. ***60. D. sulcata***

93b. Fruit ovoid or subglobose, 2-2.5 cm in diameter. Fruiting-calyx foliaceous, plicate, auriculated at base, clasping base of fruit; margins of lobes strongly undulate. Stamens usually 15-18, sometimes 12-15 or 8-10. Heartwood black, with brownish or reddish streaks. ***48. D. pilosanthera* var. *helferi***

94a. Albumen equable. Anthers glabrous or hairy, obtuse, acute or apiculate. 95

94b. Albumen ruminate. Anthers glabrous or hairy, obtuse, acute or apiculate. 98

95a. Stamens 20. Ovary 4-celled. ***53. D. pyrrhocarpoides***

95b. Stamens 8-18. Ovary 8 or 10-celled. 96

96a. Peduncles of male cymes *ca* 1 cm long. Stamens 12-15; anthers hairy at tip, apiculate or sometimes acute. Staminodes 4-5. Fruits 5-6 cm in diameter. ***52. D. pyrrhocarpa***

96b. Peduncles of male cymes *ca* 5 mm long. Stamens 8-18; anthers apiculate, hairy or glabrous. Staminodes 4-6. Fruits up to 2.6 cm in diameter. 97

97a. Male flowers pedicelled, in axillary cymes; pedicels ca 2 mm long. Stamens usually 15-18, sometimes 12-15 or 8-10. Fruits ovoid-subglobose, 2-2.5 cm in diameter. Fruiting-calyx cup-shaped, plicate, auriculated at base, enclosing lower part of fruit; lobes strongly undulate, appearing curled. Heartwood black, with brownish or reddish streaks. ***48. D. pilosanthera* var. *helferi***

97b. Male flowers subsessile, in axillary clusters. Stamens 10-12. Fruit a truncate cone, upto 0.9 x 2.6 cm. Fruiting-calyx flat, not enclosing fruit; lobes undulate-margined. No black heartwood. ***60. D. sulcata***

98a. Peduncles of male cymes *ca* 1.5 cm long. Stamens 8-18; anthers apiculate. Fruits 2-3 cm in diameter. Fruiting-calyx 2-2.5 cm across, semiwoody, not thickened. 99

98b. Peduncles of male cymes *ca* 5 mm long. Stamens 12; anthers acute or obtuse. Fruits 5-8 cm in diameter. Fruiting-calyx 3-3.5 cm across, 5-8 mm thick, woody. ***56. D. ridleyi***

99a. Leaves with impressed veins and veinlets on the upper surface, appearing wrinkled. Male cymes 3-flowered. Stamens 12-18. Staminodes 6-9 or absent. Ovary 4 or 5-celled. Ectocolpium of pollens crustate. **39. *D. melanoxylon* var. *tupru***

99b. Leaves without impressed veins and veinlets above, not wrinkled; veins and veinlets raised or obscure. Male cymes dichasial, more than 3-flowered. Stamens 8, 12 or 16. Staminodes 8-10. Ovary 4 or 8-celled. Ectocolpium of pollens tenuimarginate. **38. *D. melanoxylon* var. *melanoxylon***

100a. Male and female inflorescences and calyx distinctly black pubescent or hairy. Stamens 20-22 or more. Fruits 5-7 cm in diameter. **5. *D. atrata***

100b. Male and female inflorescences and calyx glabrous or pubescent to hairy but not black. Stamens upto 20. Fruits 1.5 – 4.5 cm in diameter. 101

101a. Calyx and corolla 5-lobed. 102

101b. Calyx and corolla 4-lobed. 105

102a. Petioles 3-12 mm long. Ovary 4-celled. Stamens 10; anthers glabrous. **11. *D. candolleana***

102b. Petioles 5-8 mm long. Ovary 8 to 10-celled. Stamens less than 10; if 10 or more, the petioles upto 2.5 cm long. 103

103a. Leaves hairy bothsides at least when young. Stamens 5-8. Albumen ruminate. **27. *D. hirsuta***

103b. Leaves glabrous bothsides or pubescent beneath and glabrous above. Stamens 10-16. Albumen equable. 104

104a. Leaves glabrous bothsides, tapering at base. Male flowers in many-flowered, axillary, cymose clusters. Stamens 10-12. Ovary 10-celled. Fruit a truncate cone, *ca* 0.9 x 2.6 cm. **60. *D. sulcata***

104b. Leaves pale pubescent beneath, rounded or subcordate at base. Male flowers in 1 to 3-flowered, axillary cymes. Stamens 16. Ovary 8-celled. Fruits subglobose, 2.5-4.5 cm in diameter. **66. *D. virginiana***

105a. Male cymes axillary, usually 3-flowered, rarely up to 9-flowered. Stamens 10-16; anthers apiculate. Staminodes 16. Ovary 6-celled, glabrous. **64. *D. undulata***

105b. Male cymes axillary, usually 3 to 5-flowered, rarely 1-flowered or many-flowered or arranged racemosely on a common, axillary peduncle. Stamens 12-20; anthers apiculate, acute or obtuse. Staminodes upto 10. Ovary 8-celled, hairy. 106

106a. Leaves pellucid-punctate. Male cymes depauperated, arranged in subracemose manner in the axils of leaves. Stamens 12-16; anthers obtuse or acute. Albumen ruminate. **37. *D. martabanica* var. *pellucido-punctata***

106b. Leaves not pellucid-punctate. Male flowers in 1 to many-flowered, axillary cymes. Stamens 14-20; anthers apiculate. Albumen equable. 107

107a. Mature leaves glabrous bothsides, except sometimes midrib. Male cymes 1-flowered or more than 3-flowered. Staminodes 8-10. Fruiting-calyx cup-shaped, enclosing lower part of fruit. 108

107b. Mature leaves pale pubescent beneath, including midrib, glabrous above. Male cymes 1 to 3-flowered. Staminodes absent or less than 8. Fruiting-calyx flat, not enclosing fruit. **66. *D. virginiana***

108a. Male cymes 3 to 5-flowered, rarely 1-flowered. Bracts hairy outside, glabrous within. Stamens 14-20. Corolla-lobes imbricate in female plants, contorted in males. Lobes of fruiting-calyx erect, touching and enclosing the lower part of fruit. **34. *D. lanceaefolia***

108b. Male cymes more than 5-flowered. Bracts hairy bothsides. Stamens 16. Corolla-lobes contorted in both sexes. Lobes of fruiting calyx spreading or reflexed, not touching the fruit. **43. *D. nilagirica***

ENUMERATION OF SPECIES

1 ***Diospyros affinis*** Thw. Enum. Pl. Zeyl. 179. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 169. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 566. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 47. 1981

Vernacular names : *Kan.*: Kunchiganamara; *Mal.*: Illaccivicca, Kattuthovara; *Tam.*: Somolpanachai, Chinnathuvarai.

Evergreen, dioecious and polygamous, unarmed trees, upto 20 m high, with glabrous or thinly puberulous branchlets and fissured-ridged mature bark peeling off in thick flakes. Leaves alternate, 3-11.5 x 1-3.5 cm, elliptic-lanceolate, narrowed at both ends, subacuminate to obtuse at apex, thinly coriaceous, pellucid-punctate, glabrous on maturity, when young with scattered medifixed hairs; midrib canaliculate above, prominent and raised beneath; lateral nerves 8-10 pairs, thin, not very prominent, reticulating nerves thin, not very prominent; some of the leaves oblong or oblanceolate-oblong, truncate and retuse at apex and cuneate at base; petioles 3-10 mm long, semiterete, canaliculate above, rounded beneath, puberulous when young. Male flowers in 5 to 10-flowered, axillary, glabrate cymes. Bracts *ca* 1 cm long, green, pilose, caducous. Calyx 3-4 mm long, campanulate-tubular, distinctly veined, shortly 4-toothed, hairy bothsides with middle fixed hairs; lobes ovate, acute, valvate. Corolla *ca* 8 mm long, hypocrateriform, tawny hairy outside, glabrous within; lobes 4, spreading, oval, acute, contorted. Stamens 12, hypogynous, seated on the torus, some or all in pairs, filaments glabrous; anthers linear, connectives fulvous pilose below on the back and shortly produced at the apex. In polygamous trees the bisexual flowers like males, but with smaller fruits than females. Female flowers solitary, axillary, pedicelled. Calyx 6-8 mm long, hairy with middle fixed hairs bothsides, 4-lobed; lobes abruptly acuminate, valvate. Corolla 8-10 mm long, tubular, hairy outside, glabrous within, narrowed at mouth; lobes 4, ovate, mucronate, fulvous tomentose outside, contorted. Staminodes 8. Ovary appressed hairy, 6-celled (rarely 8-celled), cells 1-ovuled; styles 4. Fruits upto 2.5 cm in diam., globose, apiculate, densely appressed hairy when young, glabrous with age, 4-seeded. Fruiting-calyx enlarged, almost flat, deeply lobed, not thickened, discoid, no distinct tube, without internal elevated rim; lobes foliaceous, neither constricted at base nor with intersegmental pouches, tips of lobes shortly acuminate-apiculate, pressed against fruit in young stage and spreading to patent in mature fruit, distinctly veined outside, densely pubescent bothsides, margins not reflexed; fruiting-pedicels 5-6 mm long, pubescent, thickened and articulated with calyx base. Seeds 4, ovate-wedge-shaped, 1.2-1.5 x 0.8 cm; cotyledons ovate, obtuse at apex, rounded at base; albumen strongly ruminate (**Fig.-1; Plate 1/1**).

Holotype : Ceylon Plants, *Thwaites* 2924 ♀ (PDA); *Isotype* : (K).

Fl.& Fr.: June – October, rarely fruiting extends upto January.

Ecol.: Usually scattered along dry stream beds in dry deciduous or semi-deciduous forests, upto 1000 m. The germination of seeds is epigeal and the cotyledons get detached at an early stage.

Distrib.: This species is confined to South India, particularly to Karnataka and Tamil Nadu, and extends to Sri Lanka further south (**Map-1**).

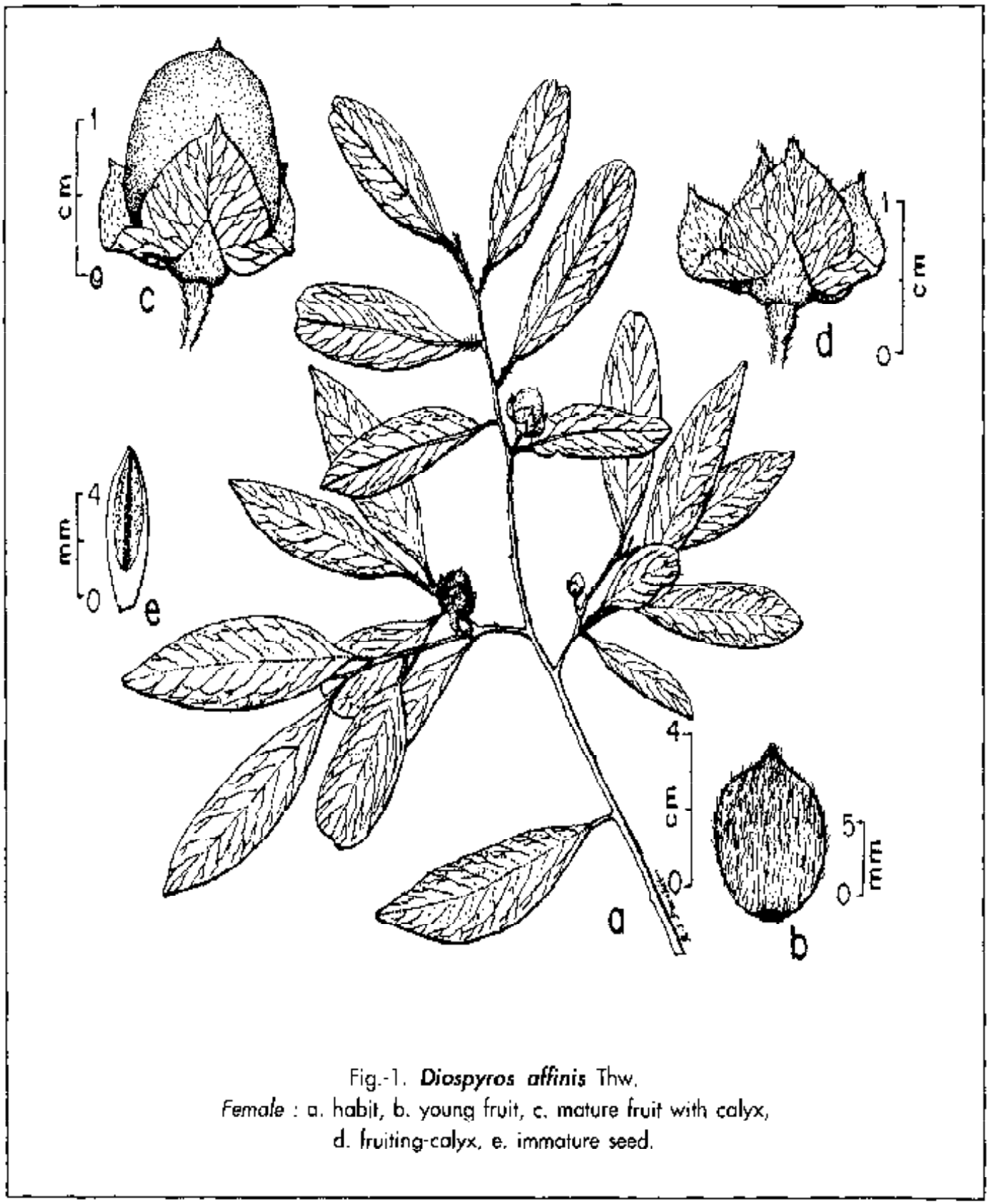


Fig.-1. ***Diospyros affinis*** Thw.
Female : a. habit, b. young fruit, c. mature fruit with calyx,
d. fruiting-calyx, e. immature seed.

Anatomy : Each cotyledon has three traces and xylem of lateral traces splits in to variable number of groups. The epicotyledonary trace is one in each leaf passing into hypocotyl and root (Wright, 1904).

The coloured heartwood is usually small and colouring matter is abundant even in sapwood. The fibre cells are high in number and possess narrow lumina. The vessels of the twigs are *ca* 0.22 mm long and 9 mm in radial and tangential diameter. The sapwood, however, bears vessels *ca* 0.45 mm long with 0.12 mm radial diameter and 0.08 mm tangential diameter. It is interesting to record that the radial and tangential diameter of twig vessels is almost identical. The tangential line of wood parenchyma are 2-celled in radial thickness and are occasionally grouped in the middle of a patch of fibres. The length of wood parenchyma cells in sapwood is about 0.09 mm, with 0.016 mm radial diameter. The radial diameter of vertical medullary ray cells is 0.02 mm, tangential *ca* 0.017 mm, with 0.048 vertical length. The radial diameter of horizontal components is 0.08 mm, tangential *ca* 0.015 mm, with vertical length about 0.018 mm (Wright, 1904).

Uses : The timber is used for fancy works and considered equal to the best woods from ornamental point of view, since it has high amount of colouring matter even in sapwood. The timber is also suitable for building works. Pulp of the fruits is sweet and edible.

Notes : The intermittently grey and black fissures and ridges of the bark are very striking in this species. Kostermans (1981) described strongly reflexed fruiting calyx in Sri Lankan plants, but in our material, in young fruiting stage, the fruiting-calyx shows patent or spreading tendency. The margins of calyx-lobes are also not reflexed in our material.

Further, part of collection of Ceylon Plants *Thwaites* 2924 (PDA) has been segregated by Clarke (1882) and described as *D. opaca* Clarke – a Sri Lankan species, differing in texture, nervation and indumentum of leaves, very deeply lobed male corolla and 16 stamens. It resembles to *D. walkeri* (Wight) Gurke (considered synonymous to *D. undulata* Wall. ex G. Don in present work), but lateral nerves on the upper surface are prominulous.

Exsicc.: KARNATAKA : Mysore, Kollegal division, Madeshwaramalai R. F., *B. R. Ramesh* 1230 (HIFP); Near Odayarapalya, Edyarhalli R. F., *B. R. Ramesh 705* (HIFP); TAMIL NADU : Tirunelveli, Kodamalai, 200 m, 9th Oct. 1992, *R. Gopalan* 99443 ♀ (MH).

2. ***Diospyros andamanica*** (Kurz) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 74. 1937; Ng in Malays. For. 40 (4) : 211.1977. *Maba sumatrana* Miq. Plant. Jungh. 1 : 204. 1852, non *D. sumatrana* Miq. 1852. *Macreightia andamanica* Kurz, Report Veget. Andaman Isl. ed. 2. 42. 1870, *nom. nud. Maba punctata* Hiern in Trans. Cambr. Philos. Soc. 12 : 136. 1873, non *Diospyros punctata* Decne. 1834. *M. andamanica* Kurz in J. Asiat. Soc. Bengal 45 (2) : 138. 1876; Clarke in Hook. f. Fl. Brit. India 3 : 551 1882, *excl. syn. Ebenus andamanica* (Kurz) O. Ktze. 1891. *M. racemosa* Ridl. Fl. Malay Penin. Suppl. 5 : 320. 1925, non *Diospyros racemosa* Roxb. 1824. *M. carpinifolia* Ridl. in Kew Bull. 2 : 73. 1926. *Diospyros carpinifolia* (Ridl.) Bakh. in Gard. Bull. Str. Settl. 7 : 162. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 72. 1937. *D. tahanensis* Bakh. in Gard. Bull. Str. Settl. 7 : 163.

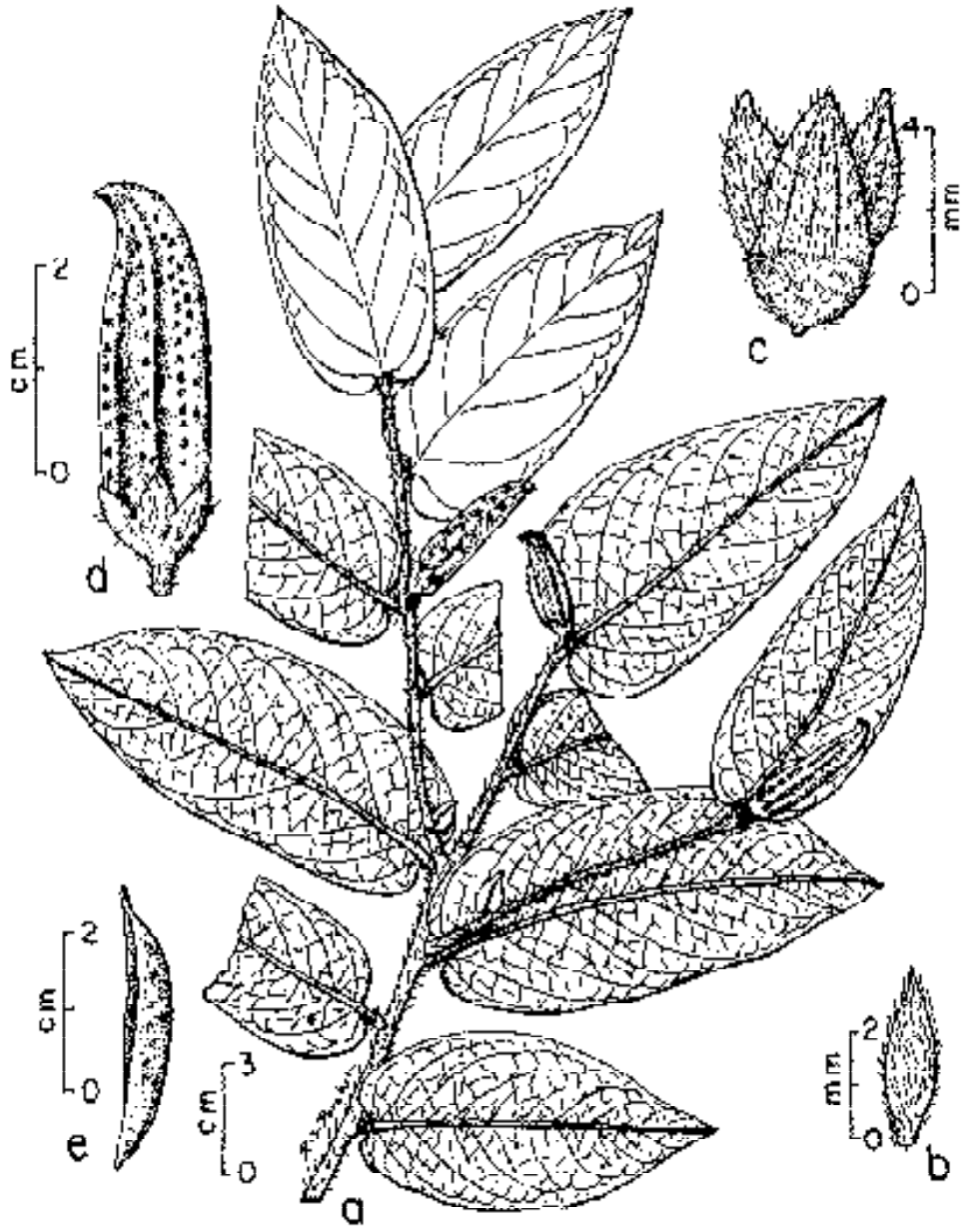


Fig.-2. ***Diospyros andamanica*** (Kurz) Bakh.
Female : a. habit, b. bract. c. fruiting-calyx,
d. fruit with calyx, e. seed.

1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 69. 1937. *D. malayana* Bakh. in Gard. Bull. Str. Settl. 7 : 163. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 75. 1937. *D. longipedunculata* Kosterm. in Blumea 23 : 462. 1977.

Shrubs or small trees, 1.5-7 m high, with rusty tomentose branchlets with short and long hairs. Leaves alternate, 9-16 x 4-6 cm, oblong-ovate, subcordate at base, abruptly subacuminate at apex, pilose with long setaceous hairs when young, soon glabrescent except with scattered long hairs on the veins and veinlets and densely so in the canaliculate midrib on the upper surface, dark green glossy above, yellowish rough beneath, not pellucid-punctate; midrib hairy bothsides, canaliculate above, raised beneath; lateral nerves 8-12 pairs, distant, conspicuous beneath; petioles 3-4 mm long, hairy, terete, not canaliculate above. Male flowers in axillary cymes, 3-merous. Calyx campanulate, hairy bothsides; lobes 3, 8-9 mm long, acute, valvate. Corolla fulvous hairy; lobes 3, contorted. Stamens 8-9, rarely 12, some connate by the filaments, rest free, unequal, hypogynous, inserted on the torus; anthers ovate-oblong or lanceolate, apiculate, glabrous. Rudimentary ovary hairy. Female flowers axillary, solitary, pedicellate, bracteate. Bracts 3-4 x 1.5 mm, lanceolate or ovate-lanceolate, acuminate, densely hairy, situated at the base of pedicels, persistent in the fruit. Calyx 6-7 mm long, campanulate, densely hairy bothsides, deeply 3-lobed; lobes ovate, acute, valvate. Corolla-tube broad; lobes 3, oblong, acute, contorted. Staminodes absent. Ovary 3-carpellary, superior, 6-celled, glabrous, cells 1-ovuled. Fruits 3-4 x 1.5 cm, elliptic-oblong, beaked at apex, beak slightly curved and mucronate, glabrous except with few scattered long hairs, 3 to 4-seeded, pericarp tuberculate. Fruiting-calyx embracing the fruit at base; tube cup-shaped, 2-3 mm deep; lobes 3, ovate, appressed to the fruit, valvate, 5-7 x 3-4 mm, not much enlarged, not thickened on the margins; fruiting-pedicels hairy, 3-5 mm long, not swollen at the top, subtended by the bracts. Seeds elliptic, 3-ganous, 2-3 x 0.3-0.4 cm, pointed at both ends or somewhat beaked at the apex, testa hard and splits into 2-halves making the beak 2-fid, black-brown; albumen equable (**Fig.-2; Plate 1/2**).

Type : Lectotype among three sheets from Andamans is to be selected (K).

Fl. & Fr.: April – August.

Ecol.: Scattered in wet evergreen tropical forests, upto 100 m.

Distrib.: This species was considered endemic to India, confined to Andaman Islands. Recently, Turner (1995) has reported it from Malay Peninsula (**Map-1**).

Uses : Timber is bluish-grey in colour, hard and durable, chiefly used for agricultural equipments.

Notes : The oldest available epithet is *andamanica* from *Macreightia andamanica* Kurz (1870) which is *nom. nud.* and cannot be accepted as basionym. Kurz (in J. As. Soc. Bengal 40 : 74. 1871) again used this name with a note that *M. andamanica* Kurz is the female plant of *Maba sumatrana* Miq., but again without diagnostic description. It was in 1876 (J. As. Soc. Bengal 45 (2) : 138) when Kurz provided a full description to this taxon under the name *Maba andamanica* Kurz. As such, the

latter publication has been accepted for the effective name and date of publication in the present work for basionym.

Further, as regard typification, Novara 148 and Jelinck 105 were cited as types by Kurz, but none of them is traceable at Kew herbarium. However, there are three sheets in Kew without number from Andamans, which are probably conspecific with the types. As such, lectotype is to be selected among these specimens (Ng, 1977).

Exsicc.: ANDAMAN & NICOBAR : South Andamans, Rutland Island, Near Forest-dera, 100 m, 8th April 1978, *N. G. Nair* 6931 ♀ (PBL); Mount Ford, Along Ghas-Nallah, 22nd Jan. 1982, *M. K. Vasudeva Rao* 8657 ♀ (PBL); Baratang Island, 50 m, 21st Jan. 1975, *N. Bhargava* 2465 ♀ (PBL); Andamans, 17th April 1916, *C. E. Parkinson* 1197 ♀ (DD).

3. ***Diospyros apiculata*** Hiern in Trans. Cambr. Philos. Soc. 12 : 186. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 553. 1882 & in J. Asiat. Soc. Bengal 74 : 213. 1905; Bakhuizen in Gard. Bull. Str. Settl. 7 : 146. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 170. 1937. *D. pahangensis* Bakh. in Gard. Bull. Str. Settl. 7 : 179. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 165. 1937.

Dioecious trees, upto 5 m high, with slender stem; young branches ferruginously pilose-hispid with upto 5 mm long, stiff hairs. Leaves alternate, bifarious, 8-12 x 3-4.5 cm (6-20 x 2.5-7 cm Bakhuizen, 1937), oblong or elliptic-oblong, subcaudate-acuminate at apex, rounded at base, thinly subcoriaceous, hispid beneath especially on the midrib, lateral veins and veinlets, glabrescent above except midrib, margins slightly reflexed and strongly ciliate with cilia upto 3 mm long; midrib canaliculate above, raised beneath, hairy bothsides but more so beneath; lateral veins 8-12 pairs, parallel, arcuating towards apex near margins, depressed above, raised beneath, reticulation parallel between the lateral veins; petioles 2-3 mm long, terete, densely hispid. Male flowers axillary, usually solitary, rarely 1 to 4-together in fascicles, subsessile, densely hispid, bracteate; pedicels less than 1 mm long, pilose. Bracts ovate, small, finely hispid outside, glabrous within, caducous. Calyx 6-7 mm long, subcampanulate, pilose outside, glabrous within; tube ca 1 mm long; lobes 4 (-5), linear-lanceolate, acute-acuminate, long-ciliate, valvate. Corolla 8-10 mm long, tubular, pilose outside, glabrous within; lobes 4 (-5), oval-elliptic, obtusely pointed at apex, sinistrorsely imbricate. Stamens usually 6-7, rarely 12, subequal, glabrous, in pairs, united at the base by filaments, inserted at the base of corolla-tube; anthers ca 2 mm long, glabrous, linear-oblong, subacute or obtuse at apex, not apiculate. Pistillode pubescent, rudimentary. Female flowers in 1 to 3-flowered, short, axillary, finely hispid cymes. Calyx and corolla as in males but little larger. Staminodes 6 or more, glabrous, inserted at the base of corolla-tube. Ovary ferruginously hirsute, 4-celled, cells 1-ovuled; styles 2. Fruits solitary, subsessile, ovoid-conical, 2.5-3 x 1.2-2 cm, apiculate at apex by 2 style remains, finely ferruginous-setose especially upwards but not so densely in lower part and subsequently subglabrescent in lower part. Fruiting-calyx 1-1.5 cm in diam., flat, disciform, no tube, fruit seated on the disc; lobes oblong-linear, divided nearly to the base, acute-acuminate, 7-10 x 2-3 mm, rufous-pilose, spreading or reflexed, not touching the fruit. Seeds 4, ca 1.5 cm long, oblong-elliptic,

Fig.-3.. ***Diospyros apiculata*** Hiern
Male : a. habit, b. bract, c. flower-bud, d. calyx, e. stamen.
Female : f. habit, g. fruit.

depressed on lateral faces, convex dorsally; albumen somewhat farinaceous-equable, not ruminate (Fig.-3; Plate 1/3 & 4).

Holotype : Malaysia : Penang, Govt. Hill, *Maingay* 1514 ♀ (K).

Fl. & Fr.: November - April.

Ecol.: Rare, in evergreen wet forests in rich soils.

Distrib.: In India, this species finds distribution in Assam which forms the western limits of its distribution from its native home Malayan peninsula through Myanmar (Map-1).

Notes : This taxon resembles *D. pruriens* Dalz. but has subsessile flowers, lesser number of epipetalous stamens, depressed lateral nerves on the upper surface, truncate-rounded leaf-base and shorter petioles. Our specimens differ from those described by Hiern (1873) in the characters that leaf-base is truncate-rounded, not cordate, solitary and 4-merous flowers, calyx being pilose outside only and corolla pilose outside, not glabrous.

Exsicc.: ASSAM : Janakmukh, 19th Dec. 1911, *I. H. Burkill* 37246 ♂ (CAL); Reugging, 17th Feb. 1912, *I. H. Burkill* 36636 ♀ (CAL).

4. ***Diospyros assimilis*** Beddome, Report Ind. For. Madras 1866-67 : 20. t. 1 1867; Clarke in Hook. f. Fl. Brit. India 3 : 558. 1882. *D. nigricans* Dalz. in Hook. Kew J. Bot. 4 : 110. 1852, non Wall. ex A. DC. 1844, nec. Beddome 1871.

English name : Malabar Ebony.

Vernacular names : *Hindi:* Abnus, Ebans, Tendu; *Kan.*: Kari, Karamaran, Kare, Karemara, Karikhanmara; *Mal.*: Karu, Mishatumpi, Mushtimbi; *Mar.*: Karu, Malya; *Or.*: Kendu; *Tam.*: Acha, Karundali, Karinthali, Karintkatto, Kaka-tati, Karunkali, Shengutam, Tai, Tumbi; *Tel.*: Nalluti, Tuki.

Large trees, with glabrous branches, unarmed. Leaves alternate, 4.4-11.5 x 1.8-4.5 cm, thin, oblong or elliptic, abruptly acuminate, cuneate at base, glabrous; midrib canaliculate above and raised below; lateral nerves 4-9 pairs, more prominent beneath, reticulate venation rhomboid and obscure; petioles 3-7 mm long, almost flat above, rounded beneath, glabrous. Male flowers in short-peduncled, axillary, 3-flowered, pubescent cymes; cymes solitary or few together. Calyx 3-4 mm long, campanulate, divided almost to the middle, densely pubescent outside, glabrous within; lobes 4, broadly ovate to suborbicular, subacute, ciliate, pubescent outside, glabrous within, contorted. Corolla 6-8 mm long, tubular, glabrous bothsides; lobes 4, ovate-oblong, contorted. Stamens 24-36 (30 in our plants), unequal of three different sizes, free, paired or 3 to 4-together attached on a common filament at the base, inserted at the base of corolla-tube; filaments upto 1.25 mm long, sparsely hairy or glabrous due to falling of hairs; anthers linear, upto 2 mm long, glabrous, shortly apiculate due to produced connectives. Pistillode globose, with somewhat flattened top, *ca* 1 x 1 mm, glabrous. Female flowers axillary, solitary, pedicellate; pedicels upto 3 mm long, pubescent, articulated with the calyx base, somewhat swollen at

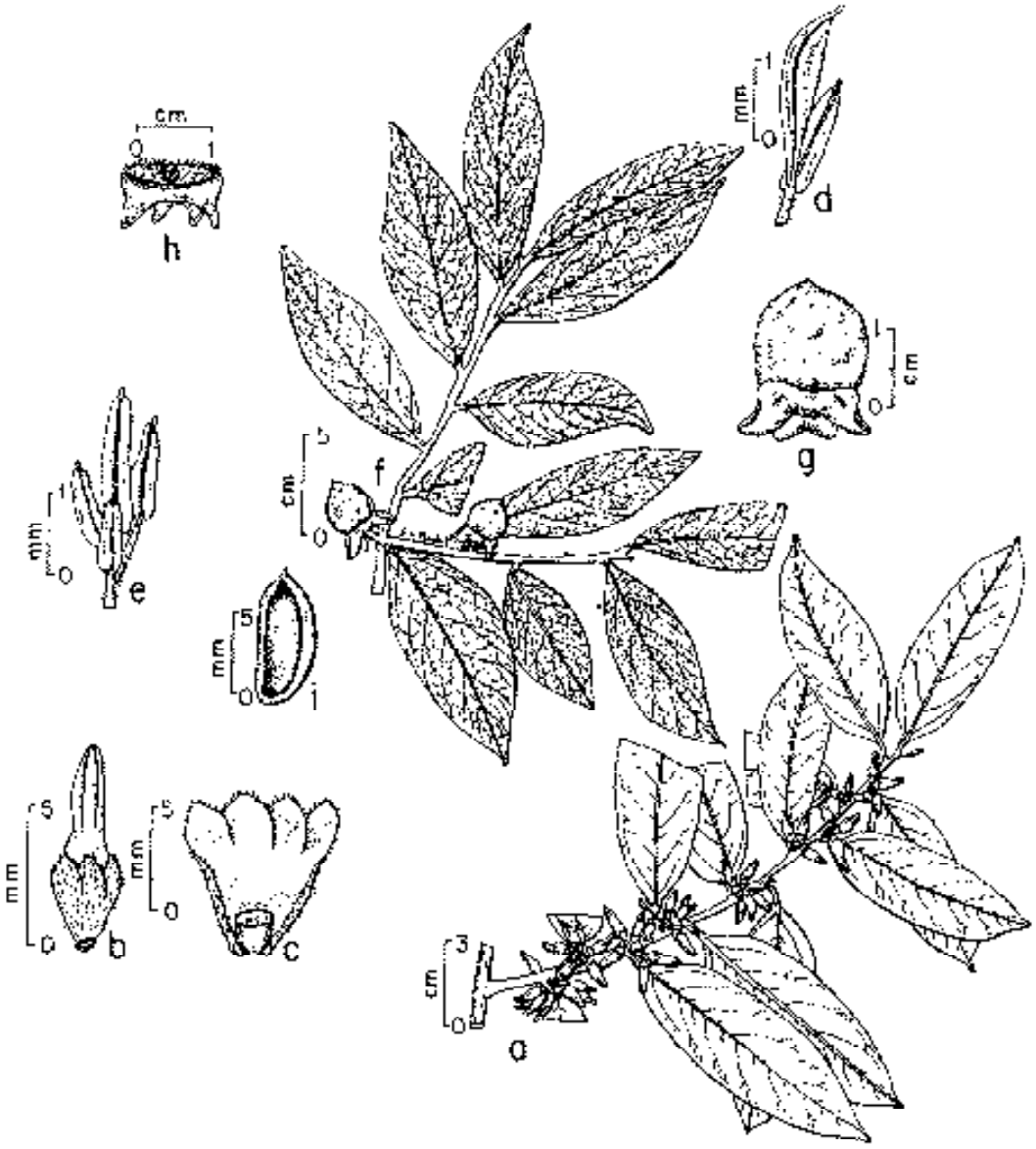


Fig.-4. ***Diospyros assimilis*** Bedd.

Male : a. habit, b. flower-bud, c. calyx within with pistillode, d-e. stamens.

Female : f. habit, g. fruit, h. fruiting-calyx, i. seed.

tip. Calyx as in males but little larger. Corolla glabrous, divided more than half way down, tube cupular; lobes 4, *acute, contorted*. Staminodes absent. Ovary glabrous, 6-celled, cells 1-ovuled; style 1, short; stigma 1. Fruits globose-oblong, 1.5-2 x 1.3-1.7 cm, glabrous, pointed at tip. Fruiting-calyx-tube woody, densely appressed hairy inside, glabrous outside, flat, circular, disc-like, fruit seated on the disc, with an internal not much elevated rim; lobes reflexed, not constricted at base, margins subrolled outside and appear horn-like, woody, sericeous within, glabrous outside. Seeds 6, oblong, flat or somewhat concave on one side, 7-10 x 3-5 mm, rounded at both ends, glabrous; albumen equable (**Fig.-4; Plate 2/1 & 2**).

Lectotype : India : Karnataka, South Canara, *Beddome s.n.* (BM).

Fl. & Fr.: February – June.

Ecol.: Occasionally found in the mountain forests, upto 900 m.

Distrib.: This species is endemic to India, chiefly confined to Maharashtra, Karnataka, Kerala and Tamil Nadu (**Map-1**).

Uses : Wood is valuable for furniture, turnery, cabinet work, piano keys, backs of brushes, chop-sticks, opium pipes and carved work. It is also considered astringent, attenuant and lithontriptic (Rao, 1914).

Notes : Hiern (1873) and Bakhuizen (1938) have considered this species conspecific to *D. ebenum* Koenig. However, the two taxa differ as delimited in the key of present monograph. In wood structure this species shows close affinity with Neogene fossil wood of *Ebenoxylon arcotense* Awasthi (Awasthi, 1974).

Exsicc.: KARNATAKA : Mysore, Shimoga, Hulical ghat, 23rd March 1964, *R. S. Raghvan* 97125 ♂ (BSI); North Kanara, 7th March 1896, *W. A. Talbot* 3559 ♂ (CAL); Kanara, Devimani, May 1939, *N. L. Bor* 11563 ♀ (DD); KERALA : Travancore, Arqaukavu, 8th Feb. 1896, *T. F. Bourdillon 757* sterile (DD); TAMIL NADU : Tirunelveli, Kannikatti, 875 m, 17th July 1989, *R. Gopalan* 90579 ♀ (MH).

5. ***Diospyros atrata*** (Thw.) Alston in Trimen, Handb. Fl. Ceylon 6 : 180. 1931; Kostermans in Ceylon J. Sci. (Biol. Sci.) 12 (2) : 92. 1976 & Rev. Handb. Fl. Ceylon 3 : 26. 1981. *D. embryopteris* Pers. var. *atrata* Thw. Enum. Pl. Zeyl. 178. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 259. 1873. *D. malabarica* (Desr.) Kostel. forma *atrata* (Thw.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 329. 1938.

Vernacular names : *Tam.*: Gusvakendu; *Tel.*: Tumika.

Trees, upto 25 m high; young branchlets thinly pubescent; apical buds black pubescent; bark smooth, black, peeling off in plates. Leaves alternate, 8-17 x 3-7 cm, oblong or elliptic-oblong, broadly subacuminate or obtuse at apex, narrowed and subcuneate at base appearing decurrent into petioles, glabrous bothsides, chartaceous or subcoriaceous; midrib glabrous, canaliculate above, rounded and

raised beneath; lateral nerves 5-9 pairs, arcuate towards apex, reticulation lax, conspicuously prominent beneath; petioles 1-1.5 cm long, flat or canaliculate above, glabrous. Male flowers pinkish-white or white, shortly pedicellate, in axillary, 3 to 8-flowered, densely black pubescent cymes; primary and secondary peduncles upto 3 mm long, densely black pubescent, secondary peduncles articulated with the flowers. Bracts oblong, 5-7 x 4-5 mm, boat-shaped, subacute, black pubescent bothsides, inserted at the base of secondary peduncles, deciduous. Flower-buds globose, enclosing corolla in initial stage, later corolla protrude conically but hardly exceeding calyx-lobes. Calyx 4-5 x 5-6 mm, broader than long, cup-shaped, black hairy bothsides; tube about 3 mm long; lobes 4, thick, 2-3 mm long, ovate-triangular, obtuse or subacute, valvate. Corolla pinkish-white, tubular, 8-12 x 10-12 mm; tube short, fleshy, urceolate-tubular, glabrous bothsides except at the junction with lobes outside; lobes 4, 3-4 mm long, fleshy, ovate, acute, glabrous within, slightly black pubescent outside, contorted. Stamens 20-22, rarely numerous (Kostermans, 1981), inserted at the base of corolla-tube; filaments short, 1-2 mm long, hairy; anthers linear-oblong, 4-5 mm long, almost equal in size, hairy, paired, apex narrowed and apiculate in some and obtuse in others. Pistillode rudimentary, hairy. Female flowers axillary, solitary or few together on short pedicels, black pubescent like males. Calyx and corolla as in males but little larger. Staminodes 5 to 12, epipetalous. Ovary globose, tomentose, 8-celled, cells 1-ovuled; styles 4. Fruits upto 7 cm in diam., globose, with rusty brown scurvy tomentum. Fruiting-calyx enlarged, densely black-haired inside, 2-3 times as large as flowering female calyx, deeply 4-lobed, no distinct tube; lobes reflexed. Seeds *ca* 2.5 x 1.5 cm; albumen equable (**Fig.-5; Plate 2/3**).

Holotype : Ceylon Plants, *Thwaites* 2731 (PDA).

Fl. & Fr.: March – September.

Ecol.: Rare, in mixed forests, upto 1200 m.

Distrib.: This species finds rather restricted distribution in India, chiefly in Andhra Pradesh, Tamil Nadu and Kerala. This also extends further south to Sri Lanka – its native home (**Map-1**).

Uses : The fruits possess a large quantity of gum and tannin which are used as a tan material for fishing nets and for the planks of boats. The leaves are sometimes cooked and eaten as vegetable. The timber is occasionally used for masts and yards for small boats.

The seeds are a rich source of oil, which is extracted by boiling and is usually used in native medicines for dysentery and diarrhoea. The bark and fruits both possess astringent and haemostatic properties. The juice of unripe fruits and bark makes a good application for fresh wounds. Infusion of the fruits is given as a gargle in apthae and throat sores. The bark is also febrifugal. It is used effectively in leucorrhoea too.

Notes : Kostermans (1981) doubts about its occurrence in India. However, Gamble (1922) has reported it from Kerala based on T. F. Bourdillon's collection from Travancore. During present study, I came across a specimen collected by C. E. C. Fischer 3704 (CAL) from Anaimalai hills (Tamil Nadu) which is undoubtedly *D. atrata* (Thw.) Alston. It is usually confused for *D. peregrina* (Gaertn.) Gurke,

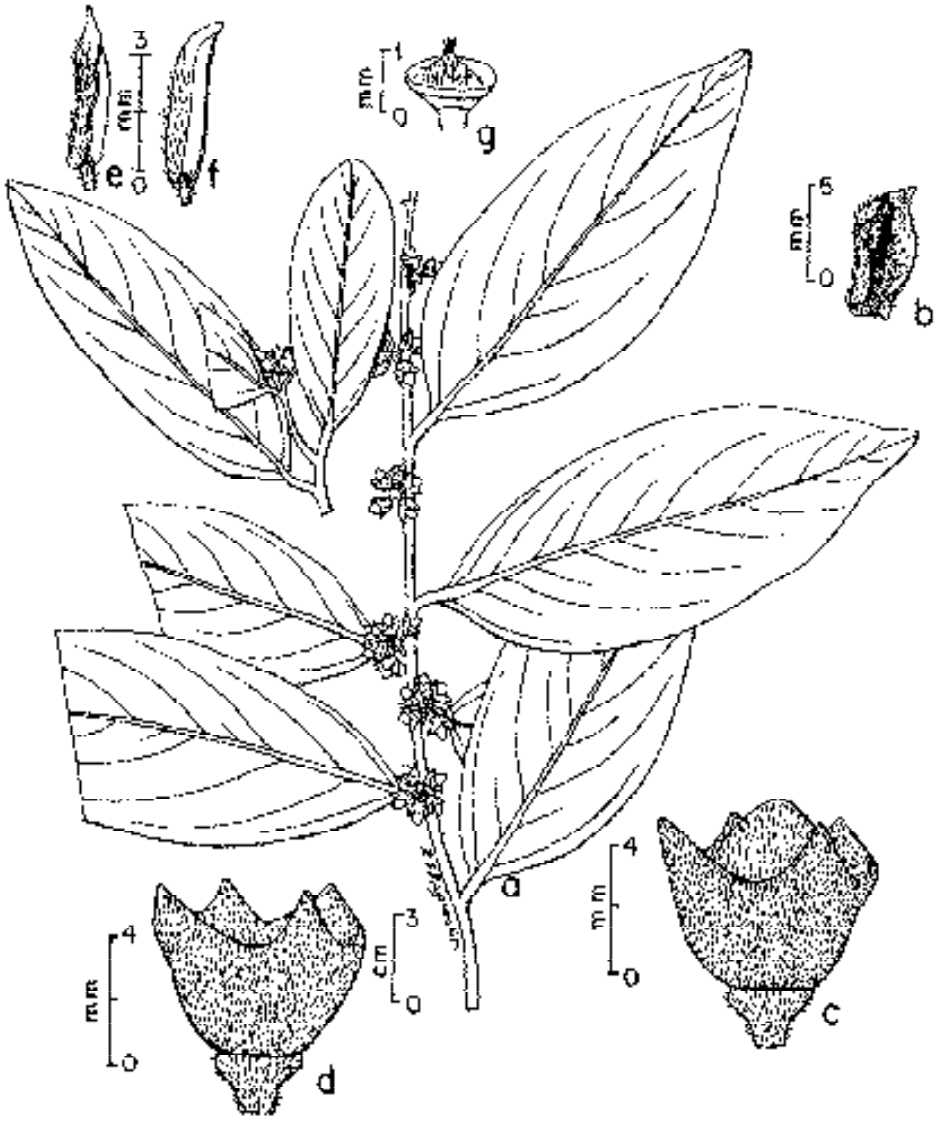


Fig.-5. ***Diospyros atrata*** (Thw.) Alston
Male : a. habit, b. bract, c. flower-bud, d. calyx, e-f. stamens, g. pistillode.

Distrib. Sketch Map – 1

● *Diospyros affinis* Thw.; ▲ *Diospyros andamanica* (Kurz) Bakh.;
■ *Diospyros apiculata* Hiern; o *Diospyros ossimilis* Bedd.;
⋆ *Diospyros atrata* (Thw.) Alston

but reflexed calyx-lobes under the fruit and black haired inflorescence and calyx best distinguish it from latter

Exsicc.: TAMIL NADU : Manjaitithu shola, Anaimalai hills, 1110 m, 3rd April 1914, *C. E. C. Fischer* 3704 ♂ (CAL).

6. ***Diospyros barberi*** Ramas. in J. Asiat. Soc. Bengal (New Series) 10 (2) : 47. t. 3 & 4. 1914.

Vernacular names : *Tam.:* Karinthovarai, Karinthali.

Trees, with pubescent branchlets and greyish black, rough bark. Leaves alternate, closely set, 3-8 x 1-3 cm, oblong or oblong-lanceolate, obtusely caudate-acuminate at apex, entire, cuneate or rounded at base, puncticulate on the upper surface, coriaceous; midrib canaliculate above; lateral nerves 6-9 pairs, oblique; petioles 7-9 mm long, canaliculate above, wrinkled. Male flowers 2 to 3-together, almost sessile, fascicled on short axillary peduncles. Calyx 3-4 mm long, campanulate-tubular, rugulose, almost truncate; teeth 4, hairy outside, obtuse, ciliolate, valvate. Corolla *ca* 6 mm long, tubular, glabrous; lobes 4, fleshy, twisted to right. Stamens 16, hypogynous, inserted on torus, paired; anthers linear, glabrous, apiculate, connectives produced. Female flowers axillary, solitary, pedicellate, pedicels thickened and articulated at the top. Calyx comparatively larger than males, crateriform; lobes 4, broadly triangular, abruptly acute, valvate. Corolla tubular, glabrous; lobes 4, twisted to right. Staminodes 4, thickened towards top. Ovary concealed by the calyx, 4-celled, covered with brown powdery excrescence when young, ovule 1 in each locule; style 1; stigmas 4. Fruits subglobose. Fruiting-calyx cupular, accrescent, much enlarged, as long as fruit or longer; tube distinct; lobes foliaceous, acute, not thickened, distinctly palminerved, erect or spreading (**Fig.-6; Plate 2/4**).

Lectotype : India, Tamil Nadu, Tirunelveli hills, Kannikatti, 750 m, May 1901, *Barber* 2951 ♀, Acc. no. 282232, (CAL-designated here); *Lectosyntype* : *Barber* 2960 ♂, Acc. no. 282235 (CAL).

Fl. & Fr.: March -- May.

Ecol.: On the hills and in humid rain forests, from sea level to 1300 m.

Distrib.: This species is endemic to India, confined to Tamil Nadu and Andaman and Nicobar Islands (**Map-2**).

Notes: This species occupies an intermediate position between *D. foliolosa* Wall. ex A. DC. and *D. ebenum* Koenig, but may be distinguished from *D. foliolosa* Wall. ex A. DC. by its sessile, small male flowers which are fascicled on short peduncles and by its broadly crateriform calyx with much shorter and broader triangular lobes. It may, however, be distinguished from *D. ebenum* Koenig by its larger, pedicelled female flowers, 4-celled and 4-ovuled ovary and in the form and deposition of lobes of the fruiting-calyx.

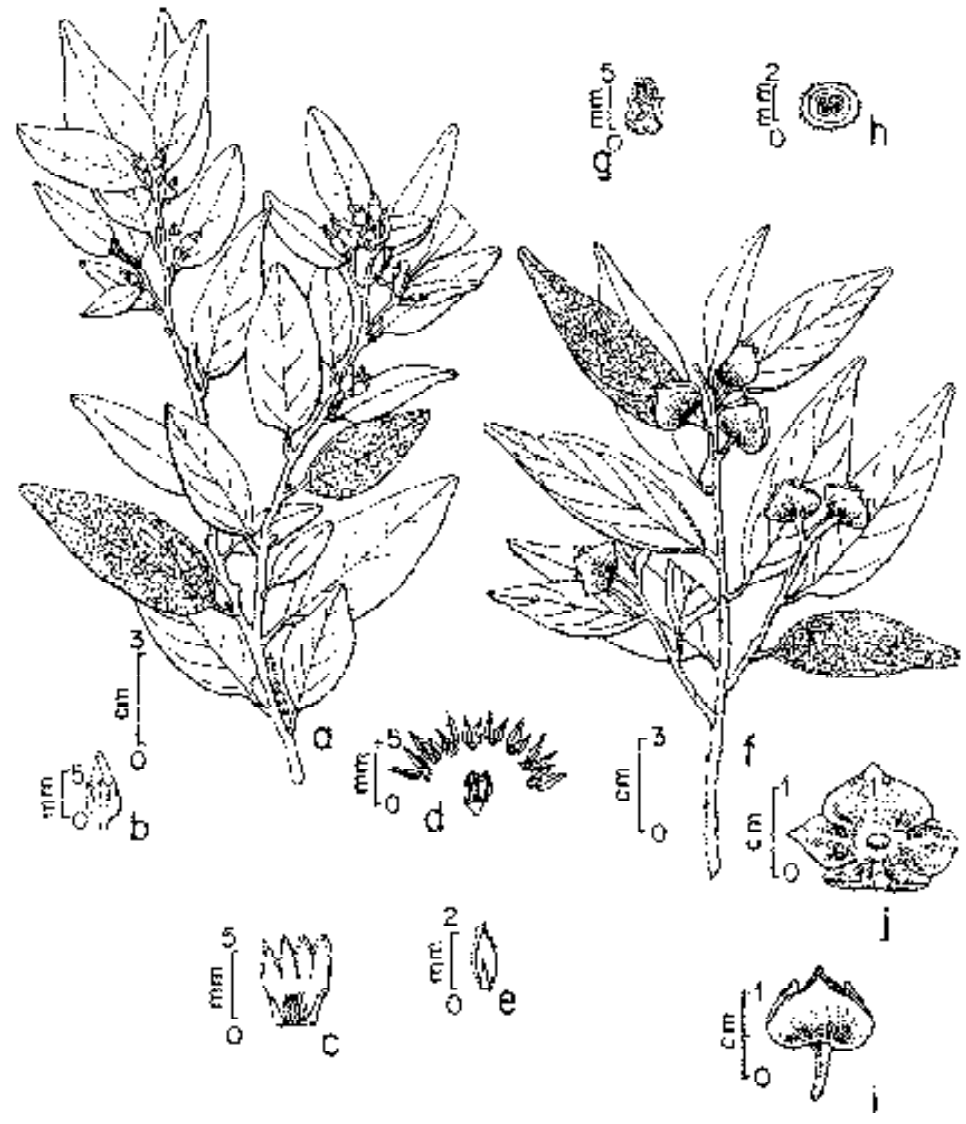


Fig.-6. ***Diospyros barberi*** Ramas.

Male : a. habit, b. flower-bud, c. corolla within with stamens, d. stamens, e. anther.

Female : f. habit, g. gynoecium with staminodes, h. T. S. of ovary,

i. young fruiting-calyx, j. mature fruiting-calyx.

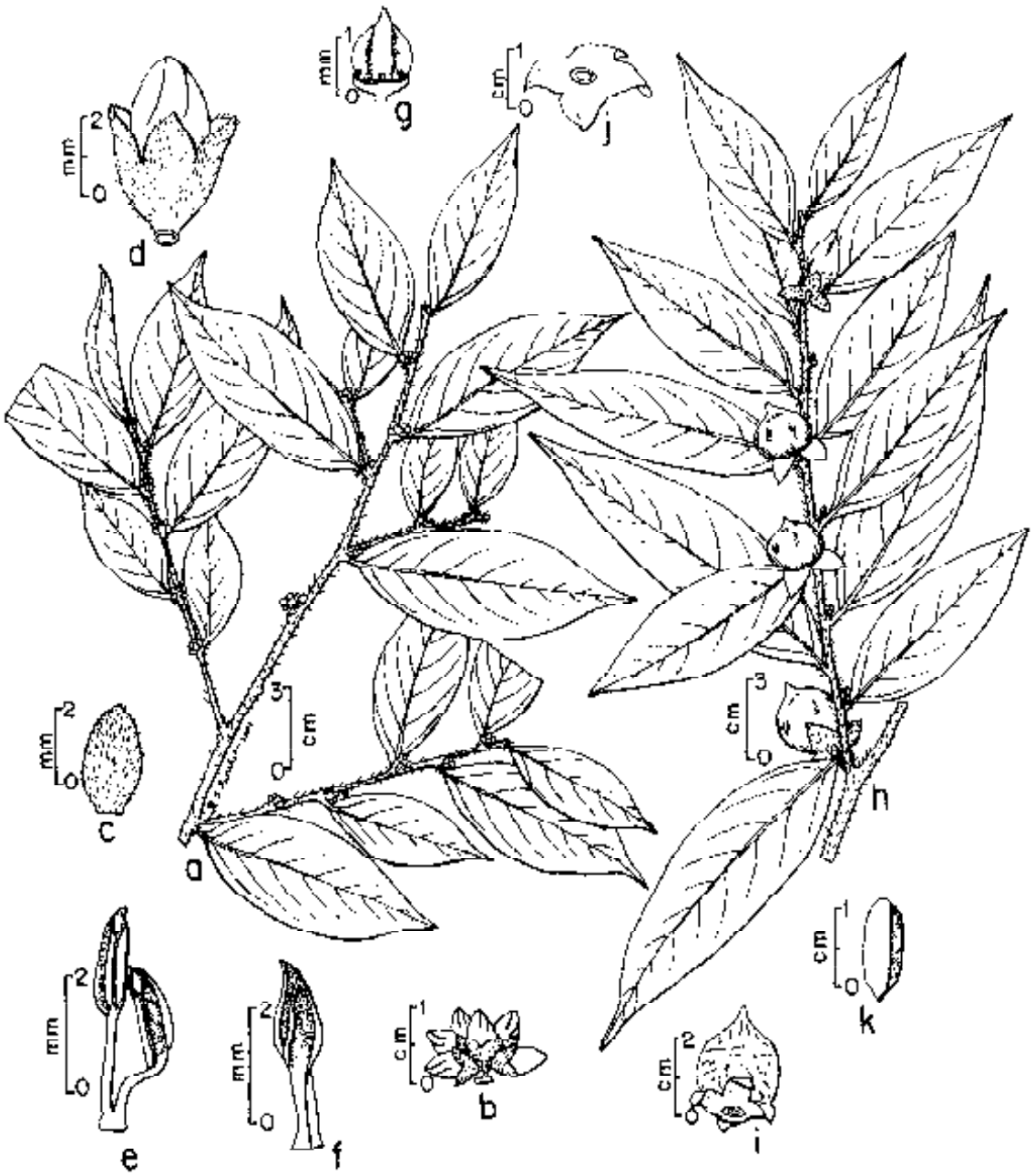


Fig.-7. ***Diospyros benghalensis*** Bakh.
Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e-f. stamens, g. pistillode.
Female : h. habit, i. fruit, j. fruiting-calyx, k. seed.

Exsicc.: ANDAMAN & NICOBAR : Arong, Car-Nicobar, 31st May 1975, *N. G. Nair* 2629 (PCM); TAMIL NADU : Tirunelveli hills, Kannikatti, 800 m, *Barber* 2946, 2948 (Lectosyntype PCM), 2960 (Lectosyntype CAL); Kannikatti, towards Agastiyamalai, 850 m, *Hooper & Ramaswami* 39438 (Lectosyntype PCM).

7. ***Diospyros benghalensis*** Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 29. 1937. *D. nigricans* Wall. ex Hiern in Trans. Cambr. Philos. Soc. 12 : 207. 1873, non Dulz. 1852, nec Beddome 1871; Clarke in Hook. f. Fl. Brit. India 3 : 557. 1882.

Vernacular name : *Asm.:* Rangkoli.

Trees, upto 20 m high, with grey pubescent branchlets. Leaves alternate, 4.5-13 x 2-4.2 cm, elliptic-lanceolate, caudate-acuminate at apex, narrowed and cuneate at base, thinly pubescent bothsides, glabrous on maturity except the midrib beneath, margins rather thick and somewhat revolute, membranous or chartaceous; midrib canaliculate above, raised beneath, thinly pubescent; lateral veins rather bold than intermediate reticulation; petioles 2-5 mm long, canaliculate above, rounded beneath, minutely pubescent. Male flowers in 3 to 6-flowered, subsessile, short, axillary, puberulous cymes; peduncles *ca* 2 mm long, ferruginously hairy. Bracts oval-oblong, boat-shaped, 2-3 mm long, obtuse, densely pubescent bothsides, each subtending a flower, imbricated. Calyx 3-4 mm long, campanulate, ferruginously puberulous outside, glabrous within, divided half way down; lobes 4, ovate, valvate. Corolla 6-8 mm long, tubular, deeply 4-lobed, glabrous bothsides; lobes contorted. Stamens usually 16 (rarely 32, Hiern, 1873), unequal, united in pairs by the filaments in lower region, hypogynous, seated on the torus; filaments 1.5-2 mm long, glabrous; anthers 1.25-2 mm long, glabrous, arrow-shaped, acute or obtuse at apex, dehiscing through apico-lateral pores, connectives much broader at base and not produced at apex. Pistillode *ca* 1 mm in diam., globose, somewhat 4-angular, glabrous, pointed at apex. Female flowers solitary, axillary; pedicels upto 3 mm long, stout, densely pubescent. Bracts unilateral, persistent. Calyx and corolla as in males but little larger. Staminodes 4. Ovary 4-celled, thinly pubescent, cells 1-ovuled. Fruits ovoid or globose, 1.5-2 cm in diam., apiculate at apex, 4-celled, 4-seeded, glabrous or with few scattered hairs. Fruiting-calyx flat, disciform, fruit seated on the disc, no distinct tube, 4-lobed nearly to the base; lobes foliaceous, ovate, acute, reflexed, not touching the fruit. Seeds 10-13 x 5 mm, oblong, two lateral faces flat, outer face convex, glabrous; albumen equable (**Fig.-7; Plate 3/1 & 2**).

Holotype : Bangladesh : Sylhet, Wallich Cat. No. 6351 (K).

Fl. & Fr.: April – November.

Ecol.: Found in wet evergreen or semi-evergreen forests, upto 600 m.

Distrib.: The species finds distribution in W. Bengal, Assam and Meghalaya in India. Probably cultivated/planted in Maharashtra. It also occurs in Bangladesh – probable native home (**Map-2**).

Pollen : Pollen grains 3-colporate, prolate-spheroidal (31.5 x 27.5 µm), range 30-34 x 25-30 µm. Amb almost circular. Colpi long, thin, running from pole to pole with psilate membrane. Maximum width

of colpus about 1.5 µm. Ora la-longate (2 x 6 µm), with psilate membrane. Exine about 1.5 µm thick. Sexine as thick as nexine. Sexine pattern psilate (Sharma & Gupta, 1979).

Notes : The name *D. nigricans* Wall. (*nom. nud.*) was proposed by Wallich (1828-32) and was as such adopted by A. De Candolle (1844) without providing any description etc. Though it is an early homonym of *D. nigricans* Dalzell (1852) and Beddome (1871) but a *nom. nud.* and cannot be accepted. It was validated by Hiern (1873) as *D. nigricans* Wall. ex Hiern (1873), which has been a later homonym of Dalzell (1852) and Beddome (1871). As such, Bakhuizen (1937) rightly proposed a new name *D. benghalensis* Bakh. for this taxon. Very closely allied to *D. candolleana* Wight.

Exsicc.: ASSAM : Kamrup, Nortak, 17th April 1915, *U. Kanjilal* 5486 ♂ (ASSAM); Sibsagar, Barpathar, 81 m, Sept. 1914, *U. Kanjilal* 4189 ♂ (DD); 81 m, April 1914, *U. Kanjilal* 4189 ♀ (DD); Jamuguri, 90 m, 24th April 1910, *U. Kanjilal* 1591 sterile (DD); Lakhimpur, Jippum, 14th Feb. 1914, *U. Kanjilal* 3402 sterile (DD); North Cachar hills, Borail Reserve, 195 m, 15th May 1915, *U. Kanjilal* 5705 ♀ (DD), 5703 ♀ (DD); MAHARASHTRA : Pune, Matheran, 3rd Dec. 1903, *G. A. Gammie* 16682 sterile (BSI); MEGHALAYA : Khasia & Jaintia hills, Tharia forest, 5th July 1940, *G. K. Deka* 19605 ♀ (ASSAM).

8. ***Diospyros bourdillonii*** Brandis, Ind. Trees 435. 1906; Bourdillon, For. Trees Travancore 254. 1908.

English name : Ebony.

Vernacular names : *Mal.*: Karimaran, Karinthuvara, Kodal, Kotal, Terika, Kari; *Tam.*: Karinthovarai, Karuncattiyam, Karunduvarai, Karunchatthi.

Dioecious trees, upto 20 m high, with strigose young branchlets with appressed rusty hairs; hairs affixed in the middle. Bark scaly, buttressed, black. Leaves alternate, 5-15.5 x 2.5-7 cm, broadly elliptic-oblong, shortly abruptly-acuminate, coriaceous, glabrous bothsides; midrib raised beneath, canaliculate above; lateral nerves 8-12 pairs, not prominent; petioles 5-8 mm long, glabrous, canaliculate above, rounded beneath. Male flowers upto 1 cm long, white, shortly pedicellate, in short, rusty tomentose, axillary, bracteate cymes; pedicels upto 2.5 mm long, rusty tomentose. Bracts ovate, acute, *ca* 1.5 x 1 mm, rusty tomentose, placed at the base of pedicels. Calyx upto 6 mm long, campanulate, rusty tomentose bothsides, divided not beyond the middle, 5-lobed; lobes triangular-ovate, acute, erect, rusty tomentose bothsides, valvate. Corolla-tube ovoid-tubular, 4-8 mm long, glabrous within, tomentose outside; lobes 5, spreading, one-third the length of tube, velvety on bothsides, contorted. Stamens 12-18, subequal, hypogynous, seated on the torus; filaments upto 2 mm long, glabrous; anthers linear-lanceolate, glabrous, connectives not produced. Female flowers in compound, rusty tomentose, bracteate cymes on old wood; pedicels upto 1.3 cm long, much longer than the calyx. Calyx and corolla as in males but larger; calyx as broad as long or broader than long. Staminodes 10, linear-oblong, glabrous, with rather short filaments. Ovary 9 to 10-celled, globose, rusty tomentose, cells 1-ovuled; style 1,

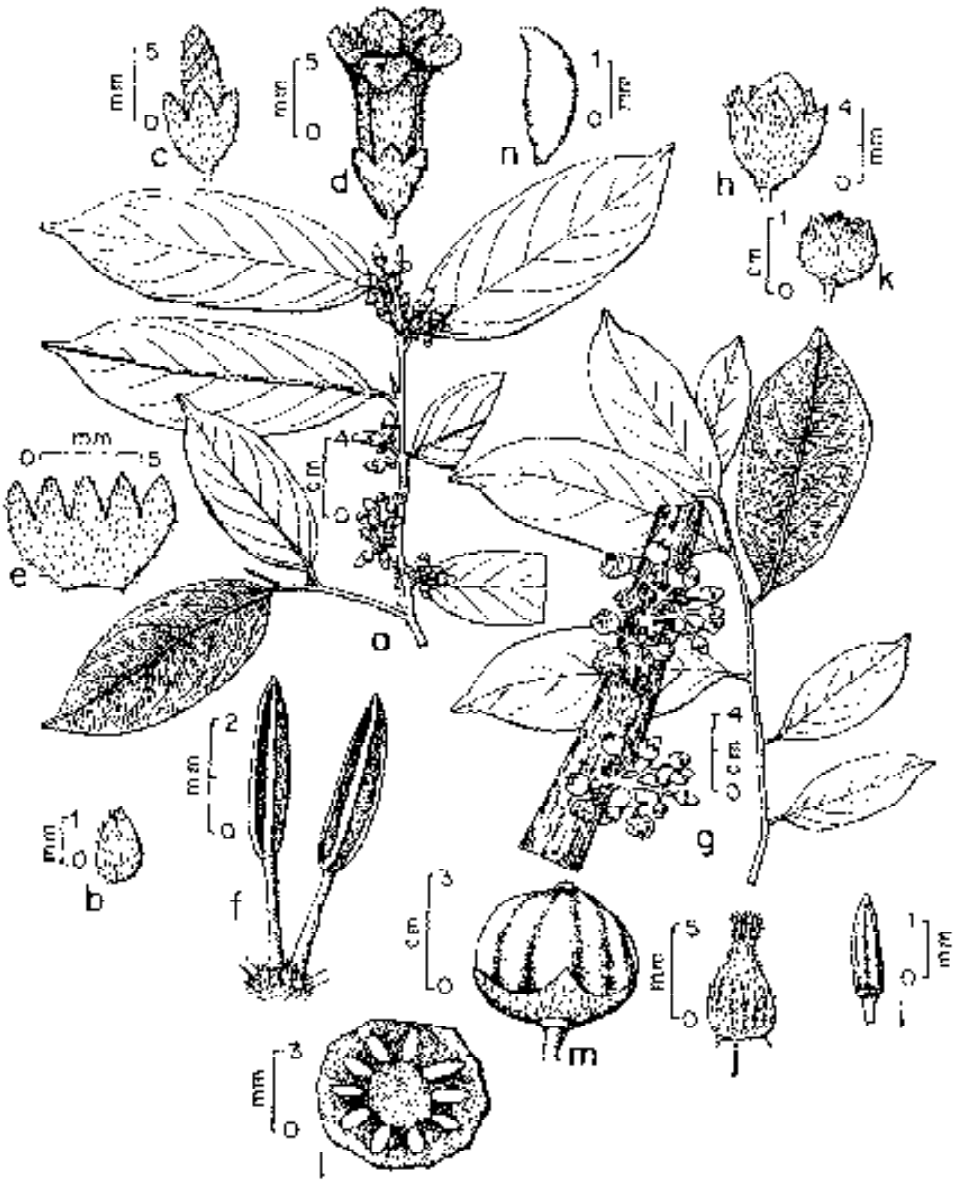


Fig.-8. ***Diospyros bourdillonii*** Brandis

Male : a. habit, b. bract, c. flower-bud, d. flower, e. calyx within, f. stamens,

Female : g. habit, h. flower-bud, i. staminode, j. gynoecium,

k. young fruit enclosed within calyx,

l. T. S. of young fruit, m. mature fruit with calyx, n. seed.

short, stout, hairy; stigmas as many as locules, oblong, as long as style, closely placed together, densely hairy. Fruits 7-7.5 x 3-5 cm, subglobose, hard, woody. Fruiting-calyx hard, woody, tomentose, globular in young stage and completely enclosing the fruit, on maturity becoming broad, pentagonal, bowl-shaped, 3-5 cm across, appressed to the basal part of the fruit; lobes flat, not thickened on the margins, appressed to the fruit, not reflexed. Seeds oblong-oval, glabrous; albumen equable (Fig.-8; Plate 3/3 & 4).

Holotype : Anamalais and Tinnevelli Ghats, *Beddome s. n.* (BM).

Fl. & Fr.: February - November; fruits hang on the tree for a year and ripen during June - September.

Ecol.: In evergreen forests, upto 1000 m. Plants usually grow on windward side of the hills. The sapwood is susceptible to dry wood borer – *Stromatium barbatum*.

Distrib.: This species is endemic to India, chiefly confined to Karnataka, Tamil Nadu and Kerala (Map-2).

Pollen : Pollen grains 3-colporate, sub-prolate (37.2 x 32.3 µm), range 36-40 x 27-35 µm. Amb almost triangular. Colpi membrane almost psilate. Apocolpium diameter about 5 µm and mesocolpium distance about 15 µm. Ora la-longate, thin, small (1.5 x 6 µm) and membrane psilate. Exine about 1.5 µm thick. Sexine thinner than nexine. Nexine about two times thicker than sexine. Sexine pattern obscure (Sharma & Gupta, 1979).

Anatomy : Sapwood is greyish or pinkish white, turning light greyish brown with age. Heartwood small, black, often streaked with comparatively thin light-coloured bands, straight-grained and fine-textured. Growth rings indistinct. Vessels small, arranged in short or long radial multiples of 2-6 or more, evenly distributed, filled with dark-coloured deposits in the heartwood; vessel lines indistinct. Parenchyma in sapwood diffuse, at places forming reticulum with rays. Rays fine, distinct, closely and evenly spaced.

Exsicc.: KARNATAKA : Kanara, May 1939, *N. L. Bor* 11603 ♀ (DD); Kodagu, Kodamakal R. F., Sampaje range, *B. R. Ramesh* 1018, 1334 (HIFP), *De Franceschii* 189 (HIFP); Mukut Forest, *De Franceschii* 219 (HIFP); KERALA : Koruthodo, 200 m, 7th March 1994, *Jony Augustine* 13461 ♂ (KFRI); Palghat, Mukkali Forest, 550 m, 7th March 1975, *E. Vajravelu* 46219 ♂ (MH); Vattaparai R. F., Siruvani western slope, 3rd April 1984, *E. Vajravelu* 80503 ♂ (MH); Vattaparai to Inchikuzhi, 675 m, 29th May 1979, *E. Vajravelu* 62879 ♂ (CAL); Trichur, Vazhachal Reserve, 250 m, 13th April 1977, *K. Ramamurthy* 49313 ♀ (MH); Travancore, Colatoorpolay, 20th April 1903, *T. F. Bourdillon* 1074 ♂ (DD); Forests of Travancore, *T. F. Bourdillon* 831 ♀, 1354 ♂ (K).

9. ***Diospyros buxifolia*** (Bl.) Hiern in Trans. Cambr. Philos. Soc. 12 : 218. 1873; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 97. 1937. *Leucoxylum buxifolium* Bl. Bijdr. Fl. Ned. Ind. 1169. 1826, non *Maba buxifolia* (Rottb.) A. Juss. 1804. *Diospyros vaccinioides* Wall. ex Voigt, Hort. Suburb. 345.

1845, non Lindl. 1825. *Vaccinium fragrans* Wall. ex Voigt, Hort. Suburb. 345. 1845. *Diospyros microphylla* Bedd. Ic. Pl. Ind. Or. 7 : 27. t. 133. 1871; Clarke in Hook. f. Fl. Brit. India 3 : 559. 1882. *D. parvifolia* Hiern in Trans. Cambr. Philos. Soc. 12 : 217. 1873. *D. sphenophylla* Hiern in J. Bot. 62. 1925. *D. elegantissima* Bakh. in Gard. Bull. Str. Settl. 7 : 169. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 103. 1937.

Vernacular names : *Kan.*: Kunchiganamara; *Mal.*: Illaccivicca, Elichevicha, Katlutuvara, Kattuthovara, Thovarakari, Tuvarakkari, Corakkari; *Mar.*: Thokarakori, Anecola; *Or.*: Guakoli; *Tam.*: Chinnattuvarai, Chorakkari, Maligaittuvarai, Molaghuthuvarei, Chinnathuvarai, Irumpalei; *Tel.*: Uti.

Large, dioecious trees, with glabrescent old branches and hirsute with dense, long, pale hairs on young branchlets. Leaves distichous, close together, subsessile, 1-3.5 x 0.5-1.5 cm, elliptic, ovate-elliptic or lanceolate with narrow ends, acute at apex, glabrous above and sparsely hirsute beneath when young, becoming glabrate with age except on midrib and margins; midrib canaliculate above and slightly raised beneath, hirsute bothsides with long hairs; lateral veins 3-5 pairs, inconspicuous bothsides; petioles absent or less than 1 mm long, terete, hirsute. Male flowers subsessile, in 3-flowered, short, axillary, densely hairy, bracteate cymes or 3 to 4-together in axillary fascicles. Bracts upto 1 mm long, ovate, acute, ciliate, hairy outside, glabrous within, each subtending a flower. Calyx campanulate, 1.5-2 mm long, mouth about as wide, divided upto middle or below the middle, hairy outside, glabrous within; lobes 4, broadly ovate, acute, ciliate, hairy outside, glabrous within, imbricate (2 inside, 2 outside). Corolla urceolate or bell-shaped; tube 2-2.5 mm long, about as long as calyx or little exserted, glabrous within, hairy along middle line of lobes outside; lobes 4, *ca* 1.5 mm long, sub-rounded, apiculate, reflexed, glabrous within, hairy along the middle line, contorted. Stamens 10-16 (16 in our material), in two rows, attached at the base of corolla-tube, united in pairs by filaments, glabrous; filaments upto 1 mm long, the inner ones shorter; anthers 1-1.5 mm long, subequal, ovate or oblong, glabrous, apiculate, dehiscing at apex, connectives very shortly produced. Rudimentary ovary globose, ca 1 mm in diam., with flat top, hairy. Female flowers subsessile, axillary, solitary, bracteate. Bracts 1-1.5 mm long, ovate, acute, ciliate, pubescent on the back, glabrous within, attached at the base of flowers. Calyx and corolla exactly like male flowers. Staminodes absent. Ovary ellipsoid, *ca* 1.5 mm long, pubescent in upper region, glabrous below, 4-celled, cells 1-ovuled; style 1, stout, short, less than 1 mm long, thinly pubescent; stigmas 2, glabrous. Fruits cylindrical or oblong, 0.8-2.1 x 0.4-0.8 cm, conical at apex, 1-celled, 1 or 2-seeded, glabrous and shining or sub-glabrous to pubescent at apex. Fruiting-calyx flat, disciform, fruit seated on the disc; lobes 4, spreading, not touching the fruit, pubescent outside, ciliate. Albumen cartilaginous equable; cotyledons about equalling the radicle. I have not seen the fruit and the characters regarding fruit given above have been borrowed from Hiern (1873) (Fig.-9; Plate 4/1).

Holotype : Java, *Blume s.n.* (L).

Fl. & Fr.: March – September.

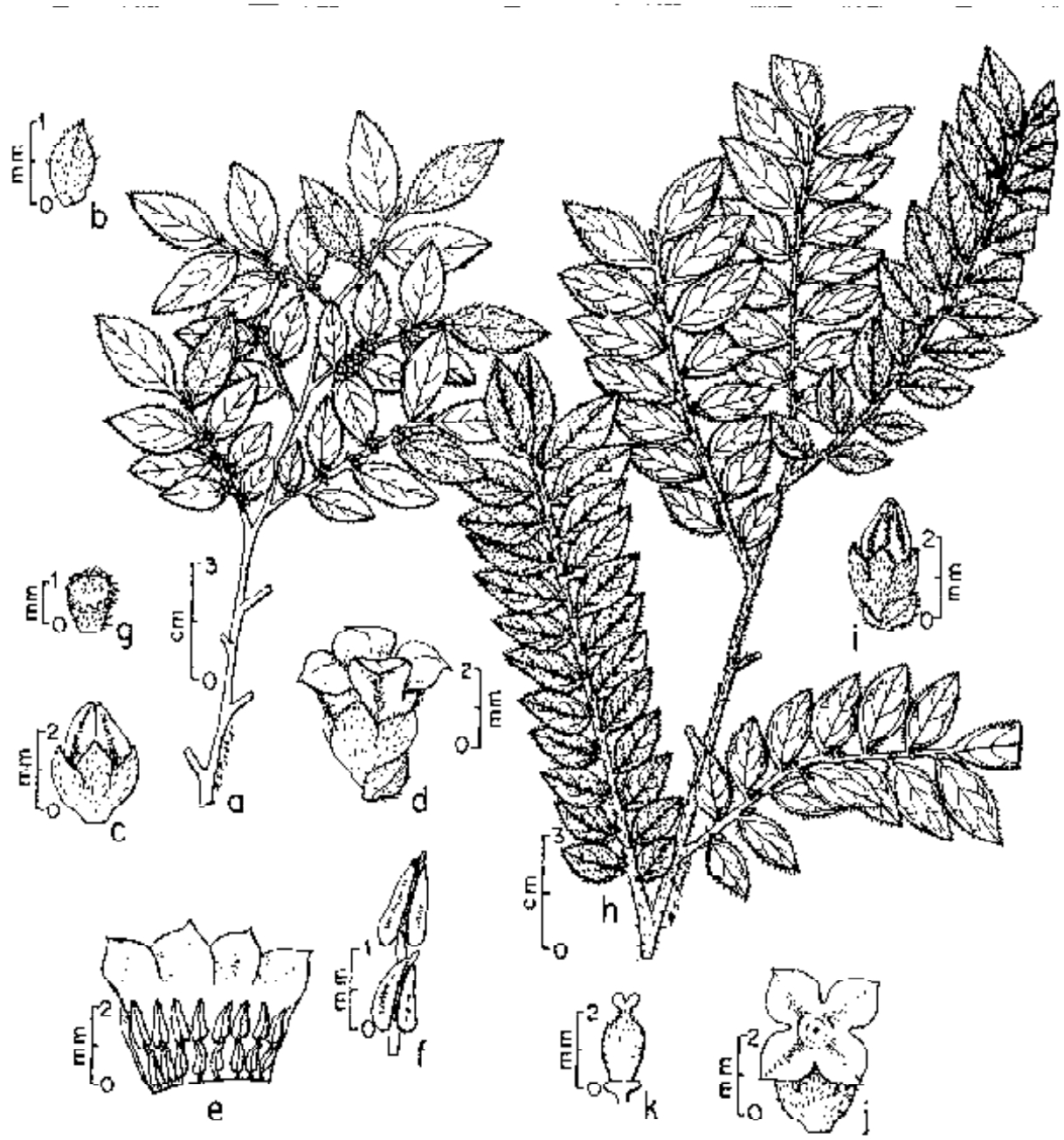


Fig.-9. ***Diospyros buxifolia*** (Bl.) Hiern

Male : a. habit, b. bract, c. flower-bud, d. flower with bract, e. corolla within with stamens, f. stamens, g. pistillode.

Female : h. habit, i. flower-bud with bracts, j. flower, k. gynoecium.

Ecol.: Found in evergreen forests on different kinds of soils, upto 1000 m. *Stromatium barbatum* - a borer, is reported to infest this species. It is also attacked by white ants.

Distrib.: In India, this species is found in Goa, Maharashtra, Karnataka, Tamil Nadu and Kerala. Beyond Indian territory, the taxon is reported from Madagascar, Myanmar, Borneo, Bali, Java, Indonesia, Singapore, Malaysia (native home), Laos, Cambodia, Vietnam, Molucca, Philippines and New Guinea (**Map-2**).

Pollen : Grains 3-zonocolporate; ectocolpium membrane crustate; endocolpium la-longate, 3 x 9 µm. Exine surface psilate. Size 31-37 x 20-30 µm (Nair & Kothari, 1985).

Anatomy : The wood is diffuse-porous. Pores large, often subdivided, obliquely arranged. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The transverse bars narrow, close and frequent, concentric. The heartwood and sapwood are indistinct, straight-grained, fine-textured (Gamble, 1881; Purkayastha, 1982).

Phytochemistry : The sapwood of this species yields a blue pigment 2, 2'-binaphthyl-1, 1'-quinone. It is closely related to manegakinone (binaphthyldiquinone) present in *D. lotus* L. (Musgrave & Skoyles, 1970). According to Rastogi & Mehrotra (1993b, 1993c), the blue pigment of wood is diasindigo – A. The plants also contain β sitosterol, betulinic acid, lupeol and betulin (Rastogi & Mehrotra, 1993b).

Uses : The wood is suitable for match boxes and splints. Branches of young plants are used for walking sticks. Fruits are edible. It is also planted as an ornamental tree.

Notes : During present study, it was observed that the specimens identified as *D. buxifolia* (Bl.) Hiern in Indian herbaria actually belong to *D. ferrea* (Willd.) Bakh. Further, the specimens identified as *Maba buxifolia* (Rottb.) A. Juss. have also been placed under the same cover of *D. buxifolia* (Bl.) Hiern. This misconception has probably developed due to consideration of *Maba buxifolia* (Rottb.) A. Juss. as synonymous to *D. buxifolia* (Bl.) Hiern due to identical specific epithets. Hiern (1873) has, however, based his *D. buxifolia* (Bl.) Hiern on *Leucoxylum buxifolium* Bl. which differs from *Maba buxifolia* (Rottb.) A. Juss. (basionym *Pisonia buxifolia* Rottb.) in the characters of leaf, hairiness, number of floral parts, aestivation, fruit shape and seed characters. *Maba buxifolia* (Rottb.) A. Juss. is synonymous to *D. ferrea* (Willd.) Bakh. without any doubt. Further, it is also confirmed here that *D. microphylla* Bedd. is synonymous to *D. buxifolia* (Bl.) Hiern as pointed out by Beddome (1871) himself.

Exsicc.: GOA : N. Goa, Mollam, Awadam, 16th March 1971, *K. N. Bahadur & R. C. Gaur* 2660 ♀ (DD); KARNATAKA : North Kanara, March 1883, *W. A. Talbot* 375 ♂ (CAL); KERALA : Travancore, Aug.-Sept. 1913, *C. C. Calder & M. S. Ramaswami* 270 sterile (CAL); Topsup, 750 m, Oct. 1949, *R. L. Awasthi* 35 ♀ (DD); Kullachickera, 16th Feb. 1987, *G. S. Puri* 15163 sterile (BSI); MAHARASHTRA : Yellapur, 25th April 1939, *N. L. Bor* 9654 sterile (DD).

10. ***Diospyros cacharensis*** (Das & Kanj. f.) Naithani *in* Ind. For. 106 (8) : 583. f. 1. 1980; Jayaraman in Bull. Bot. Surv. India 34 (1-4) : 231. 1992. *Maba cacharensis* Das & Kanj. f. in Assam Foilr. Rec. 1 : 15. t. 7. 1934 & in Kanj. *et al.* Fl. Assam 3 : 207. 1937.

Deciduous, dioecious trees, 9-12 m high, with pilose branchlets. Bark black or dark brown. Leaves bifarious, 3.5-17.5 x 0.75-5 cm, lanceolate or oblong-lanceolate, rounded at base, apex acuminate, papery, entire, ciliate, pilose bothsides especially along the nerves, not pellucid-punctate; midrib canaliculate above; lateral nerves 7-14 pairs, subarcuate, prominent beneath; petioles 2-3 cm long, pilose, depressed or canaliculated above. Male flowers in 9 to 12-flowered, axillary, pedunculate cymes, 3-merous. Bracts and bracteoles linear to ovate-lanceolate, subpersistent. Calyx-lobes 3, pilose outside, glabrous within; lobes broadly ovate, valvate. Corolla tubular; lobes 3, deeply divided, broadly ovate, subequal, pilose outside, contorted. Stamens 12, rarely 6-9. Pistillode hairy. Female flowers *ca* 1 cm long, in 8 to 25-flowered, fascicled or solitary racemes from old wood, 3-merous. Bracts lanceolate-subulate, 3-5 mm long, subpersistent; pedicels stout, 2-3 mm long. Calyx persistent, 3-lobed, pilose outside, glabrous within; lobes 2-3 mm long, suborbicular or broadly ovate, acute, valvate. Corolla tubular, 3-lobed, dull white, *ca* 5 mm long, thinly pilose on the back; lobes *ca* 2.5 mm wide, recurved, contorted. Staminodes 3, *ca* 2.5 mm long. Ovary densely pilose, 6-celled, cells 1-ovuled; style 3-fid at apex; stigmas somewhat laciniate. Fruits 3-4 x 2.5-3 cm, ovoid, shortly beaked, glabrous, with persistent calyx at base. Albumen equable (**Fig.-10**).

Holotype : India : Assam, North Cachar hills, Borail Reserve, *U. N. Kanjilal* 5716 ♀, Acc. no. 281785 (CAL).

Fl. & Fr.: April – November.

Ecol.: Occasionally found in semi-evergreen rain forests, upto 1500 m.

Distrib.: This species was considered endemic to India, chiefly confined to Arunachal Pradesh, Assam and Meghalaya. Recently, Jayaraman (1992) has reported its occurrence in Burma based on Fischer's collection no. 5426, 74285 (DD) (**Map-2**).

Notes : The characters of male plants have been borrowed from Jayaraman (1992), based on C. E. C. Fischer's collection no. 5426 ♂, 74285 ♂ (DD) collected from Burma (Bodechg, Namma Reo, 227 m, 4th May 1927). I couldn't examine the said specimens.

Exciss.: ARUNACHAL PRADESH : Siang, Likhabali, 800 m, 4th May 1977, *H. B. Naithani* 951 ♀ (DD); ASSAM : Cachar, Borail Reserve, *A. Das* 10548 ♀ (Syntype – ASSAM); Lakhimpur, Dulong Reserve, *U. N. Kanjilal* 3653 ♀ (Syntype – ASSAM); Khasi hills, Nongkhlaw, 1150 m, *C. B. Clarke* 18115 ♀ (Syntype – CAL).

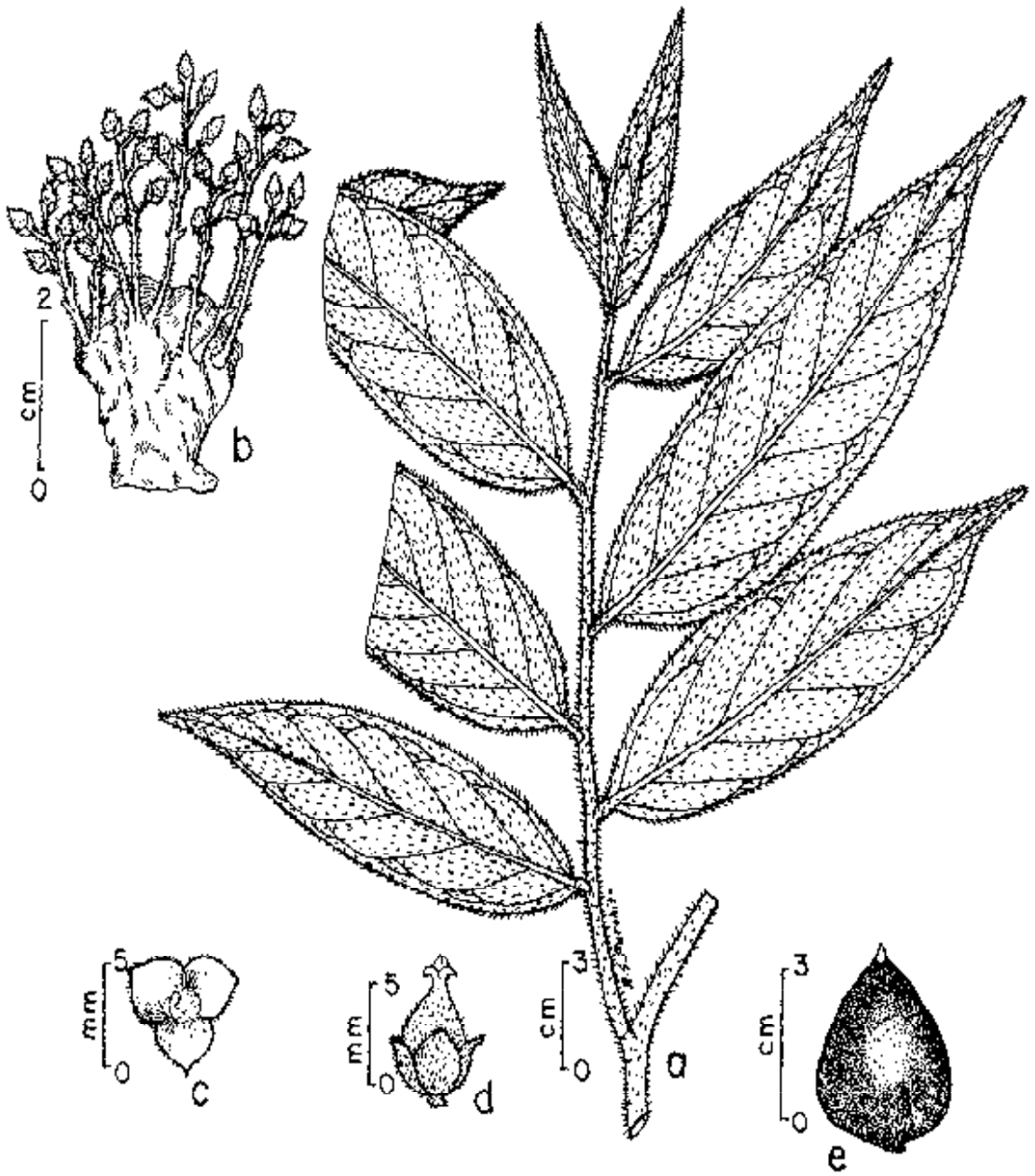


Fig.-10. ***Diospyros cacharensis*** (Das & Konj. f.) Naithani
Female : a. habit, b. inflorescence, c. calyx (top view),
d. gynoecium with calyx, e. fruit.

Distrib. Sketch Map – 2

● *Diospyros barberi* Ramas.; ▲ *Diospyros benghalensis* Bakh.;
■ *Diospyros bourdillonii* Brandis; o *Diospyros buxifolia* (Bl.) Hiern;
★ *Diospyros cacharensis* (Das & Kanj. f.) Naithani

11 ***Diospyros candolleana*** Wight, Ic. 4 (1) : 9. t. 1221, 1222. 1850, non Thw. 1860; Clarke in Hook. f. Fl. Brit. India 3 : 566. 1882. *D. hirsuta* L. f. forma *candolleana* (Wt.) Hiern in Trans. Cambr. Philos. Soc. 12 : 164. 1873.

English name : Ebony.

Vernacular names : *Kan.*: Karemara, Kari; *Mal.*: Kari, Karimaran; *Mar.*: Karamaran; *Or.*: Kaduamoriyo; *Sans.*: Nilavriksa; *Tam.*: Karimarom, Karikkattai; *Tel.*: Tadar, Jagalaganti.

Medium-sized trees, with thinly fulvous pubescent branchlets. Leaves alternate, 6-18 x 3.5-7.5 cm, ovate-elliptic or elliptic, cuneate to rounded at base, sub-acuminate at apex, coriaceous, adpressed fulvous hairy beneath when young, soon glabrescent bothsides; midrib raised beneath, canaliculate above; lateral nerves 8-15 pairs, not very conspicuous, venation reticulate towards margins and parallel on either side of the midrib; petioles 3-12 mm long, canaliculate above, rounded beneath. Male flowers sessile, in axillary dense clusters on short fulvous tomentose peduncles. Calyx 4-6 x 2-2.5 mm, campanulate, fulvous-tomentose bothsides, 5-lobed, divided half way down; lobes triangular, obtuse, fulvous-tomentose bothsides, valvate. Corolla-tube 5-7 mm long, tubular, constricted about the middle in bud, tomentose outside, glabrous within; lobes 5, ovate, acute, tomentose outside, glabrous within, contorted. Stamens 10, glabrous, inserted at the base of corolla-tube, in two rows, outer ones larger with 2 mm long anthers and as long filaments, inner ones smaller with 1.5 mm long anthers and *ca* 1 mm long filaments, the smaller and longer stamens united at base by their filaments in pairs; anthers narrowly ovate, glabrous, long apiculate. Pistillode ovoid, densely hairy with long hairs. Female flowers sessile, in axillary, bracteate clusters of few flowers. Bracts ovate, *ca* 2 x 1.5 mm, hairy bothsides, attached to the base of the calyx. Calyx-tube broadly campanulate, *ca* 3 mm long, hairy bothsides, mouth *ca* 6 mm wide; lobes 5, longer than tube, *ca* 4 mm long, ovate, subacuminate, tip curved backside, margins rolled outside, valvate. Corolla urceolate; lobes 5, contorted. Staminodes 5, glabrous, attached at the base of corolla-tube. Ovary hairy, 4-celled, cells 1-ovuled; style simple; stigma bilobed. Fruits globose or subglobose, 2.5-3 cm in diam., glabrous, pale. Mature fruiting-calyx deeply lobed, flat, without tube at base; lobes spreading, rigid, not embracing the fruit, not veined, margins rolled outside, not dilated. In young fruits, however, the calyx is shallowly bowl-shaped, enclosing the lower part of fruit with erect lobes having outwardly rolled margins showing tendency of downward reflection. Seeds 4, ovate-oblong, *ca* 3 x 0.8 cm, sub-compressed, smooth; albumen ruminate (**Fig.-11; Plate 4/2 & 3**).

Holotype : Peninsular Indiae Orientalis, Courtallum, Herb. *Wight* 1715 (K).

Fl. & Fr.: February – June.

Ecol.: In evergreen forests along the coasts and foot of Ghats, upto 2000 m. The plants may be propagated through seeds and vegetative methods (Prajapati *et al.*, 2003). The timber is susceptible to drywood borers.

Distrib.: In India, the species is confined to Goa, Maharashtra, Karnataka, Kerala and Tamil Nadu. It is also reported from Nepal, which indicates disjunct distribution in highly variable climatic zones (**Map-3**).

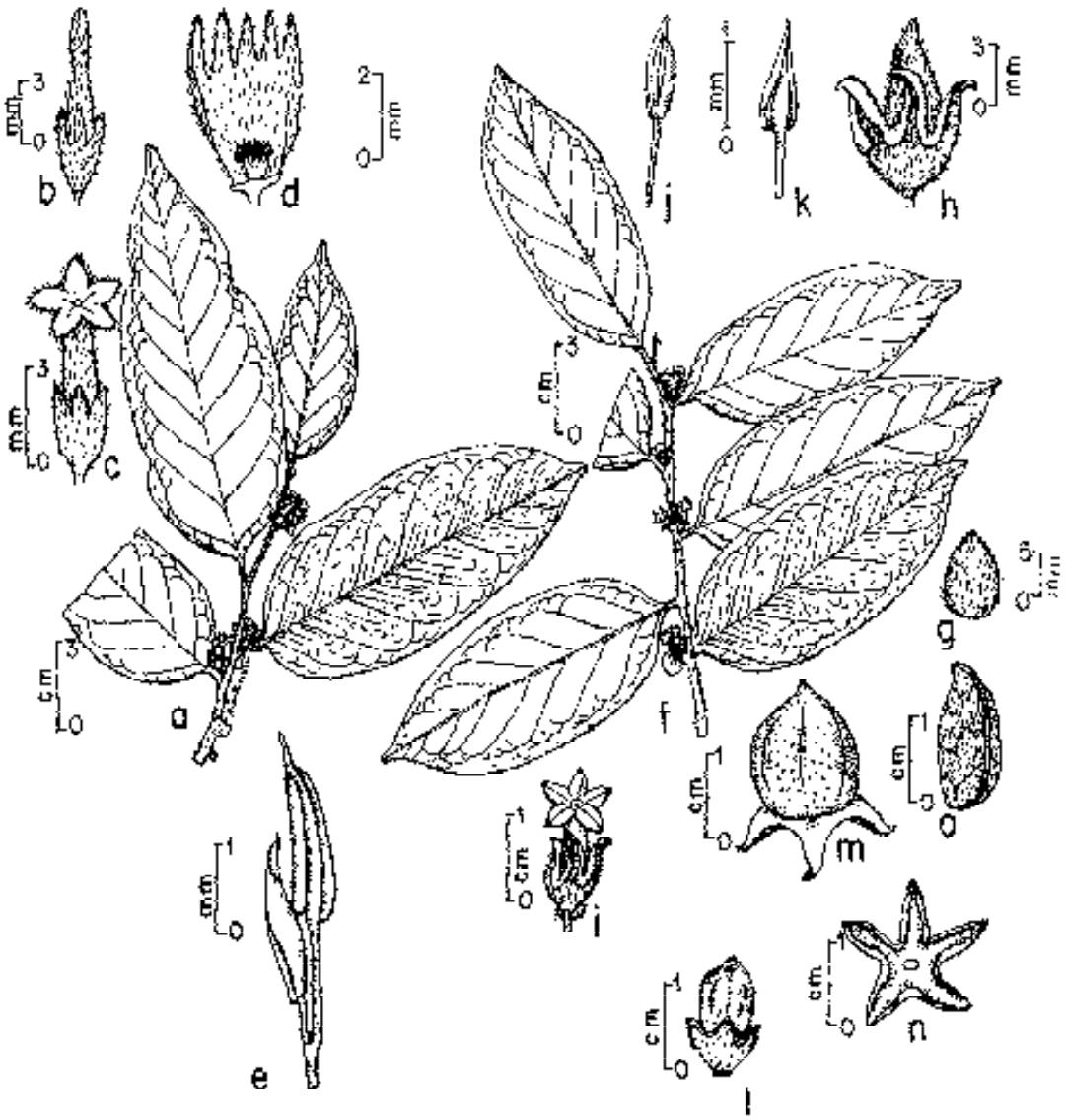


Fig.-11. ***Diospyros candolleana*** Wight

Male : a. habit, b. flower-bud, c. flower, d. calyx within with pistillode, e. stamens.

Female : f. habit, g. bract, h. flower-bud, i. flower, j-k. staminodes,

l. immature fruit with calyx,

m. mature fruit with calyx, n. fruiting-calyx (dorsal view), o. seed.

Pollen : Pollen grains 3-colporate, sub-prolate (36.3 x 30.0 µm), range 35-38 x 25-32.5 µm. Angulo-aperturate. Amb triangular. Colpi long, thin, running from pole to pole. Membrane psilate. Apocolpium indistinct and mesocolpium distance about 12 µm. Ora la-longate, small. Exine about 1.5 µm thick. Sexine thinner than nexine. Sexine pattern obscure (Sharma & Gupta, 1979).

Anatomy : The wood is diffuse-porous. Pores small to moderate-sized, scanty, subdivided. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The transverse bars are fairly prominent, combining into wavy concentric lines. The heartwood and sapwood are indistinct, straight-grained, fine-textured (Gamble, 1881; Purkayastha, 1982).

Phytochemistry : Stem and bark contain betulin, betulinic acid and lupeol. Prajapati *et al.* (2003) have reported β-sitosterol, 7-methyljuglone and diospyrin from the stem-bark and isodiospyrin and a trinaphthaquinone xylopyrin from the wood. The leaves contain taraxerol (Asolkar *et al.*, 1992). Roots have also been reported to contain diospyrin, besides betulin and betulinic acids.

Uses : The powder or decoction of the root-bark is used in rheumatism and swellings in Maharashtra (Nadkarni, 1976). The seeds yield an oil which is of high pharmacopic value (Jayaraman & Singh, 1988).

Notes : Hiern (1873) has rightly cited *D. arnottiana* Miq. ex Thw. (1860) conspecific to *D. oocarpa* Thw., contrary to Clarke's (1882) concept who considered it synonymous to *D. candolleana* Wight. Further, Wight (1850) has spelt the specific epithet as "*candolliana*" in the protologue.

Exsicc.: GOA : North Goa, Valpoi Range, Karusal, 22nd March 1972, *K. N. Bahadur & R. C. Gaur* 2852 ♀ (DD); South Goa, Sanguem Range, Juna-Sange Road, 19th March 1971, *K. N. Bahadur & R. C. Gaur* 2737 ♀ (DD); Butpal, Conacanna, 21st March 1971, *K. N. Bahadur & R. C. Gaur* 2762 ♀ (DD); Valpoi-Pacet Range, 8th May 1976, *Peerzada* 94971 ♀ (LWG); KARNATAKA : Mysore, Galingudda, Agumbe, 13th May 1962, *R. S. Raghwan* 80549 ♂ (BSI); North Kanara, Karwar, April 1918, *Sedgwick* 3874 ♀ (DD); KERALA : Agasthyamalai, Neyyar, 500 m, 29th Sept. 1993, *N. Mohanan* 11555 ♀ (TBGT); Kasaragod, Mulleria, 300 m, 8th May 1982, *V. J. Nair* 71076 ♂ (MH); Travancore, Arqaukaru, 15th July 1898, *T. F. Bourdillon* 1482 ♀ (DD); Cannanore, Manjeswer, 50 m, 3rd July 1980, *R. Ansari* 67961 ♀ (MH); Palghat, Pathenthode, Way to Silent valley, 750 m, 10th April 1978, *N. C. Nair* 56718 ♀ (MH); Iddukki, Valara water falls, 1800 m, 24th Sept. 1982, *K. Ramamurthy* 74799 ♀ (CAL); MAHARSHTRA : Nadguem-Butpal Road, 24th April 1966, *John Cheriam* 109045 ♀ (RHMD); Ratnagiri, Narur, Dukanwad, 7th April 1971, *B. G. Kulkarni* 128766 ♂ (BSI).

12. ***Diospyros cauliflora*** Blume, Bijdr. Fl. Ned. Ind. 668. 1825, non Hasselt ex Hassk. 1848, nec Mart. ex Miq. 1856; A. DC. in DC. Prodr. 8 : 238. 1844; Hiern in Trans. Cambr. Philos. Soc.

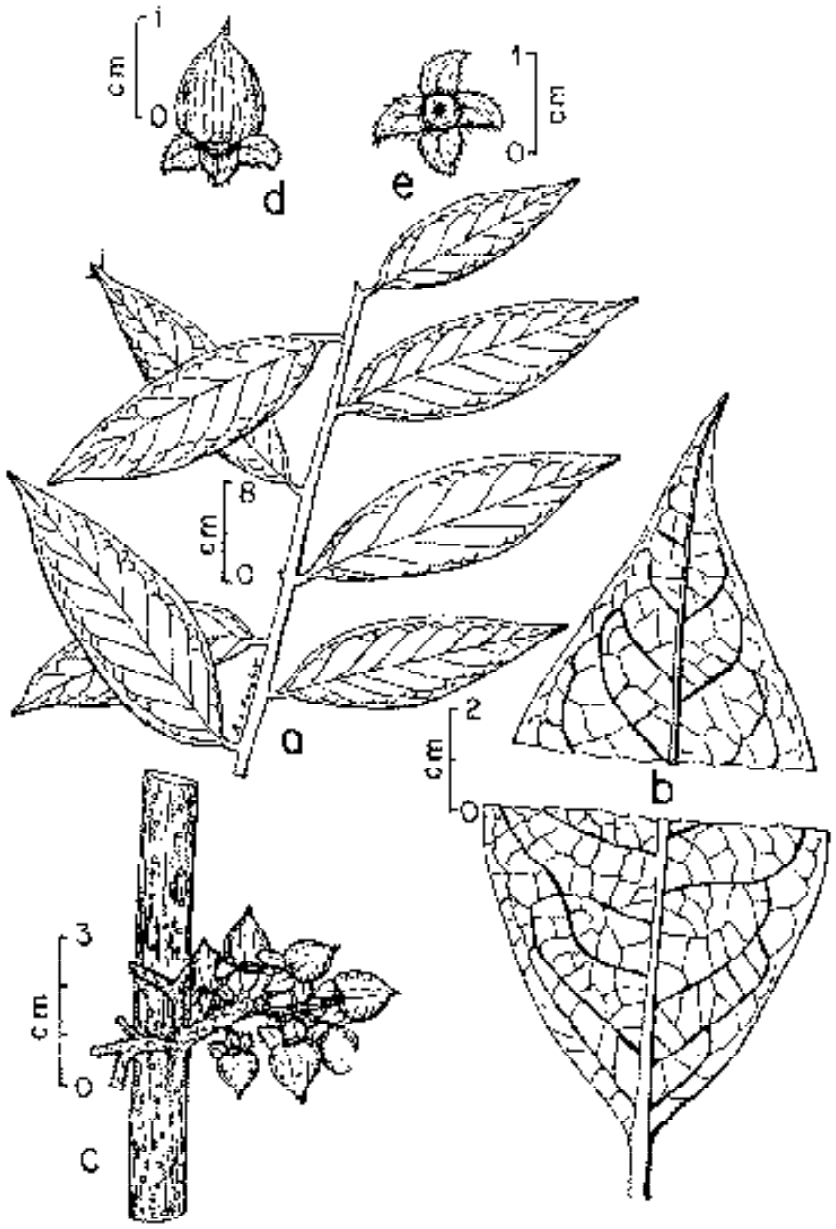


Fig.-12. ***Diospyros cauliflora*** Blume

Female : a. habit, b. leaf, c. inflorescence with immature fruits borne on old branch, d. mature fruit with calyx, e. fruiting-calyx (ventral view).

12 : 234. 1873; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 134. 1937; Rao in J. Econ. Taxon. Bot. 7 (3) : 629. 1985. *D. zollingeri* Hiern in Trans. Cambr. Philos. Soc. 12 : 222. 1873. *D. pergamena* Hiern in Trans. Cambr. Philos. Soc. 12 : 234. 1873. *D. perforata* Hiern in Trans. Cambr. Philos. Soc. 12 : 243. 1873. *D. caliginosa* Ridley in Trans. Linn. Soc. 3 (2) : 318. 1893. *D. perganacea* Hiern ex Boerl. Handl. Fl. Ned. Ind. 2 : 317. 1899. *D. treubii* Hochr. Cat. Bogor. Exsicc. 14. 1904. *D. trunciflora* Ridley in J. Str. Br. Royl. Asiat. Soc. 57 : 67. 1910. *Rinorea pulgarensis* Elm. in Leafl. Phil. Bot. 5 : 1849. 1913. *Diospyros fasciculiflora* Merr. in Phil. J. Sci. 9 : 334. 1914. *D. urdanetensis* Elm. in Leaft. Phil. Bot. 7 : 2624. 1915. *D. pulgarensis* (Elm.) Merr. in Phil. J. Sci. 12 : 286. 1917. *D. refracta* Hiern in J. Bot. Suppl. 63 : 63. 1925.

Dioecious trees, 3-7 m high. Bark blackish-grey, cracked, sparsely lenticelled, glabrescent. Leaves alternate, 10-40 x 2.5-12 cm, elliptic or oblong-lanceolate, attenuated at both ends, gradually acuminate at apex, margins somewhat revolute, glabrous on maturity, shining; midrib depressed-canaliculate above, raised beneath; lateral nerves distantly placed, 12 to 18 pairs, prominent beneath, inconspicuous above, arcuately anastomosing near margins, tertiary venation reticulate, prominent beneath; petioles 5-10 mm long, half-terete, depressed or grooved above, rounded beneath. Male flowers in axillary cymes. Calyx urceolate or campanulate, hairy outside, glabrous within; lobes 4, ovate-deltoid, ciliate, imbricate. Corolla urceolate, rufous tomentose outside, glabrous within; lobes 4, ovate, acute, contorted. Stamens 16, unequal, in pairs, pubescent, inserted at the base of corolla-tube; anthers pubescent on the back, dehiscing widely on bothsides downwards from apex, connectives produced, apiculate. Female flowers crowded in dense, lateral, 3 to 5-flowered, racemose panicles on the older wood; peduncles *ca* 2.5 cm long, thickened upwards; pedicels bracteate. Calyx campanulate, deeply 4 to 5-lobed, tomentose bothsides; lobes narrow, undulate-margined, reflexed, turning black, imbricate. Corolla urceolate; tube much constricted at the top, 4-gonal, with black hairs on the angles; lobes 4, pale-yellow, contorted. Staminodes 8-10, inserted at the base of corolla-tube. Ovary subglobose, tomentose, 4 to 6-celled, cells 1-ovuled. Fruits fleshy, ovoid or globose, 2-2.5 x 1.5-1.8 cm, gradually narrowed at apex into a beak upto 5 mm long, brown or red tomentose when young, turning black on maturity and glabrescent, 4 to 6-celled, cells 1-seeded each, some imperfect, pericarp longitudinally wrinkled in dry fruits. Fruiting-calyx enlarged, upto 1.5 cm in diam., accrescent, no tube; lobes 4, 4-5 mm long, ovate, imbricate, reflexed, not embracing the fruit, woolly tomentose bothsides. Seeds usually 4, ovate-oblong, flattened on two sides, convex on one side, *ca* 1.5 x 1 cm, smooth, white; albumen equable and radiatly striate, not ruminated; embryo turning yellow (**Fig.-12; Plate 4/4**).

Holotype : Java, *Blume s.n.* (L).

Fl. & Fr. : March – October.

Ecol.: Rare, recently invaded tropical rain forests, mostly near streams.

Distrib.: In India, this species is known from Andaman & Nicobar Islands. Sometimes cultivated in Uttar Pradesh. Further eastwards it extends to Myanmar, Thailand (Siam), Sumatra, Java, Borneo,

Lombok, Bali, Malaya (native home), Philippines, Celebes, Molucca, New Guinea, Laos, Cambodia and Vietnam (**Map-3**).

Anatomy : Utsunomiya *et al.* (1998) have studied the tannin cells in the mesocarp of the fruit and reported that they occupy 30-50 per cent area of the mesocarp.

Uses : Fruits are eaten by the Shompen tribes in Great Nicobar Island. They are used for dyeing in Thailand (Utsunomiya *et al.*, 1998).

Exsicc.: ANDAMAN & NICOBAR : South Nicobar, Great Nicobar Island, Jhau nallah, 30th Oct. 1984, *V. Rao & T. Chakraborty* 10261 (PBL); Galathea river bank, 17th Oct. 1979, *D. K. Hore* 7223 ♀ (PBL); Campbell bay to Chengappa bay, Sea level, 27th July 1976, *N. P. Balakrishnan* 4042 ♀ (PBL); UTTAR PRADESH : Lucknow, National Botanical Garden, 1st June 1965, *Mohd. Aslam & Puttilal* 20225 ♀ (LWG).

13. ***Diospyros chloroxylon*** Roxb. Pl. Cor. 1 : 38. t. 49. 1795; A. DC. in DC. Prodr. 8 : 230. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 233. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 560. 1882. *D. glauca* Rottl. in Gesell. Naturf. Freunde zu Berlin, Neue Schrift. 4 : 221 1803. *D. tomentosa* Poir. in Lam. Encycl. 5 : 436. 1804, non Roxb. 1832, nec Jeanneney 1922. *D. capitulata* Wight, Ic. 4 (1) : 9. t. 1224. 1850.

var. ***chloroxylon***

English names : Green Ebony Persimmon, Coromandel Ebony.

Vernacular names : *Beng.*: Anduli; *Guj.*: Timru, Neenye, Ninai; *Hindi*: Pankaphan; *Kan.*: Karugariathumara; *Mar.*: Nensi, Ninai, Niani; *Or.*: Kosai, Kasse, Ondodi, Aduli, Koshayo, Gaurkasa; *Tam.*: Karuva-vakkanai, Kamvakkunai, Periyulinci, Vakkanai; *Tel.*: Illinda, Illintha, Yellintha, Ullingi, Ullinda, Aulanche, Valinda, Nella ulimira, Vullinda, Vullingi, Kayakimanu, Peddavulindi, Tellavulimidi, Tori, Togarike, Ulimera, Ulanta, Yellintachettu, Allipaluchettu, Nellawoolymera.

Trees or shrubs, with spreading ferruginous young branches; branches often spinous. Bark scabrous, dark rust-coloured. Leaves alternate, 1-7.5 x 0.8-4 cm, oval-oblong to obovate-rhomboid, rounded to subcuneate at base, rounded, obtuse or mucronate at apex, coriaceous, villous hairy when young, becoming pubescent to glabrate with age; midrib prominent and raised beneath, not canaliculate above; lateral veins inconspicuous bothsides; petioles 2-6 mm long, terete, hairy, nor canaliculare above. Male flowers white, sessile or subsessile, 4 to 10-together, clustered on short, axillary, hairy peduncles; peduncles upto 2 mm long. Bracts oval, small, attached at the base of calyx. Calyx 2-3 mm long, campanulate, suddenly narrowed at base into a short stalk, mouth as wide as tube, densely hairy outside, glabrous within, 4-lobed nearly to the base; lobes obovate, densely hairy outside, glabrous within, rounded at apex, contorted. Corolla urceolate, not much exserted from the calyx, pubescent outsides along the middle line of lobes only; lobes 4, ovate-lanceolate, contorted. Stamens 16, paired,

glabrous, unequal in pairs, in 2 rows, inserted at the base of corolla-tube; anthers dimorphic, outer ones larger, oblong, apiculate, 0.75-1 mm long, with *ca* 5 mm long filaments, inner ones smaller, ovate, apiculate, upto 0.75 x 0.5 mm, with *ca* 0.2 mm long filaments, all glabrous, opening by subapical slits, connectives apiculate. Pistillode glabrous. Female flowers sessile, axillary, solitary. Bracts longer than males. Calyx 2-3 mm long and about as wide, densely hairy outside, glabrous within, somewhat shortly campanulate with very short tube at base, deeply 4-lobed; lobes broadly ovate, 2-3 mm long, apiculate, hairy outside, glabrous within, contorted. Corolla urceolate, pubescent having 4 hairy lines outside down the middle of lobes only, like males; lobes 4, ovate-lanceolate, contorted. Staminodes 7-8, rarely 9, inserted within the corolla-tube or appressed to the ovary. Ovary flask-shaped, *ca* 3 mm long, glabrous, 8-celled, 1-ovuled in each locule; styles 4, *ca* 1.5 mm long, glabrous; stigmas 2-lobed. Fruits globose, glabrous, 7-10 mm in diam., apiculate, pale-olive-coloured. Fruiting-calyx flat, disc-like, 7-9 mm in diam., fruit seated on the disc, no tube, not thickened, no internal elevated rim; lobes 4, spreading, coriaceous, margins flat, neither thickened nor revolute. Seeds 2-3, usually 1 or 2 mature and rest abortive, mature seed globular if one or flat or concave on the inner face and convex on the outer face if two mature, 4-5 mm long and about as wide, the abortive seeds trigonous or otherwise; albumen equable (**Fig.-13; Plate 5/1, 2 & 3**).

Holotype : Roxburgh Plate 49, Pl. Cor. (K).

Fl. & Fr.: April – August.

Ecol.: Common in dry evergreen and mixed deciduous forests, upto 1000 m. Plants prefer laterite and sandstone soils. The seeds germinate early in the rainy season and seedlings can withstand considerable shade. The borer *Stromatium barbatum* is reported to infest this species. Rao *et al.* (1981) have carried out physiological studies on the relationship of cuticle and epicuticular wax thickness and rate of transpiration. The study revealed no correlation between them; the higher rates of transpiration are associated with greater level of fatty acids, and the higher levels of aldehydes and alcohols in the wax are possibly correlated with lower rates of cuticular transpiration. Thus, physiological characters override ecological features in successful adaptation of this species in semi-arid environment.

Distrib.: This species is commonly found in Uttar Pradesh, Jharkhand, West Bengal, Assam, Meghalaya, Orissa, Gujarat, Chhattisgarh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu. Southwards, it extends to Sri Lanka and eastwards to Myanmar through Bangladesh (**Map-3**).

Pollen : Pollen grains 3-colporate, prolate-spheroidal (32.5 x 25.0 µm). Anguloaperturate. Amb sub-triangular. Colpi long, thin, running almost from pole to pole. Membrane ornamentally granulate. Maximum width of colpus *ca* 1.5 µm. Apocolpium *ca* 3 µm and mesocolpium *ca* 12 µm. Ora la-longate, 2.5 x 10 µm. Exine *ca* 2 µm thick. Sexines slightly thinner than nexine. Sexine pattern granulate (Sharma & Gupta, 1979).

Fig.-13. ***Diospyros chloroxylon*** Roxb. var. ***chloroxylon***

Male : a. habit, b. flower-bud, c. calyx within with pistillode, d. stamens.

Female : e. habit, f. calyx enclosing gynoecium, g. calyx-lobe (ventral view), h. calyx-lobe (dorsal view), i. staminode, j. gynoecium, k. fruit, l. fruiting-calyx (dorsal view), m. seed (concavo-convex), n. seed (globose).

Anatomy: The seeds develop mainly from the enlarged chalazal end of the ovule. The free part of testa is confined to the conical micropylar end. The tegmen disappears soon. Ruminations are as slight ridges from the chalazal part of the seed-coat (Periasamy, 1966).

Phytochemistry : Sidhu & Prasad (1967, 1970) have isolated four compounds from the wood and bark, besides diospyrin. These are (i) isodiospyrin – the first optically active binaphthoquinone; (ii) xylospyrin – the first trinaphthalene quinone; (iii) 8-dimethoxy-2, 7-dihydroxy, 3-methyl naphthalene and (iv) 1, 2, 7, 8-tetramethoxy-3-methyl naphthalene. The fruits contain lupeol, betulin, betulinic acid and β-sitosterol (Pastogi & Mehrotra, 1993a).

Uses : Ripe fruits are sweet, very palatable and edible. Sometimes the leaves are also eaten by the natives as vegetable (Jayaraman, 1996). They also serve a good fodder for cattle. Stem-bark is used medicinally for bone fracture by Konda, Reddis and Valmikis in Eastern Ghats (Andhra Pradesh). For this, the stem-bark is ground with the bark of *Holoptelea integrifolia* (Roxb.) Planch., roots of *Plumbago zeylanica* L., *Allium sativum* L. (Garlic) and *Syzygium aromaticum* (L.) Merrill & Perry (Clove) and the paste of above is made into pills which are taken orally twice a day till cure. The Chenchus tribals of this area take 2 spoonful juice of leaves twice a day to cure diarrhoea and menstrual disorders (Rao & Henry, 1996).

Wood is yellowish-grey, moderately hard and durable and used variously by the natives, particularly for ploughs, combs, furniture and tool handles. Wood is also used for fuel, especially for making charcoal.

Exsicc.: ANDHRA PRADESH : Cuddapah, Baleipalle hills, 450 m, Feb. 1883, *J. S. Gamble* 11125 ♀ (DD); Kurnool, C. N. Road-Chelama, 365 m, 6th July 1963, *J. L. Ellis* 16777 ♀ (MH); Owk R. F., 27th Feb. 1984, *R. R. V. Raju* 3030 ♀ (CAL); Chittoor, Mardana forest near Palamaner, 12th Dec. 1987, *D. R. Charyulu* 1932 ♀ (CAL); Karimnagar, Nimmagodem, 36 km from Mahadevpur, Chintakani Range, 14th Feb. 1973, *S. L. Kapoor & Party* 70906 ♀ (LWG); Mahadevpur, Near Regulagu-dem, 200 m, 13th Feb. 1986, *N. Rama Rao & T. Ravi Shankar* 83179 ♀ (MH); Mahadevpur, 10th Feb. 1973, *S. L. Kapoor* 70814 ♀ (LWG); Mannanur, 23rd Nov. 1968, *Singh & Party* 1915 ♀ (CDRI); East Godavari, Devipatanam, 200 m, 26th June 1965, *G. V. Subbarao* 24451 ♂ (MH); West Godavari, Koruturu, Polavaram, 108 m, 24th June 1983, *N. Rama Rao* 76829 ♂ (MH); CHHATTISGARH : Bastar, Jan. 1943, *H. J. Mooney* 2152 sterile (DD); JHARKHAND : Chota Nagpur, Jan. 1881, *J. S. Gamble* 9109 ♀ (DD); Palamau, Dec. 1880, *J. S. Gamble* 8782 sterile (DD); MADHYA PRADESH : Nimar, Chandni Range, 1908, *D. O. Witt* 1190 ♀ (DD); Chanda, 25th Jan. 1990, *J. F. Duthie* 9557 ♀ (DD); MAHARASHTRA : Chandrapur, Katejari, Plot No. 119, 27th Feb. 1971, *B. M. Wadhwa* 133526 ♀ (BSI); MEGHALAYA : Garo hills, *T. D. Srinivasan* 1 ♂ (CAL); ORISSA : Ganjam, Jan. 1884, *J. S. Gamble* 13761 ♀ (DD); Puri, Nabinabagh, 6th Aug. 1917, *H. H. Haines* Acc. No. 18516 sterile (DD); 19th April 1916, *H. H. Haines* 4856 ♀ (DD); Angul, 180 m, 5th Dec. 1902, *J. H. Lace* 2548 ♀ (DD); TAMIL NADU : North Arcot, Mantharakultai, Kavalur, 650 m, 18th March 1978, *E. Vajravelu* 53483 ♀ (CAL);

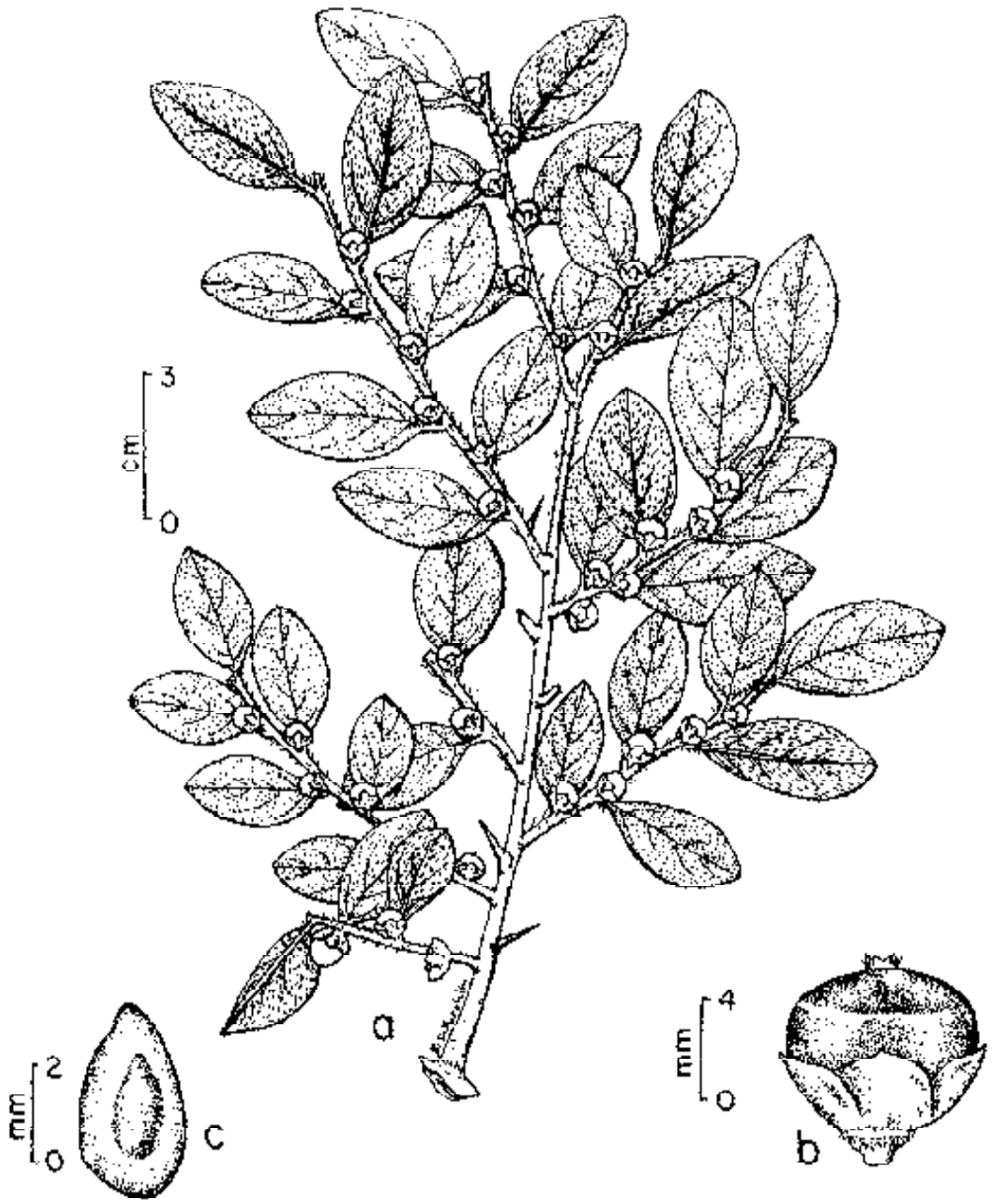


Fig.-14. ***Diospyros chloroxylon*** Roxb. var. ***cupulosa*** Singh
Female : a. habit, b. fruit with calyx, c. seed.

UTTAR PRADESH : Gorakhpur, Near Chowk, 4th May 1898, *Harsukh* 22320 ♀ (DD); Bahraich, Kakardassi, 20th April 1900, *Inayat* 23706 ♂ (DD).

14. ***Diospyros chloroxylon*** Roxb. var. ***cupulosa*** Singh, V. var. nov.

D. chloroxylon Roxb. var. *chloroxylon* arte affinis sed fructibus ad 7 mm in diam., ubi maturos atris, calycibus fructuum cupuliformibus, *ca* 8 mm in diam., ad 1/3 fructuum includentibus, lobis erectis differt.

Usually shrubs, upto 2 m high, branches armed with sharp spines. Fruits upto 7 mm in diam., globose, apiculate with the remains of styles, black on maturity. Fruiting-calyx cupuliform, upto 8 mm in diam., deeply 4-lobed, enclosing lower one-third to half part of the fruit; lobes erect, touching the fruit. Seeds 3 per fruit, rhomboid-oblong or obovate-oblong, *ca* 3.5 x 2.25 mm, concave on one face and convex on the other (**Fig.-14; Plate 5/4**).

Holotype : India : Karnataka, Kolar, Malampallis forest, 4th Sept. 1974, *N. P. Singh* 133262 ♀ (BSI).

Fl. & Fr.: July – October.

Ecol.: Rare, found in the forests.

Distrib.: Endemic to India, confined to Karnataka (**Map-3**).

Notes : In Indian herbaria, this taxon has been placed within the covers of *Diospyros chloroxylon* Roxb. proper, probably due to solitary, axillary, sessile flowers, oval-oblong leaves, globular small fruits and armed branches. However, in *D. chloroxylon* Roxb. proper, the fruits are rather large in size (7-10 mm in diam.) and fruiting calyx is flat, disciform with spreading lobes, fruit is seated on the disc, the lobes do not touch the fruit in any way. In var. *cupulosa*, on the other hand, the fruits are smaller (5-7 mm in diam.), the fruiting-calyx is cup-shaped with erect lobes touching the fruit, one-third to half lower part is enclosed within the calyx. The fruits of this taxon resembles more closely to young fruits of *D. ferrea* (Willd.) Bakh. and mature ones of *D. neilgerrensis* (Wight) Kosterm., rather than to the proper *D. chloroxylon* Roxb., in shape and cupular fruiting-calyx. But, the fruiting-calyces of *D. ferrea* (Willd.) Bakh. and *D. neilgerrensis* (Wight) Kosterm. are 3-lobed and plants are unarmed. Further, in *D. chloroxylon* Roxb. var. *cupulosa* Singh the aestivation of fruiting-calyx lobes is contorted, like proper var. *chloroxylon*, instead of valvate as found in above mentioned two species.

Exsicc.: KARNATAKA : Kolar, Mallampalli forest, 4th Sept. 1974, *N. P. Singh* 133262 ♀ (BSI).

15. ***Diospyros cordifolia*** Roxb. Pl. Cor. 1 : 38. t. 50. 1795; A. DC. in DC. Prodr. 8 : 230. 1844. *D. rugulosa* R. Br. ex Steud. Nom. Bot. ed. 1. 279. 1821; A. DC. in DC. Prodr. 3 : 229. 1844. *D. punctata* Decne. in Nouv. Ann. Mus. Hist. Nat. 3 : 407. 1834, non Korth ex Hiern 1873; A. DC. in DC. Prodr. 8 : 230. 1844. *D. waldemarii* Klotz. in Waldemar, Reise 101 t. 55. 1862. *D. montana* Roxb. var. *cordifolia* (Roxb.) Hiern in Trans. Cambr. Philos. Soc. 12 : 222. 1873; Bakh. in Bull. Jard.

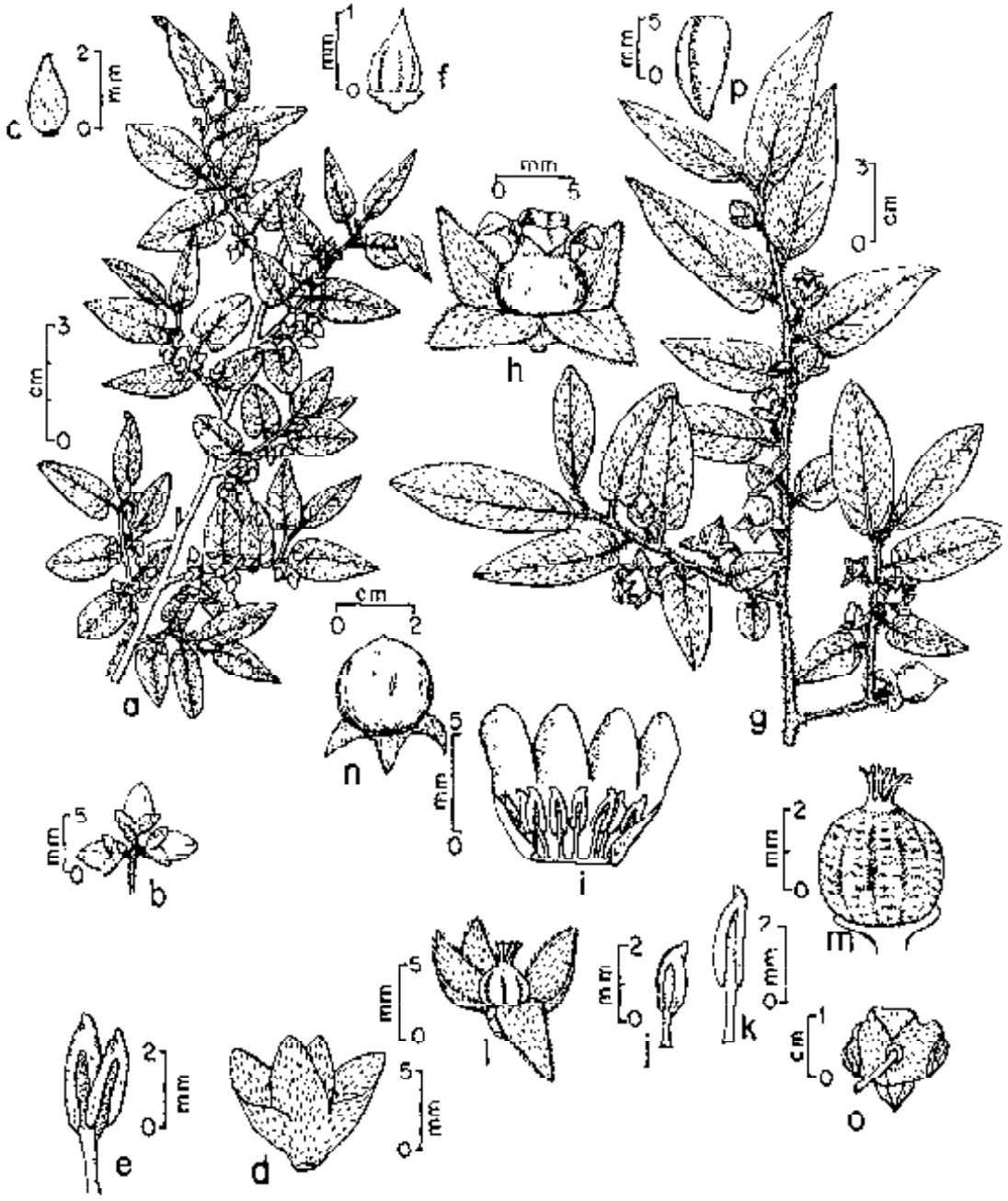


Fig.-15. ***Diospyros cordifolia*** Roxb.

Male : a. habit, b. inflorescence, c. bract, d. calyx, e. stamens, f. pistillode.

Female : g. habit, h. flower, i. corolla within with staminodes, j-k. staminodes, l. calyx within with gynoecium, m. gynoecium, n. fruit with calyx, o. fruiting-calyx (dorsal view), p. seed.

Bot. Buitz. Ser. 3. 15 (3) : 203. 1938. *D. montana* Clarke in Hook. f. Fl. Brit. India 3 : 555. 1882, *pro parte*, non Roxb. 1795.

English name : Ebony.

Vernacular names : *Asm.*: Chapraka; *Beng.*: Moishkanda, Bangaub; *Hindi* : Kendu, Bistendu, Kalarukha, Kalatendu, Lohari, Seda; *Mar.*: Goindu; *Or.*: Bhodrika; *Sans.*: Tumala; *Tam.*: Kattatti, Vakkanattan, Vakkanai, Mulkarunkali; *Tel.*: Vackana, Kakavulimidi, Kakwoolymera, Kaka-ulimera, Eddayagata.

Small trees, with spreading branches, irregular trunk, rust-coloured bark and strong thorns. Leaves alternate, highly variable in shape, size and pubescence, 1-12 x 0.4-4.5 cm, ovate-lanceolate, oblong-lanceolate, ovate-oblong, lanceolate-elliptic or elliptic-oblong, usually acuminate, sometimes obtuse, rounded, retuse or acute at apex, usually subcordate, sometimes rounded or truncate at base, sometimes different types of leaves on the same plant, thinly pubescent to densely pubescent bothsides or glabrous above and pubescent beneath, glabrate with age except the veins and veinlets; midrib flat or subcanaliculate above and raised beneath, pubescent bothsides or glabrous above; lateral veins 5-9 pairs, very inconspicuous; petioles 2-8 mm long, pubescent, flat or subcanaliculate above, rounded beneath. Male flowers in bracteate, axillary, densely pubescent, 3-flowered cymes. Calyx 6-8 mm long, campanulate, divided below the middle, 4-lobed, pubescent bothsides; lobes ovate, subacute, contorted. Corolla urceolate, glabrous; lobes 4, contorted. Stamens 16, united in pairs by their filaments, inserted at the base of corolla-tube, glabrous; anthers oblong, glabrous, narrowed at apex like a neck, obtuse, not apiculate, connectivos not produced. Pistillode glabrous, conical-pointed at apex. Female flowers axillary, solitary; pedicels 6-8 mm long, further extending in fruit, articulated with the flowers, densely pubescent. Calyx 7-10 mm long, campanulate, pubescent bothsides, deeply divided nearly to the base; tube 1-2 mm long; lobes 4, ovate, acute, contorted. Corolla urceolate, 8-10 mm long, glabrous or thinly pubescent outside in upper region; tube narrowed at apex; lobes 4, elliptic-oblong, about half as long as tube, reflexed, contorted. Staminodes usually 8-10, rarely 12 (Hiern, 1873; Gamble, 1922; Bakhuizen, 1938), inserted at the base of corolla-tube, glabrous or thinly pubescent at tip; filaments 1-1.5 mm long; sterile anthers 1.5-2 mm long, equal or unequal in size, narrowed like a neck and curved outwards at the apex, obtuse, connectivos not produced. Ovary globose, with distinct alternate 8 grooves and ridges, glabrous, 8-celled, cells 1-ovuled; styles 4; stigmas 2-fid. Fruits globose, 2-3 cm in diam., glabrous; pedicels 5-13 mm long, pubescent. Fruiting-calyx flat, 4-angular-disciform, pubescent, disc 1-1.5 cm in diam., fruit seated on the disc, no tube; lobes upto 1 cm long, reflexed, margins sometimes folded outwards. Seeds usually 4-5, sometimes upto 8, elliptic-oblong or wedge-shaped, 7-9 x 5-6 mm, dark brown, glabrous; albumen equable (Fig.-15; **Plate 6/1, 2 & 3**).

Holotype : Roxburgh Plate 50, Pl. Cor. (K).

Chr. No.: 2n=30 (Bedi *et al.*, 1980); n=15 (Bir *et al.*, 1984; Mehra, 1976).

Fl. & Fr.: January – June.

Ecol.: Found in wastelands and dry deciduous or semi-evergreen forests. If the trees are given annually a light pruning treatment by cutting branches at a certain height above the ground, they may give a beautiful look of clipped bushes for ornamental purposes. This species may grow even in highly eroded and unstable habitats. Under such ecological conditions, usually reproductive buds are developed on the exposed roots for vegetative reproduction (Ambasht, 1968).

Distrib.: The species finds wide distribution in India, including north-eastern parts. The main States of its concentration are Himachal Pradesh, Delhi, Punjab, Haryana, Uttar Pradesh, Uttranchal, Bihar, W. Bengal, Assam, Manipur, Tripura, Orissa, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Karnataka, Tamil Nadu and Andaman & Nicobar Islands. Beyond Indian territory, this taxon extends to Sri Lanka, Myanmar, Thailand (Siam), Malaya peninsula and North Australia (Map-3).

Pollen: Grains 3-zonocolporate; endocolpium la-longate, dumb-bell-shaped, 2 x 7 µm. Exine surface faint OL, Size 29-33 x 22-30 µm (Nair & Kothari, 1985). Sharma & Gupta (1979) have, however, provided detailed morphology of pollen grains as 3-colporate, prolate (40.5 x 28.5 µm), range 35-42.5 x 25-32.5 µm. Parasyncolpate. Colpi long, membrane psilate. Apocolpium diameter about 6 µm and mesocolpium distance about 12 µm. Ora la-longate. Exine about 1.5 µm thick. Sexine thinner than nexine and sexine pattern almost obscure.

Anatomy : The wood is pale brown, diffuse-porous. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Porenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained, fine-textured (Wright, 1904; Purkayastha, 1982). The timber is susceptible to dry wood borer.

Phytochemistry : Stem yields lupeol, diospyrin and its derivatives and related compounds. Tetrahydrodiospyrin has been isolated from the bark. The leaves contain dihydrodiospyrin, diospyrin, lupeol and betulic acid. The fruit-pulp yields triterpenoids and esters of α-amyrin, ursolic acid, oleanolic acid and betulinic acid. Betulinic acid has also been isolated from the seeds (Asolkar *et al.*, 1992). The phytochemical survey carried out by Daniel *et al.* (1980) also revealed the presence of saponins in the stem and alkaloids and saponins in the leaves. Flowers are lacking these constituents in this species.

Uses : Alcoholic extract of bark has CNS depressant effect as indicated by ataxia (inability to co-ordinate), decreased locomotor activity and loss of righting reflex in mice and rats. It also has spasmolytic activity on rabbit and guinea pig ileum and produces bradycardia (slowness of heart beat) and hypotension in anaesthetised dogs (Singh *et al.*, 1971). The extract also indicates potent anti-inflammatory activity and antipyretic effect in rats and analgesic effect in mice (Kohli *et al.*, 1972; Rastogi & Mehrotra, 1993b). The plants are used in fever, dysuria, gravel, neuralgia, diarrhoea and as an antidote against spider-bite poison. The plant is also used as an insecticide (Secoy & Smith, 1983).

Recently, experiments conducted by Prasad & Simlot (1982) have revealed antifungal activity of fruits against *Fusarium* species and *Helminthosporium turcicum*.

Notes : *D. montana* Roxb. and *D. cordifolia* Roxb. are very closely related species and have been variously interpreted. Gamble (1922) kept them separate and stressed the difference as *D. montana* Roxb. has larger fruits than those of *D. cordifolia* Roxb. Hiern (1873) transferred *D. cordifolia* Roxb. to the rank of variety under *D. montana* Roxb. Bakhuizen (1938) also followed Hiern's (1873) concept and added two more varieties to *D. montana* Roxb. viz. var. *heterophylla* (Wall. ex G. Don) Bakh. and var. *timoriensis* Bakh., which are, however, not recognizable in Indian subcontinent. Kostermans (1981) contrary to above views considered them as a single polymorphic taxon. However, he agrees with two forms occurring in Sri Lanka – one with smaller fruits corresponding to *D. cordifolia* Roxb. and other with larger fruits corresponding to *D. montana* Roxb., which occurs in different areas. The present study revealed that the two taxa may be easily distinguished as under :

Diospyros montana Roxb.	*Diospyros cordifolia* Roxb.
Leaves are generally oval-oblong or lanceolate-oblong with rounded or cuneate base.	Leaves are generally ovate-lanceolate, some atleast with subcordate base and rest rounded.
Anthers in male plants and staminodes in females are distinctly apiculate due to produced connectives.	Anthers in male plants and staminodes in females are obtuse at apex or slightly narrowed like a neck, not apiculate due to produced connectives.
Staminodes invariably 4 in female plants.	Staminodes vary from 8 to 12 in female plants.
Fruiting calyx-lobes broadly ovate, horizontally spreading or reflexed, margins not rolled any side.	Fruiting calyx-lobes rather narrow, almosttriangular in shape, usually reflexed, with out- rolled margins.
Mesocolpium distance in pollens is *ca* 20 µm.	Mesocolpium distance in pollens is *ca* 12 µm.

Further, the character of smaller fruits in *D. cordifolia* Roxb. than *D. montana* Roxb. does not hold good in Indian plants and the distribution of the two also overlaps in India. However, *D. cordifolia* Roxb. may be easily distinguished from *D. montana* Roxb. by the characters pointed out in the present work.

Exsicc.: ANDAMAN & NICOBAR : South Andamans, Rangachang to Chidiyatapu, Sea level, 16th March 1980, *T. A. Rao & S. Chakraborthy* 7638 ♀ (PBL); 29th May 1974, *K. Thothathari & N. G. Nair* 1085 ♀ (PBL); Littorale forest, Sea level, 8th April 1973, *N. P. Balakrishnan* 83 ♀ (PBL); Henry Lawrance hill range, 35 m, 12th Oct. 1985, *Barin Ghosh* 11594 ♀ (PBL); South Nicobar, Great Nicobar, Galathea river bank, Near Satish bridge, 17th Oct. 1979, *D. K. Hora* 7223 ♀ (PBL); Campbell Bay to Chengappa, Sea level, 27th July 1976, *N. P. Balakrishnan* 4042 ♀ (PBL); DELHI : Zoo Garden area, 16th May 1993, *B. D. Naithani* 81968 ♀ (BSD); Karnal road, 23 miles, 22nd June 1955, *K. N. Kaul & Party* 22946 ♂ (LWG); Quatla area, 12th May 1993, *B. D. Naithani* 81939 ♀ (BSD); HARYANA

: Hissar, Hansi, 29th Nov. 1961, *N. C. Nair* 18720 ♀ (BSD); 25th April 1962, *V. J. Nair* 19947 ♀ (BSD); Jind, Between Jind and Hansi, 17th Oct. 1962, *N. C. Nair* 24815 ♀ (BSD); Karnal, 7th May 1963, *N. C. Nair* 26190A ♀, 26190B ♂ (BSD); 15th Oct. 1962, *N. C. Nair* 20604 ♀ (BSD); Rewari, Sidrauli, 18th March 1962, *N. C. Nair* 20805 ♂, 20804 ♀ (BSD); Sonipat, Murthal forest, 15th Aug. 1962, *V. J. Nair* 23322 sterile (BSD); Gurgaon, Sohna, 22nd Dec. 1959, *T. A. Rao* 11075 ♀ (BSD); HIMACHAL PRADESH : Una, 10th April 1972, *O. P. Mishra* 45828 ♀ (BSD); Near Rest House Bihru, 26th July 1977, *B. P. Uniyal* 61217 ♀ (BSD); Dhundla, 23rd July 1977, *B. P. Uniyal* 61191 (BSD); Kedarpur, Near Yamuna river bank, 29th April 1986, *J. P. Sharma* 79381 ♀ (BSD); MADHYA PRADESH : Jabalpur, 10 miles before Katni, 31st Dec. 1962, *G. Panigrahi* 6696 ♀ (BSA); Sagar, Civil Station, 16th April 1914, *Doutell* Acc. No. 12390 ♀ (DD); Indore, 6th April 1991, *W. Biscoe* 2765 ♂ (DD); PUNJAB : Bhatinda, Nathana, 23rd March 1966, *N. C. Nair* 36738 ♂ (BSD); Hoshiarpur, 14th June 1928, *Prain* Acc. No. 53426 (DD); Jaijon, 8th July 1971, *O. P. Mishra* 44379 ♀ (BSD); Una Road, 24th Aug. 1977, *J. N. Vohra & P. Daniel* 60396 ♀ (BSD); Gurdaspur, Dinanagar, 28th Aug. 1969, *U. C. Bhattacharyya* 39353 ♀ (BSD); Talwara, 19th Sept. 1979, *P. Daniel* 67525 ♀ (BSD); 14th Sept. 1970, *O. P. Mishra* 41814 ♀ (BSD); Sidhchalerh, 19th July 1971, *O. P. Mishra* 44589 ♀ (BSD); Brindaban, 22nd April 1972, *O. P. Mishra* 47160 ♂ (BSD); Patiala, March 1948, *Kirat Ram* Acc. No. 103033 ♂ (DD); RAJASTHAN : Chittorgarh, 16th Sept. 1968, *K. K. Singh* 1481 ♀ (RHMD); Jaipur, Bairat forest, 20th Dec. 1965, *B. M. Wadhwa* 3377 ♀ (CAL); Udaipur, Banki, 9th Feb. 1957, *K. C. Nautiyal* 25444 ♀ (DD); TRIPURA : Kailashahar, 30 m, 1st Dec. 1956, *N. K. Endow* Acc. No. 121346 ♀ (DD); UTTRANCHAL : Dehra Dun, Mohan Iron Bridge, RNP, 12th April 1996, *K. K. Singh & Anand Prakash* 216321 ♀ (LWG); Badshahi Bagh, 13th Jan. 1900, *U. N. Kanjilal* Acc. No. 38705 ♀ (ASSAM); Near Telephone Exchange, 650 m, 17th April 1969, *U. C. Bhattacharyya* 37772 ♀ (BSD); Forest School Park, 660 m, 26th April 1904, *U. N. Kanjilal* 1256 ♂ (DD); New Forest, April 1939, *M. B. Raizada* Acc. No. 80279 ♀ (DD); Barivada R. F., RNP, 29th April 1993, *Anand Prakash* 210452 ♂ (LWG); UTTAR PRADESH : Bulandshahr, Daultabad, 28th April 1963, *N. P. Singh* 27458 ♀ (BSD); Siyana, 200 m, 28th Aug. 1964, *N. P. Singh* 33575 (BSD); Mainpuri, Tisauli village, 14 km on way to Kuraoli, 18th Oct. 1995, *Maliya & Party* Acc. No. 2154438 ♀ (LWG); Etawah, Achhalda, 10th Feb. 1995, *Tariq Husain & B. Datt* 219957 ♂ (LWG); Sitapur, Gayraia forest, 24th April 1956, *H. Lal & S. L. Kapoor* 26845 ♂ (LWG); Lucknow, NBRI, 18th Dec. 1969, *H. O. Saxena* 82259 ♀ (LWG); Mohanlalganj, 8th March 1958, *J. G. Srivastava* 46991 ♀ (LWG); Lucknow Cantt., Dec. 1969, *N. Singh* Acc. No. 61959 ♀ (LWG); Vijiyara village, 18th June 1958, *J. G. Srivastava & Hira Lal* 841918 ♂ (LWG); Faizabad, Maniparvat, 8th Aug. 1959, *Y. K. Sarin* 8986 ♀ (BSD); Bijnor, south of Najibabad towards Railway Station, 5th Nov. 1979, *J. P. Sharma* 67192 ♀ (BSD); Saharanpur, Badshahi Bagh, 300 m, 19th April 1904, *U. N. Kanjilal* 1241 ♂, 1242 ♀ (DD); Meerut, Hastinapur, March 1953, *R. N. Singh* Acc. No. 112562 ♂ (DD); WEST BENGAL : Howrah, Indian Botanic Garden, 13th June 2002, *V. Singh* 10290 (BSJO). Also examined Bangladesh : Sylhet, Chhatak Syampora, 19th Nov. 1943, *G. K. Deka* 21823 ♀ (ASSAM).

16. ***Diospyros courtallumensis*** Bahadur & Gaur in Purkayastha, Ind. Woods 5 : 124. 1982. *D. orixensis* Wight ex Hiern in Trans. Cambr. Philos. Soc. 12 : 264. 1873, non Klein ex Willd. 1805; Clarke in Hook. f Fl. Brit. India 3 : 571 1882. *D. humilis* Bourd. in J. Bombay Nat. Hist. Soc. 12 : 352. t. 6. 1898, non (R. Br.) F. v. Muell. 1867.

English name : Ebony.

Vernacular names : *Mal.*: Meruvalan, Maruvatan, Velleithuvarai; *Tam.*: Velleithuvarai, Mukkanci.

Dioecious trees, 6-12 m high, with pubescent young branchlets. Bark smooth, 5-6 mm thick, blackish brown, that of branchlets without lozenge-shaped striations. Leaves alternate, 2.5-9.5 x 1.5-4 cm, elliptic, abruptly shortly or well obtusely acuminate, rounded at base, coriaceous, fulvous pubescent bothsides when young and on the midrib bothsides or atleast beneath in mature stage; midrib raised beneath, canaliculate above; lateral nerves indistinct; petioles 2-3 mm long, fulvous hairy, terete, not canaliculate above. Male flowers subsessile, in many-flowered, fascicled cymes. Calyx campanulate, 4-lobed, hairy outside in bud stage, subsequently glabrous, glabrous within; lobes broadly ovate, acute, valvate, ciliate. Corolla urceolate, glabrous bothsides; lobes 4, contorted. Stamens usually 10-12, rarely 16-20, unequal, united in pairs at their bases through filaments, inserted at the base of corolla-tube; anthers obtuse, glabrous, not apiculate. Pistillode glabrous, with short 4 stigmas. Female flowers axillary, solitary; pedicels equalling the petioles, fulvous hairy. Bracts caducous. Calyx 4-lobed, cleft half way down, hairy outside in young stage, subsequently glabrous, glabrous within; lobes broadly ovate, acute, ciliate, contorted. Corolla urceolate or ovoid, glabrous; lobes 4, contorted. Staminodes 4. Ovary glabrous, 4-celled, cells 1-ovuled; stigmas 4, black. Fruits oblong or oblong-globose, 1.3-2 x 0.9-1.5 cm, thinly hairy at base near the place of insertion at thalamus, distinctly pedicellate; pedicels 3-4 mm long, pilose. Fruiting-calyx not enlarged, 6-7 mm across, much shorter than fruit, flat, disciform, fruit seated on the disc; lobes 4, spreading or somewhat reflexed, not embracing the fruit, not thickened at the base or margins, no tube, no internal elevated rim. Seeds 2-4, oblong; albumen equable (**Fig.-16; Plate 6/4**).

Holotype : India : Tamil Nadu, Courtallum *Wight s. n.* (K-Wight Hb.).

Fl. & Fr.: March – June.

Ecol.: Found in evergreen forests, chiefly on the eastern slopes of Western Ghats, between 600-1100 m. The timber is susceptible to dry wood borer.

Distrib.: Endemic to India, confined chiefly to Tamil Nadu and Kerala (**Map-3**).

Anatomy : The wood is diffuse-porous. Pores small, subdivided or in short radial lines of 2-3 which are very distant and arranged obliquely or in achelon. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The

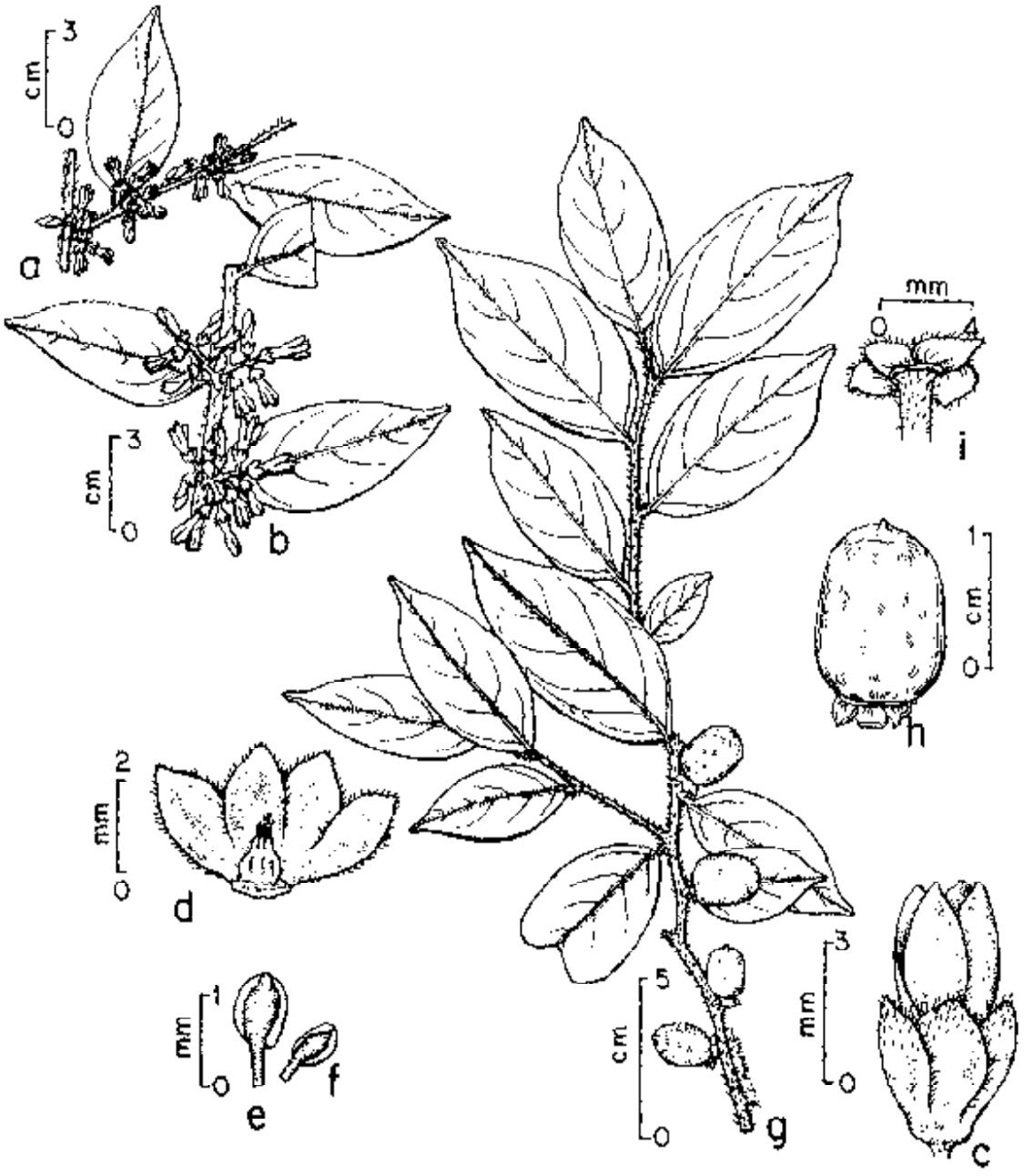
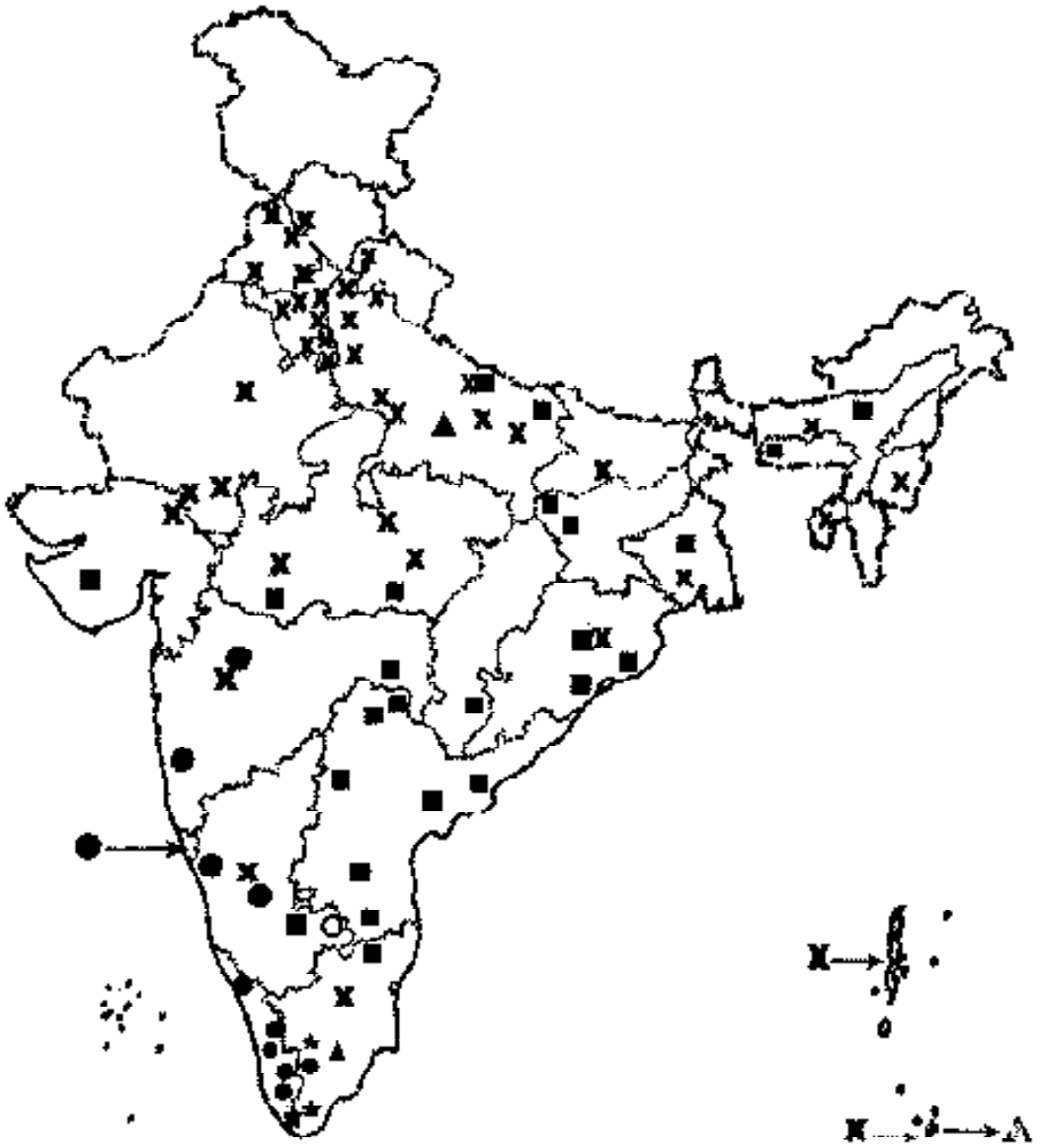


Fig.-16. ***Diospyros courtallumensis*** Bahadur & Gaur

Male : a. habit, b. habit (type), c. flower, d. calyx within with pistillode, e-f. stamens.

Female : g. habit, h. fruit with calyx, i. fruiting-calyx (dorsal view).



Distrib. Sketch Map – 3

● *Diospyros candolleana* Wight; ▲ *Diospyros cauliflora* Blume;
■ *Diospyros chloroxylon* Roxb. var. *chloroxylon*;
o *Diospyros chloroxylon* Roxb. var. *cupulosa* Singh;
× *Diospyros cordifolia* Roxb.; ★ *Diospyros courtallumensis* Bahadur & Gaur

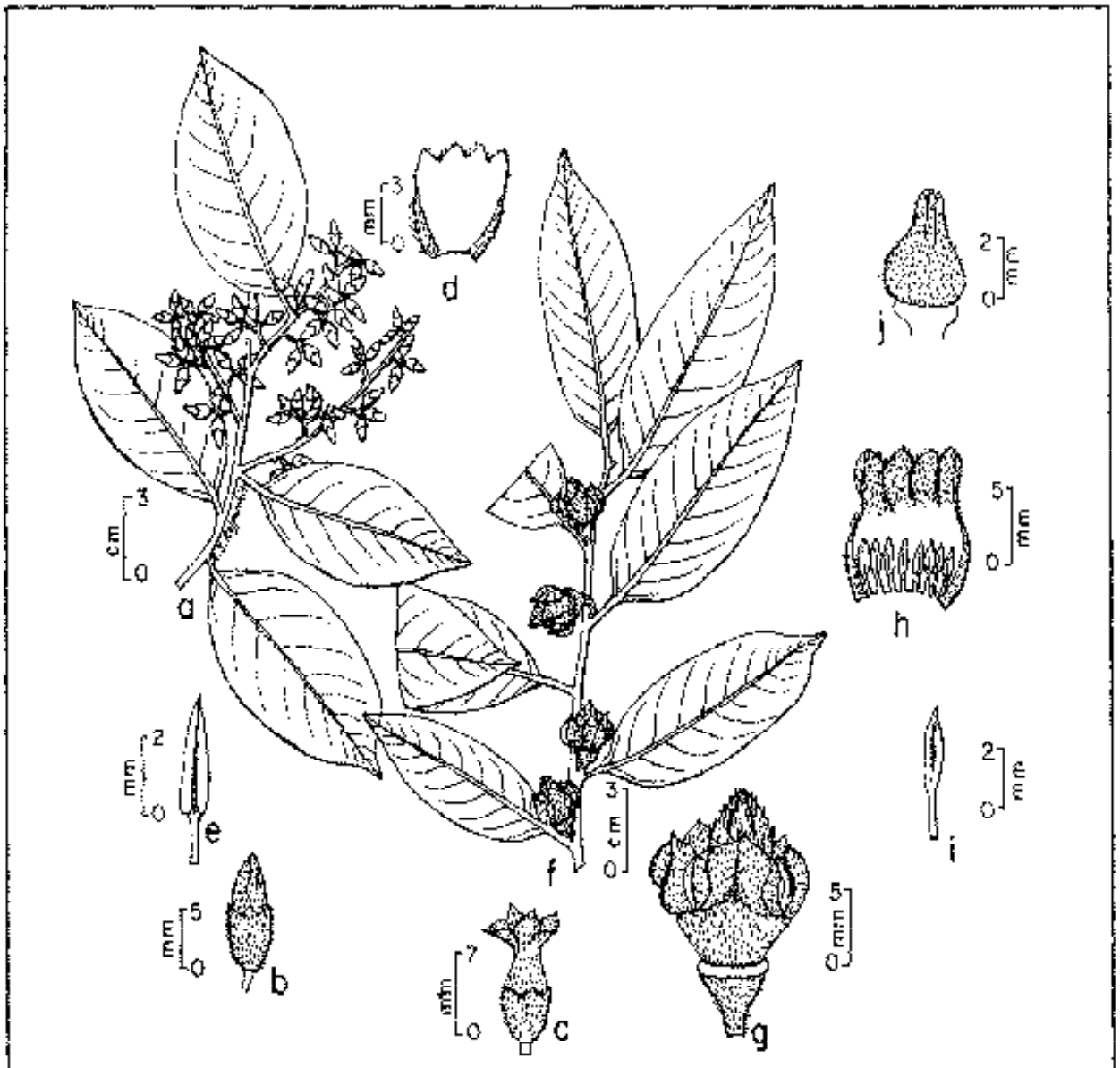


Fig.-17. ***Diospyros crumenata*** Thw.
Male : a. habit, b. flower-bud, c. flower, d. calyx within, e. stamen.
Female : f. habit, g. flower-bud, h. corolla within with staminodes,
i. staminode, j. gynoecium.

transverse bars conspicuous, joined with regular, wavy, concentric but very narrow belts. The heartwood and sapwood are indistinct, straight-grained, fine-textured.

Notes : This species is closely allied to *D. montana* Roxb., to the extent that Bakhuizen (1938) considered its conspecific taxa *D. orixensis* Wt. ex Hiern and *D. humilis* Bourd. synonymous to *D. montana* Roxb. But, the shape of fruiting-calyx, 4-celled ovary and uncleft stigmas best distinguish it from *D. montana* Roxb. During present study, I have examined few buds of male flowers and found that the number of stamens varies from 10-12 and not 16-20 as mentioned in the protologue. However, I am not fully sure about the range in the number of stamens since enough material was not available to me. In the figure provided with the protologue also only 9 or 10 stamens have been illustrated.

Exsicc.: KERALA : Trivandrum, Agasthyamalai, Athirumala, 1000 m, 1st April 1989, *N. Mohanan* 5530 ♂ (TBGT); TAMIL NADU : Tirunelveli, Way to Kanthaporai, 850 m, 9th July 1964, *A. N. Henry & M. Chandrabose* 19827 ♀ (MH); Kannikatti, May 1901, *C. A. Barber* 2959 sterile (MH).

17. ***Diospyros crumenata*** Thw. Enum. Pl. Zeyl. 179. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 169. 1873; Beddome, Ic. Pl. Ind. Orient. 26. f. 126. 1874; Clarke in Hook. f. Fl. Brit. India 3 : 567. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 51. 1981

English name : Ebony.

Vernacular names : *Kan.*: Kantumri, Karitumari; *Mar.*: Muliyo; *Tam.*: Chemelpaniche.

Evergreen, dioecious trees, with scaly bark and glabrous branches, unarmed. Leaves alternate, 7-12 x 2.5-5 cm, elliptic or elliptic-oblong, obtusely narrowed at both ends, obtusely cuneate at base, obtusely abruptly subacuminate at apex, coriaceous, totally glabrous, shining bothsides, pale-grey above, light brown beneath in dry specimens; midrib canaliculate above particularly in lower half, slightly raised beneath, glabrous bothsides; lateral nerves many pairs, thin, inconspicuous, mixed with reticulation; petioles 7-13 mm long, canaliculate above, rounded beneath, glabrous. Male flowers usually in 3, rarely 5 to 7-flowered, axillary, hairy cymes bent downwards, borne on young branches, when leaves fall down branches give an appearance of racemose cyme inflorescence; primary and secondary peduncles pubescent, 3-4 mm long; pedicels 1-1.5 mm long, pubescent, not thickened. Calyx 5-6 mm long, campanulate, subtomentose outside, glabrous within, obscurely 4-toothed; teeth *ca* 1 mm long, triangular, acute, valvate. Corolla yellow, 10-12 mm long, tubular; tube narrowed at apex, fulvous-tomentose outside; glabrous within; lobes 4, ovate, acute, undulate-margined, spreading, tomentose bothsides, contorted. Stamens 8-14, almost equal in size, free, hypogynous, seated on the torus; anthers linear, *ca* 3 mm long, gradually narrowed towards apex, glabrous, apiculate. Pistillode hairy, rudimentary. Female flowers axillary, solitary; pedicels 5-7 mm long, thickened upwards, densely tomentose, articulated with the flowers. Calyx broadly or openly cup-shaped, 8-10 mm long and about as wide at mouth, tomentose bothsides, 4-lobed, divided upto middle; lobes almost rounded, tomentose bothsides, acute at apex, margins folded outwards, lobes slightly pushed downwards at base forming dilated marsupio between the

lobes, valvate. Corolla 10-13 mm long, exceeding the calyx, tubular; tube ferruginous tomentose outside, glabrous within, 4-lobed; lobes elliptic-oblong, undulate-margined, tomentose bothsides, contorted. Staminodes usually 8, rarely upto 12, subequal in length, arranged in two rows opposite and alternate with corolla-lobes, inserted at the base of corolla-tube, glabrous; filaments 1.5-2 mm long; sterile anthers 2.5-3 mm long, almost flat. Ovary 8-celled, densely tomentose, cells 1-ovuled; styles 4, densely tomentose; stigmas 4, fleshy, short. Fruits 3-5 cm in diam., globose, 6 to 8-seeded, apiculate, glabrous. Fruiting-calyx flattened, not thickened, discoid or intersegmental areas straightened forming the calyx tetrahedral, without internal elevated rim, fruit seated on the disc; lobes somewhat constricted at base, not thickened, spreading, not reflexed. Seeds flattened, upto 2.5 cm long, elliptic, black, shining; albumen ruminate (Fig.-17; Plate 7/1 & 2).

Holotype : Ceylon Plants, *Thwaites* 2438 ♀ (PDA); *Isotype* : (K).

Fl. & Fr.: March – October.

Ecol.: Usually metwith in moist, semi-evergreen forests, upto 1200 m. The germination of seeds is epigeal and cotyledons get detached at an early stage.

Distrib.: The main zones of its concentration in India are Maharashtra, Karnataka, Tamil Nadu and Andaman & Nicobar Islands. It extends further southwards to Sri Lanka – its native home, and Myanmar (Map-4).

Pollen : Pollen grains 3-colporate, prolate (45 x 37.5 µm). Colpi long, running from pole to pole with psilate membrane. Ora more or less circular. Exine about 2 µm thick. Sexine thinner than nexine. Sexine pattern almost obscure (Sharma & Gupta, 1979).

Anatomy : There are three vascular traces in each cotyledon and xylem splits much in collet area. Each epicotyledonary leaf possesses one trace, passing into root, rarely showing splitting of xylem (Wright, 1904).

The wood is diffuse porous, red-coloured which intensifies from outward to inwards with local black strands here and there. The heartwood is usually small, containing a fair percentage of fibres of narrow lumen. The growth rings are indistinct. Vessels small to very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct to inconspicuous. The vessels of twigs *ca* 0.27 mm long, with 0.05 mm and 0.04 mm radial and tangential diameter. The sapwood, however, bears vessels having 0.16 mm radial and 0.10 mm tangential diameter. The parenchyma is distinct, diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with the rays. The length of wood parenchyma cells in sapwood varies from 0.06 mm to 0.12 mm, with 0.016 mm radial diameter. The radial diameter of wood fibres in sapwood and heartwood is about 0.01 mm. The medullary rays are fine, closely spaced and uniformly distributed. The radial diameter of vertical medullary ray cells is 0.019 mm and tangential 0.02 mm, with vertical length *ca* 0.06 mm. The radial diameter of horizontal components is 0.05 mm and tangential 0.012 mm,

with vertical length *ca* 0.02 mm. The medullary rays occur as radial rows of cells throughout the secondary xylem. In most of species of *Diospyros* L. there is only one cell in tangential width, but it is interesting to note two or three cells in width in this species. In this respect it shows close affinity with *D. racemosa* Roxb., *D. insignis* Thw. and *D. pruriens* Dalz. (Wright, 1904; Purkayastha, 1982).

Uses : Mature fruits are edible. The timber is of medium quality, used for making tools for agriculture and for house hold articles.

Notes : In Indian herbaria, the specimens of this species are sometimes mixed with or confused for *D. ridleyi* Bakh. However, two taxa may be distinguished on the basis of number and size of stamens, size of female pedicel, size of fruit and texture of fruiting-calyx etc.

Exsicc.: ANDAMAN & NICOBAR : Long Islands, July 1915, *C. E. Parkinson* 666, Acc. No. 282691, 282692 ♀ (CAL); Without locality, 12th Oct. 1970, *Without Collector* Acc. No. 125289 sterile (RHMD); KARNATAKA : North Kanara, March 1896, *W. A. Talbot* 3560 ♂ (DD).

18. ***Diospyros discolor*** Willd. Sp. Pl. 4 (2) : 1108. 1806, *nom. cons. prop.*, non Wall. ex King & Gamble 1905; A. DC. in DC. Prodr. 8 : 235. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 260. 1873; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 145. 1937. *Cavanillea philippensis* Desr. in Lam. Encycl. 3 (2) : 663. 1792. *C. mabolo* Poir. in Lam. Rec. Planch. Bot. Encycl. 2 : t. 454. 1797. *Diospyros embryopteris* Pers. Syn. Pl. 2 : 624. 1807, *pro parte;* Spreng. Syst. Veg. 2 : 203. 1825, non Fernand-Villar 1880. *D. mabola* (Poir.) Roxb. ex Lindley in Bot. Reg. t. 1139. 1828, *nom. illegit.* *D. embryopteris* Boj. Hort. Maurit. 200. 1837, non Pers. 1807, nec Spreng. 1825, nec Fernand-Villar 1880. *Embryopteris discolor* (Willd.) G. Don, Gen. Syst. 4 : 41. 1837. *Diospyros kaki* Blanco, Fl. Filip. ed. 1. 302. 1837, non Thunb. ex L. f. 1781. *Mabola edulis* Rafin. Sylva Tellur. 11. 1838. *Diospyros blancoi* A. DC. in DC. Prodr. 8 : 237. 1844. *D. malacapai* A. DC. in DC. Prodr. 8 : 237. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 247. 1873. *D. embryopteris* Blanco, Fl. Filip. ed. 2. 209. 1845, non Pers. 1807, nec Spreng. 1825, nec Boj. 1837, nec Fernand-Villar 1880. *D. melanida* Sieber ex Hiern in Trans. Cambr. Philos. Soc. 12 : 261. 1873, non (Commers.) Poir. 1804, nec Neraud. ex A. DC. 1844. *D. philippensis* (Desr.) Gurke in Engl. & Prantl, Pflanzenfam. 4 (1) : 164. 1891, *nom. rej.* homonym of *Diospyros philippinensis* A. DC. 1844, nec Dietr. 1852, nec. Naves & Villar 1880. *D. utilis* Hemsl. in Ann. Bot. 9 (33) : 154. 1895. *D. merrillii* Elmer, Leafl. Philippine Bot. 5 : 1775. 1913.

English names : Mabola Ebony, Butter Fruit, Comogen Ebony, Brazil Nut, Philippine Persimmon, Mabola Tree, Mabola-date-plum, Velvet Apple, Velvet Persimmon.

Vernacular name : *Hindi* : Bilayati Gab.

Moderate-sized trees, with fulvous-sericeous young branchlets. Bark longitudinally rugose. Leaves alternate, 12-28 x 5-10 cm, oblong, acuminate, rounded at base, glabrous above, sparsely pilose beneath when young, glabrous with age, glandular beneath, coriaceous; midrib very prominently raised beneath, pilose in young leaves, glabrous with age, canaliculate and glabrous above; lateral nerves

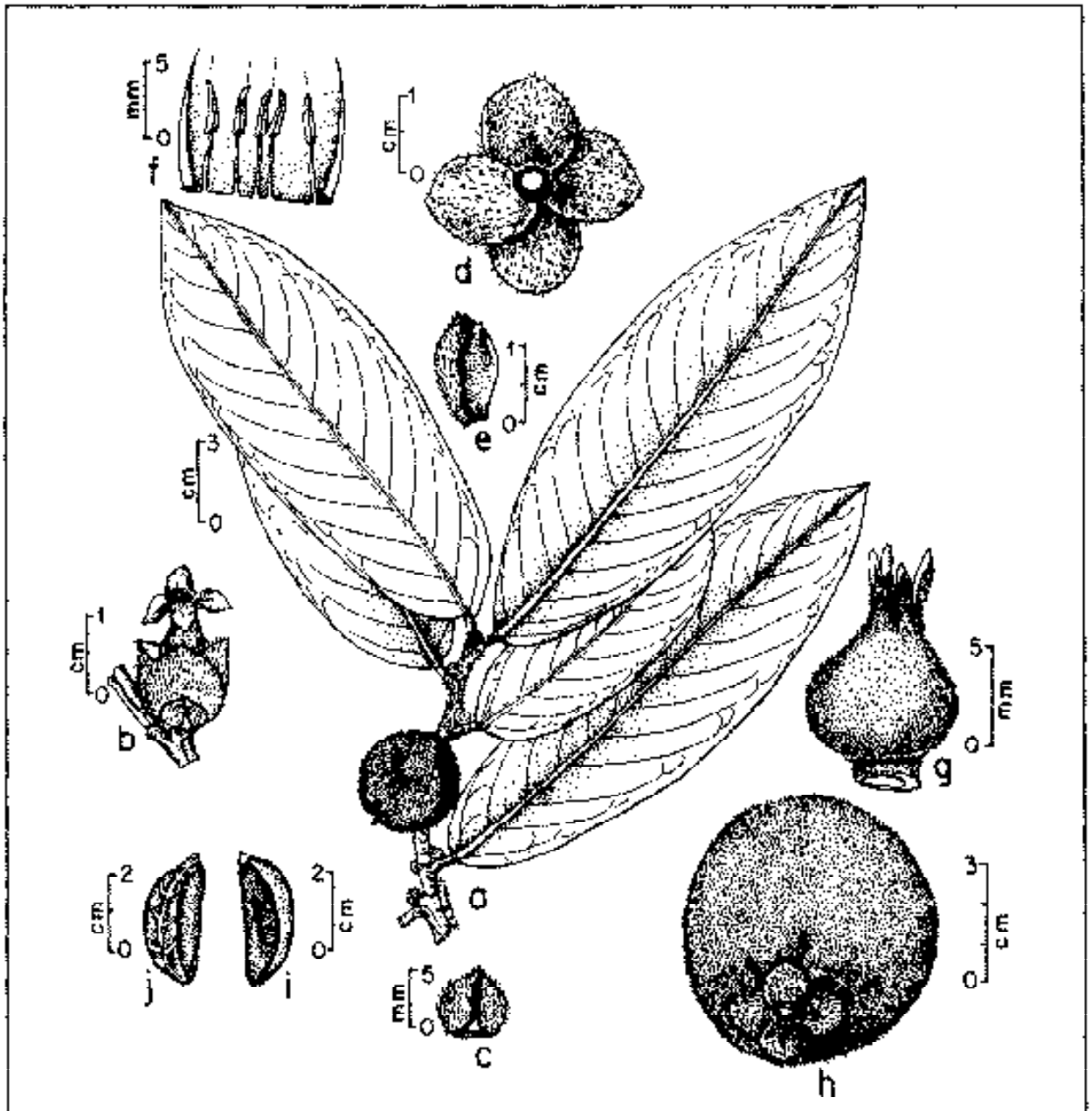


Fig.-18. *Diospyros discolor* Willd.

Female : a. habit, b. flower with bracts, c. bract, d. fruiting-calyx, e. calyx-lobe (ventral view), f. staminodes within corolla-tube, g. gynoecium, h. fruit with calyx.

several, inconspicuous; petioles 0.6-1.8 cm long, fulvous-pilose when young, glabrous with age, canaliculate above, rounded beneath, rugose. Axillary buds triangular. Male flowers subsessile, in 3-flowered, fulvo-sericeous cymes arranged in terminal and axillary, *ca* 17.5 cm long racemes. Bracts deltoid, acute. Calyx turbinate-campanulate, *ca* 1 cm long, deeply 4-lobed; lobes silky outside, imbricate. Corolla funnel-shaped, 4-lobed; lobes twisted. Stamens 24-48, hypogynous or inserted at the base of corolla-tube, sometimes both, united in pairs, nearly equal, glabrous; anthers linear, apiculate due to produced connectives, dehisce laterally. Pistillode hairy, rudimentary. Female flowers almost sessile, solitary, axillary, bracteate. Bracts 2, attached at the base of calyx, *ca* 5 mm long and as broad, broadly ovate to suborbicular, acute, pubescent outside, with prominent midrib, persistent. Calyx campanulate, deeply 4-lobed, no distinct tube; lobes broadly ovate to suborbicular, acute, 1-1.3 x 1-1.2 cm, imbricate, pubescent and glandular outside. Corolla-tube slightly constricted at the apex, silky outside upwards, 1-1.5 cm long; lobes 4, ovate, about half the length of tube, silky hairy outside, imbricate. Staminodes 4-5 or 8-10, alternating with corolla-lobes; filaments *ca* 4 mm long, attached in the lower part of corolla-tube for about their two-third length; sterile anthers linear, *ca* 3 mm long. Ovary *ca* 5 x 7 mm, almost globular, narrowed at apex, pilose-silky, 8-celled, cells 1-ovuled; styles 4, not cleft at apex, pilose except in the stigmatic region; stigmas 4, somewhat flattish, glabrous. Fruits globose, 5-10 cm in diam., densely velvety, reddish, 4 to 6-seeded (usually 6-seeded), with remains of styles at apex. Fruiting-calyx flat, no tube, not much accrescent, about two times as large as flowering female calyx, disciform, fruit seated on the disc; lobes 4, ovate-oblong, spreading, touching the base of fruit, thinly pubescent outside, glabrous within. Seeds ellipsoid-planoconvex, two faces flat and one face convex, glabrous, 2.5-4 x 1.5-2.5 cm, chocolate-coloured, with a pale or cream coloured line from hilum to micropylar end on convex face; albumen equable (**Fig.-18; Plate 7/3 & 4**).

Holotype : Cultivated, "Mabolo ver Filippinas", Herb. Lamarck No. 560 (P-Lam.; IDC microfiche 424-17).

Chr. No.: 2n=30 (Namikawa *et al.*, 1932; Chatterji, 1964; Zhuang *et al.*, 1990; Chen, 1993; Chen *et al.*, 1985).

Fl. & Fr.: February – April.

Ecol.: Rare, found along the foot of hills, upto 800 m. Often cultivated as an avenue tree along the roads and in the gardens for its ornamental foliage and showy fruits. The plant is propagated by the seeds or by grafting on seedling stock. It can also be used as a stock for grafting *D. kaki* Thunb. ex L. f.

Distrib.: In India, the species grows wild in Bihar, W. Bengal, Assam and Kerala; cultivated elsewhere. The other zones of concentration beyond the eastern boundary of the country are Myanmar, Taiwan, Philippines, Malay Peninsula (native home) and Borneo. It is also cultivated in United States of America and Singapore (**Map-4**).

Anatomy: The lower epidermis of the leaves bear coronulate papillae (Metcalfe & Chalk, 1950). Yakovlev & Zhukova (1980) have reported presence of a chlorophyllous embryo in this species.

Phytochemistry : The fruits contain protein, crude fibre, fat, reducing sugar and other carbohydrates, besides phytin (Anonymous, 1952). Betulin, betulinic acid and β-sitosterol have been isolated from the fruits and wood (Rastogi & Mehrotra, 1993a). Recently, C_{29}, C_{31}, C_{33} n-alkanes have also been reported from the fruits (Rastogi & Mehrotra, 1993c). Jain & Srivastava (1984) have isolated a glycoside 3, 3'-di-O-methylellagic acid-4-O-β-D-xylopyranosyl-(1→4)-β-D-glucopyranoside (I) from the stem-bark of this species, besides betulin, betulinic acid and lupeol as the triterpenoidal constituents. Srivastava & Pitre (1985) have isolated a new anthraquinone glycoside (1, 3, 5 trihydroxy-6-methoxy-2-methyl anthraquinone 8-O-β-D-glucopyranoside) from the stem-bark.

Uses : The quince-like fruits are eaten after removing hairs and skin. The pulp is rather hard and aromatic like clove probably due to considerable percentage of phytin. The natives relish the sweet and aromatic pulp during December-February. Recently, this species has been cultivated at many places and seedless cultivars have been developed. Wood furnishes a hard, compact ebony of deep black colour, used for making combs.

Notes : Kanjilal on the herbarium sheet no. 5452 sterile (DD) has mentioned 20 stamens in the male flowers. However, the specimens examined by me have 24-48 stamens.

Willdnow proposed the name *Diospyros discolor* Willd. in 1806 and cited *Cavanillea philippensis* Desr. (1792) in synonymy, making *D. discolor* Willd. a superfluous and illegitimate name. *C. philippensis* Desr. was formally transferred to *Diospyros* L. by Gurke (1891) to provide nomenclaturally correct name. But, this name (*D. philippensis* (Desr.) Gurke) was completely ignored upto quite recent, probably due to confusable name with *Diospyros philippinensis* A. DC. (1844), an orthographic variant, given for a Philippine endemic species. The homonymic potential of two epithets has recently also been admitted by General Committee of IAPT under the Art. 53. 5 of the ICBN (Knapp & Gilbert in Taxon 53 : 798. 2002). In such conditions, the next earliest available name is *D. mabolo* (Poir.) Roxb. ex Lindley (1828) based on *Cavanillea mabolo* Poir. (1797), not *D. blancoi* A. DC. (1844) as proposed by Howard (1971). But, this name has also not been taken up since its original publication. As such, Knapp & Gilbert (2002) have proposed the conservation of the name *D. discolor* Willd. which has been most commonly used but is illegitimate. In the present work, the concept of Knapp & Gilbert (2002) has been followed with the hope that the name *D. discolor* Willd. will be conserved against homotypic *D. philippensis* (Desr.) Gurke, *D. mabolo* (Poir.) Roxb. ex Lindley and *D. blancoi* A. DC. to stabilize the nomenclature of this widely cultivated species.

Exsicc.: ASSAM : Kamrup, Burdwara, 10th April 1915, *U. N. Kanjilal* 5452 sterile (ASSAM); KERALA : Palghat, Kallamalai area, 575 m, 13th March 1975, *E. Vajravelu* 46292 ♀ (RHMD, MH); UTTAR PRADESH : Lucknow, NBRI, 16th May 1949, *D. Awasthi* 368 ♀ (LWG); WEST BENGAL : Howrah, Indian Botanic Garden, Compartment No. 24, 13th June 2002, *V. Singh* 10289 ♀ (BSJO); Darjeeling, 10th April 1932, *E. V. Shebbeare* Acc. No. 58938 ♀ (DD).

19. ***Diospyros ebenum*** Koenig in Lund Physiogr. Salsk. Handl. 1 : 176. 1776, non Filet 1859, nec Ktze. 1898; A. DC. in DC. Prodr. 8 : 234.1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 208. 1876, *pro parte*, excl. *D. assimilis* Beddome & *D. nigricans* Dalz.; Clarke in Hook. f. Fl. Brit. India 3 : 558. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 216. 1938; Howard & Norlindh in J. Arn. Arb. 43 : 94-108. 1962; Kostermans, Rev. Handb. Fl. Ceylon 3 : 16. 1981. *Ebenum glaberrima* L. f. Suppl. Syst. Pl. ed. 13. 440. 1781. *Diospyros glaberrima* (L. f.) Rottb. Nye Saml. Kong. Dansk. Vidensk. Selsk. Skr. 2 : 540. t. 5. 1783. *D. ebenaster* Retz. Obs. Bot. 5 : 31. 1789; Roxb. Fl. Ind. 2 : 529. 1832; Spach, Hist. Nat. Veg. 9 : 407. 1840 & t. 135. 1846; A. DC. in DC. Prodr. 8 : 235.1844. *D. melanoxylon* Willd. Sp. Pl. 4 : 1109. 1805, non Roxb. 1795. *D. reticulata* Wall. Cat. 4120E. 1828-32, *nom. nud.*, non Willd. 1805. *D. ebenum* Koenig *var. glaberrima* (L. f.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 216. 1938.

English names : Ebony, East Indian Ebony, Ceylon Ebony, Black Sapote, Persimmon Ebony.

Vernacular names : *Hindi* : Abnus, Ebans, Tendu; *Kan.*: Balemara, Dumbi, Kari, Karemara, Bale, Kari, Kare, Mallai; *Mal.*: Karu, Karimaran, Mishatumbi, Vayari, Karimarom, Mushtimbi, Mushtumpi; *Mar.*: Abnus, Mushtimbi, Tai, Tendu; *Or.*: Kendu, Khenda; *Tam.*: Acha, Tai, Shengutam, Calam, Culli, Kakkayttali, Karai, Karunkali, Karunthali, Karunthovarai, Karungale, Karundali, Tumbi, Valaibattiram, Kaka-tati, Solakarimaram; *Tel.*: Nalluti, Nallati, Natlavaludu, Tumiki, Tumuki, Tuki, Tumbi.

Dioecious, polygamous or rarely monoecious trees, upto 30 m high, with glabrous branchlets, unarmed. Bark black or grey black, peeling off in small, rectangular pieces. Leaves alternate, 5-13.5 x 1.5-4.5 cm, elliptic or oblong, narrowed at base, in broadly elliptic leaves the base appears somewhat rounded, obtusely acuminate or rounded-retuse at apex, thinly coriaceous, glabrous; midrib raised beneath, canaliculate above, glabrous; lateral nerves 5-8 pairs, not very prominent but conspicuous bothsides, reticulate nervation hexagonal; petioles 3-8 mm long, glabrous, semiterete, flat or subcanaliculate above, rounded beneath. Male flowers subsessile, in 3-flowered, short, thinly pubescent, axillary cymes, cymes solitary or few together; peduncles upto 4 mm long, pubescent. Flower-buds 4-10 mm long, linear-conical. Bracts 1.5-2 mm long, broadly ovate, acute, pubescent, ciliate, attached at the base of peduncles, caducous; bracteoles like bracts, attached at the base of calyx. Calyx bell-shaped, 2-3 mm long, glabrous outside, thinly hairy within particularly in lower half, shallowly 4-lobed i.e. not exceeding the middle of the tube; lobes broadly oblong-ovate, apiculate, ciliate on the margins, glabrous outside, imbricate. Corolla tubular; tube 6-8 mm long, narrowed above the middle, glabrous, yellowish-white, 4-lobed; lobes broadly elliptic, 3.5-6 x 2-2.5 mm, obtuse, glabrous bothsides, with distinctly keeled midrib beneath, spreading or sub-erect, contorted. Stamens usually 16, unequal, in pairs, or ranging to 32 on 8 filaments in variable numbers, inserted at the base of corolla-tube; filaments 0.75-2 mm long, minutely pilose; anthers linear, 1.5-2 mm long, glabrous, connectives produced. Pistillode ovate-conical, glabrous. Female flowers subsessile, solitary, axillary; pedicels short, *ca* 2 mm long, with 2 basal bracts. Calyx-tube cupular, *ca* 3 mm long; lobes 4, 8-9 mm long, acute, imbricate, after fertilization the calyx-lobes get reflexed or spreading forming an elevated marginal rim. Corolla tubular; tube 12-15 mm

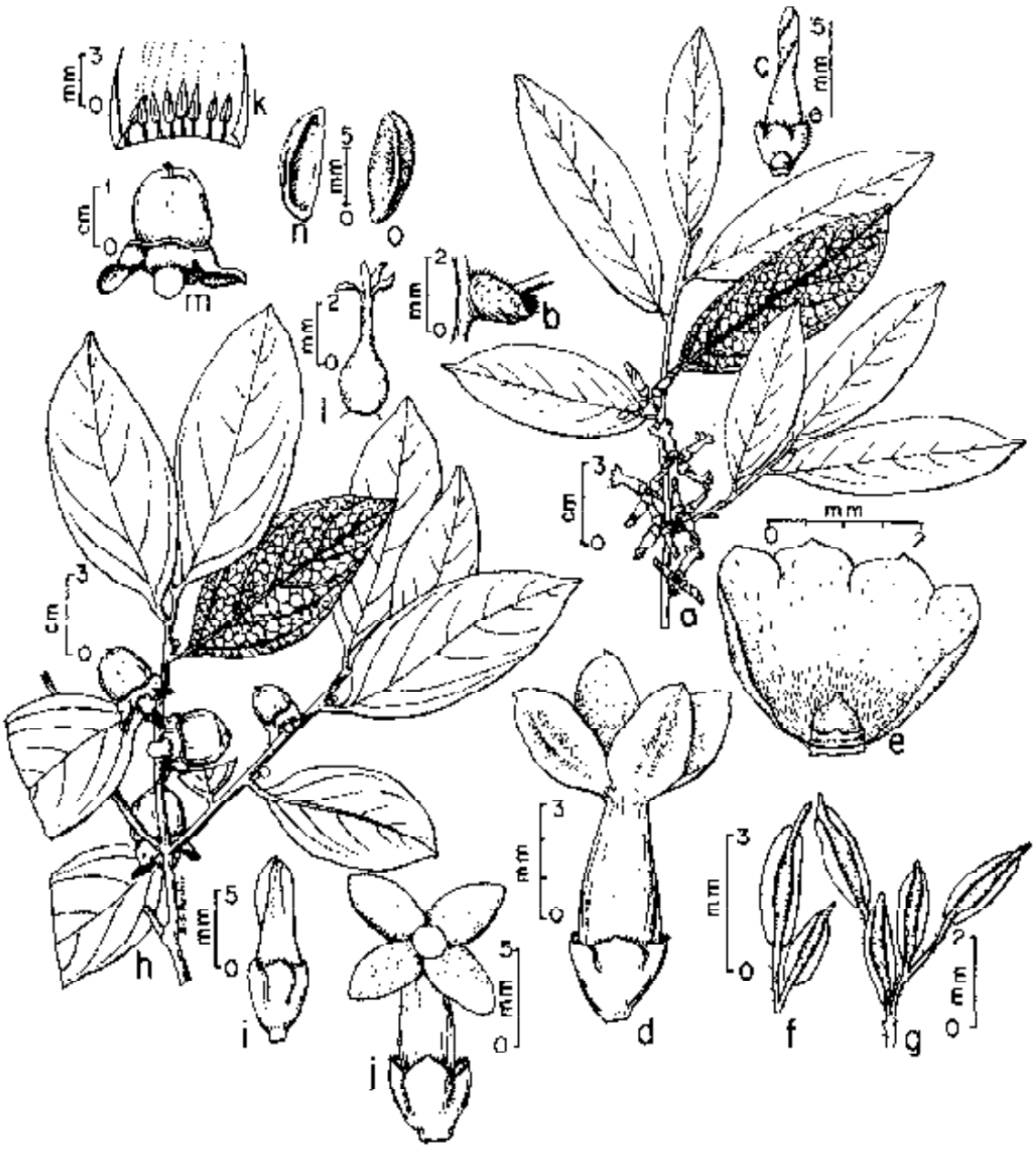


Fig.-19. ***Diospyros ebenum*** Koenig

Male : a. habit, b. bract, c. flower-bud with bract, d. flower, e. calyx within with pistillode, f-g. stamens.

Female : h. habit, i. flower-bud, j. flower, k. staminodes, l. gynoecium, m. fruit with calyx, n-o. seeds.

long, with wide mouth, glabrous; lobes 4, broadly elliptic, obtuse, 8-9 mm long. Staminodes 8 or 16, in pairs, opposite and alternate with corolla-lobes; sterile anthers deltoid, apiculate, pilose at apex; filaments glabrous, *ca* 2 mm long. Ovary glabrous, 8-celled, cells 1-ovuled; style 1, long; stigmas 4. Fruits globose or subglobose, 1.25-2 cm in diam., glabrous, tipped with style remains. Fruiting-calyx 1.5-2 cm in diam., enlarged; tube deep saucer-shaped or shallow bowl-shaped, circular or angled, encircling the basal part of the fruit, glabrous bothsides; lobes spreadingly reflexed from the point of junction with tube, forming an internal elevated rim, not constricted at base, coriaceous, margins reflexed outside. Seeds usually 4, rarely 2-8, elliptic or wedge-shaped, convex on one face and concave on the other, smooth, black; cotyledons ovate, tapering at apex, broad at base; albumen equable (Fig.-19; Plate 8/1 & 2).

Lectotype : Fruit bearing specimen, *Koenig s.n.* (Rottboell – hb.-C); *Syn-lectotype* : Male flower specimen, *Koenig s.n.* (C). For detail note on the typification, see Howard and Norlindh (1962).

Chr. No.: 2n=90 (Delay, 1947; Franceschi, 1993; Yonemori *et al.*, 2000); n=15 + 0 ~ 2B (Bir & Chatha, 1985; Chatha & Bir, 1987).

Fl. & Fr.: March – October.

Ecol.: It usually occurs in dry evergreen forests and extend to coastal and rain-fed areas, upto 1000 m. Plants also grow well in well drained rocky soils and in sandy loam with good subsoil drainage. It is propagated through seeds and seedling can withstand shade. The totally dry seeds with cracked testa, if emerged in boiling water for 5 minutes, show high percentage of germination. The germination of seeds is epigeal and the pairs of opposite, ovate cotyledons persist for many months and act as photosynthetic organ until epicotyledonary leaves come up. The growth of epicotyledonary leaves is very slow. It is a very slow growing tree.

Distrib.: In India, the species finds distribution in Assam, Orissa, Karnataka, Andhra Pradesh, Tamil Nadu, Kerala and Andaman & Nicobar Islands; cultivated elsewhere. Its occurrence in Bangladesh, Myanmar, Japan, Sumatra, Sri Lanka, Molucca, Timor, Celebes, New Guinea, New Caledonia and sometimes in Australia and Central America indicates its wide global distribution. However, Ng (1977) reported this species under cultivation in Malaya and totally absent in Philippines. According to him, the main range of distribution of this species may be divided into two widely separated regions viz. India and Sri Lanka forming one region and Molucca, Timor, New Guinea etc forming the other region (Map-4).

Pollen: Grains 3-zonocolporate; ectocolpium membrane crustate; endocolpium la-longate, dumb-bell-shaped, 2.3 x 6 µm. Exine surface smooth. Size 29-34 x 19-25 µm. (Nair & Kothari, 1985). Sharma & Gupta (1979) described pollen grains in details as 3-colporate, sub-prolate (32 x 24 µm). Colpi long, thin, running from pole to pole, with psilate membrane. Ora la-longate, with psilate membrane. Exine about 2 µm thick. Sexine thinner than nexine. Sexine pattern obscure.

Anatomy : There are two vascular traces in each cotyledon and cotyledonary xylem may or may not become diffused. The cotyledonary traces are prolonged into the primary root and the epicotyledonary leaf possesses 1 trace which dies away immediately below the cotyledonary node (Wright, 1904).

The seed anatomy of this species revealed that the testa is 5-7 cells thick. The outer epidermal layer is made up of a palisade of thin-walled cells; the outer wall of cells is slightly thickened and brownish, with colourless rather watery contents but with tannin, facets variously elongated and gyrose. Mesophyll (middle layers) is composed of compact layers of small, thin-walled, cuboid cells with flange-like thickenings on the radial walls, not lignified, without crystals. Endosperm is made up of very thick-walled cells (Corner, 1976).

The timber is jet black, hard and heavy, with very high density. The rings of growth are inconspicuous. However, in the sapwood a zoned structure of light and dark bands is present and area between two dark bands is variable radially. The dark band possesses thick-walled wood fibres completely filled with dark matter; the wood parenchyma traverse these bands of wood fibres without reduction in size; the tracheal elements are equally abundant (Wright, 1904; Metcalfe & Chalk, 1950).

The vessels are medium thick-walled, truncate or attenuate-tailed at the ends. Perforations simple, nearly horizontal to oblique. Inter-vessel pits numerous, minute, orbicular to oval or polygonal through crowding, with broad border and rounded punctate orifice; pits leading to contiguous rays numerous to each ray cell, orbicular, oval or polygonal; tyloses lacking. The vessels of twig are about 0.31 mm long, 0.045 mm in radial diameter and 0.034 mm in tangential diameter. However, the length of vessels of sapwood is about 0.45 mm, radial diameter *ca* 0.085 mm and tangential diameter *ca* 0.061 mm. Parenchyma 5 to many-rowed paratracheal and 3 to 5-rowed metatracheal, in cambiform rows along the grain. The paratracheal parenchyma sparse, restricted to a few cells which are mostly contiguous to the tangential walls of the vessels, flattened to conform to the vessel wall. The metatracheal parenchyma very abundant, partly diffused through the fibre tract, most part in concentric, close, 1 to 2-seriate more or less undulate lines separated by 5-20 fibres. The cells of metatracheal parenchyma angular and flattened in the tangential plane. Occasionally, there occurs brownish black or black gummy infilteration in both types of parenchyma in sapwood; however, it is copious in heartwood. Crystals lacking and starch deposits occur occasionally in outer sapwood. The length of wood parenchyma cells in the sapwood varies from 0.03 to 0.12 mm, with 0.015 mm radial diameter. The fibres are libriform, fine, angled, smaller than parenchyma cells, aligned in radial rows in concentric, undulate, 5 to 20-seriate bends which alternate with the narrow lines of zonate parenchyma. Inter fibre pits numerous, abundant on radial walls, bordered with very small court and slit-like orifice. Lumina in heartwood is filled with the deposits of brownish black or black gum. The radial diameter of wood fibres in sapwood and heartwood is 0.013 mm. The medullary rays are very fine, appearing as narrow whitish lines in the heartwood, separated by 1-8 fibres, frequently contiguous to the vessels. The rays of sapwood sometimes have gummy infilteration; however, it is copious in heartwood ray-cells. The radial vertical diameter of medullary ray cells is about 0.015 mm and tangential *ca* 0.02 mm, with vertical length *ca* 0.06 mm.

The radial diameter of horizontal medullary ray cells is 0.06 mm, tangential 0.012 mm, with vertical length *ca* 0.035 mm (Wright, 1904; Pearson & Brown, 1981; Purkayastha, 1982).

Phytochemistry : The wood yields lignin, pentosans, cellulose, xylose, mannose, galactose and humic acid (Anonymous, 1952). The heartwood also contains α-amyrenone, α-amyrin, betulin, ceryl alcohol, bauerenol, stigmasterol, ursolic acid and betulinic acid (Gupta & Mahadevan, 1967; Asolkar *et al.*, 1992). Gupta & Dhar (1969) have also isolated 6-hydroxy-4, 5-dimethoxy-2-naphthoic acid and its methyl ester from the heartwood. α-amyrin, betulin, lupeol, ursolic acid and an unidentified triterpene alcohol $C_{30}H_{50}O_2$, m. p. 230-232° from leaves have also been isolated (Gupta & Mahadevan, 1968; Rastogi & Mehrotra, 1993a). Recently, ebenone ($C_{22}H_{16}O_5$, mp. 231-232°), a new biogenetically significant β-naphthyl-1, 4-naphthaquinone derivative, has been isolated from the stem bark by Sankaram & Reddy (1984).

Uses : This species yields best kind of ebony, generally jet black streaked with yellow or brown. It is not attacked by the insects and fungi. The heartwood is very heavy, close and even-grained. It takes good polish. The sapwood is white, close-grained and strong, but not durable. The jet black wood is mainly exported to China for making furniture, chop sticks and opium pipes and to Europe as a fancy wood. In India, it is used for making piano keys, musical instruments, walking sticks, sports goods, brushes, chop sticks, pipes, carved stands, furniture and cabinet work, gymnastic apparatus, mathematical instruments, pedestals of statues, tobacco-pipes, caskets etc.

The pulp of fruits is edible but in less quantity. Natives have experienced lethal or harmful effects when eaten in huge quantity. It is also used as a fish poison. The Greek physicians used the fruits of *D. ebenum* Koenig as astringent and attenuant (Kirtikar & Basu, 1935). The fruits are also lithontriptic, used to dissolve bladder stones. This vesicant property is due to the presence of Lupeol group of triterpenoids. The gum obtained from the bark is used for removing obstructions in vision due to any cause. The ebony shavings mixed with *Terminalia chebula* Retz., alum and other substances are boiled in water and used as a remedy for toothache. The ebony dust with sulphur is put in dog's food as a remedy for mange. Wood is astringent, attenuant and lithontriptic (Rao, 1914).

Notes : The author's citation of this species is sometimes referred as Koenig ex Retz., not Koenig. Retzius although translated German text of Koenig into Swedish and little improved the Latin description. He has also added a foot note of some comments on the article and gave an eulogy on the work and endeavours of Koenig. This clearly indicates that Koenig was the author. As such, I consider that correct citation should be ascribed to Koenig as proposed by Kostermans (1977a) and not to Koenig ex Retz. as suggested by Howard & Norlindh (J. Arn. Arb. 43 : 94-108. 1962).

Bakhuizen (1938) recognized a variety *glaberrima* (L. f.) Bakh. based on *Ebenum glaberrima* L. f. (1781), characterized with totally glabrous and small leaves. He has not given the size of smaller leaves in the variety. The present study revealed the combination of characters does not hold good and there occur even rather larger leaves with glabrous nature. As such, it is proposed to merge the variety

glaberrima (L. f.) Bakh. under proper species to avoid taxonomic confusion. Probably, Bakhuizen (1938) has referred typical variety by the name of var. *glaberrima* (L. f.) Bakh. as evident from the citation wherein typical variety has been indicated conspecific to var. *glaberrima* (L. f.) Bakh. Further, var. *timoriana* (A. DC.) Bakh. (=*D. timoriana* (A. DC.) Miq., *D. ebenaster* Retz., *D. reticulata* Willd. var. *timoriana* A. DC.) which differs from the proper species in having rather larger leaves with scattered appressed hairs on the veins and the veinlets and large pilose fruits is confined to Timor, Celebes and Malayan Peninsula, not found in India. Hence, it is not possible to comment on the taxonomic status of latter. However, the readers are advised to go through the notes on Ceylonese ebony trees published by Kostermans (1977a) on correct citation of *D. ebenum* Koenig, typification and synonymy, particularly the status of *D. ebenaster* Retz. The latter has been considered as an obscure species by Kostermans (1977a). However, till the problem is solved, I consider it better to treat it under present species. The Indian plants belong to proper species.

Exsicc.: ANDHRA PRADESH : Cuddapah South, Balapalli, Oct. 1927, *Range Officer* Acc. No. 44712 ♀ (DD); 240 m, 25th March 1922, *C. E. C. Fischer* 4735, Acc. No. 282221 ♂ (CAL); Chittoor, Way to Papanasanam, 1000 m, 4th March 1959, *K. Subramanyam* 7883 ♂ (MH); KERALA : Palghat, Dhoni R. F., Near Dhoni river, 125 m, 27th May 1964, *E. Vajravelu* 19104 ♀ (MH), ORISSA : Puri, April 1919, *H. H. Haines* 2510A ♀ (DD); Angul, 28th March 1917, *H. H. Haines* 2510B ♂ (DD); Kutgaan Khol, 375 m, *H. F. Mooney* 2874 ♀ (DD); TAMIL NADU : Tiruchi, Thuraiyor, Pachaimalais, Sohanapuram, 250 m, 20th March 1978, *K. M. Matthew* 12563 ♂ (RHT, CAL); Nilgiri, Moyar river bank, 550 m, 19th April 1971, *N. C. Rathakrishnan* 37980 ♂ (RHMD, MH); Anna, Kodaikanal hills, Kodavanat MHEP area, 400 m, 17th June 1986, *K. Ramamurthy* 83801 ♀ (CAL); Tirunelveli, Kodamalai Range, 5th Oct. 1926, *Forest Officer* Acc. No. 42602 ♀ (DD).

20. ***Diospyros ahretioides*** Wall. ex G. Don, Gen. Hist. Dichl. Pl. 4 : 40. 1837; Hiern in Trans. Cambr. Philos. Soc. 12 : 162. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 559. 1882. *D. mollis* Wall. ex Steud. Nom. Bot. ed. 2. 1 : 514. 1840, non Griff. 1844, nec Gurke 1891, nec *Gunisanthus mollis* Kurz 1873.

Trees, upto 20 m high, with ferruginous pubescent young branchlets becoming glabrate to glabrous with age, unarmed. Leaves alternate, 5-23 x 3-13 cm, broadly elliptic, obtusely-apiculate at apex, rounded or cuneate-rhomboid at base, submembranous or coriaceous, glabrous bothsides or thinly pubescent beneath especially on the veins when young, green or slaty brown above, reddish brown beneath; midrib canaliculate above especially in lower region, raised beneath; lateral nerves 5-8 pairs, distant, more prominent towards base, reticulate venation prominent; petioles 0.5-2 cm long, canaliculate above, rounded beneath, glabrous or thinly pubescent in young leaves. Male flowers sessile, articulated with the peduncles, in compound, trichotomous, densely pubescent, lax, axillary cymes upto 6 cm long; cymes solitary or several together, usually on young branches. Bracts ovate-lanceolate, acute, reflexed at apex, pubescent outside, deciduous. Flower-buds globose, pubescent. Calyx campanulate in bud, soon

takes the shape of an umbrella due to widely separated lobes in flower; tube 1.5-2 mm long, suddenly narrowed at base, widened upwards, mouth 4-5 mm wide, pubescent outside, glabrous within; lobes 4, 5 or 6 on the same plant or even in the same inflorescence, divided about half way down, 1.5-2 mm long and about as wide, triangular-ovate or narrowly triangular when the number of calyx-lobes is 6, obtuse, ciliate, pubescent outside, glabrous within, widely separated, valvate. Corolla campanulate or urceolate, 5-6 mm long, about one and half times as long as calyx, pubescent outside, glabrous within; lobes 4, almost suborbicular, erect, margins reflexed outside, glabrous within, pubescent outside, contorted. Stamens 22-29 (20-23 in our material), distinct, subequal, inserted at the base of corolla-tube; filaments 0.5-1.25 mm long, glabrous; anthers 1.5-2.25 mm long, ovate-lanceolate, apiculate due to produced connectives, glabrous, dehiscing by apico-lateral slits extending upto half way down. Pistillode globose, densely pubescent. Female flowers axillary, solitary, on young branches; pedicels 5-6 mm long, pubescent. Calyx and corolla as in males. Ovary glabrous, 8-celled, cells 1-ovuled; styles 4. Fruits 3-3.5 cm in diam., globose, glabrous. Fruiting-calyx flattened, discoid or angular, 1.5-1.8 cm in diam., pubescent outside; lobes recurved, not thickened, margins flat, not rolled. Albumen ruminate. I could not see the female plant and the characters given here have been borrowed from the literature cited (Fig.-20; **Plate 8/3**).

Holotype : Burma (Myanmar) : Tavoy & Moolmyne, *Wallich* 4137 (K).

Fl. & Fr.: November – April.

Ecol.: Occasionally found in deciduous forests; usually cultivated in the gardens. Plants can tolerate drought conditions for quite a longer period.

Distrib.: Native of Myanmar. In India, it is reported under cultivation in West Bengal. Utsunomiya *et al.* (1998) have reported its occurrence in Thailand also (**Map-4**).

Pollen : Pollen grains 3-colporate, sub-prolate (40 x 33.5 µm), range 37.5-45 x 30-37.5 µm. Amb sub-circular. Colpi long, thin, running from pole to pole. Colpi membrane uneven and ornamented. Apocolpium diameter not distinct and mesocolpium distance about 18 µm. Ora la-longate (3.7 x 7.0 µm) with irregular margins, membrane psilate. Exine about 2 µm thick. Sexine pattern obscure (Sharma & Gupta, 1979).

Anatomy : The testa of seeds is 7-11 cells thick. The outer epidermal layer is composed of thick-walled, lignified, fibriform, obliquely longitudinal cells. Mesophyll is thin-walled, collapsed, some cells with a large tetrahedral crystal especially near the hilum and round the micropyl. The inner layer of testa is inconspicuous, some cells with a crystal. Tegmen crushed except for the narrow sclerotic endostome and its inner layer is composed of small rectangular cells with slightly thickened brownish walls, not lignified except round the endostome. Endostome wholly lignified; the outer and inner layers with thick-walled sclerotic cells; the 1-2 intervening layers of cells with thin walls. Endocarp forms a thin pellicle round each seed. It is composed of a few layers of small thin-walled cells with inner layer of more or less transversely elongated cells having mucilaginous walls, not as a palisade, not lignified (Corner,

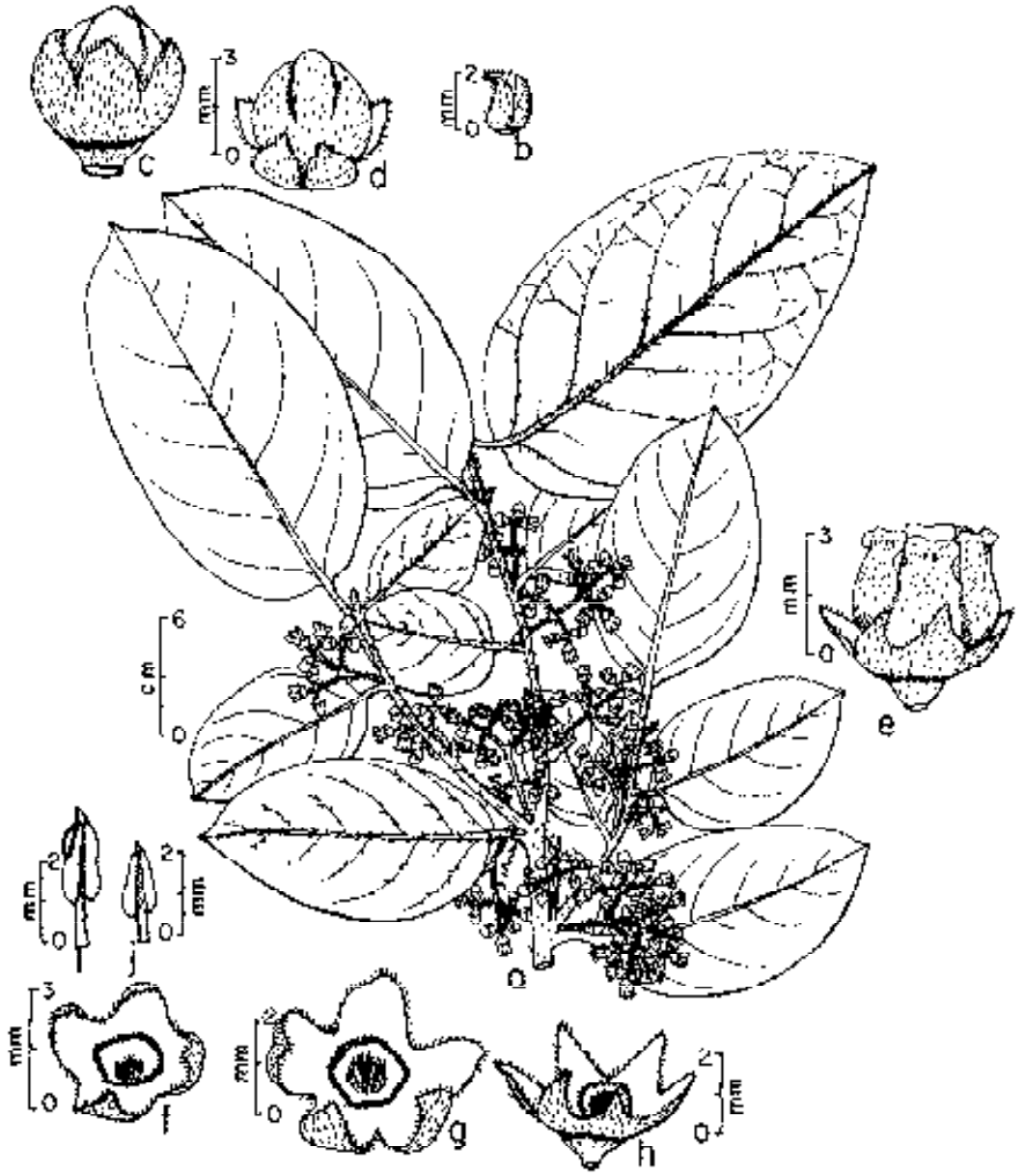


Fig.-20. ***Diospyros ehretioides*** Wall. ex G. Don
Male : a habit, b. bract (dorsal view), c-d. flower-buds, e. flower, f-h. calyx with pistillode (4, 5 & 6-lobed), i-j. stamens.

1976). Utsunomiyo *et al.* (1998) have recorded sparsely distributed tannin cells in the mesocarp of the fruit and the size of tannin cells is like rest parenchyma or slightly larger.

Sapwood yellowish white, coarse-grained and rather hard. The heartwood rather heavy, brittle, close-grained, brown or beautifully white and black mottled (Kurz, 1877). Growth rings are absent or very hardly visible and delimited by somewhat denser fibres tissue in the outer portion of the ring, with strongly sinuate margins. Vessels large to medium-sized or small, the largest in the central portion of the ring, the smallest towards the outer margin of the ring, open, with contiguous rays on one or bothsides forming broad, conspicuous, rather distant straight vessel lines along the grain. The vessels are made up of solitary radial rows of 2 to 4 cells or sometimes cells in double rows or in a number of parallel rows united into a radially aligned cluster. Vessel segments medium thin-walled, truncate or attenuate-tailed at the ends, with horizontal to oblique perforation. Inter-vessel pits numerous, orbicular or oval or polygonal, with broad border and short lenticular orifice having 4-6 mm diameter. Pits numerous in each ray-cell, orbicular, oval or polygonal due to crowding, having semi-border and short lenticular orifice of 4-5 mm diameter. Deposits of citron-yellow or brownish-yellow gum are found very occasionally.

Paratracheal parenchyma is made up of few, low broad cells which are mostly contiguous to the tangential walls of the vessels. Metatracheal parenchyma is abundant, in part diffused through the fibres tracts, with angled cells flattened in tangential plane. No crystals and no starch have been reported and yellow or yellowish brown gummy infilteration is also scanty.

Fibres are libriform or semi-libriform, fine, more or less angled, smaller than parenchyma cells in transverse section, aligned in radial rows in concentric, undulate, 4 to 8-seriate bands which alternate with the narrow lines of zonate parenchyma. The fibre-cells borne towards outer margin of rings are rather thick-walled, non-gelatinous, non septate. Inter-fibre pits are abundant on the radial walls, bordered, with small court and slit-like, oblique orifice. Fibre-lumina is usually empty.

Rays are very fine, appearing as narrow lines, close, separated by 1-6 fibres, frequently contiguous to the vessels. Pits leading to contiguous vessels numerous to each ray cell, orbicular to oval or polygonal with broad semi-border and short lenticular orifice of maximum 4-5 mm diameter. Gummy infilteration is very scanty in the form of globules; crystals abundant, solitary and large (Pearson & Brown, 1981).

Vessels of wood are medium-sized, with vasicentric sheath of parenchyma round the vessels. Rays usually 2-cell wide (Metcalfe & Chalk, 1950).

Phytochemistry : The fresh fruits contain a readily oxidizable phenolic constituent named diospyrol which is assumed to be the active principle effective as an anthelmintic. Yoshihira *et al.* (1967) and Loder *et al.* (1957) recorded the presence of tetrahydroxydimethyl – 2, 2'- binaphthyl compound from the fruits. Tezuka *et al.* (1973) have recorded the occurrence of mamsgakinone and elliptinone from the dry fruits.

Uses : The wood is grey with darker streaks, moderately hard and even grained. It is chiefly used for house posts. The fruits are used for fish poisoning in Thailand (Utsunomiya *et al.*, 1998). Plants yield a good quality of gum (Jayaraman, 1996).

Notes : The wood structure of this species shows close affinity with the neogene fossil wood of *Ebenoxylon kartikcherriense* Prakash & Tripathi (Awasthi, 1974).

Exsicc.: WEST BENGAL : Howrah, Botanic garden, April, 1918, *G. I. Lane* 4683 ♂ (CAL).

21. ***Diospyros elegans*** Clarke in Hook. f. Fl. Brit. India 3 : 571 1882, non *Maba elegans* Ridley 1915. *D. elegans* Clarke var. *hookeri* Clarke in Hook. f. Fl. Brit. India 3 : 571 1882.

Large shrubs or small trees; branchlets rather wiry, persistently densely hirsute with long, setaceous erecto-spreading hairs mixed with short ordinary hairs; older branches glabrate to glabrous with age. Leaves alternate, subsessile, lanceolate, 3-10 x 0.4-3 cm (upto 14 x 4 cm in protologue), gradually long caudate acuminate at apex, narrowed or subrounded at base, densely ciliate with long setaceous hairs, sparsely hairy with setaceous hairs on both surfaces especially on the veins and veinlets; midrib prominent beneath but not conspicuously raised, flat or subcanaliculate above, hirsute bothsides; visible lateral veins 6-10 pairs, oblique towards margins, reticulate venation rectangular between lateral veins; petioles upto 2 mm long, terete, densely hirsute. Male flowers sessile, in pedunculate, 3 to 12-flowered, bracteate, hirsute, congested cymes; main peduncles upto 1.5 cm long (3.8 cm in protologue), secondary peduncles upto 2 mm long and articulated with flowers. Bracts 4.5-5.5 x 1 mm, linear-lanceolate, acuminate, ciliate, hairy dorsally, glabrous on ventral face, seated on peduncle at the point of branching, deciduous; bracteoles 2, suborbicular-rhomboid, *ca* 1 x 1 mm, acuminate, hairy on the back, glabrous ventrally, eciliate, subtending each flower in the form of an involucre close to the calyx. Calyx campanulate, 2-3 mm long, deeply 3-lobed more than half way down; lobes suborbicular or broadly oblong, acuminate, eciliate, hairy on the back in the middle with setaceous hairs, glabrous towards margins outside and within, valvate. Corolla tubular, 4-5 mm long; tube short, included within calyx; lobes 3, divided nearly to the base, broadly oblong, apiculate, sparsely hairy outside in the middle in upper part below the apiculae, glabrous within, contorted. Stamens 5-10, unequal, of different shapes, paired as well free, 0.5-2 mm long, inserted at the base of corolla-tube; filaments upto 1.5 mm long, glabrous; anthers obtusely apiculate at apex due to slightly produced connectives, hairy dorsally along the connectives. Pistillode ovoid, densely hairy, with single style; stigma indistinctly 3-lobed. Female flowers and fruits not seen (**Fig.-21; Plate 8/4**).

Holotype : India : Assam, Khasia Mts., Nunklow, 1050 m, *Clarke* 18115C (K).

Fl. & Fr.: May – September.

Ecol.: On Khasia Mts, upto 1000 m.

Distrib.: Endemic to India, confined to Assam and Meghalaya (**Map-4**).

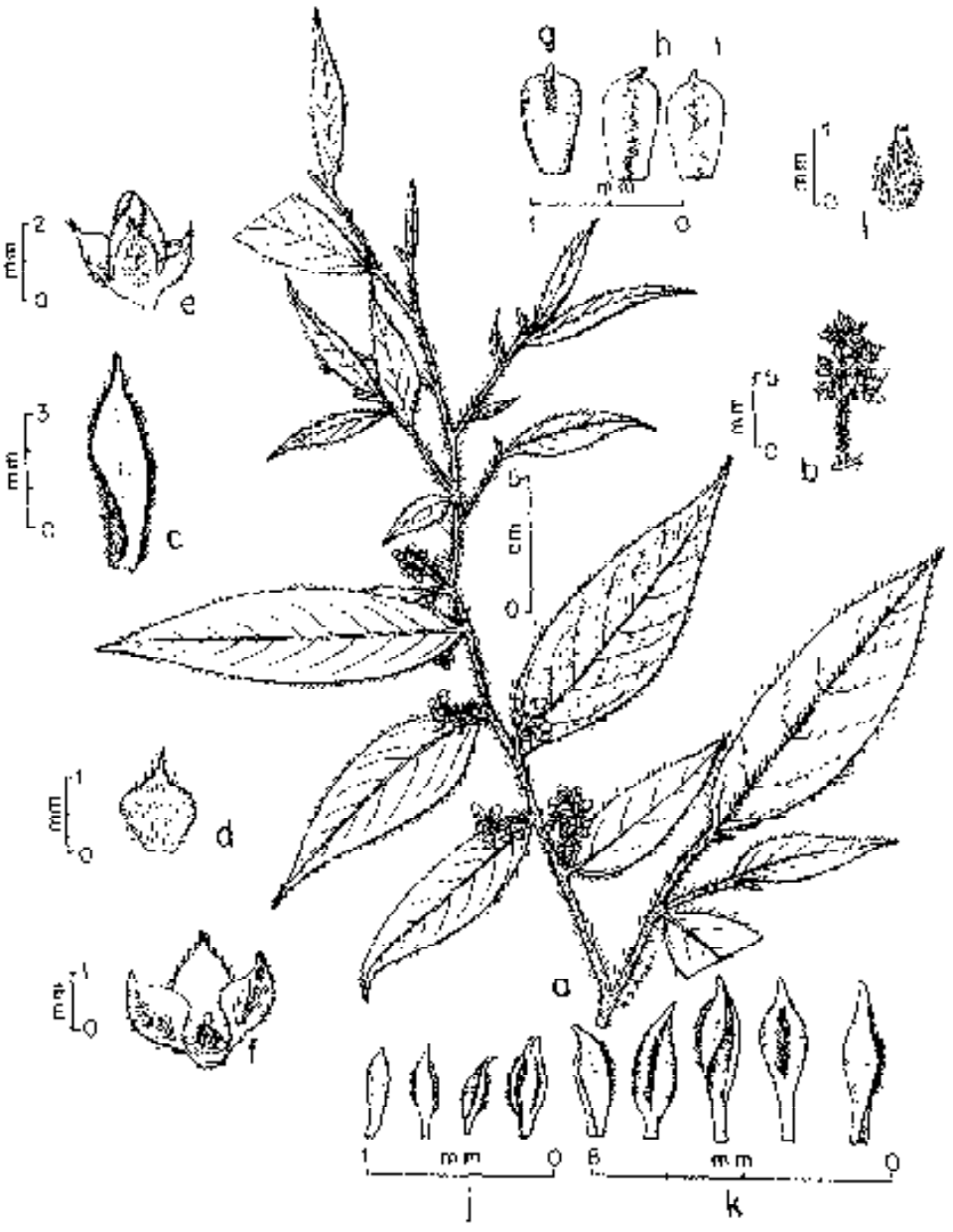
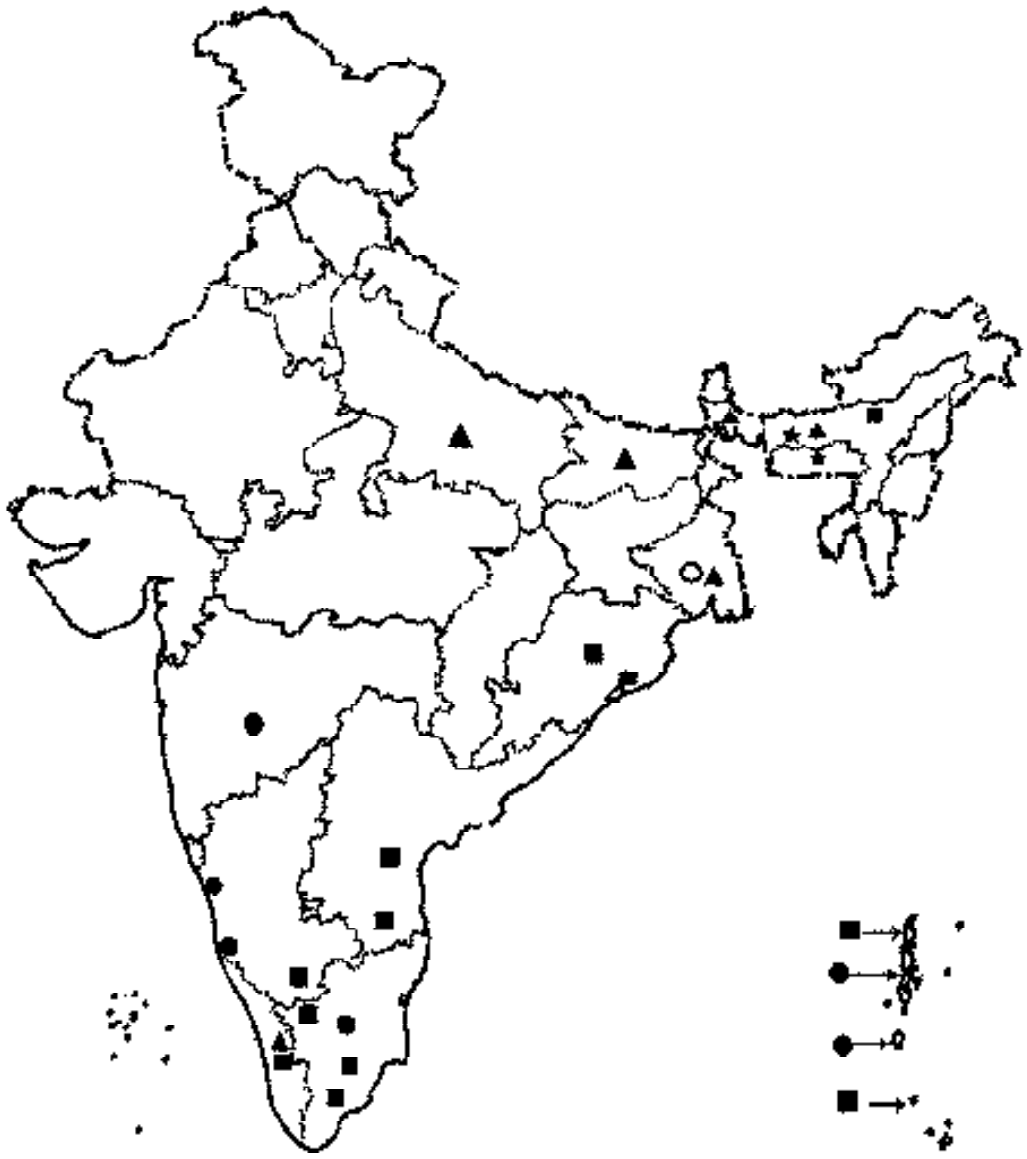


Fig. 21. ***Diospyros elegans*** Clarke

Male : a. habit, b. inflorescence, c. bract, d. bracteole, e. flower-bud, f. calyx within with pistillode, g. corolla-lobe (dorsal view), h-i. corolla-lobes (ventral view), j-k. stamens, l. pistillode.



Distrib. Sketch Map – 4

● *Diospyros cremenata* Thw.; ▲ *Diospyros discolor* Willd.;
■ *Diospyros ebenum* Koenig; o *Diospyros ehretioides* Wall. ex G. Don;
* *Diospyros elegans* Clarke

Notes : Clarke (1882) has described a variety *hookeri* from Bangladesh, distinguishing it from proper species by its shrubby habit and less finely acuminate leaves. The present study revealed that these characters do not hold good and are not enough to retain it at varietal rank. As such, in the present monograph it has been merged under *Diospyros elegans* Clarke.

I had an opportunity to examine a very old collection (1872) of *Clarke* 18115B (isotype) in CAL which bears very few flower-buds in a congested pedunculate cymes. On the sheet, the floral parts and their drawings have been pasted and labelled. An examination of available very small flower-buds revealed that so called pistillode is rather well developed in comparison to other species, seated on the disc with a distinct style and indistinctly 3-lobed stigma. Due to very limited and very old buds, I could not ensure myself whether the said organ is a pistillode or a fertile pistil. If it is a pistil, the flowers may be defined as bisexual, contrary to the protologue.

Exsicc.: ASSAM : Khasia hills, Nunklow, 1050 m, 29th Oct. 1872, *C. B. Clarke* 18115B ♂ (Isotype-K, CAL).

22. ***Diospyros fasciculosa*** (F. v. Muell.) F. v. Muell. in Austr. Veg. Intercol. Exhib. Ess. 1866-67 : 35. 1867; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 78. 1937. *Maba fasciculosa* F. v. Muell. Fragm. Phyt. Austr. 5 : 163. 1866; Hiern in Trans. Cambr. Philos. Soc. 12 : 135. 1873. *M. laxiflora* Benth. Fl. Austr. 4 : 290. 1869. *Ebenus fasciculosus* (F. v. Muell.) O. Ktze. Rev. Gen. Pl. 2 : 408. 1891. *Maba merguensis* Kds. & Val. Bijdr. Booms. Java 1 : 25. 1894, non Hiern 1873. *M. tenuinervis* Kds. & Val. ex Kds. in Tijdschr. Ned. Ind. 60 : 382. 1901.

Large trees, dioecious, with quite glabrous, divaricate, sparsely lenticelled branches. Leaves alternate, 7.5-12.5 x 1.5-4.5 cm, oblong or elliptic, obtuse or obtusely acuminate, glabrous above, slightly pubescent beneath, coriaceous, not pellucid-punctate, margins recurved, veins raised; midrib canaliculate above; petioles 5-10 mm long, depressed or canaliculate above. Male flowers in short, rufous tomentose, bracteate, fascicled, 10 to 25-flowered, axillary cymes; pedicels appressed pubescent or sub-glabrous. Bracts small, ovate, concave ventrally, appressed pubescent outside, glabrous within, ciliate, caducous. Calyx cupuliform or campanulate, 3-4 mm long, 3 to 4-lobed, pubescent outside, glabrous within; lobes valvate. Corolla campanulate, 5-6 mm long, glabrous; lobes 3-4, rounded, contorted. Stamens 8-18, hypogynous, seated on the torus, unequal; filaments ciliate; anthers glabrous, dehiscing through apico-lateral slits. Pistillode rudimentary. Female flowers in 3 to 4-flowered, pubescent, bracteate, axillary cymes. Calyx and corolla as in males, but larger and more spreading. Staminodes 0-4. Ovary ovoid, glabrous, usually 3-celled, 2-ovuled in each cell, sometimes cells get further separated by incomplete dissepiment making the ovary 6-celled and 1-ovuled in each cell; style thick, 3-fid. Fruits *ca* 1.25 cm in diam., depressed-globular, glabrous; fruiting-pedicels *ca* 5 mm long. Fruiting-calyx cup-shaped, enlarged, glabrous, 1-1.5 cm in diam., with spreading, ovate-deltoid lobes, enclosing lower part of fruit. Seeds 1-6, oblong, rugulose; albumen equable.

Lectotype : Australia, Queensland, *Mueller s.n.* (MEL-designated here).

Fl. & Fr.: April – October.

Ecol.: Rarely cultivated in the gardens.

Distrib.: In India, this species is known under cultivation in Uttranchal and Uttar Pradesh. However, its chief centres of distribution are Indonesia, Java, Fuji, New Caledonia and Australia its native home **(Map-5)**.

Pollen : Pollen grains 3-colporate, sub-prolate (35.5 x 27 µm), range 32.5-37.5 x 25-27.5 µm. Anguloaperturate. Amb almost triangular. Colpi long, streaky, margins wavy and membrane ornamented. Apocolpium not distinct. Mesocolpium about 12 µm. Ora la-longate (4.5 x 8 µm). Exine about 2 µm thick. Sexine as thick as nexine. Sexine pattern obscure (Sharma & Gupta, 1979).

Uses : Wood is suitable for carving wood stamps.

Notes : In the protologue of *Maba fasciculosa*, Mueller (1866) listed four Queensland collections viz. *C. Moore, Mueller, W. Hill* and *Thozet*. No lectotype has sofar been selected among these collections. I suggest that the specimen collected by *Mueller s.n.* may serve as lectotype.

Exsicc.: UTTRANCHAL : Dehra Dun, Forest College, 5th July 1925, *B. L. Gupta* Acc. No. 39985 ♂ (DD); May 1923, *R. N. Parker* Acc. No. 33100 ♀, 33101 ♀, 33102 ♂ 33103 ♀ (DD); Forest Park, Sept. 1913, *R. N. Parker* 5786 ♀ (DD).

23. ***Diospyros ferrea*** (Willd.) Bakh. in Gard. Bull. Str. Settl. 7 (2) : 162. 1933 & in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 50. 1937; Smith in J. Arn. Arb. 52 : 382. 1971; Kostermans, Rev. Handb. Fl. Ceylon 3 : 9. 1981. *Pisonia buxifolia* Rottb. in Nov. Act. Haffn. 2 : 536. t. 4. f. 2. 1783, non *Diospyros buxifolia* (Bl.) Hiern 1873. *Ehretia ferrea* Willd. Phytogr. 1 : 4. t. 2. f. 2. 1794. *Ferreola buxifolia* (Rottb.) Roxb. Pl. Cor. 1 : 35. t. 45. 1795. *Maba buxifolia* (Rottb.) A. Juss. in Ann. Mus. Hist. Nat. Paris 5 : 418. 1804; Pers. Syn. Pl. 2 : 606. 1807; A. DC. in DC. Prodr. 8 : 240.1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 116. 1873, *pro parte;* Clarke in Hook. f. Fl. Brit. India 3 : 551. 1882. *M. laurina* R. Br. Prodr. Fl. Nov. Holl. 1 : 527. 1810. *Ferreola guineensis* Schum. & Thonn. Beskr. Guin. Pl. 488. 1827. *Maba cumingiana* A. DC. in DC. Prodr. 8 : 241. 1844. *M. madagascariensis* A. DC. in DC. Prodr. 8 : 241. 1844. *M. sandwicensis* A. DC. in DC. Prodr. 8 : 242.1844. *M. smeathmanni* A. DC. in DC. Prodr. 8 : 241. 1844. *M. guineensis* (Schum. & Thonn.) A. DC. in DC. Prodr. 8 : 241. 1844. *M. vacciniaefolia* Benth. in Hooker, Niger Fl. 442. 1849. *M. buxifolia* (Rottb.) A. Juss. var. *ebenus* Thw. Enum. Pl. Zeyl. 183. 1860. *Ehretia buxifolia* (Rottb.) Pickering, Chron. Hist. Pl. 746. 1879, non Willd. 1798. *Ebenus buxifolia* (Rottb.) O. Kuntze, Rev. Gen. Pl. 2 : 408. 1891. *Maba secundiflora* Hutch. in Kew Bull. 1921 : 384. f. 8. 1921. *Diospyros ferrea* (Willd.) Bakh. var. *buxifolia* (Rottb.) Bakh. Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 57, 59. 1937. *D. ferrea* (Willd.) Bakh. var. *guineensis* (Schum. & Thonn.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (4) : 433. 1941. *D. ferrea* (Willd.) Bakh. var. *madagascariensis* (A. DC.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (4) . 432. 1941.

English name : Philippine Ebony, Persimmon.

Vernacular names : *Beng.:* Angaru; *Kan.:* Karugana, Piccane; *Or.:* Gourokholi, Pitonu, Guakoli; *Tam.:* Irumbali, Kuruvinci, Irrumbili, Frambulli, Kirummal, Irungili, Irumbul, Karianthovarai, Mariathovarai, Irumoalampazhem, Vakkanai; *Tel.:* Pisinika, Uti, Yerruti, Cinnavullinji, Tellavulimidi.

Dioecious shrubs or small trees, 2-7 m high, with brownish black to dark grey bark; branchlets pubescent with small hairs mixed with few scattered long hairs. Leaves alternate, 0.6-3.5 x 0.4-1.5 cm, usually obovate, elliptic-obovate, oblong-spathulate, narrowed at base, usually obtuse or sometimes retuse at apex, margins prominently thickened and sometimes undulate in dry specimens, coriaceous, mature ones almost glabrous bothsides except with few scattered long hairs along the midrib, lateral veins and veinlets and young leaves with rather more appressed long hairs; midrib raised beneath, with few scattered long hairs, not canaliculate above or sub-canaliculate in lower half of leaf, the latter condition is more prominent in female plants; lateral nerves inconspicuous on upper surface, on lower side 5-6 pairs, arcuately connected at some distance from margin in lower part of leaf, upwards mixed up with reticulate venation which is more conspicuous than lateral veins; petioles 1-2 mm long in males, upto 5 mm in females, densely appressed pilose when young and becoming glabrate with age, semi-terete, flat or grooved above, rounded beneath. Male flowers white, subsessile, 1 to 3-together in short, axillary, hairy cymes on young branches, trimerous. Flower-buds ellipsoid, 2.5-3 x 2 mm, subsessile, hairy throughout; peduncles *ca* 1 mm long or less, hairy. Bracts 1.25-1.5 mm long, oblong, acute, boat-shaped, hairy outside, subtending each flower. Calyx 2-3 mm long, campanulate, with mouth about as wide, divided upto one-third of its length, sericeous outside with short hairs, glabrous within; lobes 3, ovate-triangular, 1-1.5 mm long, erect, hairy outside, glabrous within, valvate. Corolla-tube 3-4 mm long, slightly exceeding the calyx, tubular, slightly swollen (2 mm) in the middle, not narrowed at mouth, glabrous within, sericeous outside with long hairs particularly above the middle; lobes 3, oblong-ovate, obtuse, 1-1.5 mm long, hairy outside particularly in the middle, glabrous within, contorted. Stamens 6 (in our material) or 12 (Bakhuizen, 1937), hypogynous, seated on torus; filaments 1.25-1.75 mm long, sparsely pubescent or glabrous; anthers 1.5-2 mm long, glabrous, narrowly oblong, obtuse. Rudimentary ovary depressed globose, densely pilose at the apex. Female flowers axillary, usually solitary or rarely upto 3 in some leaf axils. Calyx campanulate; tube 2-2.5 mm long, with mouth about as wide, hairy outside, glabrous within; lobes 3, triangular, 1-1.5 mm long, not more than half the length of tube, sub-acute or obtuse, hairy outside, glabrous within, valvate. Corolla tubular; tube 3-4 mm long, about as long as calyx or little exserted, densely hairy with long hairs in upper region and glabrous in basal part outside, glabrous within; lobes 3, oblong-spathulate, *ca* 2 mm long, obtuse, hairy outside in the middle with long hairs, glabrous within, contorted. Staminodes absent. Ovary *ca* 2 mm long, globose, silky-appressed hairy, 3-celled, cells 2-ovuled; style *ca* 1.5 mm long, sericeous in lower half; stigmas 3. Fruits 0.5-1 x 0.4-0.8 cm, globose or ovoid-globose, with style remains at the apex, initially sericeous at the top in young stage, smooth and glossy when mature. Fruiting-calyx cupuliform, cup 2-3 mm deep, enlarged, encircling the lower part of fruit; lobes erect and touching the fruit, much broader than long, neither thickened nor revolute; in some plants the fruiting-calyx is cupuliform in semi mature fruits and becomes flat with spreading lobes in the mature condition on the same plant. Seeds usually

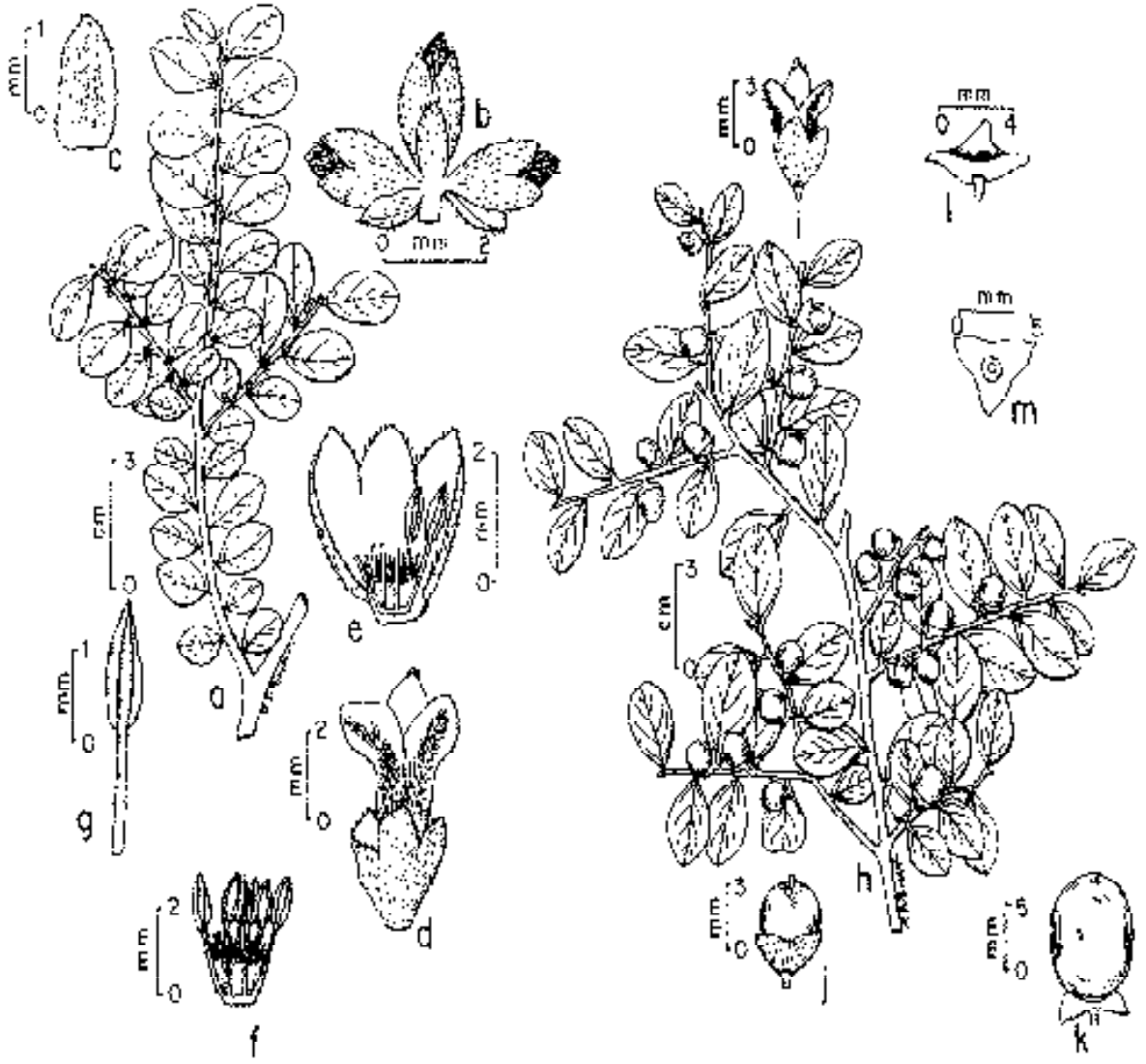


Fig.-22. ***Diospyros ferrea*** (Willd.) Bakh.
Male : a. habit, b. inflorescence, c. bract, d. flower,
e. calyx within with stamens and pistillode, f. stamens, g. stamen.
Female : h. habit, i. flower, j. immature fruit with calyx, k. mature fruit with calyx,
l. fruiting-calyx (dorsal view), m. fruiting-calyx (ventral view).

1, rarely upto 3, wedge-shaped when more than one, *ca* 4 mm long, blackish brown, the solitary seeds rather larger, upto 7 x 4 mm, ovoid-oblong, turgid; albumen equable (**Fig.-22; Plate 9/1 & 2**).

Holotype : India : Malabar coast, *Koenig s. n.* ♂ (Herb. Willd.- B).

Fl. & Fr.: February – September.

Ecol.: Usually found in mixed forests in rather dry conditions at low altitude, upto 1200 m. This is an ochlospecies as its variations are very complicated and imperfectly correlated with geography. It is an ecological and chorological transgressor having wide distributional range. The main agents for the dispersal of seeds are cats, monkeys, bats and birds.

Distrib.: This species is chiefly confined to southern parts of the country, particularly to Orissa, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. The other regions of its occurrence include Sri Lanka, Myanmar, Malaysia, Indonesia, Singapore, Japan, Pacific Islands including Hawaii, Taiwan, Polynesia, N. Australia, Madagascar, East, West and South Africa (**Map-5**).

Phytochemistry : The roots yield four naphthoquinones viz. 7-methyljugulone, isodiospyrin, 2, 2′ – binaphthyl - 1, 1′ quinone a new red quinone and hydroxyisodiospyrin, besides crusgallin (sawamilletin, taraxerol 3-methyl ether), betulinic acid and β-sitosterol. Presence of crusgallin is a unique example outside Gramineae as it is usually found in the grasses. The stem and leaves also contain triterpenoides (Tezuka *et al.*, 1973; Rastogi & Mehrotra, 1993b). Recently, Friedelin and 3-friedelinal have also been isolated from the leaves (Rastogi & Mehrotra, 1993c).

Uses : The fruits are often eaten by the villagers particularly during famine in Tamil Nadu. They are said to become more tasty when fully ripe. The decoction of the fruits is used in the treatment of the back pain. Wood is hard and durable, used for cabinet work, boat anchors, handles and sheaths of weapons and rafters.

Notes : It is a highly polymorphic species. Bakhuizen (1937) has recognized many of its forms into eighteen varieties and thirteen forma under them. However, he could not provide statical diagnostic delimitations for these varieties as they pass gradually into each other. In this context, an examination of Indian material revealed that variations in few varietal populations found in India are, however, constant, rather abrupt and prominent enough to raise these varieties to specific level, and rest may be merged under proper species or under other taxa, as presented in the present monograph.

This species resembles closely to *D. chloroxylon* Roxb. var. *chloroxylon* to the extent that the specimens of latter species have been placed under the cover of *D. ferrea* (Willd.) Bakh. due to apparent similarity in fruit. But, *D. ferrea* (Willd.) Bakh. may be best distinguished by its 3-lobed fruiting-calyx not only from *D. chloroxylon* Roxb. but also from *D. buxifolia* (Bl.) Hiern to which it is sometimes wrongly assigned. *D. buxifolia* (Bl.) Hiern may be segregated from *D. chloroxylon* Roxb. by cylindrical-oblong fruits and closely placed bifarious, ovate-elliptic or elliptic-lanceolate, acute leaves.

Fig.-23. ***Diospyros foliolosa*** Wall. ex A. DC.

Male : a. habit, b. flower-bud, c. stamens, d. calyx within with pistillode.

Female : e-f. habit, g. flower, h. gynoecium, i. fruit with calyx, j-k. seeds.

Exsicc.: ANDHRA PRADESH : Cuddapah, Balapalla, 250 m, 18th July 1962, *J. L. Ellis* 14231 ♀ (CAL); Kodur, 24 m, April 1883, *J. S. Gamble* 11076 ♂ (CAL); *J. S. Gamble* 11077 ♀ (DD); KERALA : Travancore, Chimunji, 600 m, 15th April 1903, *T. F. Bourdillon* 1376 ♀ (DD); ORISSA : Konarak, 9th April 1966, *Mehrotra & Party* 1049 ♀ (RHMD, CDRI); Beghmani to Ihhureh, 5th April 1917, *H. H. Haines* 4852 ♂ (DD); Mayurbhanj, Bamra (Rupsa), 22nd July 1940, *Without Collector* 872 ♀ (DD); Cuttack, Mahanadi delta, Jambu, 7th June 1949, *H. J. Mooney* 3404 ♀ (DD); TAMIL NADU : Thanjavur, Kodikadu, 25 m, 24th May 1978, *V. J. Nair* 57085 ♂ (CAL, MH); South Arcot, Gomukanadhi MHEP area, Kalrayans, 1200 m, 25th June 1986, *K. Ramamurthy* 83861 ♀ (CAL); Madurai, Way to Sirumalai, 967 m, 25th April 1958, *K. Subramanyam* 5769 ♂ (MH); Tirunelveli, Kodamady-Nadukani, 230 m, 23rd July 1966, *B. V. Shetty* 27918 ♀ (MH); Otacamand, 29th Oct. 1931, *C. C. Wilson* Acc. No. 57486 sterile (DD); Coimbatore, Pattrakad, 21st Nov. 1975, *K. N. Subramaniam* 5397 ♀ (DD); *Without Collector* 36783 ♀ (DD).

24. ***Diospyros foliolosa*** Wall. ex A. DC. in DC. Prodr. 8 : 234. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 188. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 556. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 181. 1938. *D. calycina* Beddome in Ann. Rep. Forests Madras Pres. 1867-68 : 26. 1868.

Vernacular names : *Mal.:* Kattupanachi; *Tam.:* Vellaithovarai, Palivellaittuvarai, Vellaytoveray.

Medium-sized glabrous trees; branches longitudinally striated to 4-gonous. Leaves alternate, 3-13 x 1-5 cm, oblong-lanceolate, lanceolate or elliptic-lanceolate, obtusely acuminate to long acuminate, cuneate at base, coriaceous, glabrous bothsides; midrib prominent and raised beneath, grooved on the upper side especially in basal region; petioles 3-9 mm long, rounded beneath, canaliculate above, glabrous. Male flowers in lax, 3 to 9-flowered, almost umbellate axillary cymes; peduncles 1-1.5 cm long, glabrous; pedicels 3-10 mm long, glabrous. Flower-buds ovate-ovoid, gradually narrowed at apex, glabrous. Calyx 2-4 mm long, bowl-shaped, tube very short, glabrous bothsides, divided half way down into 4-lobes; lobes deltoid or ovate, acute, glabrous bothsides, valvate. Corolla urceolate, gibbous at base, constricted at apex, glabrous bothsides, bright yellow; lobes 4, pointed, spreading, contorted. Stamens usually 12 (in our material) or rarely 16 (Hiern, 1873), all of equal size, closely united in pairs, inserted on the receptacle around the pistillode; filaments *ca* 1 mm long, long hairy; anthers 3-4 mm long, lanceolate, dehiscing at base, connectives produced, long acuminate, glabrous. Pistillode globose-4-angled or lobed, glabrous, with a terminal acumen. Female flowers axillary, solitary, long pedicelled; pedicels 1.5-2.5 cm long, glabrous. Calyx deeply 4-lobed nearly to the base, tube very small or none; lobes broadly ovate, 1-1.8 x 0.7-1.2 cm, foliaceous, flat-margined, obtusely sub-acuminate, glabrous, sub-cordate at the base when removed from the tube, reticulately palmi-nerved, imbricate. Corolla urceolate, gibbose, included within calyx; tube nearly globose, glabrous; lobes 4, rounded, reflexed, acute, glabrous, contorted. Staminodes absent. Ovary globose, 3-4 mm in diam., densely rusty-sericeous, 4-celled, cells 1-ovuled; style 1, very short, glabrous; stigmas 4, elliptic, *ca* 1 mm long, glabrous. Fruits oblong-globose, 2-3 cm in diam., sometimes narrowed at base, squamose with small hair-scales

appearing pubescent in nature. Fruiting-calyx divided upto base, accrescent, no tube; lobes 1.5-2.5 x 0.8-1.25 cm, ovate-cordate, acuminate, foliaceous, sub-erect or spreading, neither reflexed nor thickened, reticulately palmi-nerved, fruit seated on the receptacle subtended by the calyx-lobes, not enclosed within the calyx. Mature seeds usually 3, rarely 4, oblong, 1.3-1.5 x 0.7-0.8 cm, flat on one face and convex on the other or two faces flat and one face convex, glabrous or rough due to the covering of dry layer of pulp of fruit; albumen slightly ruminate (**Fig.-23; Plate 9/3, 4 & 10/1**).

Holotype : India : Courtallum, *Wallich s. n.* (K).

Fl. & Fr.: March – November.

Ecol.: Abundant in evergreen wet forests of Western Ghats, upto 1100 m.

Distrib.: Endemic to India, confined to Kerala and Tamil Nadu (**Map-5**).

Pollen : Pollen grains 3-colporate, prolate-spheroidal (40 x 35 µm) or sub-prolate (40 x 30 µm). Anguloaperturate. Amb triangular. Colpi long, thin, running almost from pole to pole, with granulate membrane and uneven margins. Maximum width of colpus about 2.5 µm. Apocolpium diameter about 4 µm and mesocolpium distance about 12 µm. Ora la-longate (2.5 x 10 µm), rarely dumb-bell-shaped, with psilate membrane. Exine about 2 µm thick. Sexine thinner than nexine. Sexine pattern almost obscure (Sharma & Gupta, 1979).

Uses : Timber is light-coloured and valued for agricultural and building articles.

Exsicc.: KERALA Trivandrum, Bonaccord, 700 m, 17th May 1988, *N. Mohanan* 9915 ♀ (TBGT); Teppakulam, Tenmalai Range, 16th May 1961, *K. N. Subramanian* 71198 ♀ (BSI); Travancore, Aryanthavu, Dec. 1900, *T. F. Bourdillon* 1203 ♀ (DD); TAMIL NADU : Tennevelly, Kalakkadu R. F., 450 m, 8th March 1963, *J. Joseph* 15840 ♀ (MH); Tirunelveli, Mudalimppam bridge, Kalakkadu Forest, 8th Feb. 1983, *E. Vajravelu* 76524 ♂ (MH); Eruttupurai, Ayyanar Kail, 21st Sept. 1971, *E. Vajravelu* 38652 ♀ (RHMD); Srivilliputtur, *Range Officer* Acc. No. 13048 ♀ (DD); Ramnad, Virusadi-Srivilliputtur R. F., 1025 m, 21st July 1965, *E. Vajravelu* 24819 ♀ (MH).

25. ***Diospyros ghatensis*** Ramesh & Franceschi in Blumea 38 (1) : 131 f. 1. 1993.

Trees, upto 25 m high, with hirsute young twigs, becoming glabrous with age and with scars of fallen leaves. Axillary buds covered with imbricated, caducous scales. Leaves alternate, 3-13.5 x 2-6 cm, broadly elliptic, ovate-elliptic or elliptic-lanceolate, obtusely abruptly short acuminate at apex, subrounded or attenuate at base, coriaceous, pubescent bothsides when young and becoming glabrous on maturity except on the midrib and lateral nerves bothsides; midrib raised beneath, flat above; lateral nerves 3-8 pairs, arching towards apex, tertiary nerves nearly percurrent; petioles 3-11 mm long, pubescent, terete, not canaliculate above. Male flowers sessile, in brown tomentose, axillary, shortly pedunculate, dense, bracteate cymes. Bracts broadly ovate-triangular, appearing suborbicular, boat-shaped, upto

2 x 1.5 mm, glabrous within, tomentose outside, ciliate, persistent, imbricated on the peduncles. Calyx *ca* 3 mm long, campanulate, mouth *ca* 4 mm wide; tube *ca* 1 mm long, rusty tomentose outside, glabrous within; lobes 4, ovate-rounded, *ca* 2 mm long, sub-acute, valvate, hairy outside, glabrous within. Corolla creamy white, tubular, hairy outside, glabrous within; tube 5-6 mm long, not narrowed at apex, densely hairy outside, glabrous within; lobes 4, obliquely ovate-oblong, *ca* 3 x 2.5 mm, obtuse, thinly hairy outside, glabrous within, contorted. Stamens usually 16 or rarely 17 (in one of the Indian material), subequal, in unequal pairs, attached at the base of corolla-tube; filaments of large anthers 1-1.25 mm long, glabrous, of the small anthers less than 1 mm long, connected at the base with longer ones; anthers linear-oblong, subequal, 1.5-2 x 0.5-0.75 mm, glabrous, sub-acute, connectives not produced, glabrous. Pistillode globose, *ca* 0.5 x 1 mm, 4-lobed, with shortly bifid apex, glabrous. Female flowers not seen. Fruits axillary, solitary, pedicellate, globose, upto 2.5 cm in diam., glabrous, 4-celled, cells 1-ovuled; pedicels with scars of fallen bracts. Fruiting-calyx *ca* 1 cm across, not very accrescent, flat, disciform, lobes spreading horizontally, fruit seated on the disc. Seeds 4 but only 1 matures and rest abortive, mature one elliptic-wedge-shaped, *ca* 1.3 cm long, glabrous; albumen equable (**Fig.-24; Plate 10/2**).

Holotype : India : Kerala, Quilon, Yerur R. F., 250 m, 23rd April 1992, *Ramesh & Franceschi* 280 ♂ (HIFP).

Fl. & Fr.: September – May.

Ecol.: Occasionally found in wet evergreen forests forming subcanopy upto 1200 m, particularly in Western Ghats of South India.

Distrib.: Endemic to India, confined to South India, particularly to Karnataka, Kerala and Tamil Nadu (**Map-5**).

Notes : This species shows close affinity to *D. saldanhae* Kostermans and *D. pruriens* Dalz. in floral organization and hairiness on one hand and to *D. philippinensis* A. DC. – a Philippine species, in having 4-merous flowers and several imbricated bracts covering axillary buds and the peduncles. However, venation pattern with arched lateral veins and percurrent tertiary nerves best distinguish it from allied species. Further, number of stamens and non impressed and non canaliculated midrib are also characteristic of *D. ghatensis* Ramesh & Franceschi.

Exsicc.: KARNATAKA : Kodagu, Kadamakkal R. F., *Ramesh & Pascal* 1950 ♀ (HIFP-Paratype); KERALA : Arjunamkotta, 700 m, 8th April 1995, *Jony Augustine* 15095 ♂ (KFRI); Trivandrum, Merchiston, *T. F. Bourdillon* 884 (FRC-Paratype); TAMIL NADU : Coimbatoire, Udumanparai, Anamalais, *Barber* 5859 (MH-Paratype); Tirunelveli, Walaiyar Cardamon Estate, *Kostermans* 26306, 26322 (L, HIFP-Paratypes); Kalakkad & Mundanturai Sanctuary, *Ramesh & Franceschi* 103 ♀, 105, 375, 378, 451 (HIFP-Paratypes); Puliaray R. F., *Ramesh & Franceschi* 504 (HIFP-Paratype).

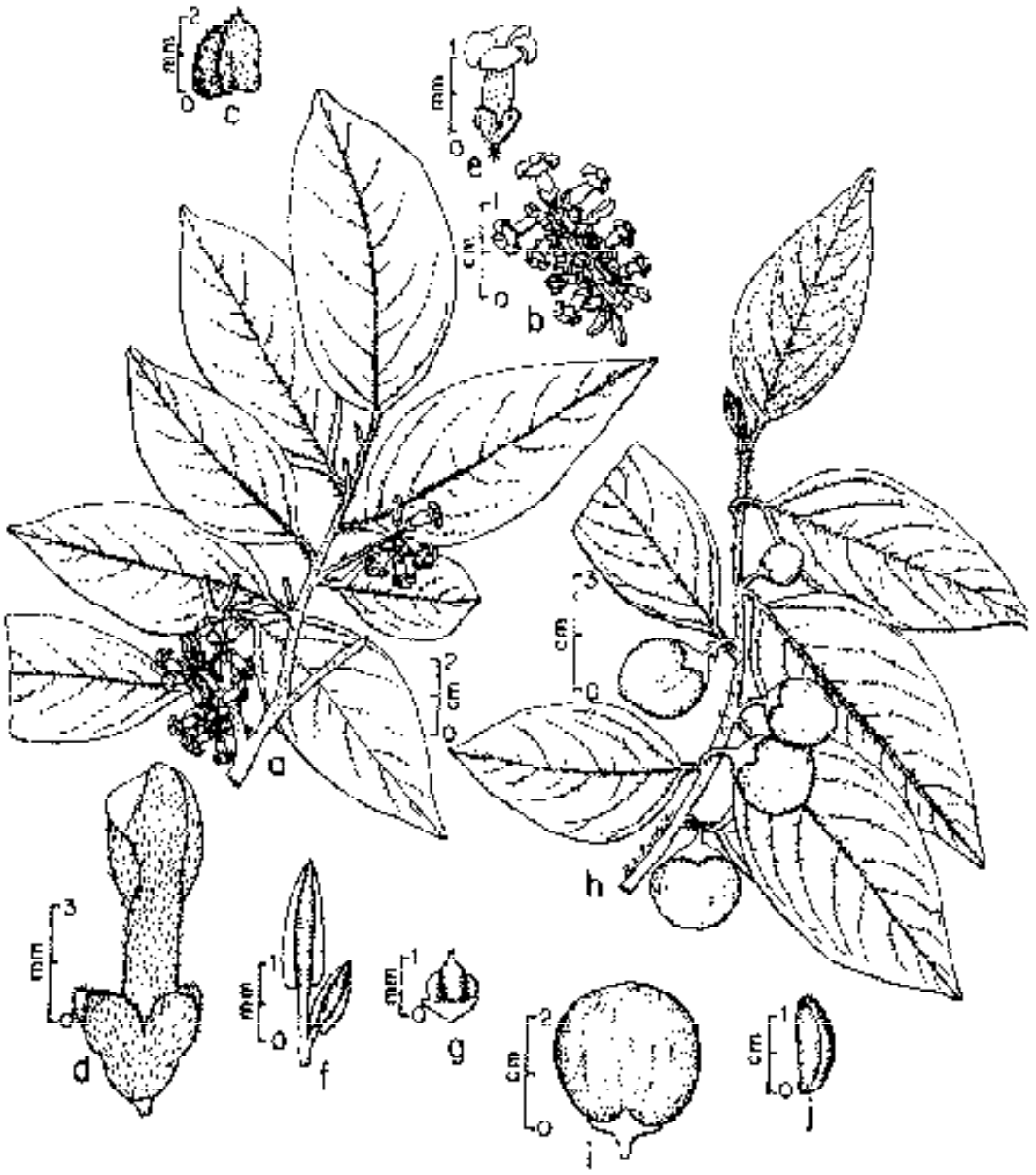


Fig.-24. *Diospyros ghatensis* Ramesh & Franceschi
Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. flower, f. stamens, g. pistillode.
Female : h. habit, i. fruit with calyx, j. seed.

26. ***Diospyros glandulosa*** Lace in Kew Bull. 1915 : 349. 1915. *D. mollis* Griffith in J. Agr. Hort. Soc. India 3 : 145. 1844, non Wall. ex Steud. 1840, nec Gurke 1891, nec *Gunisanthus mollis* Kurz 1873.

Vernacular name : *Asm.*: Diengiong.

Dioecious trees, 5-12 m high, with dichotomous branching; young branches densely hairy, older ones glabrate and lenticelled. Bark dark brown to black, rough with exfoliating scales. Leaves alternate, 6-13.5 x 3-6 cm, usually lanceolate, some leaves ovate-oblong or oblanceolate, long acuminate, cuneate at base, chartaceous, hairy bothsides but become sparsely so with age especially on the veins and the veinlets, ciliate with long hairs on the margins, glandular on the lower surface but glands caducous and not visible in the mature leaves; midrib raised and densely hairy beneath, on the upper surface canaliculate in lower region and flattish upwards, filled with dense long hairs; lateral nerves 5-6 pairs, arcuating towards tip, inconspicuous upwards; petioles 5-11 mm long, rounded beneath, canaliculate above, densely hairy especially in the groove. Male flowers in bracteolate, 3 to 6-flowered, densely hairy cymes. Calyx 4-5 mm long, campanulate, hairy bothsides; tube 2-3 mm long, very short; lobes 4, 2.5-3 mm long, as long as tube or longer, ovate-triangular, acute, valvate. Corolla urceolate, 6-8 mm long, tube glabrous; lobes 4, *ca* 2 mm long, almost rounded, contorted, hairy on the mid nerves and towards margins outside, glabrous within, ciliate. Stamens 20 (in Indian material), rarely 25 (Lace, 1915), in 2 rows of 10 each, almost equal in size, united in pairs, hypogynous, seated on the torus, not attached to the corolla-tube; filaments small, 1-1.5 mm long, hairy, those of inner row almost sessile; anthers 4-5 mm long, apiculate due to produced connectives, dehiscing through apico-lateral slits, hairy on the back along the mid line. Pistillode absent. Female flowers axillary, solitary, pedicelled; pedicel 4-6 mm long, densely pubescent. Calyx-tube short, campanulate, pubescent bothsides; lobes 4, deeply divided, suborbicular, shortly acuminate, *ca* 1 cm long, pubescent bothsides, valvate. Corolla urceolate, tube *ca* 5 mm long and as broad, glabrous; lobes 4, *ca* 9 mm long, recurved, hairy in the middle and on the margins outside, contorted. Staminodes 12, sessile, linear, acute, hairy. Ovary globose, clothed with dense brown hairs, 8-celled, cells 1-ovuled; styles 4, connate towards base; stigmas bifid. Fruits globose, upto 2.5 cm in diam., densely pubescent; pedicels elongated upto 1 cm long, densely pubescent. Fruiting-calyx tube shallowly concave-disciform, fruits seated on the disc and the lower part of the fruit is encircled by the disc and folded lobes, upto 3 cm in diam.; lobes ovate, *ca* 1 cm long or about as long as fruit, long acuminate, spreading. Seeds 8, 1 in each locule, all viable, obovate-oblong, wedge-shaped, 5-7 x 3-4 mm, glabrous, convex on one face and concave on the other; albumen equable (**Fig.-25; Plate 10/3 & 4**).

Lectotype : Burma (Myanmar) : Maymyo plateau, 1050 m, *Lace* 3119 (K-designated here).

Fl. & Fr.: April – September.

Ecol.: Rare, in semi-evergreen rain forests, upto 1410 m; usually cultivated in the gardens.

Distrib.: Native of Myanmar. In India, this taxon is confined to North-East India, particularly to Meghalaya and Nagaland in wild state, otherwise known under cultivation. Fischer (1938) has also reported it indigenous to Naga hills, Kohima (Nagaland) at an altitude of 1410 m. Utsunomiya *et al.* (1998) have reported its distribution in Thailand at high altitude zones (**Map-5**).

Pollen : Pollen grains 3-colporate, sub-prolate (40 x 30.2 µm), range 38-42 x 28-32 µm. Anguloaperturate. Amb sub-triangular. Colpi long, thin and running almost from pole to pole. Maximum colpus width about 3 µm and mesocolpium about 18 µm. Ora la-longate (3.5 x 10.5 µm), membrane psilate. Exine about 2.5 µm thick. Sexine slightly thinner than nexine. Sexine pattern obscure (Sharma & Gupta, 1979).

Anatomy : Wood parenchyma forms a distinct vasicentric sheath round the vessels. Strands typically of 4-cells in apotracheal parenchyma, but in this species strands of 2-cells are more common. Rays 3-4 cell wide (Metcalfe & Chalk, 1950). Utsunomiya *et al.* (1998) have studied the tannin cells in the mesocarp of the fruit and reported that they occupy 30-50 per cent area of the mesocarp.

Phytochemistry : Fruits contain diospyrol, dinaphthol and 3-Me-naphthalone-1, 8-diol (Loder *et al.*, 1957). The plants also yield n-alkanes, lupeol, α-amyrin and β-sitosterol (Asolkar *et al.*, 1992). A new diospyrol glycoside elucidated as diospyrol-8, 8'-di-O-(6-β-D-apiofuranosyl-β-D-glucopyranoside) has been isolated from the leaves (Paphassarang *et al.*, 1984).

Uses : Extract of fresh fruits is widely used as anthelmintic against human hookworm (*Necator americanas*). It is also effective against tapworm, but not so strongly.

Exsicc.: MEGHALAYA : Nongpoh, Umsning-Noonmati, 11th May 1965, *J. Joseph* 37598 ♀ (ASSAM); Khasia & Jaintia hills, On way to Ingarso, 1160 m, 16th Jan. 1916, *U. N. Kanjilal* 6528 sterile (ASSAM); Umsaw forest, 9th April 1936, *Shri Ram Sarma* 13037 sterile (ASSAM); NAGALAND : Naga hills, 1935, *N. L. Bor* 2720 ♀ (DD); UTTRANCHAL : Dehra Dun, Forest Research Institute, April 1939, *M. B. Raizada* 18441 ♂ (ASSAM); April 1937, *M. B. Raizada* Acc. No. 74172 ♀ (DD); 21st April 1949, *M. B. Raizada* Acc. No. 103267 ♀ (DD); 12th June, 1946, *M. B. Raizada* Acc. No. 97980 ♀ (DD); 16th April 1934, *M. B. Raizada* Acc. No. 65531 ♀ (DD). Also examined Myanmar, Maymyo Plateau, 1050 m, 18th April 1910, *J. H. Lace* 5196 ♀, 5197 ♂, ♀ (Lectosyntypes-K); Pegu, *Kurz* 1008 (K).

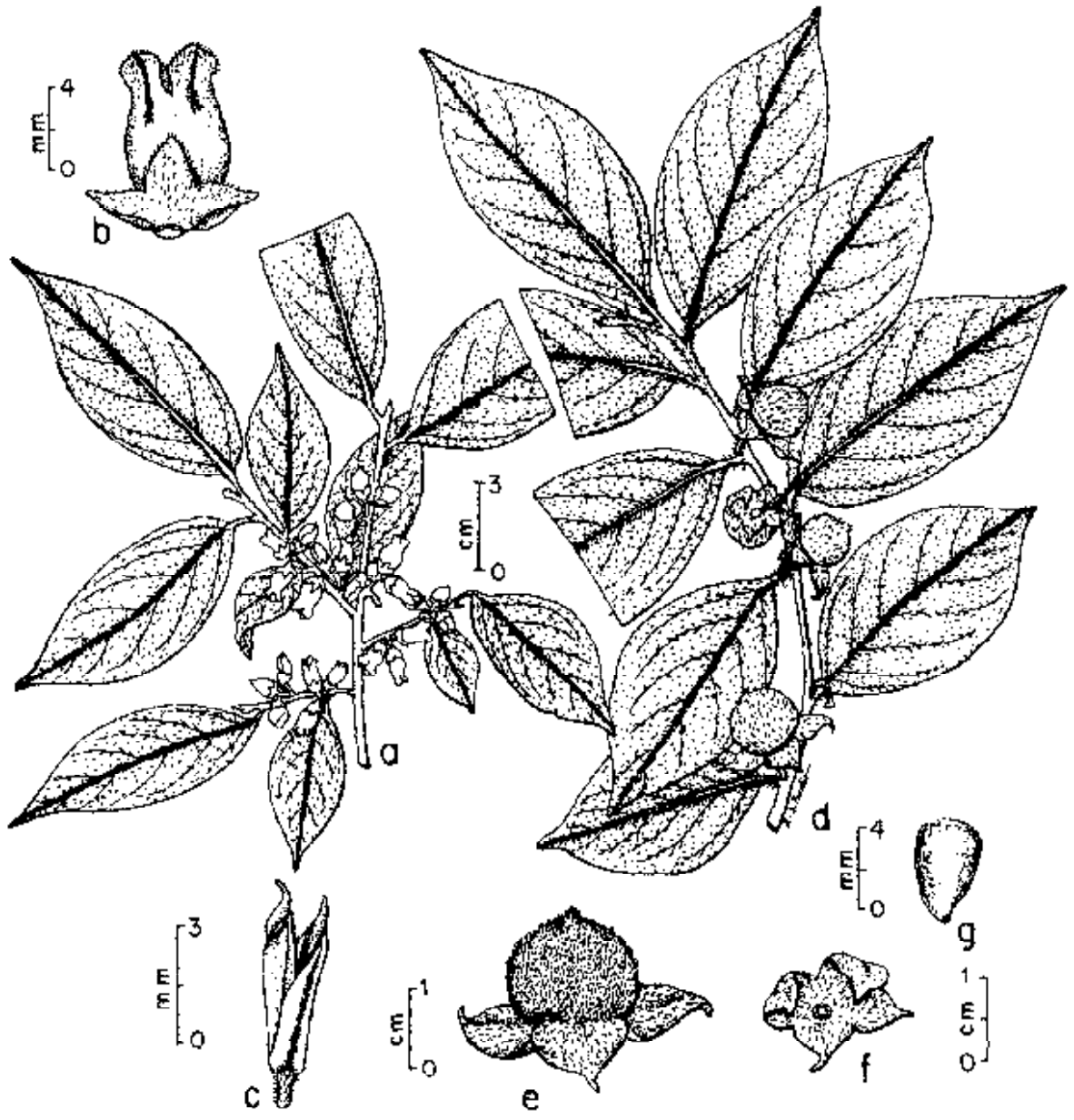
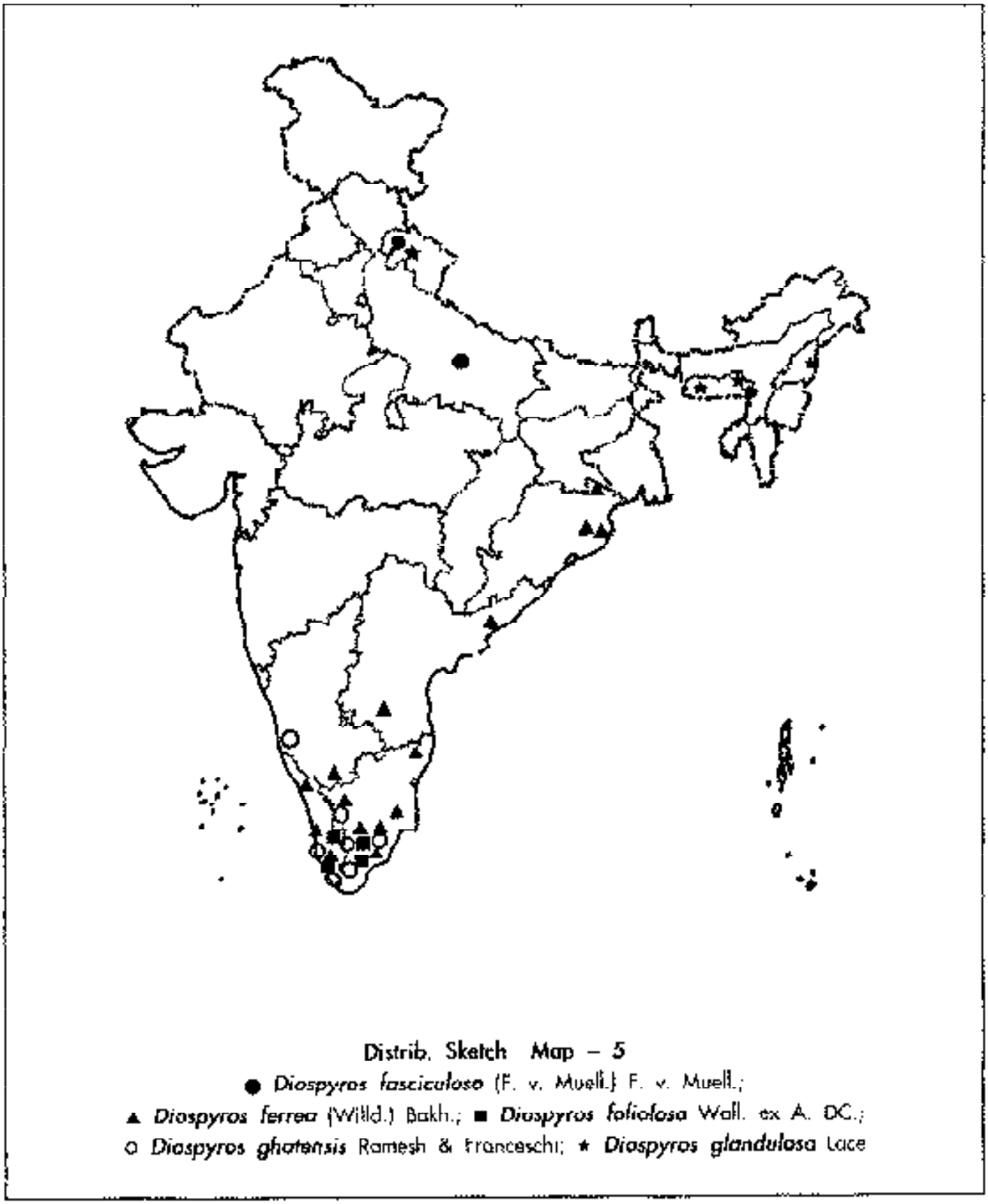


Fig.-25. ***Diospyros glandulosa*** Lace

Male : a. habit, b. flower, c. stamens.

Female : d. habit, e. fruit with calyx, f. fruiting-calyx (dorsal view), g. seed.



Distrib. Sketch Map – 5

● *Diospyros fasciculosa* (F. v. Muell.) F. v. Muell.;
▲ *Diospyros ferrea* (Willd.) Bakh.; ■ *Diospyros foliolosa* Wall. ex A. DC.;
○ *Diospyros ghatensis* Ramesh & Franceschi; ★ *Diospyros glandulosa* Lace

27. ***Diospyros hirsuta*** L. f. Suppl. Pl. 440. 1781, non Desf. 1805, nec Hochr. 1905; A. DC. in DC. Prodr. 8 : 223. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 163. 1873, excl. forma; Clarke in Hook. f. Fl. Brit. India 3 : 565. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 39. 1981; Nair & Mohanan in J. Econ. Taxon. Bot. 3 : 285. 1982.

Trees, 10-13 m high, dioecious, monoecious or polygamous, with ferruginous-tomentose branches and other young parts. In monoecious plants, the female flowers either develop in separate axils of leaves or mixed with male fascicles (Hiern, 1873). Bark black, finely fissured. Leaves alternate, 7.5-19 x 2.5-6.5 cm, elliptic-oblong or elliptic, obtusely acuminate at apex, narrowed at base and shortly passing into the petiole, fulvous pubescent bothsides when young, becoming glabrescent with age except the midrib bothsides; midrib raised beneath, canaliculate above; lateral nerves 9-15 pairs, arching at margins, not much conspicuous; petioles 5-8 mm long, rounded beneath, canaliculate above, densely hairy and canal filled with hairs. Male flowers sessile, in many-flowered, axillary, hairy cymose fascicles. Bracts in opposite pairs, borne at the base of flowers, broadly ovate to suborbicular, boat-shaped, upto 4 x 3 mm, finely acute, densely pilose outside, glabrous within, sometimes two bracteoles smaller than bracts also occur on the lateral sides of the flower partly enclosing the flower-buds, bracts and bracteoles deciduous. Calyx 5-6 mm long, campanulate, densely hairy bothsides, 5-lobed, divided about the middle; tube *ca* 3 mm long; lobes *ca* 3 mm long, oblong, acute, valvate, easily break up from the tube. Corolla 7-8 mm long, tubular, hairy outside, glabrous within; lobes 5, hairy outside, glabrous within, contorted. Stamens usually 6-8 in our plants or 5 (Kostermans, 1981; Nair & Mohanan, 1982), attached at the base of corolla-tube in one row, not paired, subequal; filaments 1-1.5 mm long, glabrous; anthers 2-3 mm long, connectives hairy between the anther-lobes, produced at the apex into glabrous apiculae. Rudimentary ovary globose, brown tomentose. Female flowers 1 to 3-together, axillary, subsessile, bracteate. Calyx and corolla as in males but broader and deeply divided than males, margins of calyx-lobes reflexed and wavy. Staminodes 5-10. Ovary 10-celled, densely hairy, cells 1-ovuled. Fruits 2-2.5 cm long, ovoid, apiculate, rufous hairy. Fruiting-calyx flat, disciform, the fruit seated on the disc and not enveloped by the calyx; lobes spreading, undulate on the margins. Seeds 6-10, 1-1.5 cm long, black, oblong, compressed; cotyledons ovate, obtuse at apex, rounded at base; albumen ruminate (Fig.-26; Plate 11/1).

Holotype : *Thunberg s.n.* (Lost); *Lectotype* : Ceylon Plants, *Thwaites* 382 (PDA).

Fl. & Fr.: March -- July, usually most part of the year.

Ecol.: Occasional, found along the streams in wet semi-evergreen forests, upto 300 m. The germination is epigeal and cotyledons get detached early. The plants start blooming when they are quite young.

Distrib.: This species is confined to Kerala in India and extends to its native home Sri Lanka, further southwards (Map-6).

Anatomy : Each cotyledon has three vascular traces, of which median is abortive and laterals split considerably. Each epicotyledonary leaf has one trace which prolongs into the root (Wright, 1904).

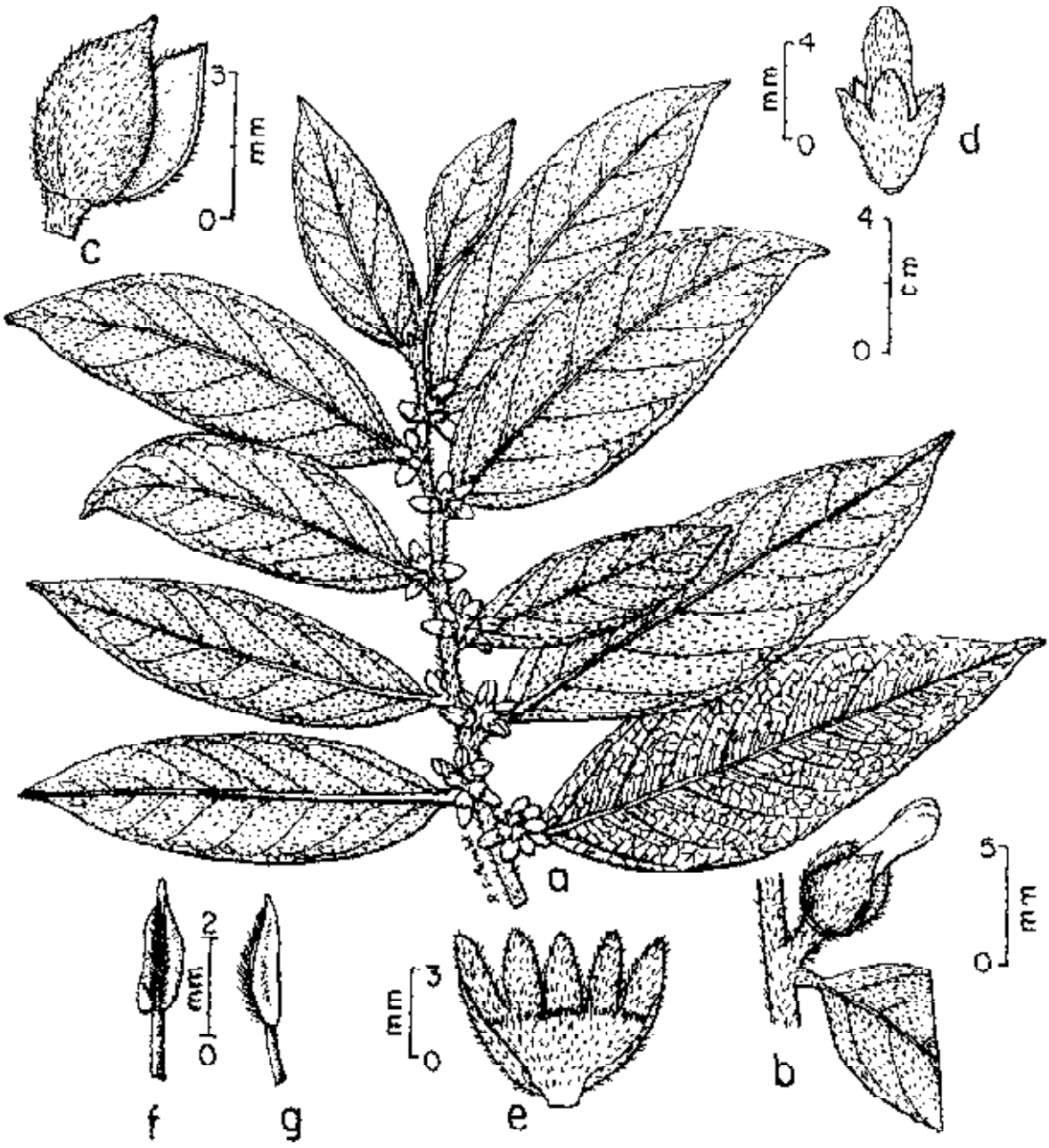


Fig.-26. ***Diospyros hirsuta*** L. f.

Male : a. habit, b. bracts and bracteoles enclosing flower-bud, c. bracts, d. flower-bud, e. calyx within, f-g. stamens.

There is no black heartwood and most of the wood is usually dirty white, turning to reddish on exposure. The colour contents occur only in wood parenchyma and medullary ray cells. The fibre cells are in abundance and tracheal elements are very poorly represented. The rings of growth are inconspicuous. The vessels in the twigs have 0.03 mm radial and 0.026 mm tangential diameter. However, the vessels in the sapwood are with 0.18 mm and 0.09 mm radial and tangential diameter. The length of wood parenchyma cells in sapwood varies from 0.05 to 0.13 mm, with radial diameter 0.018 mm. The radial diameter of wood fibres in sapwood is 0.014 mm and in heartwood 0.001 mm. The radial diameter of vertical medullary ray cells is 0.022 mm and tangential 0.012 mm, with vertical length *ca* 0.12 mm. The radial diameter of horizontal components is 0.04 mm and tangential 0.009 mm, with vertical length *ca* 0.06 mm (Wright, 1904).

Phytochemistry : The bark and timber of this species yield lupeol, betulin, betulinic acid, sitosterol, taraxerol, taraxerone, ursolic acid, oleanolic acid, scopoletin, plumbagin, elliptinone, diospyrin and diosindigo A. The leaves chiefly contain sitosterol and lupeol. The fruits have sitosterol, betulin, betulinic acid, taraxerol and roots have chiefly sitosterol and lupeol (Herath *et al.*, 1978).

Notes : Hiern (1873) has reduced well recognized five species to the rank of forma under this species viz. forma *moonii* (Thw.) Hiern, *nilagirica* (Bedd.) Hiern, *candolleana* (Wight) Hiern, *thwaitesii* (Bedd.) Hiern and *canarica* (Bedd.) Hiern. Most of these have, however, been again raised to specific level by recent workers and the latter concept has been followed in the present work. Further, *D. moonii* Thw. and *D. thwaitesii* Beddome do not occur in India and are confined to Sri Lanka only. Wright (1904) has also mentioned a variety from Sri Lanka with flat circular fruits and stout persistent style. But, Kostermans (1981) found that so called fruit is a gall-like abnormality and so called style is a hardened corolla-tube. No such abnormality was observed in Indian plants. However, the specimens examined by me have 6-8 stamens instead of 5 in male flowers and pistillode is not conspicuous. The Indian plants belong to proper species.

Exsicc.: KERALA : Quilon, Thekkuthode Koni R. F., 300 m, 9th April 1978, *C. N. Moham 54976* ♂ (MH).

28. ***Diospyros holeana*** Gupta & Kanjilal in Ind. For. 50 : 255. t. 11 & 12. 1924, non *D. hoyleana* White, 1956.

English name : Ebony.

Medium-sized trees, with straight trunk having dark grey, rough, shallowly fissured bark exfoliating in small plates and minutely pubescent branchlets. Leaves alternate, 6.5-19 x 3-6 cm, elliptic or oblong-elliptic, acuminate, base cuneate or obtuse, coriaceous, entire, glabrous; midrib canaliculate above, raised beneath; lateral nerves distantly placed; petioles 4-7 mm long, half-terete, depressed or grooved above, rounded beneath. Male flowers 3 to 4-together, subsessile, in reddish-brown hairy, axillary cymes; peduncles 2-3 mm long. Calyx *ca* 4 mm long, shortly cup-shaped, pubescent bothsides, 4 to 5-lobed; lobes small, ciliate, imbricate. Corolla tubular; tube *ca* 1.2 cm long, adpressed hairy outside, glabrous

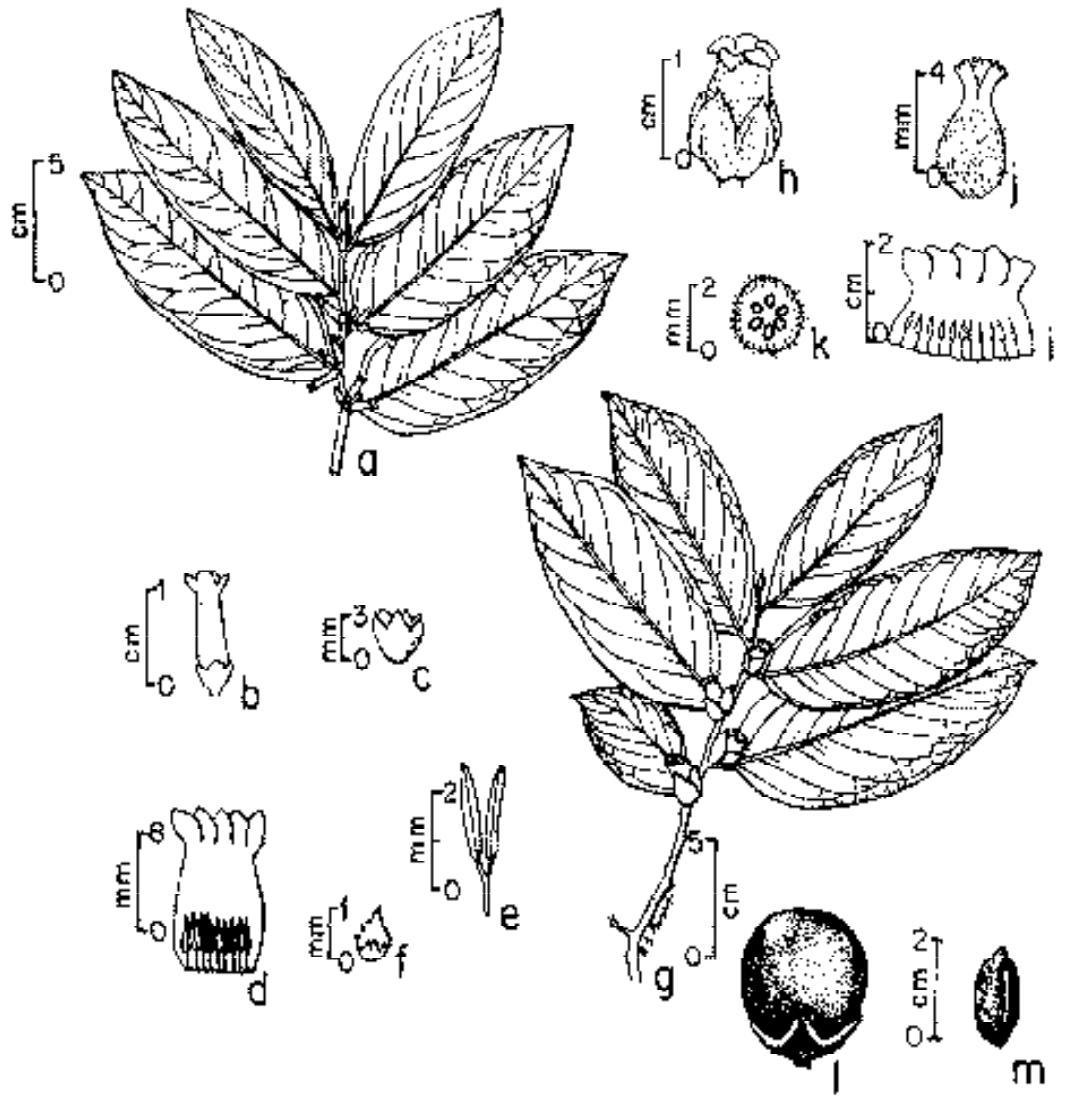


Fig.-27. ***Diospyros holeana*** Gupta & Kanjilal

Male : a. habit, b. flower, c. calyx, d. corolla within with stamens, e. stamens, f. pistillode.

Female : g. habit, h. flower, i. corolla within with staminodes, j. gynoecium,

k. T. S. of ovary, l. fruit with calyx, m. seed.

within, 4 to 5-lobed; lobes contorted. Stamens 16, united in pairs, inserted at the base of corolla-tube, pubescent; anthers linear, minutely hairy, connectives produced and apiculate. Rudimentary ovary hairy. Female flowers axillary, solitary, subsessile. Calyx hemispheric or crateriform, apparently broadly ovate or rounded, *ca* 1 cm long, appressed hairy outside, tomentose within, subauriculiform at base with ear-like appendages, 4 to 5-lobed; lobes imbricate. Corolla-tube *ca* 1.4 cm long, pubescent; lobes 4-5, *ca* 6 mm long, contorted. Staminodes 11. Ovary 6-celled, 1-ovuled in each locule, hairy; styles 3; stigmas further lobed. Fruits *ca* 3 cm in diam., globose, glabrous. Fruiting-calyx enlarged, accrescent, bowl-shaped, fruit seated in the cavity of bowl; lobes erect, margins slightly reflexed; lobes reflexed. Albumen equable (Fig.-27).

Lectotype : Nepal Frontier : Jalesani nala, 29th April 1900, *Inayet* 23709 ♂ Acc. no. 282109 (CAL-designated here).

Fl. & Fr.: May – October.

Ecol.: Occasionally found on the foot of Central Himalaya and along Vindhyan range.

Distrib.: In India, this taxon is found in Uttar Pradesh and Madhya Pradesh, and northwards it extends to Nepal – native home. The timber is susceptible to dry wood borer (**Map-6**).

Anatomy: Wood greyish brown with dark concentric bands. It is diffuse-porous; pores scanty, radially arranged in short groups. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Medullary rays numerous, distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained, fine-textured (Purkayastha, 1982).

Notes : This taxon is closely allied to *D. peregrina* (Gaertn.) Gurke, but may be distinguished by its rough bark exfoliating in small plates, more densely silky tomentose flowers, fewer stamens, few-celled ovary and glabrous fruits. The name should not be confused with *D. hoyleana* F. White – an African species, which is, however, an orthographic variant and have homonymic potential for rejection under Art. 53. 5 of the ICBN.

Exsicc.: UTTAR PRADESH : Gonda, Nepal border, Sungarah forest, *P. C. Kanjilal* 2440, 2441, 2441A (Lectosyntypes DD); 1st Jan. 1922, *P. C. Kanjilal* Acc. No. 36779 ♀ (DD); 14th May 1922, *Tara Datt* Acc. No. 36794 (DD); 23rd June 1919, *Sri Ram* Acc. No. 36797 ♀ (DD); Tulsipur R. F., 20th June 1922, *Sri Ram* Acc. No. 36803 ♀ (DD).

29. ***Diospyros insignis*** Thw. Enum. Pl. Zeyl. 180. 1860; Beddome, Ic. Pl. Ind. Or. 7 : 26. t. 130. 1871; Hiern in Trans. Cambr. Philos. Soc. 12 : 157. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 565. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 43. 1981

Vernacular names : *Tam.*: Pottuvarai, Walmederiya.

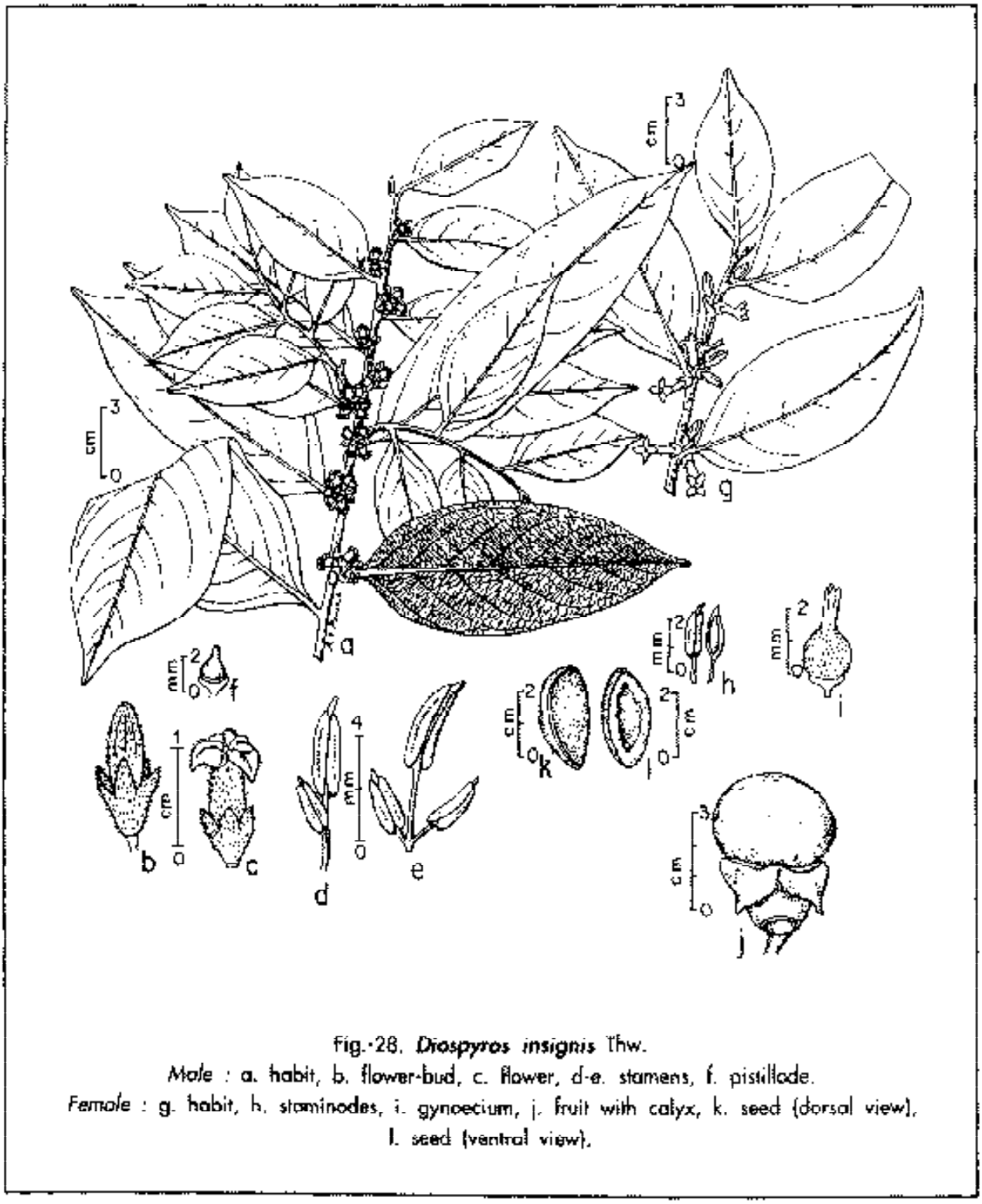


Fig.-28. *Diospyros insignis* Thw.

Male : a. habit, b. flower-bud, c. flower, d-e. stamens, f. pistillode.

Female : g. habit, h. staminodes, i. gynoecium, j. fruit with calyx, k. seed (dorsal view), l. seed (ventral view).

Medium-sized trees, upto 6 m high, dioecious and polygamous, rarely monoecious, with pubescent young branchlets becoming glabrous with age. Bark black, finely fissured, peeling off in flakes. Leaves usually alternate, rarely subopposite, 7-35 x 2.5-15 cm, oblong-elliptic, abruptly acuminate, subrounded or cuneate at base, submembranous, chartaceous, glabrous except the midrib bothsides in young leaves; midrib raised beneath, flat or subcanaliculate above, glabrous or thinly pubescent in young leaves; lateral nerves 8-12 pairs, widely spaced, conspicuous, venation of veinlets parallel or horizontal and conspicuous bothsides; petioles 5-10 mm (rarely upto 2 cm) long. Male flowers and bisexual flowers in separate or same, axillary cymose clusters, 4-merous; male clusters 3 to 20-flowered, sessile. Calyx 3-5 mm long, campanulate, minutely pubescent outside, glabrous within; lobes 4, about as long as tube, divided half way down, ovate, acute, slightly pubescent outside, glabrous within, valvate. Corolla 8-10 mm long, tubular, tomentose-silky outside, glabrous within, tube narrowed at the throat, white or yellowish white; lobes 4, ovate, acute, pilose outside, glabrous within, contorted. Stamens 14-20, glabrous or rarely with few scattered coloured hairs, unequal, free, in unequal pairs or in threes, attached at the base of corolla-tube; filaments white, glabrous or sparsely pilose; anthers glabrous, connectives produced, apiculate. Pistillode in all gradient stages of development. Hermaphrodite flowers like males, with well developed pistil like female flowers. Female flowers axillary, subsessile, 1 to 3-together, rarely 6. Calyx as in males, pilose outside, glabrous within; lobes 4, *ca* 5 mm long, recurved-margined, valvate. Corolla as in males; lobes 4, somewhat recurved, contorted. Staminodes 4-5, epipetalous, with apiculate sterile anthers and glabrous filaments. Ovary globose, 4 or 8-celled, completely enclosed in the accrescent calyx after fertilization, slightly pubescent when young, cells 1-ovuled; stigmas 4. Fruits subglobose, 3-4 cm in diam., depressed at apex, smooth. Fruiting-calyx cup-shaped, with distinct tube enclosing the lower part of the fruit, much enlarged, *ca* 2 x 3 cm and 2 cm deep, woody, thickened; lobes reflexed, hardly distinguishable from the tube, tips protruding outwards and downwards. Pedicels subtending the fruits much thickened at the apex, disc-like and disc upto 15 mm in diameter and 2-3 mm thick, remains attached with the fruiting-calyx in detached fruits. Seeds 4 or 8, ovate-wedge-shaped, 2-3 x 0.75-1.5 cm, *ca* 7 mm thick; testa deep brown, smooth, obscurely transversely striated; albumen ruminated; hypocotyl 1.5-2 cm long **(Fig.-28; Plate 11/2)**.

Lectotype : Ceylon Plants, *Thwaites* 2730 (PDA); *Lectosyntype* : Ceylon Plants, *Thwaites* 3477 (PDA, K).

Fl. & Fr.: May – September, usually most part of the year.

Ecol.: Rare, in the wet evergreen forests, upto 900 m. The germination of seeds in this species shows hypogeal tendency, since the cotyledons are hardly raised above the ground.

Distrib.: Confined to Karnataka, Kerala and Tamil Nadu in India and extends southwards to Sri Lanka – its native home **(Map-6)**.

Anatomy : Each cotyledon has three traces and xylem splits at different levels of hypocotyl and primary root. Each epicotyledonary leaf possesses one trace vascular supply, but due to the splitting cannot be followed (Wright, 1904).

The timber is white, turning to dirty colour on exposure. The gum-resin is found in very small quantity. The parenchymatous cells are in abundance. The rings of growth are very inconspicuous, sometimes occurring as broad dark bands alternating with narrow light zones. Occasionally, the rings are set very closely or very spatially. The size of vessels in twigs is about 0.21 x 12 mm, with 0.03 mm radial and 0.034 tangential diameter. The sapwood, however, bears the vessels with 0.11 mm radial and 0.073 mm tangential diameter. The length of wood parenchyma cells in sapwood varies from 0.06 to 0.19 mm, with 0.014 mm radial diameter. The radial diameter of wood fibres in sapwood is 0.011 mm and in heartwood *ca* 0.012 mm. The radial diameter of vertical medullary ray cells is 0.03 mm and tangential 0.016 mm, with 0.08 mm vertical length. In horizontal components, the radial diameter is 0.056 mm and tangential 0.012 mm, with 0.018 mm vertical length. The medullary rays occur as radial rows of cells throughout the secondary xylem. In majority of the species there is only one cell in tangential width, but it is interesting to record two or three cells in width in this species. In this character it shows close affinity with *D. crumenata* Thw., *D. racemosa* Roxb. and *D. pruriens* Dalz. (Wright, 1904).

Uses : EtOH extract of plants, excluding roots, has been reported to show antifertility (Asolkar *et al.*, 1992) and semen coagulant activity (Dhawan *et al.*, 1977).

Notes : Kostermans (1981) has reported a variety viz. var. *parvifolia* Kosterm. from Sri Lanka, which is characterized by lanceolate small leaves. This was not observed within Indian territory and our plants belong to proper species.

Exsicc.: KARNATAKA : Coorg, Koynad, Sompaje, 266 m, 26th Feb. 1973, *B. Gupta & Party* 4446/2287 ♀ (RHMD); KERALA : Travancore, Colaloorpaly, 28th Nov. 1893, *M. A. Lawson* 70 sterile (DD).

30. ***Diospyros kaki*** Thunb. in Nova Acta Soc. Sci. Upsala 3 : 208. 1780 ex L. f. Suppl. 439. 1781; Thunb. Fl. Jap. 157. 1784; Murr. in Linnaeus, Syst. Veg. ed. 14. 918. 1784; A. DC. in DC. Prodr. 8 : 229. 1844, excl. var. *glabra* A. DC.; Hiern in Trans. Cambr. Philos. Soc. 12 : 227. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 555. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 205. 1938. *D. lobata* Lour. Fl. Cochinch. 1 : 227. 1790; A. DC. in DC. Prodr. 8 : 233. 1844. *D. chinensis* Blume, Cat. Buitenz. 110. 1823. *D. amara* Perrott ex Perrott in Mem. Soc. Linn. Par. 3 : 112. 1825. *D. schi-tse* Bunge, Enum. Pl. Chin. Bor. 42. 1832. *Anona sariffa* Roxb. ex Hemschel, Clavis Rumph. in Vita Rumphii 142. 1833. *Embryopteris kaki* (Thunb. ex L. f.) G. Don, Gen. Dict. Gard. Bot. 4 : 41. 1837. *Diospyros kaki* Thunb. ex L. f. var. *cordata* A. DC. in DC. Prodr. 8 : 229. 1844. *D. costata* Carriere in Revue Hort. 284. 1869; 133. 1870; 410-413. 1871. *D. kaki* Thunb. ex L. f. var. *costata* (Carriere) Andre in L'Illustration Hort. 18 : 176. t. 78. 1871. *D. roxburghii* Carriere in Revue Hort. 253. f. 28, 29. 1872. *D. mazeli* Thib. & Ketel. ex E. Morr. Belg. Hort. 24 : 111 1874, non Carr. 1874. *D. mazeli* Carr. Revue Hort. 70. 1874. *D. lycopersicon* Carriere in Revue Hort. 470. 1878. *D. kaempferi* Naud. in Nouv. Arch. Mus. Par. Ser. 2. 3 : 226. 1880. *D. foudekaki* Dupont in Carr. Revue Hort. 352. f. 69. 1880. *D. kizawa* Dupont in Carr. Revue Hort. 352. f. 70. 1880. *D. ochirakaki* Dupont in Carr. Revue Hort. 353. f. 73. 1880. *D. tayama-kochioumarou* Dupont in Carr. Revue Hort. 352. f. 71. 1880.

D. aurantium Hort. ex Andre in Rev. Hort. 349. 1887. *D. bertii* Hort. ex Andre in Rev. Hort. 349. 1887. *D. wieseneri* Carr. in Rev. Hort. 83. 1887. *D. elliptica* Hort. ex Andre in Rev. Hort. 349. 1887. *D. sahuti* Hort. ex Andre in Rev. Hort. 349. 1887. *D. kaki* Thunb. ex L. f. var. *tanenashi* Van Deman in U. S. Dept. Agric. Pomol. Bull. 1 : 6. 1888, non Trabut 1925. incl. vars. *hatchiya* & *yemon*. *D. kaki* Thunb. ex L. f. var. *tsuru* Anon. in Yearbook U. S. Dept. Agric. 1890 : 423. 1891. *D. kaki* Thunb. ex L. f. vars. *dai-dai* & *yama-tsuru* Van Deman in Rep. Secr. Agric. U. S. A. 1891 : 386-387. 1892. *D. kaki* Thunb. ex L. f. var. *hyakume* Semler in Trop. Agrik. 4 (1) : 273-274. 1892, incl. vars. *among, dai-dai-mane, goschanaki, haycheya, kurokuma, masu, minokaki, taikun* & *zingi*. *D. kaki* Thunb. ex L. f. var. *kako* Van Deman in Rep. Secr. Agric. U. S. A. 1892 : 259. 1893, incl. var. *mestio*. *D. kaki* Thunb. ex L. f. var. *aurantium* (Hort. ex Andre) Mottet in Nicols. & Mott. Dict. Prat. Hort. Jard. 2 : 218-219. 1893-94, incl. vars. *berti, elliptica* & *sahuti*. *D. kaki* Thunb. ex L. f. var. *wieseneri* (Carr.) Mottet in Nicols. & Mott. Dict. Prat. Hort. Jard. 2 : 218-219. 1893-94, incl. var. *mazeli*. *D. kaki* Thunb. ex L. f. var. *grandifolia* Diels in Engl. Bot. Jahrb. 29 : 527. 1901. *D. kaki* Thunb. ex L. f. var. *myotan* Burnette in Bull. Agric. Exp. Stat. Louis Stat. Univ. 99 : 10-11. f. 3-6. 1907, incl. vars. *nero-zami* & *okame*. *D. kaki* Thunb. ex L. f. var. *silvestris* Makino in Tokyo Bot. Mag. 22 : 159. 1908, incl. var. *domestica*. *D. sinensis-kaki* Hort. Gubb. Fl. Algeria t. 39. 1909. *D. si-tche* Hubert, Fr. Pays Chauds 535. 1912. *D. tiodemon* Hubert, Fr. Pays Chauds 536. 1912. *D. kaki* Thunb. ex L. f. var. *yama-yemon* Hubert, Fr. Pays Chauds 541. 1912, incl. vars. *amagaki, sibugaki, hachiyagaki, zenzi, xenzi, o-zenzi, kura-kuma, goraku, tsuro-no-ko, shina-mo-kakis, aoso, ko-kaki, hiza, tara* & *go-sho*. *D. kaki* Thunb. ex L. f. var. *ormond* Taylor & Gould in U. S. Dept. Agric. 1912 : 270-71. f. 6. 1913. *D. kaki* Thunb. ex L. f. var. *egosho* Yasui in Bot. Gaz. 60 : 363-64. 1915, incl. vars. *fuju, hyakume-gaki, jenjimaru, tenryubo, tsuru-no-ko* & *yamagaki*. *D. kaki* Thunb. ex L. f. var. *zengi* Condit in Bull. Calif. Agric. Exp. St. 316 – 252. 1919, incl. vars. *saburosa, daruma, deinukoroshi, futaye, futae-gaki, maruza, enzagosho, obishi, yotsuwari, suyugaki, gailey, fuyu, kurokuma, siang-shi-tse* & *mikado*. *D. kaki* Thunb. ex L. f. var. *twentieth-century* Trabut in Rev. Bot. Appl. d'Agric. Colon. 5 : 668-674. 1925, incl. vars. *delicious, gocho, daidai-maru, hyakoumi, yeddolchi, chimomaru, yotsuonari, tsourou, tsourounoko, acclimatation-de-toulon, gabriel-dupont* & *maculata*. *D. sphenophylla* Hiern in J. Bot. Suppl. 63 : 62. 1925. *D. kaki* Thunb. ex L. f. var. *kachioumarou* Trabut in Rev. Bot. Appl. d'Agric. Colon. 5 : 665. f. 9. 1925. *D. kaki* Thunb. ex L. f. var. *fouyou* Trabut in Rev. Bot. Appl. d'Agric. Colon. 5 : 667. 1925. *D. kaki* Thunb. ex L. f. var. *lycopersicon* (Carr.) Trabut in Rev. Bot. Appl. d'Agric. Colon. 5 : 607. 1925. *D. kaki* Thunb. ex L. f. var. *tanenachi* Trabut in Rev. Bot. Appl. d'Agric. Colon. 5 : 665. 1925, non Van Deman 1888.

English names : Persimmon, Divine Pear, Ebony, Oriental Persimmon, Japanese Persimmon, Japanese Date Plum, Chinese Persimmon, Chinese Fig, Chinese Plum, Keg Fig, Red Fig.

Vernacular names : *Asm.:* Diengiong, Soh-tang-jong; *Hindi:* Halwa-tendu; *Kh.:* Diengiong; *Tel.:* Tatuti.

Dioecious or polygamous trees, upto 15 m high, with villous or pubescent young branchlets becoming glabrate with age, unarmed. Bark lenticelled. Leaves alternate, 10-15 x 3-10 cm, elliptic with cuneate base and acuminate apex or broadly ovate with rounded base and short acumin at the apex,

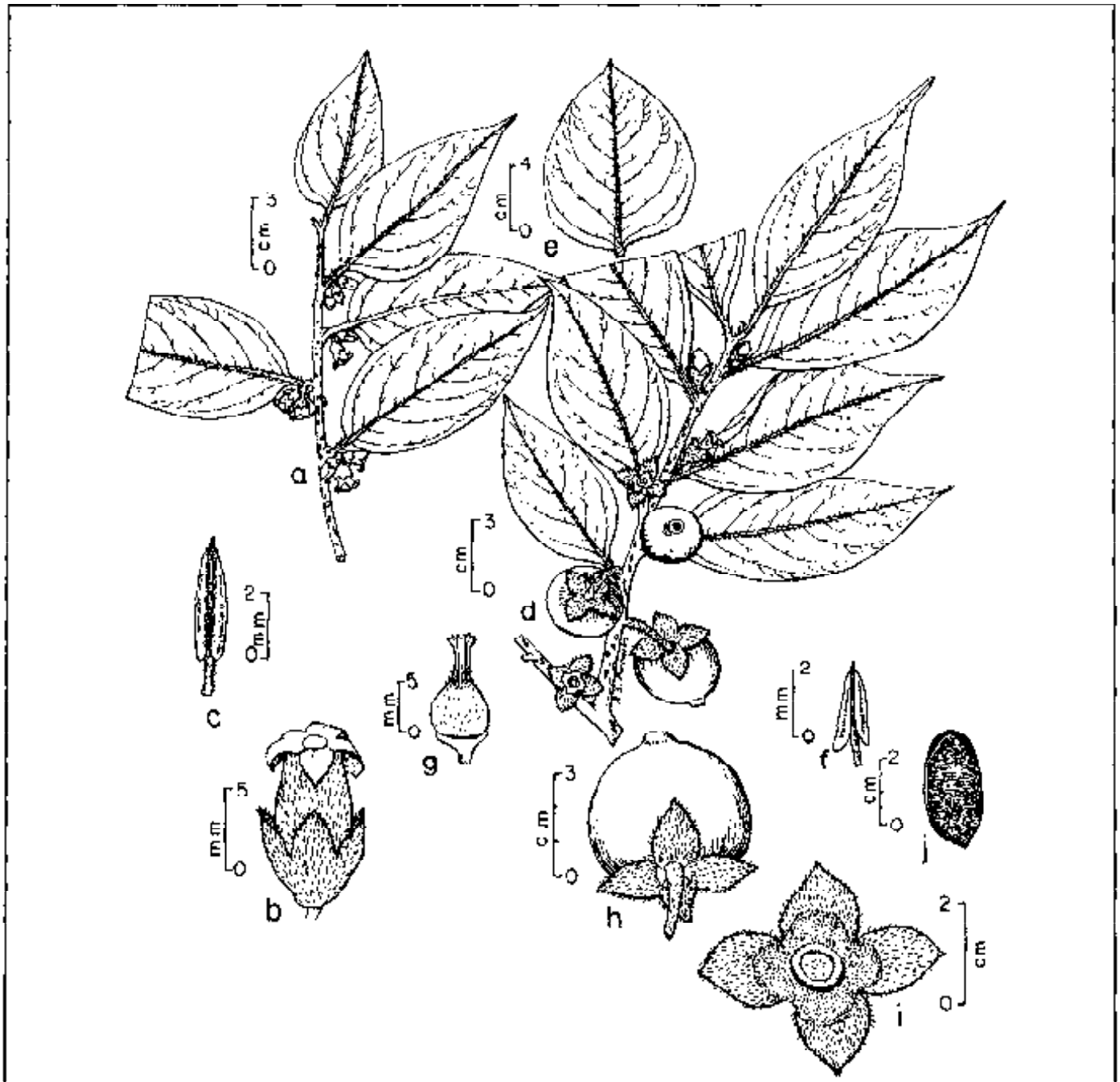


Fig.-29. ***Diospyros kaki*** Thunb. ex L.f.
Male : a. habit, b. flower, c. stamen.
Female : d. habit, e. leaf, f. staminode, g. gynoecium, h. fruit with calyx, i. fruiting-calyx (ventral view), j. seed.

sometimes obovate with cuneate base, pater beneath, pubescent bothsides when young and become glabrate on maturity except the veins and the veinlets; midrib canaliculate above, canal filled with hairs, raised beneath, hairy; lateral nerves 5-8 pairs, oblique, conspicuous bothsides especially in lower part of the leaves; petioles 0.5-2 cm long, canaliculate above, rounded beneath, pubescent especially in the groove. Male flowers almost sessile, 8-15 mm long, in 3-flowered, shortly peduncled, pubescent, axillary, *ca* 1 cm long, drooping cymes. Calyx campanulate, 5-7 mm long, deeply 4-lobed, divided below the middle, pubescent outside, glabrous within; lobes 3-5 mm long, ovate, acute, valvate. Corolla 8-10 mm long, yellowish white, urceolate, hairy outside, glabrous within; lobes 4, ovate or lanceolate, contorted. Stamens 16-24, subequal, in pairs, attached at the base of corolla-tube; filaments short, hairy; anthers apiculate due to produced connectives, hairy on the dorsal face of connectives. Female flowers solitary, axillary, on 1-1.5 cm long pedicels; pedicels pubescent, dilated at top and articulated with the flowers. Bracts 2, lanceolate, pubescent. Calyx 8-9 mm long, campanulate, hairy bothsides; lobes 4, deeply divided, ovate, acute, spreading, valvate. Corolla 8-13 mm long, urceolate, puberulous outside; lobes 4, ovate, recurved, contorted. Staminodes 8. Ovary 8 to 10-celled, glabrous, cells 1-ovuled; style hairy, 4-fid. Fruits 3-7 cm in diam., globose, fleshy, glabrous, glossy, reddish or yellow. Fruiting-calyx 2.5-5 cm in diam., flat, thickened, discoid or 4-angular, no distinct tube, fruit seated on the disc, disc densely silky tomentose, no internal elevated rim; lobes 4, ovate, 1-1.5 x 0.8-1.2 cm, acute, hairy bothsides, spreading horizontally at the base of fruit, not thickened, somewhat constricted at base, margins not reflexed. Seeds 6-8, oblong, plano-convex, 1.5-2.5 x 0.9-1.2 cm, smooth; mature albumen milky-white, equable, cartilaginous; embryo straight; radicle terete, straight or slightly curved; cotyledons ovate or rounded, lying parallel side by side (**Fig.-29; Plate 11/3**).

Holotype : Described from Japan *Thunberg s.n.* (UPS).

Chr. No.: 2n=54-56 (Yasui, 1915); 2n=90 (Namikawa & Higashi, 1928; Chen, 1993; Solovyova & Omarav, 1986; Namikawa *et al.*, 1932; Wood & Channell, 1960; Tao *et al.*, 1992; Zhuang *et al.*, 1990, 1992; Zhuang, 2000); 2n=135 (Zhuang *et al.*, 1990, 1992); 2n=107-114 (Zhuang *et al.*, 1992). DNA restriction fragment length variability has been studied by Nakamura & Kobayashi (1994). Sugiura *et al.* (2000) have got success through culture in producing nonaploids (2n=9x) by crossing unreduced (2n=6x) pollen and embryo.

Fl. & Fr.: March – November.

Ecol.: Rare, in the forests, particularly in Naga and Khasia hills, upto 1500 m; also cultivated in the orchards for its edible fruits since long back. The plants are comparatively more tender and sensitive to cold and less productive. Propagated by the seeds as well as through budding and grafting. Propagation from cuttings and layering have proved unsuccessful. Tissue culture studies conducted by Yokoyama & Tekeuchi (1976) revealed callus induction on excised hypocotyls of young embryo and the roots and shoots differentiated on the primary callus culture on MS medium containing 1 ppm of NAA and 0.1-1 ppm of Kinetin. Tao & Sugiura (1992) have also got success in adventitious bud formation from callus cultures. Further, Matsumoto *et al.* (2001) have recorded the possibilities in caryopreservation by vitrification of dormant shoot-tips. Nakamura *et al.* (1998) have got success in plant regeneration from

hypocotyl segments. Tamura *et al.* (1996) have been able to produce dodecaploid plants by colchicines treatment of protoplasts. Choi *et al.* (2001) studies have resulted in plant regeneration via organogenesis from leaf segment cultures. Tao *et al.* (1992) studies resulted in adventitious bud formation on callus derived from anthers. As such, it is now well possible to propagate this species vegetatively. Tao & Sugiura (1994) have studied the growth and rooting characteristics of micropropagated adult plants and juvenile seedlings of this species. Kang *et al.* (1998) have recorded cold-hardiness character of buds. The trees thrive well in well drained lighter loam soils. Periodic pruning of bearing trees stimulates new growth and enhance yield. Plants begin to bear fruits when about 5-6 years old. George *et al.* (1996) have studied the effect of shoot variables and canopy position on fruit set, fruit quality and starch reserves in this taxon. Kaki trees are usually not attacked by insects and fungi. However, *Stromatium barbatum* has been reported on this species. Lester *et al.* (1995) have reported occurrence of light-brown apple moth (*Epiphyos postvittana*) and long-tailed mealy bug (*Pseudococcus longispinus*) on persimmons which may be disinfested through hot water immersion. The pollination is usually by large number of insects and honey bees. Studies carried out by Kapil (1970) revealed twenty per cent increase in yield in bee pollinated plants. Seedless fruits are also noticed in this species (Wood & Channell, 1960).

Persimmon was first of all cultivated in China and then in Japan where it is now considered as a national fruit. In 1796, it was introduced to Europe, but couldn't found place in the commerce. In United States, its seeds were brought by Perry in 1852-54 from Japan and now it is grown at higher scale in California. In India, it was introduced first of all by Col. Kyd in Botanical garden at Calcutta during early years of nineteenth century. Ng (1978a) inferred that *D. kaki* Thunb. ex L. f. has arisen directly from *D. roxburghii* Carriere which has been considered conspecific in the present work.

Distrib.: Indigenous in North-Eastern parts of India, particularly in Assam, Nagaland and Meghalaya; cultivated in Punjab, Himachal Pradesh, Uttar Pradesh, Madhya Pradesh, W. Bengal, Uttranchal, Maharashtra, Andhra Pradesh etc. The other zones of its distribution on the globe are Myanmar, Bhutan, China (native home), Japan, Korea, Laos, Cambodia, Vietnam and Java; also reported under cultivation in Iraq, Pakistan, Nepal, Turkey, S. Europe, USSR, USA, Singapore etc (Map-6).

Anatomy: The lower surface of leaves bears small epidermal club-shaped glandular hairs with curved, uniserial stalks (Metcalfe & Chalk, 1950). The wood is diffuse porous. The black heartwood is small. The growth rings are demarcated by dark-coloured latewood fibres. Vessels moderately large or small, evenly distributed, solitary and in radial multiples of 2-3; vessel lines distinct. Parenchyma diffuse to diffuse in aggregates. Rays fine, closely spaced and evenly distributed. Ripple marks present (Wright, 1904; Purkayastha, 1982). Yakovlev & Zhukova (1980) have reported presence of achlorophyllous embryo in this species. Utsunomiya *et al.* (1998) have studied the tannin cells in the mesocarp of fruit and reported that they occupy 10-30 per cent area of the mesocarp.

Embryology : The embryological studies have been carried out by Yamazaki (1972). The superior ovary has 8 locules and an anatropous pendulous, bitegmic, tenuinucellate ovule in each locule. The inner integument consists 10 cell layers and forms micropyle; the inner most layer represents the endothelial layer. The outer integument is massive. A single hypodermal archesporial cell differentiates

into young nucellus which degenerates early. The archesporial cell functions directly as megaspore mother cell and gives rise after divisions to a linear tetrad of four megaspores. Of these, only the chalazal one remains functional and gives rise to embryo sac. The functional megaspore undergoes three nuclear divisions leading to the formation of 2, 4, 8-nucleate gametophyte. The mature embryo sac is linear-oblong. Three antipodal cells penetrating into chalazal region lie in a linear row and degenerate before the final formation of the embryo sac. This is Polygonum type of embryo sac formation.

The endosperm is cellular type. The first division of the primary endosperm cell is transverse, resulting in micropylar and chalazal chambers. Second division in them is again transverse and third longitudinal. The endosperm cells have a tendency to be arranged in a linear row of six tiers. Subsequent divisions are irregular, resulting in ruminate shaped young endosperm. The mature endosperm is elliptical with cells containing much oil but no starch. Endosperm haustorium is not formed at all.

After fertilization, the zygote swells up and forms an elliptic body containing a large vacuole. The first division is transverse, resulting in apical and basal cells. The basal and apical cells divide longitudinally followed by transverse and vertical divisions, forming tiers of cells which are subsequently diffentiated in Chenopodial type of embryogeny into an embryo.

Phytochemistry : The roots of this species contain 3-methoxy-7-methyljugulone, 8'-hydroxyisodiospyrin, quinone, maritinone, mamegakinone, diospyrin, neodiospyrin, plumbagin and shinanolone (Tezuka *et al.*, 1973). The pulp of the fruits contain protein, minerals, carbohydrates, calcium, phosphorus, iron, carotene, vitamin A, thiamine, riboflavin, niacine, ascorbic acid, zeaxanthin, lycopin, glutathione and soluble carbohydrate mannan. Mannan has also been isolated from the seeds (Anonymous, 1952). Cryptoxanthin, phytoene, phytofluene, α–β–δ– and γ–carotenes, locopene, zeaxanthin, anthraxanthin, violaxanthin and lutein have been isolated from the leaves. The wood yields β-sitosterol (Rastogi & Mehrotra, 1993a). Betulic acid, oleanolic acid and ursolic acids have been isolated from the leaves and astragalin (Kaempferol-3-β-D-glucopyranoside) from the calyx. Kaki-tannin, obtained from the fruits, belongs to proanthocyanidin B group and yields delphinidin and cyanidin on hydrolysis along with catechin-3-gallate, gallocatechin and gallocatechin-3-gallate (Rastogi & Mehrotra, 1993b). Recently, leaves have also been found to have astragalin and isoquercitrin, which have been reported to produce hypotensive effect in urethane-anaesthetised rats (Rastogi & Mehrotra, 1993c; Asolkar *et al.*, 1992). Matsuura & Iinuma (1978) have also isolated astragalin (Kaempferol-3-β-D-glucopyranoside) and n-butyl-β-D-fructopyranoside from the calyx of this species. A new lignan (-) divanillytetrahydrofuran ferulate has been isolated from the calyx (Matsuura & Iinuma, 1985). Recently, flavonoids viz. Kaempferol 3-O-β-D-glucopyranoside, quercetin-3-O-β-D-glucopyranoside and Kaempferol from the leaves of this species have also been isolated. Paknikar *et al.* (1996) have isolated 4-Hydroxy-5-methylcoumarin derivatives from the fruit. Cutillas-Iturralde *et al.* (1998) have reported that xyloglucan-derived oligosaccharides induce ethylene synthesis in persimmon fruit. N-terminal amino-acid sequence of persimmon fruit β-galactosidase has been studied by Kang *et al.* (1994). Cutillas-Iturralde *et al.* (1993) have reported that pectin solubilization during fruit ripening occurs in the absence of polygalacturonase activity during

his studies on metabolism of cell wall polysaccharides. Gondo *et al.* (1999) have isolated a naphthalene glycoside from callus cultures.

Uses : This is the most popular edible species of *Diospyros* L. in India as well as in United States, China and Japan. Thousands of cultivars of this species have been developed by geneticists and plant breeders all over the World. The fruits have delicious plum like taste. The immature fruits are astringent due to high percentage of tannin contents. However, astringency may be removed with a mixture of ethanol and carbon dioxide (Taira *et al.*, 1992). The cultivators usually collect mature but slightly hard fruits and before marketing, cure them by storing them in close containers with other ripening fruits like banana, tomato, kiefer pears etc or immersing the fruits in boiling water and leaving soaked over night. The immature fruits can also be ripen within short period by putting them in gas-tight containers containing ethylene or carbon dioxide. The north-eastern tribals usually soak the fruits in lime water for 24-36 hours and then ripen them in heap of grass. The ripen fruits may be stored in cold storage.

Roasted seeds are used as a substitute for coffee. Wood is heavy and strong, suitable for golf club heads and for ornamental work in boxes, desks and moisaics. The fruits are cut and put into the water to furnish an oily varnish type substance which is used for rendering umbrellas, hats, wrapping-paper etc waterproof and for strengthening fishing nets and angling-lines. The seeds contain semi-drying brownish-yellow oil which is a good source for solid fatty acids. The musk from kaki fruits on fermentation by *Saccharomyces diospirii* yield a cider with low alcohol titer. The tannins have been found capable of detoxifying snake venoms and bacterial toxins. Tannin activity is much stronger than tannic acid in this regard (Asolkar *et al.*, 1992). In China, the calyx and peduncle are dried and stocked and used for the treatment of cough and dyspnoea (Burkill, 1935). Japanese produce a black dye from the fruits by treatment with sulphate of iron (Watt, 1890). The extract of plant has been found useful for pest control in China, particularly for *Erwinia carotovora* var. *carotovora* and vegetable pest *Aphis gossypii* (Yang & Tang, 1988). Achiwa *et al.* (1997) have recorded inhibitory effects of persimmon extract and related polyphenol compounds on growth of human lymphoid leukemia cells. Umekawa *et al.* (1999) have also reported the extract and related polyphenols to inhibit eukaryotic DNA polymerase. Kotani *et al.* (1999) have observed inhibitory effect of leaf extract on allergic reaction in human basophilic leaukemia cells and in mice. Kotani *et al.* (2000) have found that leaf extract and astragalin inhibit development of dermatitis in mice.

Notes : This species under cultivation have acquired great variations in the size of fruits (sometimes upto 7 cm in diam.), foliage shape, size and pubescence, fruit colour (yellow, reddish, scarlet, orange-scarlet), number of seeds (6 or 8), shape of seeds particularly apex of seeds (blunt or rounded), cotyledons (ovate or round) etc. Based on above, a large number of varieties have been recognized under cultivation with latin or fency names (Bakhuizen, 1938). In the present work these cultivars have been considered conspecific to proper species.

Further, Hemsley (1911) considered *D. kaki* Thunb. ex L. f. and *D. roxburghii* Carr. as two distinct taxa, the former native to Central and Eastern China and Japan and latter to Eastern India and Western China. He distinguished the two taxa by their foliage. In *D. roxburghii* Carr. the leaves are mentioned

as lanceolate or lanceolate-oblong, attenuate at both end, while *D. kaki* Thunb. ex L. f. is said to have leaves rather broader in upper half. Bakhuizen (1938), however, did not agree as characters do not hold good and intermediate forms are available, especially among the cultivars of *D. kaki* Thunb. ex L. f. An examination of Indian material during the present study also revealed that on the basis of leaf-shape character two taxa cannot be separated. Since no other character is available in support, I admit Bakhuizen's (1938) view in this regard. This species is also sometimes confused for *D. lotus* L. in the field and herbaria.

The name *D. kaki* Thunb. ex L. f. is usually accredited to L. f. (Suppl. 439. 1781). However, Thunberg published this species in 1780 in Nova Acta Soc. Sci. Upsala 3 : 208. I could not see the latter reference in original. As such, not sure whether Thunberg (1780) has provided description or the name is *nom. nud.* If the name published by Thunberg (1780) is supplemented with short diagnostic description, Thunberg (1780) should be considered its author.

Exsicc.: HIMACHAL PRADESH : Mandi, Panarsa, 1000 m, 28th Aug. 1977, *S. K. Murthi & R. Prasad* 62154 ♀ (BSD); MADHYA PRADESH : Pachmarhi, Fort garden, 10th April 1951, *M. B. Patel* Acc. No. 107679 ♀ (DD); MEGHALAYA : Khasia & Jaintia hills, Mamloo forest, 12th Sept. 1931, *P. C. Kanjilal* 9550 ♀ (ASSAM); On way to Mynso, 1050 m, 16th Jan. 1916, *U. N. Kanjilal* 6528 ♀ (DD); Near Tumpet, 1200 m, 23rd Oct. 1913, *U. N. Kanjilal* 2842 sterile (DD); Khongsnong, 1166 m, 6th Feb. 1915, *U. N. Kanjilal* 6808 ♀ (ASSAM); Jowai, Khline Kine, 1500 m, 23rd July 1965, *N. P. Balakrishnan* 42908 ♀ (ASSAM); Umsaw forest, 9th April 1936, *Shri Ram Sarma* 13037 ♀ (DD); Shillong, Nirala compound, 17th April 1958, *G. K. Deka* 11167 ♀ (CAL); UTTRANCHAL : Dehra Dun, 6th April 1911, *Pundit Kurhavanand* 2821 ♀ (DD); 10th Aug. 1915, *U. N. Kanjilal* 5828 ♀ (ASSAM); Runcrit Hishavan, 22nd Dec. 1911, *Without Collector* 28210 ♀ (DD); Viccroy's grounds, 29th March 1922, *R. N. Parker* Acc. No. 25580 ♀, 25581 ♂ (DD); Ballupur, July 1965, *M. D. Dabral* Acc. No. 141999 ♀ (DD); UTTAR PRADESH : Saharanpur, Botanic garden, *M. B. Raizada* Acc. No. 105816 ♀ (DD). Also examined BHUTAN : Eastern Bhutan, Tashiyangtsi, 24th Oct. 1965, *N. P. Balakrishnan* 44268 ♀ (RHMD, ASSAM).

31. ***Diospyros kanjilali*** Duthie in Ind. For. 31 : 307. t. 29. 1905 & Fl. Gangetic Plain 2 : 15. 1911

Vernacular names : *Kan.*: Kakatumburu, Kalnandi, Kunike, Katikatiro; *Or.*: Pittakhatijya, Koduapitta; *Tam.*: Nacavakkarai; *Tel.*: Sitakaluvucu, Tellagata.

Dioecious or polygamous, medium-sized or small trees; branches not spinescent, forming a rather open crown, densely tomentose when young, glabrate to glabrous with age. Bark ashy grey or greenish, smooth, cracked in rectangular or square pieces, often exfoliating on older trunk. Leaves alternate, 2.5-6.5 x 1.5-5 cm (3.75-13.75 cm long in protologue), broadly elliptic to suborbicular, thick, coriaceous, obtusely shortly apiculate at apex, cuneate at base, tomentose bothsides when young, with age becoming almost glabrous above except the veins and thinly pubescent below with more hairs on

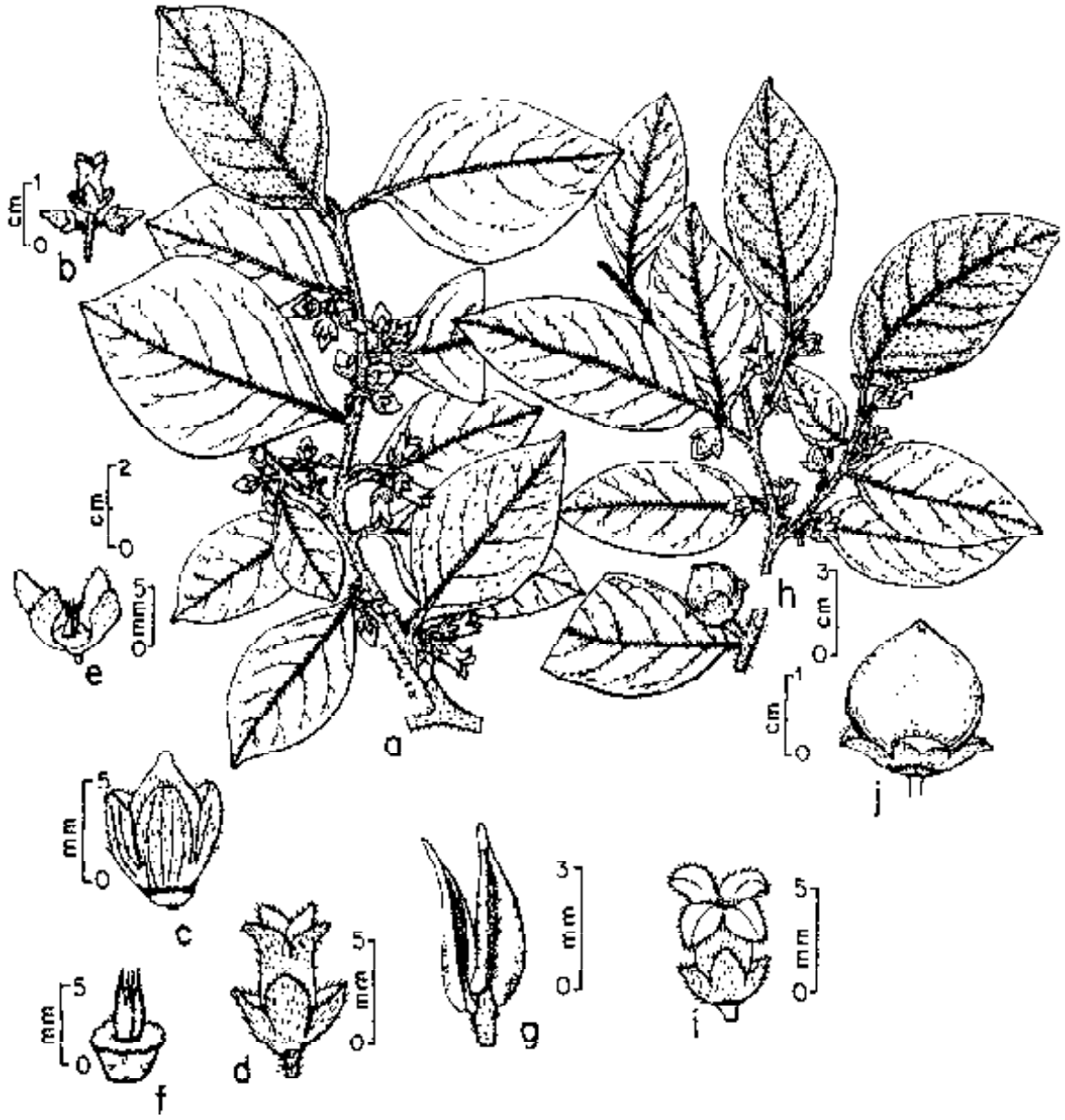


Fig.-30. ***Diospyros kanjilali*** Duthie

Male : a. habit, b. inflorescence, c. flower-bud, d. flower, e. calyx within with pistillode, f. pistillode, g. stamens.

Female : h. habit, i. flower, j. fruit with calyx.

midrib and lateral veins; midrib canaliculate above, canal densely filled with hairs, raised and hairy beneath; lateral veins 8-10 pairs but 4-6 pairs more prominent, arching upwards towards margins; petioles 2-7 mm long, densely hairy, canaliculate above and rounded beneath. Male flowers sessile, in short, 3-flowered, hairy, bracteate, axillary cymes; main peduncle upto 1 cm long, hairy; lateral peduncles 1-3 mm long, hairy, articulated with flowers at apex. Bracts ovate, subacute, ciliate. Flower-buds ovate, pubescent. Calyx 4-5 mm long, campanulate, 4-lobed, divided nearly to the base, pubescent outside, glabrous within; lobes broadly elliptic-oblong, 3-4 x 3-3.5 mm, obtuse, palmately 5 to 7-parallel-nerved and nerves converging towards apex, ciliate, valvate. Corolla urceolate, 5-7 mm long, thinly pubescent outside, glabrous inside; lobes 4, broadly oblong, almost erect, ciliate, contorted. Stamens 16, attached at the base of corolla-tube, almost equal in size, united in pairs, sometimes upto apex on a common filament and as such one anther apparently sessile; filaments short, upto 1 mm long, hairy; anthers narrowly lanceolate, 3-3.25 x 1 mm, glabrous or sometimes hairy all along the connectives on both faces, apiculate, connectives produced at apex and about half as long as anther-cells and glabrous. Pistillode globose-obconic, flat-topped, glabrous; styles 2, 2-fid at apex, hairy. Female flowers axillary, solitary, nodding; pedicels *ca* 6 mm long, pubescent. Calyx as in male flowers but little larger. Corolla dark-green, otherwise like males. Staminodes 8, small and longer alternately arranged, longer ones toothed near the acuminate apex, shorter ones obtuse. Ovary globose, glabrous, 8-celled, cells 1-ovuled. Fruits upto 2.5 cm in diam., globose, glabrous. Fruiting-calyx shallowly concave, discoid or somewhat angular, lower part of fruit encircled by the calyx, without internal elevated rim; lobes spreading, without reflexed margins. Seeds *ca* 1.25 cm long, somewhat curved; albumen equable **(Fig.-30; Plate 11/4)**.

Lectotype : India : Madhya Pradesh, Chanda district, *J. F. Duthie* 9559 (K-designated here).

Fl. & Fr.: April – May.

Ecol.: Occasional, found in moist semi-evergreen forests, upto1000 m.

Distrib.: Endemic to India, chiefly found in Uttar Pradesh, Madhya Pradesh, Andhra Pradesh, Karnataka, Orissa, West Bengal, Assam and Meghalaya **(Map-6)**.

Anatomy: Wood brownish-grey, with sometimes iron grey streaks, soft to moderately hard, no heartwood. Pores small, scanty, in radial groups of 1-3 which are distant between the medullary rays and faintly to echelon. Medullary rays numerous, very fine. Transverse lines very faint.

Notes : This species occupies a position intermediate between *D. montana* and *D. cordifolia* Roxb. However, it may be distinguished from *D. montana* by having thick coriaceous leaves, male flowers in 3-flowered cymes and twice the number of staminodes. From *D. cordifolia* Roxb. it differs in having awned anthers and by lesser number of staminodes. Contrary to protologue, the anthers are hairy in some specimens. Probably this species hybridise with *D. montana* Roxb. in nature.

Distrib. Sketch Map – 6

● *Diospyros hirsuta* L. f.; ▲ *Diospyros holeana* Gupta & Kanjilal;
■ *Diospyros insignis* Thw.; ○ *Diospyros kaki* Thunb. ex L. f.; ★ *Diospyros kanjilali* Duthie

Exsicc.: ANDHRA PRADESH : Anantapur, *Gamble* 20873 (Lectosyntype-K); KARNATAKA : Bellary, *Gamble* 16583 (Lectosyntype-K); North Kanara, *Ritchie* 972 (Lectosyntype-K); ORISSA . Ganjam, *Gamble* 13657 (Lectosyntype-K); UTTAR PRADESH : Saharanpur, 3rd April 1961, *M. A. Rau* 14664 ♂ (BSD); WEST BENGAL : *Gamble* 10614 (Lectosyntype-K).

32. ***Diospyros kika*** Debbarman & Biswas in J. Ind. Bot. Soc. 16 : 57. f. 1-3. 1937.

Unarmed trees; branchlets alternate, terete, young ones clothed with yellowish- brown fulvous tomentum of rather long hairs, becoming glabrate to glabrous with age. Bark leathery, linearly marked, sparsely lenticelled. Leaves alternate, in male plants 2.5-9.5 x 1 2 cm, elliptic-lanceolate, cuneatly obtuse at base, gradually acuminate at apex, margins entire and ciliate, fulvous-tomentose bothsides but more densely beneath, becoming sparsely hairy to glabrate on maturity except the midrib and the lateral veins, upper surface blackish and lower yellowish-brown in mature leaves; midrib narrowly canaliculate above, slightly raised beneath, hairy bothsides; lateral nerves 4-6 pairs, very distant, arcuating towards apex, reticulation prominent beneath and inconspicuous above; petioles 3-5 mm long, densely tomentose, canaliculate above, rounded beneath. Male flowers in 3-flowered, axillary, shortly peduncled, bracteate, tomentose cymes; peduncles *ca* 3 mm long; pedicels *ca* 1 mm long. Bracts 2-3 mm long, oval lanceolate, tomentose, deciduous. Calyx cup-shaped, tomentose bothsides; tube 1.5-2 mm long; lobes 4, *ca* 3 mm long, divided below the middle, ovate, acute, erect, valvate. Corolla urceolate, tomentose outside, glabrous within; tube 2-3 mm long; lobes 4, ovate, *ca* 5 x 1 mm, obtuse, tomentose outside, glabrous within, contorted. Stamens 20-22, subequal, subsessile, paired, inserted at the base of corolla-tube; anthers linear or narrowly ovate-lanceolate, slightly falcate, connectives produced into apiculae, pilose along connectives. Pistillode absent or inconspicuous. Female plants not seen (**Fig.-31; Plate 12/1**).

Lectotype : Burma (Myanmar) : Unan, Poneshee, 27th Mar. 1868, *D. J. Anderson s.n.* ♂ Acc. no. 283094 (CAL-designated here).

Fl. & Fr.: March – May.

Ecol.: Occasional, found in wet semi-evergreen forests and in the wastelands, upto 1500 m.

Distrib.: This species finds distribution in North-Eastern parts of India, particularly in Assam, Manipur and Meghalaya. It extends further east to Myanmar (**Map-7**).

Exsicc.: MANIPUR : Neung Shong Khong, 1300 m, Apr. 1882, *G. Watt* 6264 ♂ (Lectosyntype-CAL); MEGHALAYA : Nongkhlow, Khasia hills, 1450 m, 10th Apr. 1914, *U. N. Kanjilal* 6706 ♂ (Lectosyntype-CAL); MYANMAR : Kelloh to Lowadhoh, *S. Kurz* 1008, Acc. No. 283096 ♂ (CAL).

33. ***Diospyros kurzii*** Hiern in Trans. Cambr. Philos. Soc. 12 : 162. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 559. 1882; Parkinson, For. Fl. Andaman Islands 198. 1922; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 173. 1937; Ng in Malays. For. 40 (4) : 227. 1977. *D. nitida* Merr. in Phil. Govt. Lab. Bur. Bull. 35 : 57. 1905; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 176. 1937. *D. wrayi*

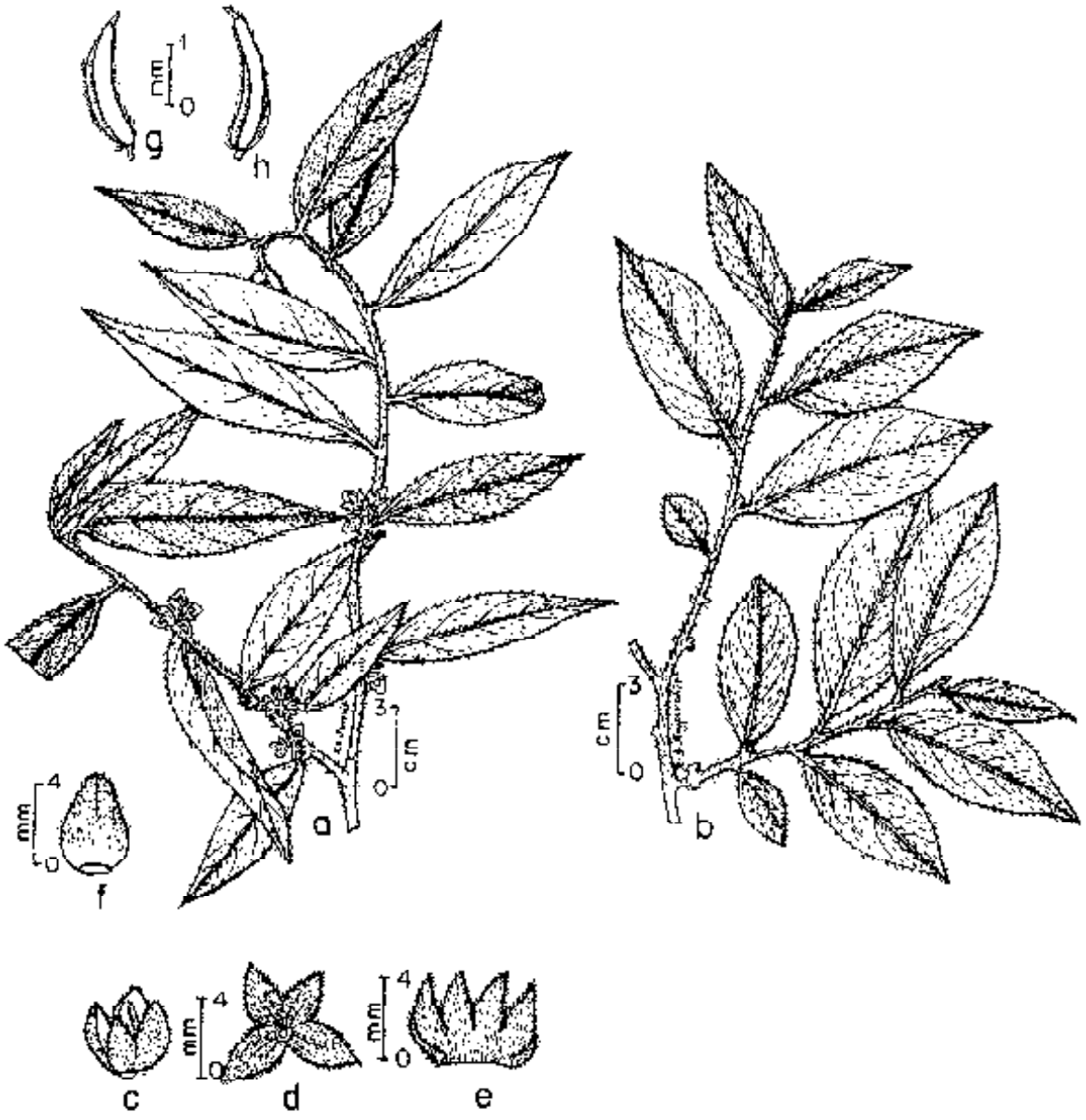


Fig.-31. ***Diospyros kika*** Debbarman & Biswas
Male : a. habit, b. habit (type), c. flower-bud, d. calyx (dorsal view), e. calyx within, f. corolla in bud, g-h. stamens.

King & Gamble in J. Asiat. Soc. Bengal 2 : 74. 1905. *D. alata* Elmer, Leaflets Phil. Bot. 5 : 1774. 1913. *D. pubicarpa* Ridley, Fl. Mal. Penin. 2 : 286. 1923. *D. fulvopilosa* Fletcher in Kew Bull. 1937 : 385. 1937.

English names : Andaman Marble wood, Andaman Zebra wood.

Vernacular names : *And.*: Pechada; *Tel.*: Kala-lakri.

Trees, 3.5-15 m high, with whitish bark and pubescent branchlets with short silky appressed hairs. Leaves alternate, 4.5-9 x 1.8-3.5 cm, elliptic or ovate-elliptic, acuminate, narrowed at base, coriaceous, dark and shining above, thinly pubescent when young especially beneath, soon glabrescent except the midrib especially beneath; midrib raised and pubescent beneath, canaliculate and glabrous above except with few hairs in the canal; lateral veins several pairs, almost parallel, thin, with reticulate venation between the lateral veins; petioles 3-5 mm long, pubescent, canaliculate above, rounded beneath. Male flowers in 5 to 15-flowered, axillary, dichasial, pubescent, bracteate cymes upto 1.5 cm long; main peduncle and its branches wiry and pubescent. Flower-buds ovoid or ovate, pubescent. Bracts linear-oblong, 1-1.5 x 0.5-0.75 mm, obtuse, hairy bothsides, ciliate, inserted at the base of flowers, deciduous. Calyx campanulate, 2-3 mm long, pubescent outside, glabrous within, 4-lobed, divided upto the middle; lobes ovate-triangular, 1.1.5 mm long, finely acute, thinly pubescent outside, glabrous within, ciliate, valvate. Corolla tubular-campanulate, tube as long as calyx, deeply 4-lobed, pubescent outside, glabrous within; lobes ovate-oblong, obtuse or rounded at apex, rotate. Stamens 12-16, unequal, in equal or unequal pairs, inserted at the base of corolla-tube; filaments hardly upto 0.5 mm long, much smaller than anthers, glabrous; anthers 1-1.5 mm long, glabrous, apiculate, connectives produced. Pistillode subglobose, glabrous, with apparently single style having 2-lobed apex. Female flowers in short-peduncled, 3-flowered, axillary, thinly pubescent, bracteate cymes. Bracts oblong-elliptic, pubescent, ciliate, caducous, borne at the base of calyx. Calyx sub-campanulate, puberulous outside, glabrous within, 2-3 mm long, deeply 4-lobed; lobes broadly oblong or ovate-oblong, pubescent outside, glabrous within, obtuse, valvate. Corolla urceolate, 5-6 mm long, pubescent bothsides; lobes 4, rounded, contorted. Staminodes 4, glabrous, alternating with corolla-lobes. Ovary glabrous except at the apex, 4-celled, cells 1-ovuled; styles 2, straight, hairy, connate at base. Fruits globose, 1.5-1.8 cm in diam., of the size of a small cherry, glabrous, smooth, 4-seeded; peduncles upto 5 mm long, thinly pubescent, articulated with the fruit. Mature fruiting-calyx ca 1.5 cm in diam., deeply 4-lobed, basal part of the tube get thickened in the form of a disc on which the fruit is seated, glabrous; lobes reflexed or spreading horizontally, never touching the fruit, foliaceous with out-rolled margins, obtuse at apex; in young fruits the deeply divided calyx-lobes are rather erect and almost touching the fruit but soon get reflexed as the fruit grows up. Seeds elliptic oblong, 8-10 x 5-7 mm; albumen equable **(Fig.-32; Plate 12/2 & 3)**.

Holotype : India, South Andaman, *Kurz s. n.* (K).

Fl. & Fr.: February – November.

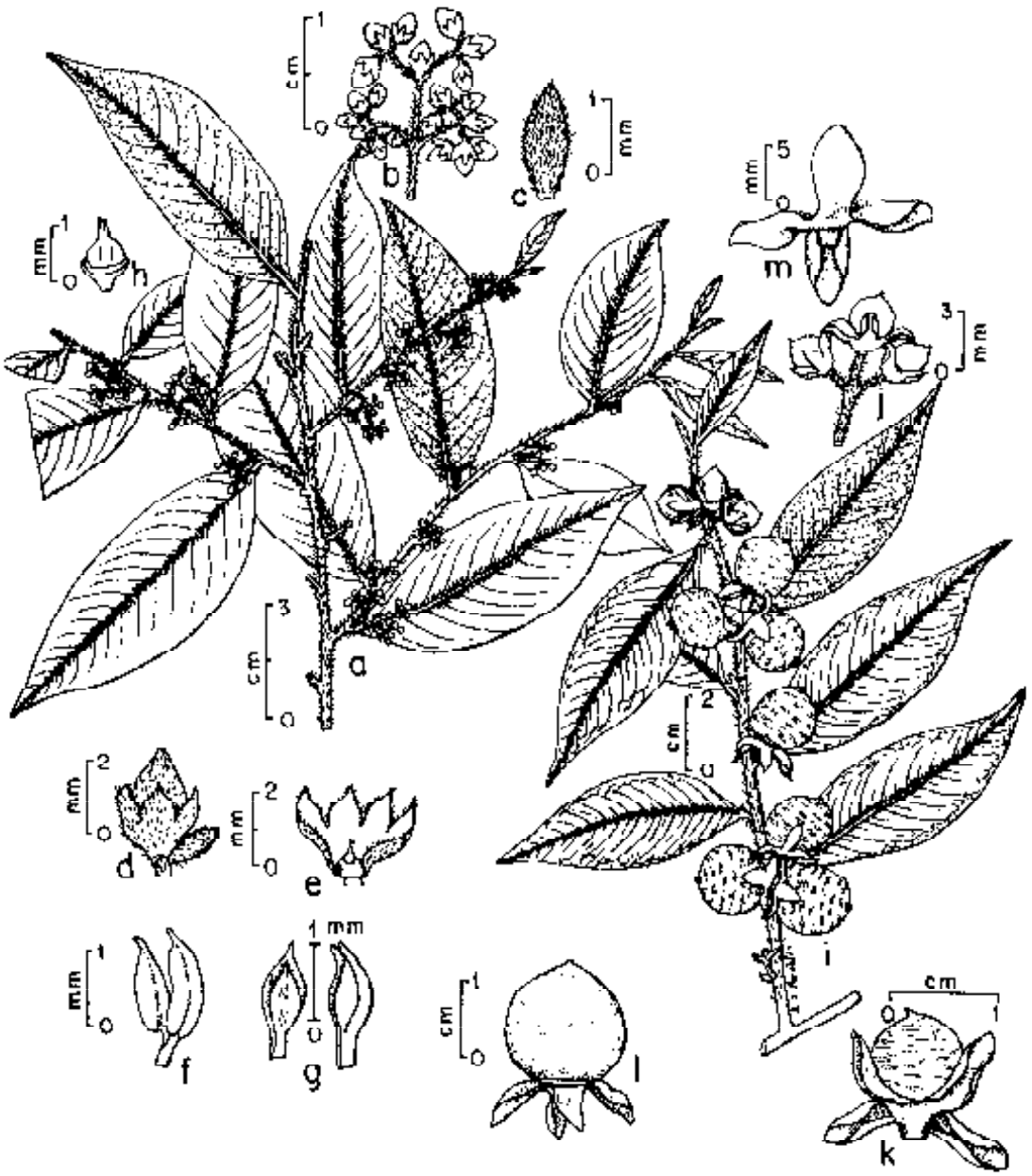


Fig.-32. ***Diospyros kurzii*** Hiern

Male : a. habit, b. inflorescence, c. bract, d. flower-bud with bract, e. calyx within with pistillode, f-g. stamens, h. pistillode.

Female : i. habit, j. inflorescence, k. young fruit with calyx, l. mature fruit with calyx, m. fruiting calyx.

Ecol.: Found mixed with tropical and rain forests, upto 25 m.

Distrib.: This species is known from Andaman & Nicobar Islands in India and further east from Myanmar, Malay peninsula, Borneo and Molucca (**Map-7**).

Anatomy : The heartwood is greyish, close-grained, black or grey interlaid with black.

Uses : The wood is often marbled and, therefore, called Marble wood or Zebra wood. The timber produced by Indian trees is called as Andaman Marble wood. It is streaked grey and black with more or less alternate streaks, hard, sometimes apt to warp and split in seasoning. It polishes beautifully and planes always to a natural polish. The timber is largely used for furniture, cabinet work, carving and other fancy works and for walking sticks. It is much valued in Europe.

Notes : Very close to *D. benghalensis* Bakh. Bakhuizen (1937) felt that the denser venation is the only character to distinguish this species from *D. benghalensis* Bakh. However, he ignored the characters used in the present key which stand good to distinguish two taxa.

Exsicc.: ANDAMAN & NICOBAR : Middle Andamans, Camp No. 15, 24 km from Rangat, 25 m, 4th Nov. 1977, *N. Bhargava* 6345 ♀ (PBL); Way to Parnashala, 7th Nov. 1977, *N. Bhargava* 6429 ♀ (PBL); Kalsi No. 6, 24th Jan. 1994, *Marcel Tigga* 16623 (PBL); South Andamans, Chiriatapu, *A. K. Goel* 16835 ♀ (RHMD); Sea level, 8th April 1973, *N. P. Balakrishnan* 78 ♀ (PBL); Myonyo, 10 m, 20th Oct. 1973, *N. P. Balakrishnan* 519 ♀ (PBL); Manpur, Hill Jungle, 20th Feb. 1894, *Dr. King's Collector s.n.*, Acc. No. 1641 ♀ (PBL); Jusnabad-Manganj Hill Jungle, 23rd Dec. 1893, *Dr. King's Collector s.n.*, Acc. No. 1634 ♀ (PBL); Rutland Island, Along Ghasnullah, Towards Mount Ford, 22nd Jan. 1982, *M. K. V. Rao* 8640 ♀ (PBL); Baratang Island, Sundergarh, 20 m, 23rd July 1975, *N. Bhargava* 2494 ♀ (PBL); M. S. Cowri, 19th Jan. 1979, *P. Basu* 7089 ♀ (PBL); South Creek, Lauruji forest, 26th Oct. 1979, *P. Basu* 7367 ♀ (PBL); North Andamans, 4th March 1936, *Jen Gupta* 6093 ♀ (DD); Diglipur-4, Sea level, 26th Nov. 1976, *N. G. Nair* 4919 ♀ (PBL); North Nicobar, Passa, Car Nicobar, Sea level, 30th May 1975, *N. G. Nair* 2624 ♂ (CAL); Little Andaman, Hut Bay, Sea level, 14th Jan. 1977, *N. Bhargava* 5133 ♂ (CAL); 13th Jan. 1977, *Kishanlal* 22 sterile (DD); Andaman, Bara lung, Pa-Jigs, 10th Feb. 1915, *C. E. Parkinson* 291 ♀ (DD); Bose-lung-la, June, 1915, *C. E. Parkinson* 631 ♀ (DD).

34. ***Diospyros lanceaefolia*** Roxb. Fl. Ind. 2 : 537. 1832; A. DC. in DC. Prodr. 8 : 232. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 213. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 562. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 273. 1938. *D. amoena* Wall. ex G. Don, Gen. Hist. Dichl. Pl. 4 : 40. 1838; A. DC. in DC. Prodr. 8 : 231. 1844. *D. multiflora* Wall. ex A. DC. in DC. Prodr. 8 : 231. 1844, non Blanco 1837. *D. grata* Wall. ex A. DC. in DC. Prodr. 8 : 232. 1844; Clarke in Hook. f. Fl. Brit. India 3 : 571 1882. *D. lucida* Wall. ex A. DC. in DC. Prodr. 8 : 233. 1844, non Lodd. ex Steud. 1840, nec. Hort. ex Loud. 1841; Clarke in Hook. f. Fl. Brit. India 3 : 568. 1882. *D. lanceaefolia* Roxb. var. *amoena* (Wall. ex G. Don) Clarke in Hook. f. Fl. Brit. India 3 : 562. 1882. *D. pachyphylla* Clarke in Hook. f. Fl. Brit. India 3 : 568. 1882. *D. hirsuta* L. f. var. *lucida* (Wall. ex

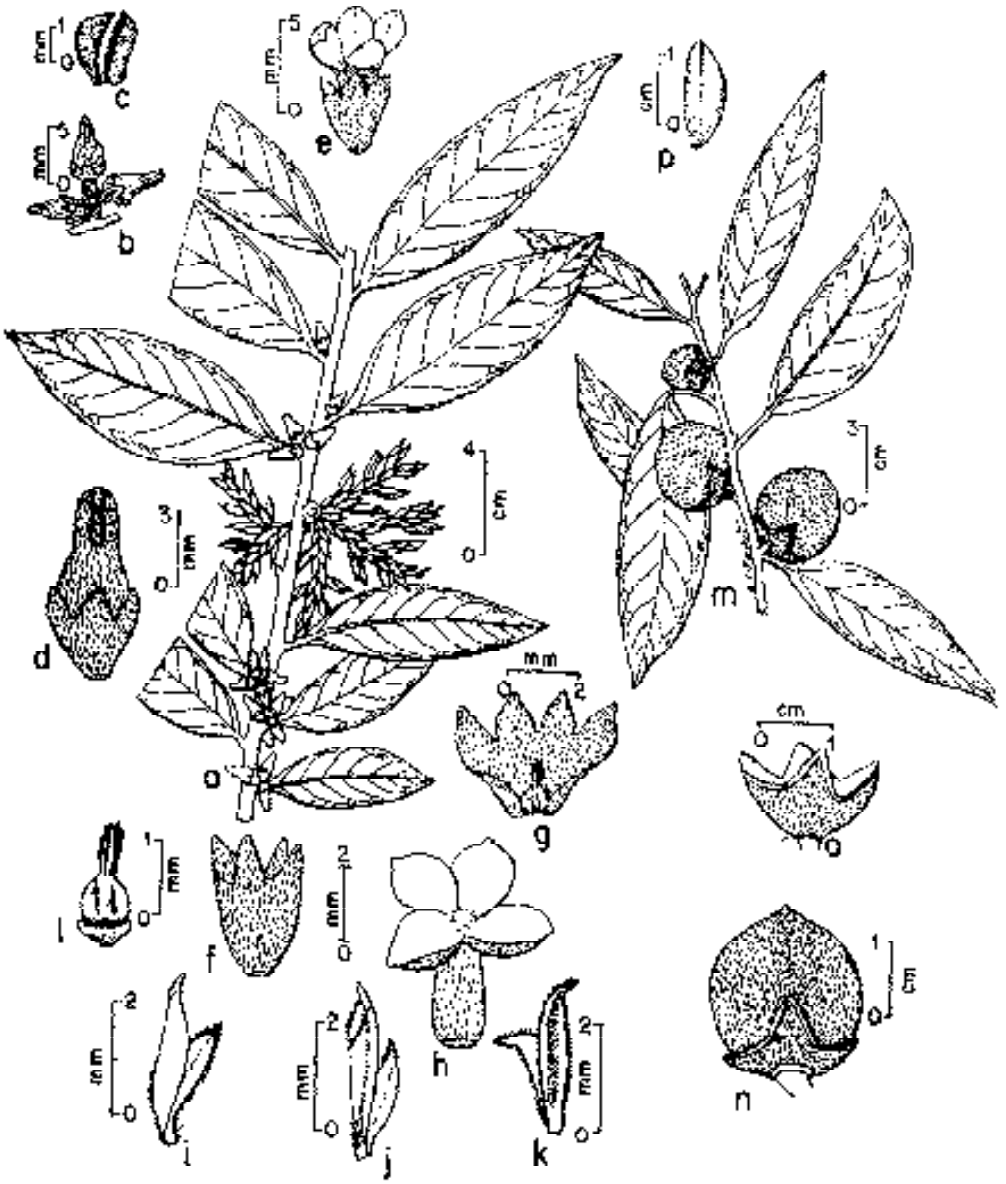


Fig. 33. ***Diospyros lanceaefolia*** Roxb.

Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. flower, f. calyx, g. calyx within with pistillode, h. corolla, i-k. stamens, l. pistillode.

Female : m. habit, n. fruit with calyx, o. fruiting-calyx, p. seed.

A. DC.) De Clercq & Greshoff in De Clercq, Nieuw Plantk. Woordenb. Ned. Ind. 222. 1909. *D. clavigera* Clarke var. *pachyphylla* (Clarke) Ridley, Fl. Mal. Pen. 3 : 288. 1923. *D. lonchophylla* Hiern in J. Bot. Suppl. 63 : 63. 1925.

English name : Ebony.

Vernacular names : *Asm.*: Kendu, Gulal; *Beng.*: Goolal, Goolul, Armida; *Kh.*: Dieng-sohleu, Soilo, Sohleu; *Nag.*: Puja; *Nep.*: Tezu, Paklam.

Dioecious trees, upto 30 m high; young branchlets densely pubescent with short appressed hairs. Some lateral branches in male plants become abnormally much branched with imbricate small leaves, often forming dense bunches with or without male flowers. The leaves give appearance of imbricated bracts and entire bunch as an axillary male inflorescence. Leaves alternate, 6-20.5 x 1.6-5 cm, lanceolate or oblong-lanceolate, abruptly or gradually acuminate at apex, subobtuse or cuneate at base, coriaceous, mature ones glabrous bothsides, young ones pubescent beneath, margins flat or slightly recurved; midrib channelled above, raised beneath, glabrous; lateral veins 8-12 pairs, prominent beneath; petioles 5-15 mm long, flat and canaliculate above, rounded beneath, glabrous. Male flowers sessile, 3 to 5-together fascicled in axillary, bracteate, ferruginously pubescent cymes, rarely solitary. Bracts 1.5-2 mm long, almost suborbicular, obtuse, ferruginously sericeous on dorsal surface and glabrous inside, borne at the base of flowers and on peduncles. Flower-buds ovoid, 5-8 mm long, pubescent. Calyx campanulate, 3-5 mm long, ferruginously sericeous bothsides; lobes 4, 1-2 mm long, divided above the middle or rarely in some flowers below the middle, ovate-deltoid, thick, sometimes 2 rather narrow when deeply divided, obtuse, valvate. Corolla somewhat salver-shaped, pubescent outside, glabrous within; tube 3-4 mm long, cylindrical, not much narrowed at apex; lobes 4, almost rounded, 3-4 mm long and as broad, spreading, hairy outside, glabrous within, contorted. Stamens 14, 16, 18 or 20, unequal, inner ones smaller, united in unequal pairs and inserted at the base of corolla-tube; filaments 1-2 mm long, finely pubescent at apex; anthers linear, 1.5-3 x 0.5-0.75 mm, apiculate due to produced connectives, glabrous or pilose variously at base, apex, along the edges and on the back. Receptacles hairy. Pistillode subglobose-4-angular, pubescent, with 4, filiform, pubescent styles, absent in some flowers. Female flowers subsessile, solitary, axillary, bracteate, about as large as males. Flower-buds ovoid, 5-8 mm long, pubescent. Bracts broadly oblong to suborbicular, 2-3 mm long, pubescent outside, glabrous within, borne at the base of flowers. Calyx campanulate, 3-5 mm long, 4-lobed, divided above the middle, hairy bothsides; lobes ovate-triangular, 1.5-2 mm long, obtuse, valvate. Corolla somewhat salver-shaped, 7-8 mm long, pubescent outside, glabrous within; lobes 4, almost suborbicular, with reflexed margins, imbricate. Staminodes 8-10, linear. Ovary 8-celled, hairy, cells 1-ovuled; styles usually 4, more or less united at base; stigmas 8. Fruits globose or ovoid-globose, somewhat pointed at apex, 2.5-3 cm in diam., tawny-tomentose. Fruiting-calyx broadly cup-shaped with shallow tube encircling the lower part of fruit, pubescent outside; lobes almost erect and touching the fruit with reflexed margins. Seeds 5 or more, elliptic, *ca* 15 x 5-6 mm, smooth, shining, chocolate-coloured; albumen equable (Fig.-33; Plate 12/4 & 13/1).

Holotype : Roxburgh's Plate No. 2508 (K).

Fl. & Fr.: February – August.

Ecol.: In tropical rain forests, upto 1050 m or more. The seeds are usually dispersed by the cats, monkeys, bats and birds. The timber is susceptible to dry wood borer.

Distrib.: In India, this species finds distribution in W. Bengal, Assam, Arunachal Pradesh, Meghalaya, Mizoram and Tripura. It is also known from Nepal, Bangladesh, Myanmar (native home), Sri Lanka, Singapore, Malaya, Sumatra, Borneo and Philippines (**Map-7**).

Anatomy : The wood is diffuse-porous. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Medullary rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained, fine-textured (Wright, 1904; Purkayastha, 1982).

Uses : The fruits with sweet edible pulp are much relished by the tribals of eastern India during rainy season. The fruits and seeds are also used as a fish poison in N. E. India. Wood is suitable for building purposes. The seeds are used for the treatment of skin diseases (Jain & Filipps, 1991; Rao & Jamir, 1982).

Notes : This is a highly variable species, hardly distinguishable from the closely related species of the section Nesindica Bakh. Bakhuizen (1938) has recognized five forma viz. *consanguinea* (Merr.) Bakh., *cagayanensis* (Merr.) Bakh., *wenzelii* (Merr.) Bakh., *sabtanensis* (Merr.) Bakh. and forma *lanceaefolia* under this species. Of these forma, only typical (autonym) occurs in India and rest are confined to Borneo, Sumatra and Philippines. It is interesting to record that corolla of Indian material has dimorphous hairs outside i.e. reflexed on the tube and erect appressed on the lobes.

Exsicc.: ASSAM : Kamrup, Kamakhya, 3rd June 1958, *B. K. Nayar* 51227 ♂ (LWG); Mowgong, Mikir hills, 80 m, 14th Jan. 1914, *U. N. Kanjilal* Acc. No. 102737 ♀ (DD); MEGHALAYA : Khasia & Jaintia hills, *Geo Gall.* 389 ♂ (CAL); Pongtung, 27th Sept. 1939, *G. K. Deka* 19139 ♀(ASSAM); 820 m, 5th Sept. 1941, *R. N. De* 1 ♀ (DD); 39 miles G. S. Road, 10th May 1935, *Shriram Sarma* 9266A ♂ (ASSAM); Garo hills, Tura forest, 26th March 1941, *R. N. De* 20450 sterile (ASSAM); MIZORAM : Aizol, Lushai hills, 4th Dec. 1953, *Godfrey* 611 ♀ (CAL); Mizo hills, Aizol protected forest, 1050 m, 11th Jan. 1963, *D. B. Deb* 30526 ♂ (ASSAM); Sabual, 900 m, 28th Jan. 1962, *D. B. Deb* 27218A ♂ (ASSAM), *D. B. Deb* 27218B ♀ (CAL).

35. ***Diospyros lotus*** L. Sp. Pl. 1057. 1753, non Iour. 1790, nec Blanco 1845; A. DC. in DC. Prodr. 8 : 228. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 223. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 555. 1882; Carder in Curtis's Bot. Mag. 180 (4) : 165. 1975; Ng in Malays. Forest. 42 (2) : 165. 1979. *Dacrylus trapezuntinus* Forssk. Fl. Aegypt.-Arab. 36. 1775. *D. kaki* Thunb. ex L. f. var.

β Thunb. Fl. Jap. 158. 1784. *D. kaki* Thunb. ex L. f. var. *glabra* A. DC. in DC. Prodr. 8 : 229. 1844. *D. microcarpa* Sieb. in Ann. Soc. Hort. Pays Bas 28. 1844, non Span 1835, nec (Jacq.) Gurke 1890. *D. japonica* Sieb. & Zucc. in Abh. Bayer Acad. 4 (3) : 136. 1846. *D. umlovok* Griff. Itin. Not. 355. 1848.

English name : Date Plum Persimmon.

Vernacular names : *Hindi:* Amlok; *Kang.:* Amlok; *Punj.:* Amlok, Amluk, Maluk, Gwaladar.

Dioecious trees, 2-10 (-20) m high, with pubescent young branchlets becoming glabrous with age, unarmed. Leaves alternate, 2.5-15 x 0.8-6.6 cm, of the female plants rather broader than males, elliptic or broadly lanceolate, shortly acuminate, rounded-cuneate at base, submembranous, thinly pubescent bothsides, young ones densely pubescent; midrib canaliculate above, raised beneath, pubescent bothsides or glabrous above with age; lateral veins 6-8 pairs, arcuated upwards; petioles 4-15 mm long, flattish-canaliculate above, rounded beneath, pubescent. Male flowers subsessile, in 3-flowered, short, axillary, bracteate cymes especially on young branches in the axils of small leaves, sometimes 2-4 flowers fascicled on the common small peduncle; peduncles 1-2 mm long, pubescent. Bracts 2-3 x 1-1.5 mm, ovate-oblong or ovate-lanceolate, glabrous bothsides, ciliate, borne at the base of flowers and appressed to the calyx. Calyx broadly campanulate, 2.5-4 x 3-4 mm, suddenly much narrowed at base like a 4-angled stalk, lobed 1/3rd to half way down or sometimes more; lobes 4 or rarely 5, ovate-triangular, subacute or obtuse, ciliate, glabrous bothsides, pubescent within, valvate. Corolla urceolate, tube little longer than calyx, glabrous outside; lobes 4, almost suborbicular, ciliate, horizontally spreading, contorted. Stamens usually 16, subequal or unequal, paired in two opposite rows consisting one inner little short and other outer rather long stamen, inserted at the base of corolla-tube; filaments *ca* 1 mm long, rather thick, hairy; anthers 2-3 mm long, narrowly ovate-lanceolate, pilose on the connectives on both faces, connectives produced and apiculate. Pistillode globose, rudimentary, glabrous, with closely associated 4 styles. Female flowers solitary, axillary, subsessile; pedicels 1-2 mm long, thick, densely pubescent. Bracts deciduous. Calyx campanulate; lobes 4, divided below the middle, broadly ovate-triangular, larger than males, glabrous bothsides, eciliate, imbricate. Corolla urceolate, yellowish white; lobes 4, suborbicular, ciliate, spreading horizontally, contorted. Staminodes 8, in one row, inserted at the base of corolla-tube, hairy. Ovary globose or ovoid, glabrous except in the apical region, 8-celled, cells 1-ovuled; styles 4, united at base, hairy, subpersistent. Fruits 1.4-2.5 cm in diam., globose or ovoid, dark purple to black when ripe, glaucous. Fruiting-calyx 1-1.8 cm across, foliaceous; tube almost flat, disc-like, fruit seated on the disc, with a ring of hairs on the inner-side below the fruit; lobes 4, broadly ovate, divided 2/3rd down or nearly to the base, 7-9 x 6-8 mm, glabrous bothsides, eciliate, imbricate, spreading horizontally, not enclosing the fruit and without an internal elevated rim, margins of lobes not reflexed. Seeds laterally compressed, brown-black; albumen equable **(Fig.-34; Plate 13/2 & 3)**.

Holotype : In Gallia Narbonenai, Italia, Mauritania, Linn. 1231/102 (LINN).

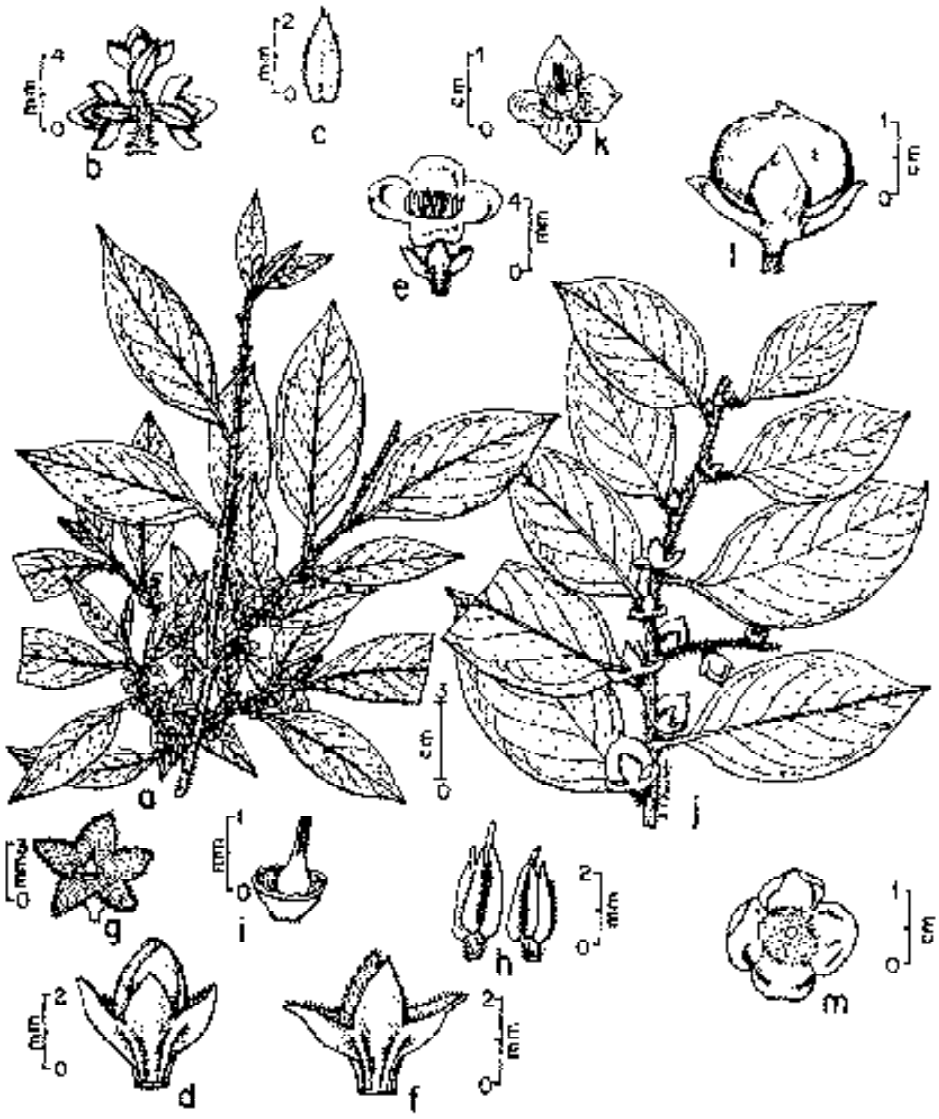


Fig.-34. *Diospyros lotus* L.

Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. flower, f. calyx, g. calyx within with pistillode (top view), h. stamens, i. pistillode.

Female : j. habit, k. calyx within with gynoecium (top view), l. fruit with calyx, m. fruiting-calyx (ventral view).

Chr. No.: 2n=30 (Namikawa & Higashi, 1928; Astanova, 1984; Ceschmedjiev, 1983; Solovyova & Omarov, 1986; Namikawa *et al.*, 1932; Wood & Channell, 1960); 2n=30 +1s (Chen, 1993).

Fl. & Fr.: May – November.

Ecol.: Grows at N. W. Himalaya, between 1000-2100 m. The plants prefer open sunny places and well drained soil. It is propagated through seeds. This species is used as a stock for grafting or ring budding Kaki persimmon. The grafted trees are reported to remain productive for centuries. It is a slow growing tree.

Distrib.: Native of North-East China. In India, this species is confined to Himalayan mountain passing through Jammu & Kashmir, Himachal Pradesh, Punjab to Uttar Pradesh. Other regions of the World where this taxon grows frequently are Asia Minor, Russia, S. Europe, Mediterranean region, Turkey, Iran, Caucasus, Myanmar, Nepal, Afghanistan, Pakistan, N. Vietnam, Korea and Japan. It is also known under cultivation in Cyperus (U. S. A.) and Europe since 16th century. Ng (1979) has studied the distribution pattern of this taxon in the World. He observed that the geographical range is broken in three parts viz. East Asia (North Vietnam, China, Korea, Japan), Central Asia (Soviet Central Asia, Afghanistan, North Pakistan, N. W. India) and Western Asia (between Black Sea and Caspian Sea). Morphologically, the three widely separated populations are uniform. One widely accepted theory of distribution believes that the species has originated in China and from there distributed to other parts of the World by man. But, occurrence of fossil remains in ancient deposits in Central Asia, present occurrence in remote mountain areas and its association with relicts of the Tertiary flora such as walnut, fox grape, eastern plane-tree and fig in Central Asia supports the view that species first originated in Central Asia and subsequently ancestral transeurasian range broken by orogenic and climatic changes resulting in present distribution pattern (**Map-7**).

Pollen : Pollen grains 3-colporate and rarely 4-colporate, prolate. Colpi long, thin, running from pole to pole, with psilate membrane. Ora not distinct. Exine about 2 µm thick. Sexine thinner than nexine. Sexine pattern obscure to granulate (Sharma & Gupta, 1979).

Anatomy : The testa of the seeds is 7-9 cells thick; the outer epidermal layer is made up of variously tangentially elongated cells with subgrose facets (Corner, 1976).

The wood is diffuse porous. The black heartwood is small. The growth rings are demarcated by dark-coloured latewood fibres. Vessels moderately large or small, evenly distributed, solitary and in radial multiples of 2-3; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates. Rays fine, closely spaced and evenly distributed. Ripple marks present (Wright, 1904; Purkayastha, 1982).

Phytochemistry : The roots of this species yield four naphthoquinones viz. 7-methyljugulone, a quinone-mamegakinone (8, 8'- dihydroxy – 6, 6'- dimethylbinaphthoquinonyl 2, 2'), isodiospyrin and another quinone which is assumed to be 7-methyljugulone a tetrameric quinone named basisodiospyrin (Yoshihira *et al.*, 1970, 1971). Besides above, the roots also contain some amount of diospyrin,

neodiospyrin, tetralon derivatives, shinanolone and isoshinanolone (Asolkar *et al.*, 1992; Tezuka *et al.*, 1973). The fruits contain tannic acid, invert sugar and malic acid. Taraxerol, betulinic acid and β-sitosterol have also been isolated from the leaves (Rastogi & Mehrotra, 1993b). The leaves also contain hentriacontanol and oxy-allobetulin. Bark is reported to have triterpenoids (Asolkar *et al.*, 1992). The seeds contain 9.3 % protein and 2.6 % oil (Barclay & Earle, 1974).

Uses: The ripe fruits are eaten fresh or dried, with rice. They are sometimes used in the preparation of sherbets by the local people. The poor rural families collect the fruits and sell them in the market. In Kurram valley, it is being cultivated since long back for its edible fruits which are considered next to walnut (Aitchison, 1880). In France, the fruits are said to be consumed when half rotten. The fruits are antifebrile and are used to promote the secretions. The seeds are regarded as sedative. The plants also show antiviral activity (Asolkar *et al.*, 1992).

Notes : Contrary to the description given in the present work, Hiern (1873) described male calyx-lobes acute, filaments glabrous and almost so the anthers. These characters were not observed in the Indian material.

Exsicc.: HIMACHAL PRADESH : Chamba, 1050 m, 28th April 1968, *Singh & Party* 1812 ♀ (CDRI); Sao Valley, 1200 m, 29th May 1896, *J. H. Lace* 1400 ♀ (DD); JAMMU & KASHMIR : Bhadarwah, Manthala nala, 19th May 1986, *B. P. Uniyal* 80159 ♂ (BSD); Doda Berth, Aug. 1986, *J. N. Vohra & Naithani* 82719 ♀ (BSD); Muzaffarabad, 900 m, 15th May 1987, *Hukam Singh* 1655 ♀ (DD); Batoti, 1650 m, 25th May 1958, *H. D. Thaplayal & M. B. Raizada* 26264 ♀ (DD); Kurram Valley, 23rd June 1894, *Harsukh* 15399 ♀ (DD); Jonga Valley, 1800 m, 17th July 1906, *Keshvanand* 264 ♀ (DD); Nuri Kangan, 2100 m, 9th July 1899, *Inayat s.n.* ♀ (DD); Kangan Valley, 16th May 1896, *Inayat* 19933 ♀ (DD); MAHARASHTRA : Poona, 23rd April 1961, *Without Collector* 72158 (RHMD); PAKISTAN : Hazara, Jaborai-Soran Range, 1350 m, 5th June 1899, *Inayat* 102 ♀ (DD); Chitral, Bundai, 10th May 1895, *Surg. Lt. Harriss* 16357 ♀ (DD).

36. ***Diospyros marmorata*** Parker in Ind. For. 57 : 210. 1931.

English names : Andaman Marble wood, Persimmon.

Vernacular names : *And.:* Pechada; *Hindi* : Kala-takri, Kala-lakri; *Tam.:* Vellaikkarungali.

Trees, with glabrescent branches. Leaves alternate, 7-11 x 2.5-6 cm, ovate or elliptic, entire, acuminate, rounded at base, coriaceous, glabrous, not pellucid-punctate; midrib depressed above; lateral nerves *ca* 9 pairs, inconspicuous above, prominent beneath; petioles *ca* 5 mm long, depressed or canaliculate above. Male flowers in 3 to 4-flowered, hairy, axillary, short cymes, 3-merous; pedicels 4-5 mm long, pubescent. Calyx 5-6 mm long, tubular, 3-lobed, hairy outside; lobes valvate. Corolla 1.2-1.5 cm long, tubular, pubescent outside; lobes 3, elliptic, *ca* 7 x 3 mm, contorted towards right. Stamens 12, 3 inserted near the base, 3 at middle of corolla and rest in between; anthers *ca* 2 mm long, apiculate due to produced connectives, sparsely hairy. Pistillode rudimentary or absent. Female

flowers not seen. Fruits *ca* 3 cm in diam., 6-locular and 1-ovulate in each locule when young, glabrous, globose, 3-seeded on maturity. Fruiting-calyx flat, disciform, fruit seated on the disc; lobes spreading horizontally. Albumen ruminate (**Fig.-35**).

Lectotype : India, Andaman Islands, *Parkinson* 593 ♂ (DD-designated here).

Fl. & Fr.: April – October.

Ecol.: Frequent in deciduous and semi-deciduous to wet evergreen forests, upto 200 m. Sharma (1977) has studied the germination behaviour of the seeds and concluded that the seeds remain viable upto 20 days. They start germinating after 29 days and germination continues to a maximum period of 76 days from the date of sowing. The germination percentage of seeds varies from 36 to 80 per cent. This species may also be raised successfully artificially in the nurseries by collecting fruits and storing them preferably for a period of 14 days and then sowing the seeds after extracting them from the fruits the same day, without any pre-treatment.

Distrib.: Endemic to India, confined to Andaman & Nicobar Islands (**Map-7**).

Pollen : Pollen grains 3-colporate, sub-prolate (34.7 x 26.2 µm), range 32.5-37.5 x 25-30 µm. Amb sub-triangular. Colpi long, thin, running from pole to pole. Maximum width of colpus about 3 µm, membrane psilate. Ora la-longate (2.5 x 8 µm), membrane psilate. Exine about 2 µm thick. Sexine thinner than nexine. Sexine pattern obscure (Sharma & Gupta, 1979).

Anatomy : The wood is diffuse porous, light yellowish grey, with a small heartwood variegated with black and grey alternating streaks or black spotted. Growth rings indistinct. Vessels small, evenly distributed, in radial multiples of 2-6, usually filled with brownish black deposits in the heartwood; vessel lines indistinct. Vessel cells medium thick-walled, truncate or attenuate at the ends. Perforation simple, horizontal to oblique. Inter vessel pits numerous, minute, orbicular to oval or polygonal, with broad border and short lenticular orifice. Tyloses lacking. Parenchyma 3 to many-rowed paratracheal and 3 to 5-rowed metatracheal, in cambiform rows along the grain. The paratracheal parenchyma is sparse, restricted to a few cells which are mostly contiguous to the tangential walls of the vessels, flattened to conform to the vessel walls. The metatracheal parenchyma is abundant, partly diffused through fibrous tract and for the most part in concentric, fine, close, 1 to 2-seriate, more or less undulate lines separated by 2-15 fibres which extend across the rays and form a fine reticulum. Parenchyma cells angular, filled with brownish-black or black gummy infilteration in lighter zones of the wood. Fibres are semi-libriform to libriform, fine, occasionally contiguous to the vessels, angled and smaller to the parenchyma, aligned in radial rows in concentric, undulate, 2 to 5-seriate bands which alternate with the narrow lines of zonate parenchyma. Those located towards the outer margin of the ring, somewhat thick-walled, non-gelatinous, non septate. Inter-fibre pits numerous, abundant on the radial walls, bordered, with small court and slit-like vertical orifice. Fibre-lumina in lighter zones of wood, empty; however, in darker zones filled with brownish black or black gummy infilteration. Rays fine, closely spaced and uniformly distributed. They are frequently contiguous to the vessels. The pits leading to contiguous vessel numerous

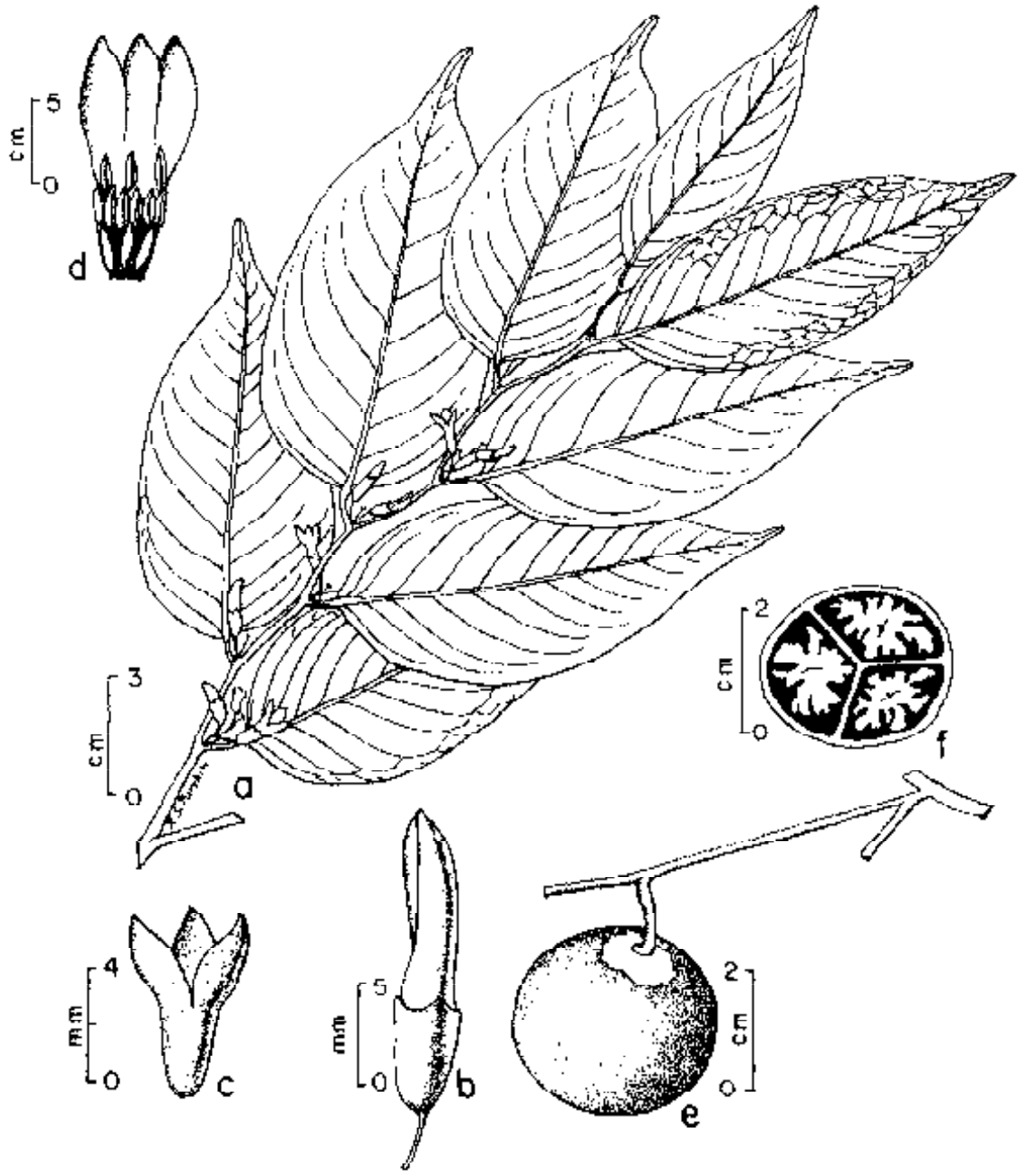
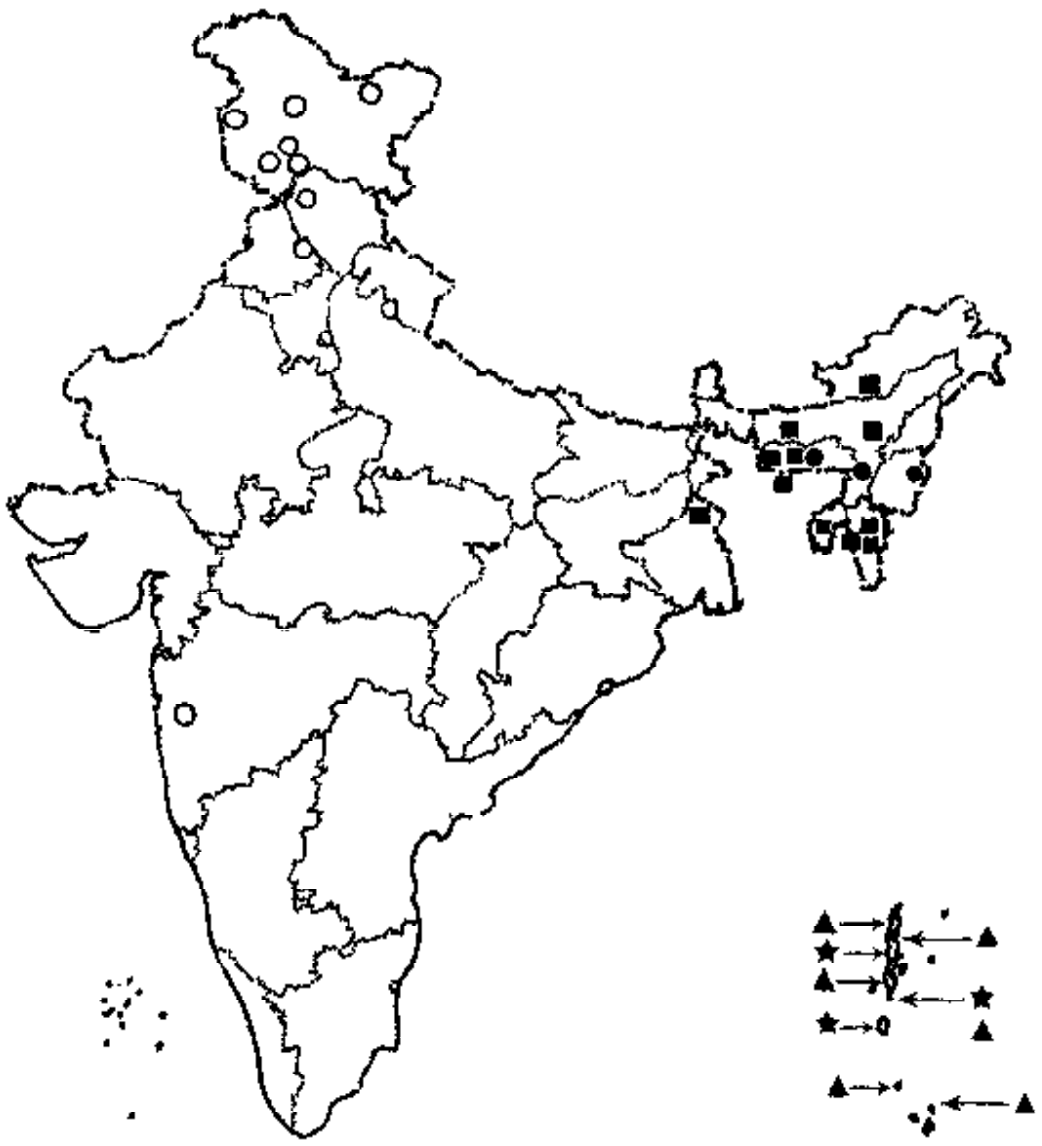


Fig.-35. ***Diospyros marmorata*** Parker

Male : a. habit, b. flower-bud, c. calyx, d. corolla within with stamens.

Female : e. fruit with calyx, f. T. S. of fruit.



Distrib. Sketch Map – 7

● *Diospyros kika* Debbarman & Biswas;

▲ *Diospyros kurzii* Hiern; ■ *Diospyros lanceaefolia* Roxb.; ○ *Diospyros lotus* L.; ★ *Diospyros marmorata* Parker

to each ray cell, orbicular to oval or polygonal, with broad semi-border and short lenticular orifice. Gummy infilteration is abundant in both lighter zones and darker zones of the wood. Crystal large, solitary, numerous, embedded in gum in darker zones of the wood. Starch deposits lacking (Wright, 1904; Purkayastha, 1982; Pearson & Brown, 1981).

Uses : The timber light grey to greyish brown, smooth, difficult to season and quite durable. It takes good polish and is used for ornamental purposes, especially for cabinet work, carving, turnery, inlay, picture frames and card boxes. It also find use in making brush backs, bent walking sticks and razor cases, particularly in United Kingdom.

Notes: The species shows great affinity with *D. oocarpa* Thw., but may be distinguished by the stamens being inserted at three different levels in the corolla-tube and not all at the base or hypogynous as found in *D. oocarpa* Thw. The shape of fruit and seeds with ruminate endosperm also differ from that of *D. oocarpa* Thw.

Exsicc.: ANDAMAN & NICOBAR : Andamans, Porlob Island, Feb.-March 1934, *Kirat Ram* 3696 ♀ (DD); Ins. Andaman, *Forest Officer* Acc. No. 57134 ♀ (DD); *Parkinson* 740 ♂ (Lectosyntype), Acc. No. 46497-46499, 50622 (DD); South Andamans, Baratang Island, Kenchi road, 25 m, 15th July 1977 *N. Bhargava* 5903 ♀ (PBL).

37. ***Diospyros martabanica*** Clarke var. ***pellucido-punctata*** (Hiern) Clarke in Hook. f. Fl. Brit. India 3 : 554. 1882. *D. vaccinioides* Lindl. var. *pellucido-punctata* Hiern in Trans. Cambr. Philos. Soc. 12 : 231 1873.

Trees, upto 10 m high, with persistently villous or hirsute branchlets, old branches becoming glabrate to glabrous on maturity. Leaves alternate, 1.6-5 x 0.8-2 cm, narrowly oblong, acuminate, obtuse or rounded at base, glabrous above, villous beneath with fulvous, upto 5 mm long hairs, on maturity becoming pilose beneath, pellucid-punctate, thinly coriaceous; midrib canaliculate and hairy above, raised and hairy beneath; lateral nerves oblique; petioles 3-4 mm long, hairy. Male flowers in lax, depauperated subracemose, fulvous-hairy cymes, 4-merous; pedicels 1-2 cm long. Bracts ca 5 mm long, ovate, deciduous. Calyx-lobes 4, narrowly lanceolate, 4-5 mm long, pubescent bothsides, valvate. Corolla tubular; tube 7-9 mm long, slender, fulvous-villous outside; lobes 4, about as long as calyx-lobes, narrowly oblong or lanceolate, villous outside along the middle line, contorted. Stamens 12-14, rarely 16 (Hiern, 1873), in pairs, inserted at the base of corolla-tube, glabrous; anthers small, oblong, dehiscing along apico-lateral pores, glabrous, connective hardly produced. Pistillode hairy, rudimentary. Female flowers subsessile, solitary, axillary. Calyx and corolla as in males. Staminodes 4-8, glabrous, in one row, inserted at the base of corolla-tube. Ovary 8-celled, sparsely hairy, cells 1-ovuled. Fruits globose or ellipsoid, scattered hairy. Albumen ruminate.

Holotype : India : South Andaman, *Kurz s.n.* (K).

Fl. & Fr.: April – August.

Ecol.: Rare, in wet evergreen forests of South Andaman.

Distrib.: This species is endemic to India, confined to Andaman and Nicobar Islands (**Map-8**).

Notes : The species has been included on the authority of Dagar & Singh (1999). Hiern (1873) has also reported this taxon from South Andaman based on Kurz's collections, and subsequently by Clarke (1882). I could not examine any specimen and the description given here has been borrowed from the literature cited.

38. ***Diospyros melanoxylon*** Roxb. Pl. Cor. 1 : 36. t. 46. 1795, non Willd. 1805, nec Blume 1825, nec Hassk. 1844; A. DC. in DC. Prodr. 8 : 224. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 159. 1873, *pro parte*; Clarke in Hook. f. Fl. Brit. India 3 : 564. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 37. 1981. *D. rubiginosa* Roth, Nov. Pl. Sp. 385. 1821; A. DC. in DC. Prodr. 8 : 239. 1844. *D. montana* Heyne ex Roth, Nov. Pl. Sp. 385. 1821, non Roxb. 1795, nec Pancher & Sebert 1874. *D. exculpta* Beddome, Fl. Sylv. 1 : t. 66. 1871, non Buch.-Ham. 1827. *D. wightiana* Wall. ex A. DC. in DC. Prodr. 8 : 223. 1844. *D. roylii* Wall. ex A. DC. in DC. Prodr. 8 : 239. 1844 "*roylei*"; Clarke in Hook. f. Fl. Brit. India 3 : 572. 1882. *D. dubia* Wall. ex A. DC. in DC. Prodr. 8 : 223. 1844, non Goeppert 1854, nec Elm. ex Merr. 1923. *D. melanoxylon* Roxb. var. *beddomei* Clarke in Hook. f. Fl. Brit. India 3 : 564. 1882.

var. ***melanoxylon***

English name : Ebony, Coromandal Ebony.

Vernacular names : *Beng.*: Kendh, Kiu; *Guj.*: Tembru, Tamrug; *Hindi*: Abnus, Kendu, Tendu, Timburni, Temru, Tindu, Timbarvo, Tamruj, Tumri; *Kan.*: Balai, Thumbri, Tupra, Kendu, Makartendu, Toomrie, Temru; *Mal.*: Kari; *Mar.*: Tendu, Toomrie, Temru, Timburni; *Or.*: Kendu; *Sans.*: Dirghapatraka, Tumvuru, Patriko, Kenduka, Kakatinduka, Jaraja; *Tam.*: Karunthumbi, Karumthumbi, Karunthovarai, Tumi, Tunki, Tumballi, Tumbi, Thumbai; *Tel.*: Abnus, Taindu, Tamburni, Damadi, Gike, Tellagada, Thuniki, Kendu-gochh, Tuki, Tumbi, Tumi, Tunki, Tumiki, Timmurri, Tumballi, Tumida, Karuppu, Karundumki, Thumramaran, Oovamaran, Nallatumki; *Urdu*: Abnus.

Medium-sized, dioecious, deciduous trees, 2-10 m high, rarely upto 20 m, with ferruginous tomentose young branchlets and pelican-coloured, deeply fissured bark. Leaves highly variable, opposite, subopposite or alternate, 3-17.5 x 1.8-11 cm, oblong, elliptic, oblong-obovate, oval, ovato-oblong or oblong-suborbicular, sometimes of different shapes on same tree, thick, coriaceous, pubescent on both surfaces but more densely so beneath, leading towards glabrate nature on maturity especially in female plants, cuneate or rounded at the base, obtuse or retuse to emarginate at apex, sometimes narrowed at apex in elliptic-lanceolate leaves and subacute; midrib not canaliculate above or subcanaliculate and densely filled with hairs and appear flat, slightly raised beneath; lateral nerves 7-12 pairs, not very conspicuous, secondary nerves and venation raised on the upper surface or obscure; petioles 5-15 mm long, terete or flat above and rounded beneath, densely pubescent, not canaliculate. Male flowers 1 1.5

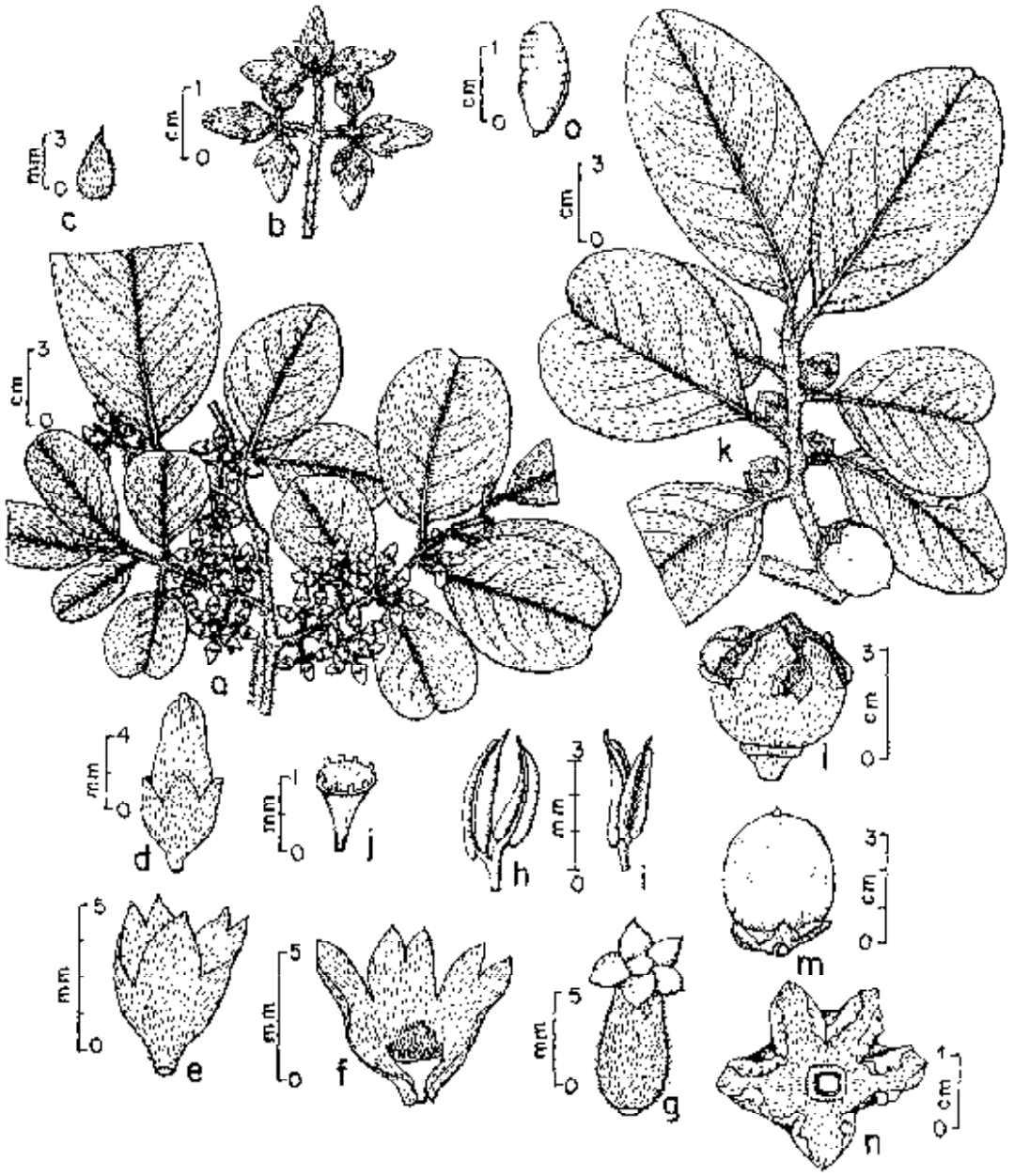


Fig.-36. ***Diospyros melanoxylon*** Roxb. var. ***melanoxylon***

Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. calyx, f. calyx within with pistillode, g. corolla, h-i. stamens, j. pistillode.

Female : k. habit, l. young fruit enclosed within calyx, m. mature fruit with calyx, n. fruiting-calyx (dorsal view), o. seed.

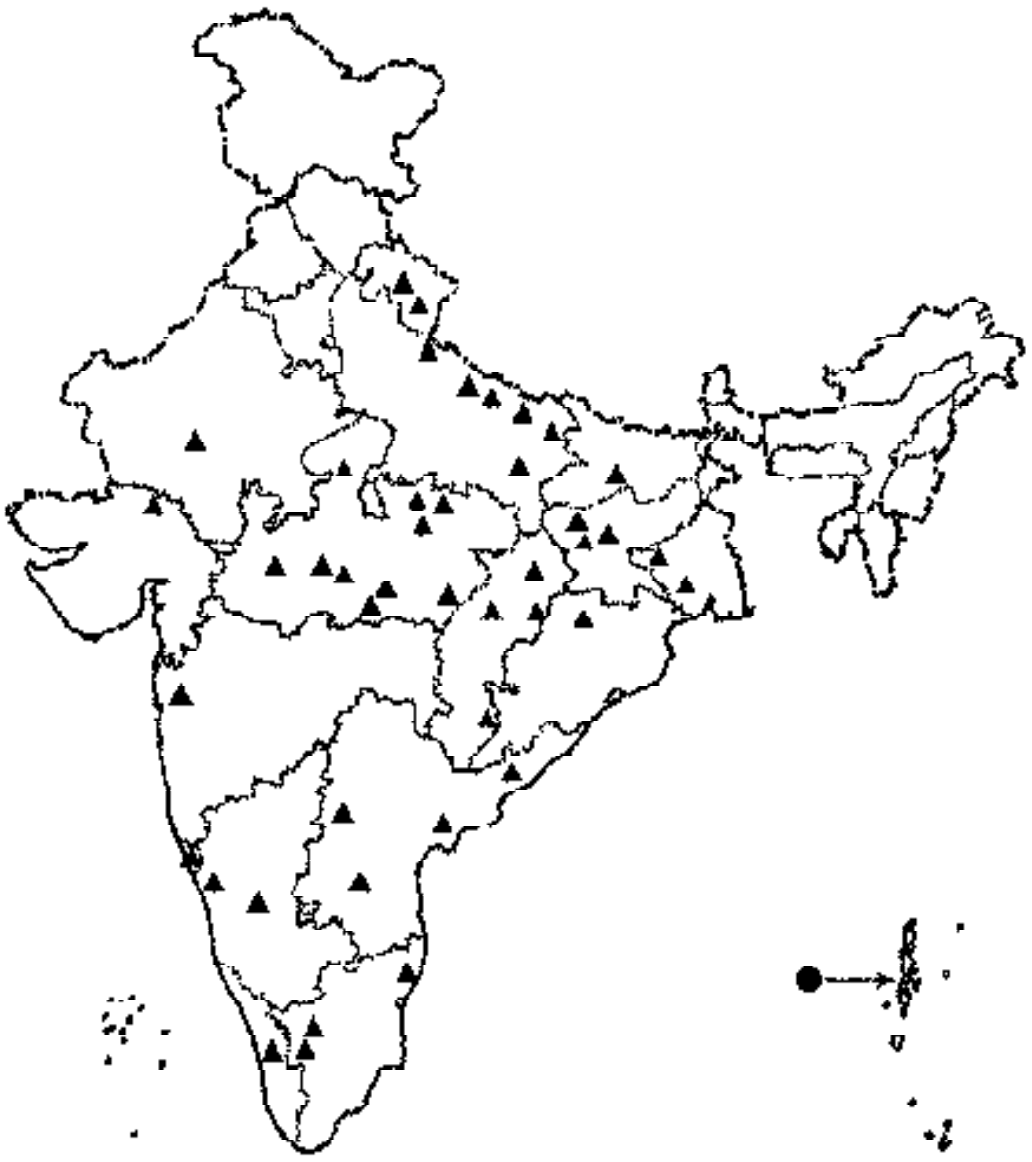
cm long, in axillary or extra-axillary, tomentose, bracteate, dichasial cymes on young tomentose branchlets; main peduncles upto 1.5 cm long, secondary ones upto 5 mm long, densely pubescent, articulated with the flowers. Bracts *ca* 4 x 2 mm, ovate-lanceolate, acuminate, hairy bothsides, caducous, inserted at the apex and base of secondary peduncles. Flower-buds ovoid, 7-9 mm long or smaller, densely tomentose. Calyx campanulate, 5-7 mm long, densely tomentose bothsides, much narrowed at base like a stalk, divided half way down or some lobes divided one-fourth or less; lobes usually 5, rarely 4-6 (Hiern, 1873), ovate, acute, valvate. Corolla tubular, 9-12 mm long or sometimes more, densely hairy outside, glabrous within; lobes usually 5, rarely 4-6 (Hiern, 1873), almost suborbicular, apiculate, contorted. Stamens usually 16, sometimes lesser upto 8 or 12 (Hiern, 1873), hypogynous, seated on the torus, subequal, in pairs; filaments upto 1.5 mm long, united upto top, glabrous; anthers 2-2.5 mm long, linear, shortly apiculate at apex due to produced connectives, glabrous or hairy on the dorsal face on the connectives. Pistillode densely hairy with long hairs or rarely glabrous in some specimens. Female flowers 1-2 cm long, subsessile, axillary, solitary, short-pedicelled; pedicels densely hairy. Calyx broadly campanulate, larger than males, tomentose bothsides, usually deeply 5-lobed, rarely 4-lobed (Hiern, 1873); lobes ovate, acute, margins reflexed and projected outside giving winged shape to the calyx, valvate. Corolla tubular, hairy outside, glabrous within, usually 5-lobed; lobes almost suborbicular, contorted. Staminodes 8-10. Ovary globose, usually 4-celled, rarely 8-celled (Hiern, 1873), densely hairy, cells 1-ovuled; styles bifid, somewhat hairy; stigmas 4. Fruits globose-ovoid, 2.5-3.5 x 2-3 cm, usually 4-seeded, rarely 2 to 8-seeded (Roxb., 1795; Hiern, 1873), apiculate, hairy when young, becoming glabrous with age, yellowish on maturity and becoming light brown on drying, smooth, shining, pulp sweet. Fruiting-calyx 2-2.5 cm in diam., thick, flat, disciform, fruit seated on the disc, no tube at base, deeply lobed, tomentose bothsides; lobes flattened, thick, not veined, horizontally spreading, not enclosing the fruit, rigid, reflexed along the margins forming deep sinus in between, margins undulating, not dilated. Seeds 1.5-2 x 0.6-0.8 cm, oval-wedge-shaped, subcompressed or convex on both faces, smooth, shining, light brown; albumen ruminated (**Fig.-36; Plate 13/4 & 14/1**).

Holotype : Roxb. Pl. Cor. t. 46 (K).

Chr. No.: 2n=30 (Bir *et al.*, 1979); n=15 (Gill *et al.*, 1990).

Fl. & Fr.: March – November. Rathore (1970) has studied the phenology of this species in greater details and recorded that flowering and foliation periods start simultaneously between 15th March and 15th May, pollination is completed and the fruits start ripening between mid of May to mid July, upto mid November new leaves and fruits get mature.

Ecol : Found scattered in the forests, chiefly in dry mixed deciduous ones, upto 1000 m. The plants thrive well in black cotton soils and on dry rocky hills. The germination of seeds is epigeal and cotyledons get detached at an early stage. The fresh seeds usually germinate after the on set of monsoon rains. The fresh seeds cleaned from the pulp of fruit show better germination (Athaya, 1985). Dormancy may, however, extend germination for one year. Studies carried out by Ghosh *et al.* (1976) on the planting techniques revealed that naked planting of seedlings is more encouraging as compared to direct



Distrib. Sketch Map 8

● *Diospyros martabanica* Clarke var. *pellucido-punctata* (Hiern) Clarke;

▲ *Diospyros melanoxylon* Roxb. var. *melanoxylon*

dibbling of seeds and planting of 3-12 month old seedlings give better results. Seedlings are frost and drought hardy, but susceptible to water logging and dampness. They can withstand moderate shade but for better development more light is needed. The trees coppice well and produce root suckers in large numbers (Rathore, 1972). Studies carried out earlier by Rathore (1971) on the root system and regeneration through root-suckers have revealed that for sprouting the detached suckers deep soil fixation is necessary and this unique pattern of regeneration explains increased incidence in proportion to biotic disturbances and increased drought and wind resistance plants. Awasthi (1986, 1990) observed a thick network of root suckers in three to four tiers binding nearly 60 cm soil layer and reaching a horizontal distance of 30-40 meters. The trees become leafless for a short period in hot season. Pruning operations at proper time may enhance the leaves production (Dhar *et al.*, 1989). Further, the studies carried out by Udgate (1997) provide indications that the fertilizers like Calcium Ammonium Nitrate, Single Super Phosphate and Muriate of Potash when applied mixed in equal quantity (20 kg each) during monsoon period, may increase the quality and quantity of leaves. The species is of importance for afforestation purposes. It is interesting to record that in Indian forests 70-80 per cent populations are of the male plants. In Brihat Samhita, the plant is recognized to decide water-level in the soil and to break exceptionally hard rocks. Prasad & Mishra (1984) have studied the root-system in this species and reported that total root length is very poor in this species because of poor branching of primary lateral roots. The lateral roots, however, form extensive horizontal system which reduces the chances of uprooting by wind. Athaya *et al.* (1982) have also studied root-systems in seed-generated and sucker-generated male and female trees. The root-system of mature seed generated plants was found much compact and symmetrical because of well developed vertical (4-8 m deep) and horizontal roots forming compact interveined network of suckers, giving mechanical support to plants. The sucker-generated plants have much developed horizontal network than the vertical. Further, they observed that in male plants suckers do not form compact interwoven network and dieing-back phenomenon in male seedlings is more frequent. In female plants the condition was found just reverse.

Borer insects *Placaederus ferruginous, Stromatium barbatum* and *Xyleborus noxius* and leaf defoliators *Hypocala rostrata* and *Lamida carbonifera* are found on this species during post monsoon season. Kumar *et al.* (1989) have found two organophosphorus insecticides namely Nuvan and Monocrotophos effective to control the larvae of *Hypocala rostrata*. Mani (1973) has reported yellowish-red, sometimes agglomerate pouch galls on the leaves produced by *Trioza obsolete* in this species. This species is also liable to attack by fungi *Daedalea flavida, Lenzites palisati* and *Stercum lobatum* which cause white rot in the fallen timber. Recently, Bhandari & Upadhyay (1986) have recorded root and stem borer *Cossus cadambae* damaging young plants of *Diospyros melanoxylon* Roxb. in Madhya Pradesh and Maharashtra. Modi *et al.* (1992) have reported changes in morphology, anatomy and chemistry in the plants exposed to auto-emissions. Lal & Ambasht (1981, 1982) observed that leaves may accumulate fluoride when plants are exposed to flouride-emission and the concentration of fluoride in leaves is more in the plants growing near emission point. The fluoride concentration in the foliage also has direct relation with the age of the leaves. Chlorosis and necrosis are the main symptoms of fluoride effect and result in the reduction of

individual leaf biomass and size. Williams *et al.* (1996) have also studied the impact of pollutants produced by thermal power plants viz. sulphur dioxide, nitrogen oxides etc on this species and recorded marginal necrosis, marginal chlorosis and interveinal chlorosis in the leaves. Roy *et al.* (1983) reported that the fungus *Curvularia lunata* infest the leaves of this species. However, Mishra *et al.* (1986) have reported about seven species of *Aspergillus* viz. *A. niger, A. candidus, A. repens, A. flavus, A. clavatus, A. amostelodami* and *A. fumigatus* which constitute dominate fungal flora on the leaves, particularly in processed leaves for Bidi. Besides these, several species of *Penicilium* (*P. purpurogenum, P. chermesinum, P. chrysogenum, P. oxalicum, P. implication, P. rugulosum, P. hanthocitrinum* and *P. minio-luteum*), *Geliocladium catenulatum, Cladosporium herbarum, C. cladosporoides, Curvularia pallescens,* species of *Fusarium* (*F. oxysporium, F. udum*) and *Rhizopus* species also infest the leaves during processing the leaves for Bidi --making and degrade the quality.

Distrib.: This species finds distribution in major part of the country except north, north-east and eastern zones. The main States of its concentration are Uttar Pradesh, Uttranchal, W. Bengal, Bihar, Jharkhand, Orissa, Chhattisgarh, Madhya Pradesh, Rajasthan, Gujarat, Maharashtra, Goa, Andhra Pradesh, Karnataka, Kerala and Tamil Nadu. Further southwards, this taxon extends to Sri Lanka **(Map-8)**.

Rathore (1969) has studied the distribution pattern of male and female plants in Madhya Pradesh and reported that male plants are about 3 times more frequent than female plants. It is because of drastic changes in the microclimatic pattern which favour the male plants more in comparison to female plants, thereby leading to much imbalance in over all sex ratio.

Pollen: Ectocolpium tenuimarginate. Exine very thin, *ca* 1 µm; surface faintly reticulate. Size 30-44 x 22-32 µm (Nair & Kothari, 1985). Sharma & Gupta (1979) have recorded the pollen grains 3-colporate, sub-prolate (43.7 x 34.9 µm), rarely prolate-spheroidal (42.5 x 37.5 µm). Angulo-aperturate. Amb sub-circular. Colpi long, thin, running from pole to pole. Maximum width of colpus about 1.5 µm. Colpi membrane ornamented. Apocolpium diameter not distinct, mesocolpium distance about 16.6 µm. Ora la-longate (2.5 x 10 µm), with psilate membrane. Exine about 2 µm thick but thicker at the equatore (3 µm). Sexine slightly thinner than nexine. Sexine pattern obscure.

Anatomy : There are three vascular traces in each cotyledon. The epicotyledonary traces are prominent and distinguishable in the resting embryo (Wright, 1904).

The heartwood is black or streaked. The contents of the paranchymatous cells and tracheal elements are conspicuous. The sapwood is red and coloured contents are almost limited to the medullary ray cells. But, in the black heartwood every element is filled with reddish brown material. The differentiation of the elements is comparatively regular. The fibre cells are high. Insignificant growth rings are sometimes continuous throughout or occur only on one side. The vessel cells are medium thick-walled, truncate or attenuated at the ends. Perforations are simple, horizontal to oblique. Inter-vessel pits numerous, minute, orbicular to oval or polygonal, with broad border and rounded, punctate orifice. Tyloses occasional,

solitary or several clustered and thick-walled. Orange-brown gummy deposits abundant in the vessels of sapwood generally in a parietal layer. The vessels of heartwood, however, contain brownish-black or black gum. The size of vessels of twigs is 0.36 mm long, having 0.13 mm radial and 0.09 mm tangential diameter. The parenchyma is 5 or more-rowed paratracheal and 3 to 5-rowed metatracheal, in cambiform rows along the grain. The paratracheal parenchyma is sparse, restricted to a few cells which are mostly contiguous to the tangential walls of the vessels, flattened to conform to the vessel walls. The metatracheal parenchyma is rather abundant, partly diffused through fibrous tract and for the most part in concentric, fine, close, 1 to 2-seriate, more or less undulate lines separated by 2-12 fibres which extend across the narrow rays and form a fine reticulum. The cells of metatracheal parenchyma are angular and frequently flattened in the tangential plane. The orange-brown gummy substance is occasional in the parenchyma of sapwood. The heartwood, however, contains copious brownish-black or black gummy deposits. Crystals lacking and starch deposits are also occasional in sapwood. The size of wood parenchyma cells in sapwood varies from 0.07 to 0.13 mm, with radial diameter 0.017 mm. Fibres are libriform, fine, occasionally contiguous to the vessels, angled and smaller to the parenchyma cells, aligned in radial rows in concentric, undulate, 2 to 12-seriate bands which alternate with the narrow lines of zonate parenchyma. The fibre cells are somewhat thick-walled towards the outer margin of the ring, non-gelatinous, non-septate. Inter-fibre pits numerous, abundant on the radial walls, bordered, with small court and slit-like vertical orifice. Lumina of fibres in heartwood contains brownish black or black gum. The radial diameter of wood fibres in sapwood is 0.011 mm and in heartwood 0.010 mm. The medullary rays are very fine, separated by 1 to 6 fibres, frequently contiguous to the vessels. Pits leading to contiguous vessels are numerous to each ray cell, small, orbicular to oval or polygonal, with broad semi-border and rounded, punctate orifice. Orange-brown gummy deposits abundant in sapwood and heartwood rays contain brownish-black gum. Crystals are common in both woods, solitary, embedded in gummy substance. Starch deposits are rare, found in sapwood only. The radial diameter of vertical medullary ray cells is 0.02 mm and tangential 0.02 mm, with 0.056 mm vertical length. The radial diameter of horizontal components is 0.05 mm and tangential 0.01 mm, with 0.027 mm vertical length (Wright, 1904; Pearson & Brown, 1981; Purkayastha, 1982). Nair & Mohan Ram (1989) reported absence of vestured pits and vestured vessel member wall in this species.

Phytochemistry : The leaves contain crude protein, crude fibre, N-free extract, ether extract, calcium and phosphorus (Sen & Ray, 1971). Mallavadhani *et al.* (2001) reported the leaves to be a good source of pentacyclic triterpenes. Rathore (1972) has analysed different parts of this plant and recorded that root-suckers and bark outpass other organs in locking up minerals. The root-suckers have nitrogen (1.36 %), phosphate (0.0375 %), potassium (0.132 %) and calcium (1.62 %). The bark, on the other hand, accumulates nitrogen (1.36 %), phosphate (0.0625 %), potassium (0.112 %) and calcium (1.6 %). The fruits and seeds have nitrogen 1.43 % and 1.36 %, phosphate 0.0125 % and 0.425 %, potassium 0.146 % and 0.132 % and calcium 1.32 % and 1.35 % respectively. Bark and leaves are rather rich in phosphate content (0.0425-0.0625 %). The highest percentage of calcium (1.65 %) was recorded in the leaves and of the potassium in branches (0.155 %).

Ceryl alcohol, lupeol, betulin, β-sitosterol, sequoyitol and a new triterpene carboxylic acid-diospyric acid, mp. 272° have been isolated from the bark and leaves. Sundararamaiah & Row (1963) have reported high percentage of lupeol and betulin in the bark. 2-methyl-5-methoxy-1, 4-naphthoquinone, 3-methyl-8-methoxy-1, 2-naphthoquinone, 2-methyl-3-hydroxy-5-methoxynaphthoquinone and 2-methyl-5, 6-dimethoxy-1, 4-naphthoquinone have been isolated from the heartwood. A new naphthoquinone-diomelquinone- A has also been found in the heartwood. The bark and sapwood yield 7-methyljugulone and some other naphthoquinones. Lupeol, betulin, diospyric acid, mixture of betulinic, oleanolic and ursolic acids and bauerenol, mp. 212° have been isolated from the leaves (Row *et al.*, 1969; Rastogi & Mehrotra, 1993a). During recent years, hentriacontane, hentriacontanol and α-amyrin from leaves and a new binaphthoquinone characterized as 3, 3′-dimer of 6-hydroxy-5-methoxy-2-methylnaphthoquinone from heartwood have also been isolated (Rastogi & Mehrotra, 1993b). The seed-oil yields capric acid, lauric acid, myristic acid, palmitic acid, strearic acid, arachidic acid, behenic acid, oleic acid and linoleic acid (Daulatabad & Ankalagi, 1982). A new pentacyclic quinone (I) ($C_{73}H_{16}O_6$ – characterized as 4, 11-dihydroxy-5-methoxy-2, 9-dimethyl-dinaphtho (1, 2-b : 2′ 3′-d) furan 7, 12-quinon) has been isolated from the heartwood along with diosindigo A ($C_{24}H_{20}O_6$) and B ($C_{24}H_{20}O_6$) and biramentaceone (Sankaram *et al.* 1981). Asolkar *et al.* (1992) have also reported bauerenol, ursolic acid and oleanolic acid from the leaves. The phytochemical survey carried out by Daniel *et al.* (1980) also revealed presence of saponins and tannins in the stem, leaves and flowers. No alkaloid could be isolated from these organs. Billore *et al.* (1976) have studied the changing pattern of chlorophyll and carotenoid in summer leaves. They recorded that chlorophyll a is degenerated more rapidly than chlorophyll b and carotenoids disappear more slowly than the total chlorophyll. Recently, a phenolic compound cresol has been isolated from the seed coat which has been found responsible for inhibition of germination of seeds.

Uses: Leaves are used as wrappers in Bidi making which fetches large revenue to several States, particularly Orissa, Madhya Pradesh and Andhra Pradesh. Madhya Pradesh alone is producing about 60 per cent of the total tendu leaves produced in the country and annually earns a net receipt of Rs. 1500-2000 millions, providing employment to over two million people in the State (Hunter, 1981; Desarkar, 1963; Lal & Dave, 1991). This species is also the main source of Indian ebony and Watt (1890) called it Coromandel wood. It is probably the first ebony of Asia brought to Europe. The timber from old trees is more valuable and used for furniture, cabinet, rafters, shafts and poles of carts. It is also used for picking arms, billiard cues, plumber's tools and agricultural implements. The wood is most suitable for shuttles, buildings, shoulder poles, axles, yokes, wheel spokes, rice-pestles, walking – sticks, scale-beam, combs, toys, snuff-boxes, carving and other fancy works. Bark is used in tanning (Rao, 1914). The plants provide good fuel wood and considered as one of the best woods for charcoal. In Tamil Nadu, the wood is used for black wood butts etc and in Uttar Pradesh for brush backs, inlay work, tool handles, railway work, carpenter's mallets and bodies of planes. The wood is slightly susceptible to diseases and insects.

The ripe fruits are astringent and not very palatable. Yet, the tribals eat the mature fruits and also sell them in the market. Certain tribes near Hoshangabad (Maharashtra) are reported to bake and eat the fruits. They believe that nature has given them Mahuwa (*Madhuca indica* J. F. Gmelin) and Tendu (*D. melanoxylon* Roxb.) as a gift to survive in adverse conditions. In Uttar Pradesh, the leaves serve a good fodder for cattle and for it the plants are lopped every year (Laurie, 1945).

The seeds are prescribed as cure for mental disorders, palpitation of heart and nervous breakdown. In arid regions of India, the seed kernels are used for the treatment of dysentery (Maheshwari, 1995). The leaves are diuretic, carminative, good in epistaxis and night blindness. They improve the eyesight and are used in opthalmia, in trichiasis and as a remedy for burns, tuberculous glands, scabies and old wounds. Dried flowers are aphrodisiac and diuretic. They have also been found useful in leucorrhoea, urinary discharge, inflammation of the spleen, scabies, night blindness and in anaemia. The bark possesses astringent properties and is, therefore, powdered and mixed with pepper, and given for dysentery. In the form of decoction, it has been found useful in diarrhoea, rheumatism, liver disorders, dyspepsia and disease of debility (Sundararamaiah & Row, 1963). In a dilute form, the decoction is used as an astringent lotion for the eyes. It is also known to have antitubercular properties (Chopra *et al.*, 1958). The astringent property of bark is due to the presence of β-sitosterol, lupeol, betulin and betulinic acid (Maheshwari & Singh, 1965). Rathore (1972) reported that bark is burnt by the tribals of Madhya Pradesh and smeared to cure small pox. The stem-bark is crushed with the roots of *Holarrhena pubescens* (Buch.-Ham.) Wall. ex G. Don and mixture is given orally to cure malaria (Joshi, 1993). Gum (5 gm) of this species is mixed with the stem-bark (100 gm) of *Ailanthus excelsa* Roxb. and seeds (8 gm) of *Balanites aegyptiaca* (L.) Del. along with Jaggery (Gur) and tablets are formed, which are given twice in a day for one week to the patient of jaundice. Fat and curd are totally avoided during the treatment (Singh, 1993). In Charak Samhita (1000-800 B. C.), the plant is listed under astringents and in Sushruta Samhita (1000-600 B. C.), it is known for curing ulcers, disorders of uterus and vagina. The seed-oil shows antibacterial activity. *D. melanoxylon* Roxb. has been considered as a source of Ayurvedic drug Tinduka or Visatinduka (Pandey, 1988).

In Andhra Pradesh, the Konda and Reddis take orally the extract of bark mixed with Jaggery (*Saccharum officinerum* L.) to cure cough and cold twice a day till cure. The Koyas take two spoonful leaf-juice thrice a day for 5 days to cure diarrhoea. Valmikis apply the paste of immature fruits for bone fracture and use the wood ash as detergent (Rao & Henry, 1996). In Orissa, about 10 green fruits are boiled in about 1 liter water till it comes down to one-fourth. The decoction is orally prescribed in dysentery (Srivastava & Rout, 1994). The fixed oil obtained from the seeds exhibits antimicrobial properties against *Escheichia coli, Chigella negatore* and *Staphylococcus aureus* (Srivastava & Omray, 1979).

Notes : The specimens examined by me were dioecious. Athaya and Mishra (1979) have, however, reported monoecious trees for the first time from Naryaoli forest, Sagar district in Madhya Pradesh.

Interestingly, they recorded differences in fruit, pedicel, calyx and seed characters of dioecious and monoecious plants as under :

Dioecious plants : Pedicels *ca* 5 x 3 mm, short, thick and stout; calyx fleshy, green, *ca* 9 x 7 mm, grooved; fruit globose, *ca* 2.7 x 2.7 cm; seeds 4 or 5, 10-19 x 6-12 mm, average weight *ca* 910 mg per seed.

Monoecious plants : Pedicels *ca* 10 x 1 mm, long, narrow, filiform; calyx dry, scaly, thin, *ca* 9 x 3 mm; fruits oblong, *ca* 1.7 x 1.4 cm; seeds 2-4, *ca* 7-10 x 4-5 mm, average weight *ca* 156 mg per seed.

Exsicc.: ANDHRA PRADESH : Cuddapah, Kodur Red Sanders Plantation, 190 m, 25th July 1962, *J. L. Ellis* 14357 ♀ (CAL); Godavari, Rampa Country, Gokav, 500 m, 24th Sept. 1920, *V. Narayana Swami* 15 sterile (CAL); Kurnool West, *D. F. O.* Acc. No. 42601 ♀ (DD); BIHAR : Dadaburu, 28th Dec. 1960, *G. V. S. Rao* 22848 ♀ (ASSAM); CHHATTISGARH : Bilaspur, Kathgora, 17th April 1965, *G. Panigrahi & C. M. Arora* 8638 ♂ (BSA); 17th Dec. 1964, *C. M. Arora* 6100 ♀ (BSA); Keonchi, 500 m, 15th July 1973, *S. K. Murti* 19156 ♀ (BSA); Raigarh, Baramkila, Surangarh, 300 m, 29th March 1976, *N. C. Rathakrishnan* 24313 ♂ (BSA); Bastar, Bhopalpatnam, Indravati Tiger Reserve, 20th May 1987, *Anand Kumar* 16272 ♂ (CAL); Ambikapur, Pandaripat, 18th Nov. 1972, *G. Sen Gupta* 17200 ♀ (BSA); Sawari forest, 18th March 1975, *L. K. Banerjee* 22066 ♀ (BSA); Abujh-Marh, Badgaon, 25th May 1983, *G. P. Roy* 34047 ♀ (BSA, CAL); JHARKHAND : Palamau, Palamau village, Tol ghat, 11th Aug. 1956, *V. Chandra & Party* 35567 sterile (LWG); Chetag Pahar, 13th Aug. 1956, *V. Chandra & Party* 35833 sterile (LWG); Neterhat, 8th Nov. 1971, *S. R. Paul & Party* 96720 sterile (LWG); Parasnath hills, March 1954, *J. G. Srivastava* 21572 sterile (LWG); 7th Oct. 1956, *V. Chandra & Party* 34160 sterile (LWG); KARNATAKA : North Kanara, 8th May 1896, *W. A. Talbot* 3637 ♂ (BSI); Mandya, Melkote, 30th March 1978, *S. M. Ahamed* 498 ♂ (CAL); MADHYA PRADESH : Damoh, Balakot road, 10th Aug. 1978, *B. K. Shukla* 28689 ♀ (BSA); Mandla, Kisli, Kanha Tiger Reserve, 12th Sept. 1982, *J. Lal & A. Kumar* 33166 ♀ (BSA); Hoshangabad, Banglapore, 356 m, 23rd April 1961, *J. Joseph* 12408 ♂ (BSA); Indore, Balwadaghat, 20th April 1963, *A. R. K. Sastry* 87523 ♂ (BSI); Mahanpur, 15th Oct. 1980, *Ram Lal* 31307 ♀ (BSA); Balaghat, Balaghat forest, 390 m, 18th Sept. 1973, *V. J. Nair* 18077 ♀ (BSA); Satna, Sidhi, Mara P. S. S.-Lower Reservoir, 50 m, 3rd May 1995, *S. K. Srivastava & B. K. Shukla* 47901A ♀ (BSA); Panna, Mahandra, 15th Oct. 1980, *Ram Lal* 31307 ♀ (BSA); Pachmari hills, 17th Aug. 1969, *Hari Om Saxena* 83348 ♀ (LWG); Bhopal, Sagar road, 17th Dec. 1953, *K. N. Kaul* 5271 ♀ (LWG); Shivpuri, National Park, 15th July 192, *G. Panigrahi* 17013 (BSA); MAHARASHTRA : Thana, Ashokavan, 16th Jan. 1969, *K. C. Sahni* 6051 ♀ (DD); RAJASTHAN : Pali, Sewari R. F., 425 m, 13th Nov. 1974, *B. V. Shetty* 1459 ♀ (BSJO); TAMIL NADU : Nilgiri, Mettupalayam, Bhavani Sagar view, 850 m, 10th May 1971, *E. Vajravelu* 38349 ♂ (MH); Coimbatore, Palamai-Manguli, 860 m, 15th June 1971, *M. V. Vishwanathan* 998 ♂ (MH); Chingleput, Tirupporur R. F., 75 m, 3rd Oct. 1974, *A. N. Henry* 45576 ♀ (MH); UTTRANCHAL : Nainital, Jhirna, Corbett National Park, 28th Nov. 1970,

P. C. Pant 43449 ♀ (BSD); Ramnagar, 23rd May 1956, *Kapoor & Jhamman* 27705 ♂ (LWG); UTTAR PRADESH : Bahraich, Mahalva, 11th July 1984, *U. Chander* 12327 ♀ (LWG); Sohalwa, 29th Nov. 1954, *Hira Lal* 16686 ♀ (LWG); Abdullaganj, 5th July 1954, *U. Chander* 11909 ♀ (LWG); Dharmapur, 2nd May 1986, *K. K. Khanna & R. Saran* 37104 ♂ (BSA); Pilibhit, 1st June 1898, *Inayat* 22320A ♀ (CAL); Varanasi, Chandraprabha, 10th May 1984, *K. K. Singh* 1774 ♂ (LWG); Awarawantad, 16th May 1995, *K. K. Singh & A. Prakash* 8526 sterile (LWG); Gorakhpur, 21st May 1987, *K. K. Singh & Party* 6130 sterile (LWG); Lakhimpur Khiri, Kukra, Bhira forest, 17th April 1956, *G. Saran & Party* 26242 ♂ 26272 ♂ (LWG); Gonda, Sangurah, 10th May 1898, *Harsukh* 22320 ♂ (DD); WEST BENGAL : Purulia, Ajodhy hills, 600 m, *U. Chatterjee* 24 ♂ (CAL); Midnapur, Rangamati, *S. Majhi* 1429 ♀ (CAL).

39. ***Diospyros melanoxylon*** Roxb. var. ***tupru*** (Buch.-Ham.) V. Singh comb. *et* stat. nov. *D. tupru* Buch.-Ham. in Journey 1 : 183. 1807 & in Trans. Linn. Soc. 15 : 111. 1827; Hiern in Trans. Cambr. Philos. Soc. 12 : 158. 1873, *pro parte*; Clarke in Hook. f. Fl. Brit. India 3 : 563. 1882. *D. exculpta* Buch.-Ham. in Trans. Linn. Soc. 15 : 110. 1827, non Bedd. 1871; A. DC. in DC. Prodr. 8 : 223. 1844. *D. insculpta* Buch.-Ham. in Trans. Linn. Soc. 15 : 112. 1827; A. DC. in DC. Prodr. 8 : 223. 1844. *D. tomentosa* Roxb. Fl. Ind. 2 : 532. 1832, non Poir. 1804, nec Jeanneney 1922; Clarke in Hook. f. Fl. Brit. India 3 : 564. 1882. *D. speciosa* Wood in Rep. For. Oudh 1867-68 : 33. 1869, *nom. nud.*

English names : Ebony of Northern India, Nepal Ebony.

Vernacular names : *Beng.*: Kyoun, Kendu, Makrogav, Tumala, Kendh; *Bhoj.*: Tumri, Tumki; *Hindi* : Tumal, Tendu, Abnus, Kendu, Temru; *Kan.*: Timburni, Tumari, Tupru, Tindura, Bandadamra, Kakatinduka, Tuparanda; *Mal.*: Thambbilpazam; *Mar.*: Tartar, Tumboorne; *Or.*: Kendu; *Punj.*: Tendu, Kinnu; *Raj.*: Timru, Tibru; *Sans.*: Kakatinduka, Kakinduka, Tinduka, Virala, Kallindoo; *Tam.*: Chilta-tumiki, Tumbi, Thumbai; *Tel.*: Tuki, Tunki, Tumiki, Cittatumiki, Mancitumuki, Pasarugata, Pasaraghata; *Urdu* : Kendu.

Dioecious trees, upto 15 m high, with deeply transversely and longitudinally cracked spongy bark; branches ferruginous tomentose, alternate or opposite, ramified. Leaves alternate, opposite and subopposite, 3.5-16 x 3-11 cm, elliptic, elliptic-ovate, broadly ovate, obovate-elliptic, oblong, obovate-oblong to almost suborbicular, highly variable in shape, obtuse or rounded at apex, sometimes obtusely emarginate, rounded or cuneate at base, sometimes decurrent with petiole, hairy bothsides when young, later glabrous above and pubescent beneath, bright green, thick, coriaceous; midrib flat or subcanaliculate above, raised beneath; lateral nerves 8-12 pairs, prominent beneath; secondary nerves and venation distinctly impressed on the upper surface; petioles 0.5-3 cm long, flat or subcanaliculate above, rounded beneath, pubescent. Male flowers shortly pedicelled, in axillary, 3-flowered, tomentose cymes; peduncles upto 1.5 cm long, thickened, tomentose. Bracts small, ferruginously downy. Calyx campanulate, hairy bothsides, 4 or 5-lobed, tube widened at mouth; lobes ovate-triangular, valvate. Corolla tubular; tube somewhat urceolate or gibbous but longer than calyx, ferruginously lanate outside, glabrous within; lobes 4 or 5, ovate, acute, short, contorted. Stamens 12-16, rarely 18, shorter than corolla-tube, hypogynous, seated on the torus; filaments glabrous; connectives of anthers fulvous-pilose on the back, slightly

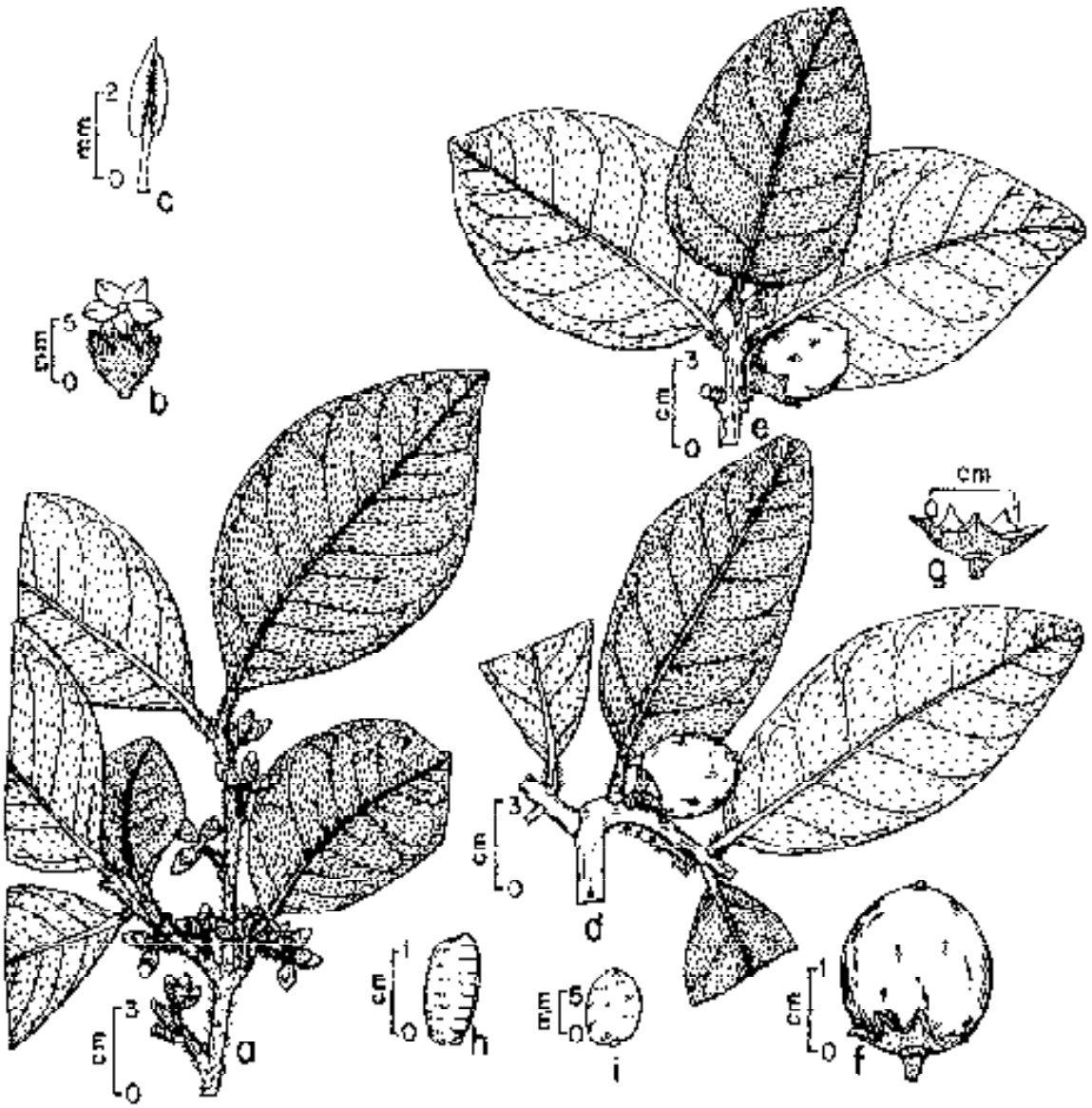


Fig.-37. ***Diospyros melanoxylon*** Roxb. var. ***tupru*** (Buch.-Ham.) Singh

Male : a. habit, b. flower, c. stamen.

Female : d-e. habit, f. fruit with calyx, g. fruiting calyx, h. seed (when more than one), i. seed (when solitary).

produced. Female flowers subsessile, axillary, solitary; pedicels small, hairy. Bracts 3-4, scale-like, caducous. Calyx 4 to 5-gonal, campanulate, hairy bothsides; lobes 4 or 5, rarely 6, triangular, with reflexed margins, valvate. Corolla tubular; tube cylindric-urceolate, hairy outside, glabrous within; lobes 4 or 5, contorted. Staminodes 6-9 or sometimes absent. Ovary globose, hairy, 4 to 5-celled, 1-ovuled in each locule; styles 2; stigmas 4. Fruits oval-globose, with smooth and hard rind and yellow and soft pulp. Fruiting-calyx upto 2.5 cm in diam., flat, disciform, thick, fruit seated on the disc; lobes spreading horizontally with reflexed margins. Seeds 5 or less upto 1; albumen ruminate (**Fig.-37; Plate 14/2**).

Fl. & Fr.: April – October.

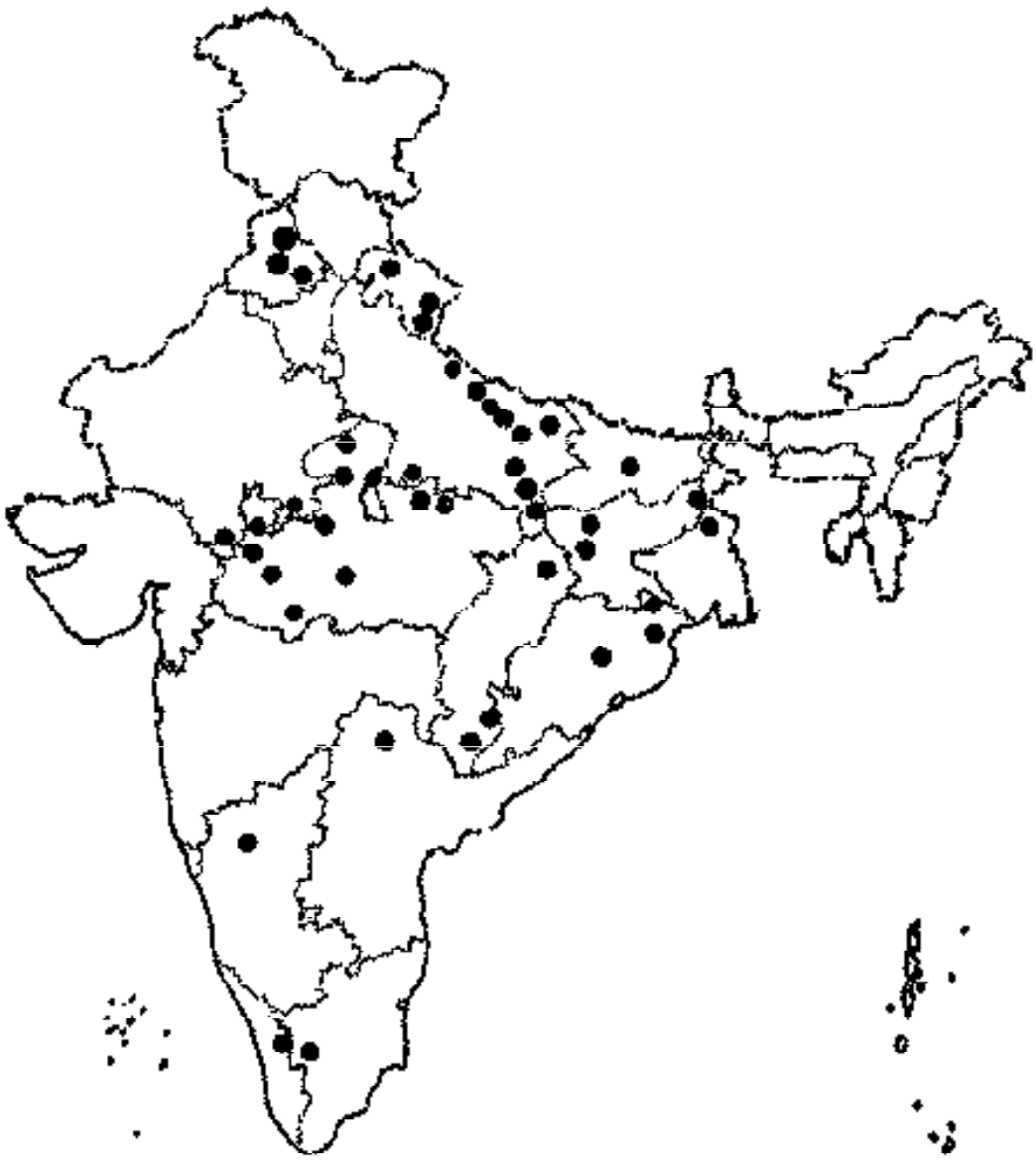
Ecol.: Common in wastelands. The trees shed their leaves during winters and new leaves appear during April and May. It reproduces by the seeds as well through root suckers. The rate of the growth of the plant is very slow. Plants attain a good height in sub-Himalayan tract and remain shrubby in dry zones. The main insect pests associated with this species are *Stromatium barbatum* – borer, *Hypocala biacuata* and *H. rostrata* defoliators. Rao & Subramoniam (1976) have reported a fungal disease in fruits caused by *Trichothecium roseum*. The disease appears initially in the form of small, irregular, light brown to tan-coloured, water-soaked lesions scattered over the fruits which enlarge subsequently and result in the rotting of fruits.

Distrib.: In India, the species is widely distributed, chiefly in Punjab, Uttar Pradesh, Uttranchal, Bihar, Jharkhand, W. Bengal, Orissa, Madhya Pradesh, Chhattisgarh, Rajasthan, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala. This taxon also extends to Nepal in the north and upto Afghanistan in the west (**Map-9**).

Pollen: Grains 3-zonocolporate; ectocolpium crustate, slightly constricted at center, expanding at poles; endocolpium la-longate, constricted at center, 5 x 10 µm. Exine surface faintly foveolate. Size 42-49 x 28-37 µm (Nair & Kothari, 1985). Sharma & Gupta (1979) have provided the description in rather details as grains 3-colporate, sub-prolate (43.1 x 35.8 µm), range 40-50 x 30-42 µm. Amb sub-circular. Colpi long, running from pole to pole. Maximum width of colpus about 2 µm. Ora la-longate, membrane indistinct. Exine about 1.5 µm thick. Sexine thinner than nexine, sexine pattern obscure.

Anatomy : The seeds develop mainly from the elongated chalazal end of the ovules. The free part of the testa is confined to the conical micropylar end. Tegmen disappears soon. Ruminations are as longitudinal flanges from the chalazal end of the seed (Periasamy, 1966).

Sapwood is greyish or pinkish white, turning light greyish brown with age. Heartwood small, black, often streaked with comparatively thin light-coloured bands, straight-grained and fine-textured. Growth rings indistinct. Vessels small, arranged in short or long radial multiples of 2-6 or more, evenly distributed, filled with dark-coloured deposits in the heartwood; vessel lines indistinct. Vessel cells medium thick-walled, truncate or attenuate-tailed at the ends. Perforations simple, horizontal to oblique. Inter-vessel



Distrib. Sketch Map – 9

● *Diospyros melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh

pits numerous, minute, orbicular to oval or polygonal, with broad border and rounded punctate orifice. Tyloses lacking. The parenchyma is 5 or more-rowed paratracheal and 3 to 5-rowed metatracheal, in cambiform rows along the grain. The paratracheal parenchyma is sparse, restricted to a few cells which are mostly contiguous to the tangential walls of the vessels, flattened to conform to the vessel walls. The metatracheal parenchyma is abundant, partly diffused through the fibrous tract and for the most part in concentric, fine, close, 1 to 2-seriate, undulate lines separated by 2-12 fibres which extend across the rays and form a fine reticulum. The metatracheal parenchyma is more or less angular and frequently flattened in the tangential plane. In both types of parenchyma of sapwood, the orange-brown infilteration is abundant; however, in heartwood brownish-black infilteration is copious. Starch deposits occasionally occur in outer sapwood. Fibres are libriform, fine, occasionally contiguous to the vessels, more or less angled and smaller than parenchyma cells, aligned in radial rows in concentric, undulate, 2 to 12-seriate bands which alternate with the narrow lines of zonate parenchyma. Those towards outer margin of the ring, thick-walled, non-gelatinous, non-septate. Inter-fibre pits numerous, abundant on the radial walls, bordered, with very small court and slit-like vertical orifice. Fibre-lumina of heartwood contains copious brownish-black or black gummy substance. Rays fine, distinct, closely and evenly spaced. The medullary rays are usually separated by 1-6 fibres and frequently contiguous to the vessels. The pits leading to contiguous vessels numerous to each ray cell, small, orbicular to oval or polygonal, with broad border and rounded, punctate orifice. Orange-brown gummy substance is abundant in the rays of sapwood, while heartwood rays contain blackish-brown gum. Crystals numerous in sapwood and heartwood, solitary, embedded in gummy substance (Wright, 1904; Pearson & Brown, 1981; Purkayastha, 1982).

Phytochemistry : Lupeol, betulin, betulinic acid, oleanolic acid and β-sitosterol have been isolated from this species (Rastogi & Mehrotra, 1993b).

Uses : Leaves are used for making Biris, particularly in Bundelkhand area. In West Bengal, they are used as dishes by the natives. The pulp of fruits is very soft, yellowish, sweet and astringent; the villagers eat the mature fruits. Raw fruits are costive and alleviative of the vitiated wind. The mature ones are alleviative of vomiting and bile. Raspings of the wood are a good source of medicines. Gum is used as a remedy for toothache (Nayar *et al.*, 1989). The fruits are also little phlegm-exciting. They are also given medicinally to cure dysentery and diarrhoea. The bark is applied on cuts (Jain & Filipps, 1991). It is also used in the preparation of Ayurvedic drug Tinduka. Roots are applied against scorpion sting (Prajapati *et al.*, 2003). Bhakuni *et al.* (1971) have reported that the plant, except roots, has positive effect in the treatment of cardiovascular problems. The plant is also used for treating bleeding gums, fever, atrophy, tumours, emaciation or cachexy, sores, tuberculosis, fistula, syphilis, carbuncle, dysuria, gravel, stomach trouble, dry cough, bronchitis, neuralgia etc. The seeds are used for antifertility in Madhya Pradesh. The unsaponifiable matter of seeds is reported to produce fall in blood pressure and increase in respiration rate in anaesthetized rats. It also shows anorexia, CNS depression in mice and antibacterial properties against *Bacillus subtilis* and *Staphylococcus aureus* (Srivastava & Kharya, 1980; Asolkar *et al.*, 1992).

Wood is also a chief source of fire. It is resistant to insects and used commercially for buildings, shoulder poles, carriage, shafts, plough, cart axles, cogs of wheels, curved walking sticks, combs, picture frames, furniture and mine-props in West Bengal.

Notes : This taxon is closely allied to highly variable *D. melanoxylon* Roxb., to the extent that taxonomic confusion is prevailing regarding its taxonomic status and the status of its synonyms. Some workers have considered *D. tupru* Buch.-Ham. as correct name for this Indian taxon and *D. exculpta* Buch.-Ham., *D. insculpta* Buch.-Ham. and *D. tomentosa* Roxb. as its synonyms (Hiern, 1873; Troup, 1921). Brandis (1874) merged all the above mentioned species under *D. tomentosa* Roxb. The palynological studies carried out by Nair & Kothari (1985), however, revealed circular endocolpium, with *ca* 3 µm equatorial length and psilate exine surface in *D. exculpta* Buch.-Ham. In *D. tupru* Buch.-Ham. the endocolpium is la-longate, with *ca* 10 µm equatorial length and foveolate exine surface. The circular endocolpium is unique in *D. exculpta* Buch.-Ham., not found in other taxa in *Diospyros* L., and suggest an independent line of evolution. As such, *D. tupru* Buch.-Ham. and *D. exculpta* Buch.-Ham. may not be considered conspecific based on palynological observations provided the identity of the pollen material is correct. Gamble (1922) has considered *D. tupru* Buch.-Ham. as conspecific to *D. melanoxylon* Roxb. But, pollen grains in *D. melanoxylon* Roxb. are 3-colporoidate and exine surface is reticulate – a primitive character. On the other hand, *D. tupru* Buch.-Ham. has 3-colporate grains with foveolate exine surface. This suggests that *D. melanoxylon* Roxb. forms the base taxa in evolutionary succession in this genus. Again, I feel that the concept of Gamble (1922) that *D. tupru* Buch.-Ham. and *D. melanoxylon* Roxb. are conspecific should be rejected. Gamble (1922) adopted the name *D. tomentosa* Roxb. (1832) for the Indian taxon bearing impressed lateral veins which is, however, a later homonym of *D. tomentosa* Poir. (1804) and cannot be followed. Further, the present study supported by palynological data suggests that *D. tupru* Buch.-Ham. and *D. tomentosa* Roxb. are conspecific and the name *D. tupru* Buch.-Ham. finds priority over *D. tomentosa* Roxb. – which is a later homonym.

Morphologically *D. melanoxylon* Roxb. and *D. tupru* Buch.-Ham. both are highly variable and the plants material of two have been much mixed up in herbaria. The degree of variability, particularly in leaf shape, may be assessed by an example of two leaf collections of Dr. Ritchie from the hills north of Belgaum (India) at two different seasons of the year from the same tree bearing the same number (Kew 1108 and 1108/2) and one has been identified as *D. tupru* Buch.-Ham. and other as *D. melanoxylon* Roxb. by Clarke (Rathore, 1976). Similarly, Griffith's collections 3630 and 3626/1 (from East Bengal and Jabalpur respectively) and Stocks & Law *s.n.* (from Mysore) deposited in Kew herbarium have been identified as *D. melanoxylon* Roxb = *D. tupru* Buch.-Ham. Further, Wallichian specimen 4133 (CAL) has been identified as *D. exculpta* Buch.-Ham. = *D. tomentosa* Roxb. and another specimen with same number 4133C (CAL) as *D. tomentosa* Roxb. Some specimens viz. *Clarke* 25132A, *Hooker* 441 (from Bihar) and Edgeworth 6004 (from Bundelkhand) deposited in Kew herbarium also bear the names as *D. tomentosa* Roxb. = *D. tupru* Buch.-Ham. and *D. tomentosa* Roxb. = *D. exculpta* Buch.-Ham. = *D. tupru* Buch.-Ham. This indicates the taxonomic and morphological complexity among these taxa. However, the present study revealed that the mixed herbarium specimens of these taxa may be distinguished into two

groups on the basis of characters like secondary veins and reticulation distinctly impressed on the upper surface giving the leaf a wrinkled shape in one group lead by *D. tupru* Buch.-Ham. and secondary nerves and venation distinctly raised on the upper surface or obscure representing second group of *D. melanoxylon* Roxb. Besides above, I could not trace any other constant morphological character to separate *D. tupru* Buch.-Ham. from *D. melanoxylon* Roxb. due to wide range of variability in both taxa. As such, I have reduced the former to the varietal rank, considering *D. exculpta* Buch.-Ham., *D. insculpta* Buch.-Ham. and *D. tomentosa* Roxb. as synonyms of var. *tupru*. As the palynological data about all synonyms and variable specimens of this complex is not available, the variability in *D. exculpta* Buch.-Ham. has been ignored, also with the doubt of correct identity of pollen materials.

Exsicc.: ANDHRA PRADESH : Karimnagar, Kvoorpalli village, 9th Feb. 1973, *Without Collector* 70735 sterile (LWG); Nimmagodem, 14th Feb. 1973, *Without Collector* 10909 sterile (LWG); BIHAR : Rajgeer hills, Dec. 1954, *J. G. Srivastava* 20646 ♀ (LWG); CHHATTISGARH : Bastar, Sonpur Range, Khursel valley, Feb. 1980, *R. Shahi & R. D. Raturi* 37 ♀ (DD); Dantiwada, Bhairamgarh, 21st Jan. 1977 *B. G. Kulkarni & Party* 6309 sterile (RHMD); Raipur, Dugli, 432 m, 15th Jan. 1976, *D. M. Verma* 23684 ♀ (BSA); Surguja, Kundi, 16th Nov. 1984, *R. P. Dwivedi* 3537 ♀ (LWG); JHARKHAND : Sahibaganj, 90 miles on way to Borio, 12th Dec. 1957, *G. Panigrahi* 11676 ♀ (ASSAM); Choto Nagpur, Jan. 1881, *J. S. Gamble* 9109 ♀ (DD); Handragarh, 11th Sept. 1896, *D. Prain* Acc. No. 282577 ♀ (CAL); Palamau, Dec. 1880, *J. S. Gamble* 8782 sterile (DD); KERALA : Palghat, Peringathukavu, Way to Kollengode, 325 m, 23rd Nov. 1973, *E. Vajravelu* 44813 ♀ (MH); MADHYA PRADESH : Shivpuri, National Park, March 1986, *A. N. Singh* 35804 ♀ (BSA); Satna, Majhgawan R. F., 20th Feb. 1987 *R. Prasad* 38409 ♀ (BSA); Panna, Vishramganj hills, 4th Oct. 1981, *Ram Lal* 31465 ♀ (BSA); Indore, Kasturbagram Krishi Kshetra, 11th Sept. 1986, *K. K. Khanna & R. Saran* 37567 ♀ (BSA); Guna, Singhpur valley, 27th Jan. 1959, *A. Singh & Party* 55927 ♀ (LWG); Morena, Vijaypur, Feb. 1987, *R. M. Painuli* 4884 ♀ (LWG); Mandsaur, Sukhanand, 16th Nov. 1987 *R. P. Dwivedi* 5221 ♀ (LWG); Ratlam, Bajna, 26th May 1986, *R. P. Dwivedi* 4621 ♀ (LWG); Bhopal, Ridge Simla, 17th Dec. 1953, *Kaul & Party* 5271 sterile (LWG); Khandwa, Near Khirgaon, 9th Jan. 1889, *J. F. Duthie* 8330 ♀ (DD); ORISSA : Dukura to Udala, 12th Feb. 1958, *G. Panigrahi* 12213 ♀ (ASSAM); Angul, Antulia, 300 m, 15th Dec. 1902, *J. H. Lace* 2599 ♀ (DD); Mayurbhanj, Dongadiha, Jan. 1940, *Without Collector* 479 ♀ (DD); PUNJAB : Hoshiarpur, Dholbah, 22nd Sept. 1970, *O. P. Mishra* 41896 ♀ (BSD); Manguwal, 27th July 1971, *O. P. Mishra* 44678 ♀ (BSD); Bhatinda, Bankhandi, 13th April 1972, *O. P. Mishra* 46927 ♀ (BSD); 11th Nov. 1959, *T. A. Rao* 10754 ♀ (BSD); Sangrur, Maler Kotla, 15th April 1972, *O. P. Mishra* 47004 ♀ (BSD); RAJASTHAN : Jhalawar, 28th Dec. 1965, *R. B. Majumdar* 10060 ♀ (BSA); Banswara, 12th Feb. 1957, *K. C. Nautiyal* 25456 ♀ (DD); UTTRANCHAL : Garhwal, Kharamba, Mundali, 2nd July 1951, *D. D. Awasthi* 2626 ♀ (LWG); Nainital, Corbett National Park, Bijrani, 21st April 1971, *P. C. Pant* 43616 ♀ (BSD); Jhirna, 350 m, 17th Dec. 1972, *K. P. Janardhanan* 51501 ♀ (BSD); Mailani, 5th Oct. 1980, *P. C. Pant* 72349 sterile (BSD); Haldwani, 16th June 1988, *U. Singh* 575 ♀ (BSD); North Khiri, Sonaripur Range, 24th April 1920, *Sis Ram s.n.* (DD); UTTAR PRADESH :

Mirzapur, Baleri, 19th Feb. 1981, *K. K. Singh & S. Saha* 559 sterile (LWG); Hallis village, 7th March 1970, *G. Panigrahi* 8487 ♀ (BSA); Bahraich, Abdullaganj, 17th Nov. 1964, *G. Panigrahi* 6395 ♀ (BSA); Gonda, Jarwa forest, 22nd May 1967, *S. L. Kapoor & Party* 70072 sterile (LWG); Barchwa forest, 12th May 1918, *Shri Ram* 1252 ♀ (DD); Lakhimpur Khiri, Golago Karan Nath forest, 21st April 1956, *G. Saran & Party* 26529 ♂ (LWG); Varanasi, Chakia Nanpara, 13th Feb. 1959, *M. A. Rau* 28256 ♀ (BSD); Chakia, Deadhari fall, 6th Jan. 1957, *Kaul & Party* 47571 sterile (LWG); Banda, Chitrakoot, *Ram Singh* 3893 ♀ (LWG); Mandakini river bank, 14th Nov. 1957, *M. A. Rau* 3739 ♀ (BSD); Jhansi, Sonyar, 4th June 1957, *G. Saran & Party* 41270 sterile (LWG); Faizabad, Ganeshpur forest, 9th Aug. 1959, *Y. K. Sarin* 8813 ♀ (BSD); Pilibhit, Garba, 31st May 1898, *Inayat* 22321 ♀ (DD); Mathna, 1st June 1898, *Inayat* 22320 ♀ (DD); Gorakhpur, 16th May 1916, *Shri Ram* 1252 ♂ (DD).

40. ***Diospyros montana*** Roxb. Pl. Cor. 1 : 37. t. 48. 1795, non Heyne ex Roth 1821, nec Poech. & Sebert. 1874; A. DC. in DC. Prodr. 8 : 230. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 220. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 555. 1882, *pro parte*; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 200. 1938; Kostermans, Rev. Handb. Fl. Ceylon 3 : 20. 1981 *D. bracteata* Roxb. Fl. Ind. 2 : 539. 1832; A. DC. in DC. Prodr. 8 : 239. 1844. *D. sylvatica* Wall. ex A. DC. in DC. Prodr. 8 : 231 1844, non Roxb. 1795. *D. sylvatica* Wall. ex A. DC. var. *velutina* A. DC. in DC. Prodr. 8 : 231. 1844. *D. goindu* Dalz. in Kew J. Bot. 4 : 111 1852. *D. pubicalyx* Bakh. in Gard. Bull. Str. Settl. 7 : 182. 1933 & in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 179. 1938. *D. diversitimba* Merr. & Chun, Sunyatsenia 2 : 300. 1935.

English names : Ebony, Mountain Persimmon.

Vernacular names : *Beng.*: Bangaub, Ban-gal, Gadatirel; *Bhoj.*: Makarkend, Hardu, Kadal, Kanchau; *Guj.*: Timbarao, Timru; *Hindi:* Bistendu, Chamber, Dasaundu, Kanchan, Kadal, Pattewar, Patwan, Makarkend, Makar-tendi, Lohari, Tendu; *Kan.*: Balkuniki, Bulguni, Jagalaganti, Kadubalekayi, Kichnas, Kulagunda, Vankane, Bukkana, Vakkanai, Goindu, Kalanji, Kala-Goindu, Kalagonda, Kalputti, Kolingi, Kalanudi, Tendu; *Mal.*: Bali; *Mar.*: Goindu, Govindu, Tembhurni, Kundu, Lohari, Timburni, Kanlu, Timru; *Or.*: Bhodrika, Gourokoshayo, Kossekuli, Kossaikulai, Koshakholi, Kalicha; *Punj.*: Hirek, Kendu, Temru, Pasendu; *Raj.*: Pasend, Temru, Ambia, Hadru, Goindu; *Sans.*: Tumala; *Tam.*: Karukanni, Vakkanathi, Vakkanattan, Vakkanai, Vel-vakkanas, Vellaittuvarsi, Velleithuvarai, Vakkania, Muchi-tanki, Kariamaram, Kuruttualisu; *Tel.*: Eddayagata, Gatugata, Muchi, Tanki, Yerragadha, Mullatumki, Micha-tummurra, Pudumaddi, Jagadagondi, Goddigattu, Goddigatta, Kakavulimidi, Muchi-tanki, Nallavulimii, Yerragoda, Kakwoolymera, Gatha-chettu, Kaka-chettu.

Dioecious, small trees, with glabrous or pubescent young branchlets becoming glabrous with age, crooked trunk and rusty bark; trunk and old branches often bear scattered spines. Bark almost white, smooth like guava, with a greenish yellow, thin sap. Leaves alternate, 3-16 x 1.5-8 cm, much variable in size and shape, usually oval-oblong or lanceolate-oblong, coriaceous, truncate, cuneate or rounded at the base, rounded, obtuse or obtusely subacuminate at apex, pubescent when young, becoming glabrous

with age except on the veins and veinlets; midrib flat or subcanaliculate above, raised beneath, pubescent or glabrous; lateral nerves 5-9 pairs, not much conspicuous; petioles 0.2-1.2 cm long, flat or canaliculate above, rounded beneath, pubescent or glabrous. Male flowers in bracteate, 3 or more-flowered, axillary cymes; peduncles pubescent, articulated with the flowers. Flower-buds ovate, upto 10 mm long. Bracts ovate or rhomboid-ovate, upto 2 mm long, acute, pubescent bothsides, ciliate, borne at the base of secondary peduncles. Calyx 4-7 mm long, campanulate, divided half way down, thinly pubescent bothsides, 4-lobed; lobes triangular-ovate, subacute, ciliate, valvate. Corolla urceolate, twice the length of calyx, glabrous bothsides, divided half way down, 4-lobed; lobes rounded, recurved, glabrous, contorted. Stamens 16, united through filaments in pairs, inserted at the base of corolla-tube; common filaments 1-2 mm long, glabrous; anthers subequal in each pair, 3-4 mm long, apiculate due to produced connectives, glabrous. Pistillode ovoid-globose, 2.5-3 mm long, glabrous, with pointed styles at apex. Female flowers axillary, solitary, on 1-2 mm long pedicels which extend upto 1 cm in fruit; pedicels pubescent, articulated with the flowers. Bracts 2, inserted at the apex of pedicels, ovate-lanceolate, densely hairy bothsides, ciliate, caducous. Calyx campanulate, 5-7 mm long, deeply divided three-fourth down or nearly to the base, 4-lobed, thinly pubescent bothsides; lobes ovate-elliptic, obtuse at apex, ciliate, contorted. Corolla urceolate, exceeding calyx, glabrous, 4-lobed; lobes contorted. Staminodes 4, attached at the base of corolla-tube, sterile anthers ovate-elliptic, obtuse, upto 3 mm long, narrowed at apex, glabrous. Ovary globose, glabrous or with few scattered long hairs visible in high power, 8-celled, cells 1-ovuled; styles 4, glabrous; stigmas 2-fid. Fruits globose, 1.5-2.5 cm in diam., glabrous, apiculate. Fruiting-calyx flat, disciform, upto 3 cm in diam., no tube, no internal elevated rim, fruit seated on the disc; lobes 4, ovate-elliptic, foliaceous, horizontally spreading or reflexed, not touching the fruit, rounded at apex, coriaceous. Seeds usually 4-8, sometimes 2 only, wedge-shaped, flat on one face and convex on others, smooth, blackish-brown; cotyledons ovate, tapering at apex, rounded at the base; albumen equable, copious; embryo small, white **(Fig.-38; Plate 14/3 & 4)**.

Holotype : Plate 56 of Roxburgh (K), which is t. 48. Pl. Cor.

Chr. No.: 2n=30 (Sobti & Singh, 1961; Chatterji, 1964; Mehra & Bawa, 1969); n=15 (Bir *et al.*, 1980; Bir & Chatha, 1983; Chatha & Bir, 1987; Mehra, 1976).

Fl. & Fr.: March – October.

Ecol.: Sparsely grows in wastelands and open dry deciduous forests, upto 1500 m. Plants can tolerate drought conditions for quite a longer period. This species grows at a rather quicker rate than other species. The plants become semi-deciduous during early flowering period. It reproduces by the seeds which germinate in rainy season. After epigeal germination, the cotyledons persist for many months and carry out the function of photosynthesis until epicotyledonary leaves are developed. The growth of epicotyledonary leaves is, however, rather slow. The seedlings may withstand dense shade for a much longer time than other species. The flowering starts at young age. Plants also coppice well. Studies carried out by Singh *et al.* (1982) revealed that *D. montana* Roxb. is more productive than some other forest species because of high conserving efficiency and vigorous growth rate. Experiments conducted at

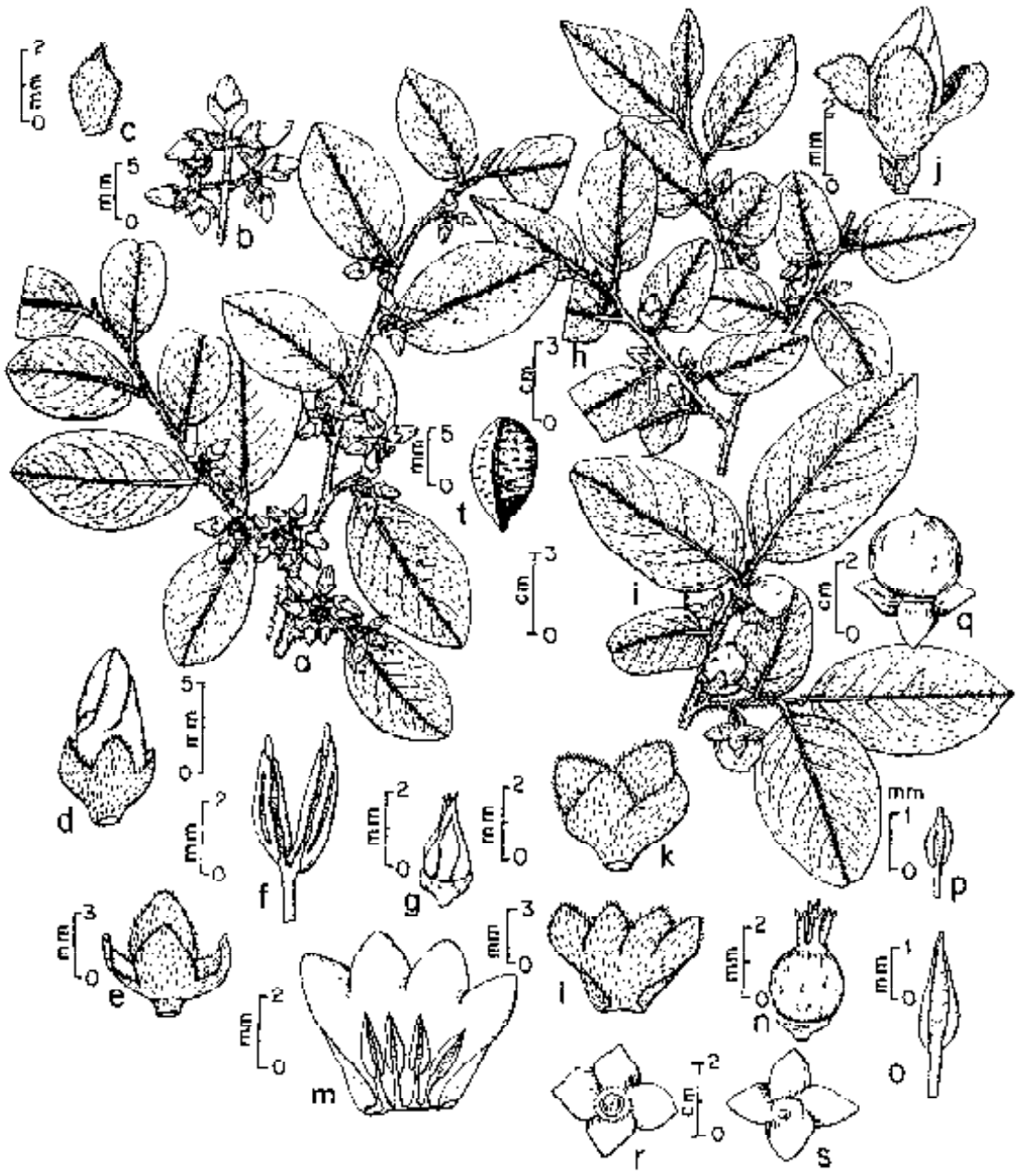


Fig.-38. ***Diospyros montana*** Roxb.

Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. calyx, f. stamens, g. pistillode.
Female : h-i. habit, j. flower-bud with bracts, k. calyx, l. calyx within, m. corolla within with staminodes, n. gynoecium, o-p. staminodes, q. fruit with calyx,
r. fruiting-calyx (ventral view), s. fruiting-calyx (dorsal view), t. seed.

Banthra Research Station, NBRI, Lucknow indicated that this species is well adaptable to alkaline land and may be used for wind break, to maintain eco-balance and for the improvement of soil for cropping (Srivastava, 1979). Among defoliator insects *Margaronia laticostalis, Grammodes geometrica, Hypocala biacuata, H. moorei, H. rostrata, H. subsatura* and *Prodenia litura* are commonly found on this species. The other insect pest associated with this species is borer *Stromatium barbatum*.

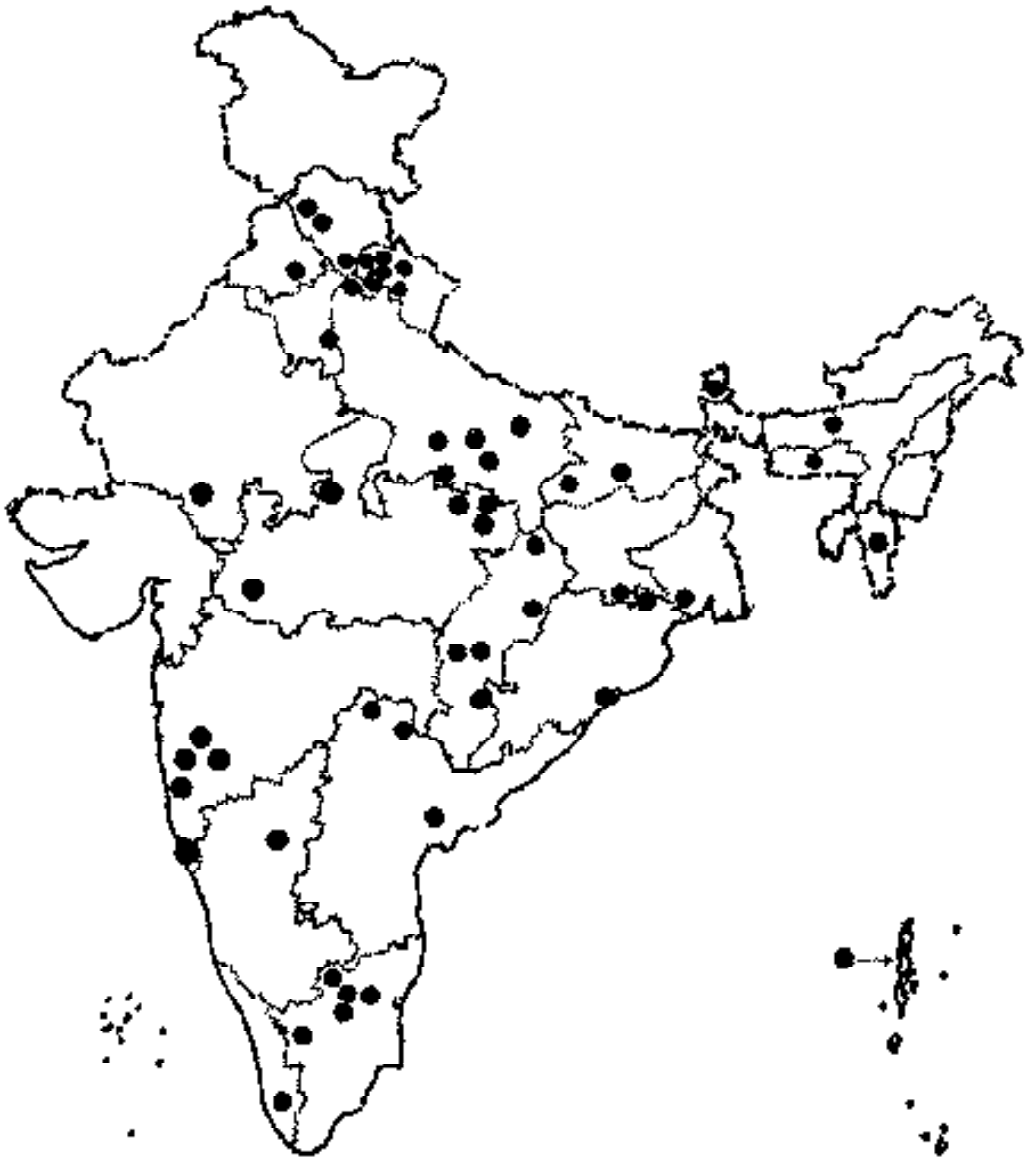
Distrib.: This species is widely distributed from Himalaya in the north to sea coasts in the south and humid areas of east to dry zones of Thar desert in the west. The main States of its concentration are Himachal Pradesh, Punjab, Delhi, Uttar Pradesh, Uttranchal, Bihar, Jharkhand, W. Bengal, Sikkim, Assam, Manipur, Meghalaya, Orissa, Madhya Pradesh, Chhattisgarh, Rajasthan, Maharashtra, Goa, Andhra Pradesh, Karnataka, Tamil Nadu, Kerala and Andaman & Nicobar Islands. Out side India, the species is reported from Nepal, Pakistan, Myanmar, Sri Lanka, Java, Philippines, Thailand, Lombok, Sumba, Timor, Celebes, Malaya, Luzon, China, Laos, Cambodia, Vietnam, Sumbawa and Tropical Australia (**Map 10**).

Pollen: Exine surface psilate. Size 30-36 x 22-28 µm (Nair & Kothari, 1985). Sharma & Gupta (1979) have carried out rather detail studies and recorded the pollen grains 3-colporate, sub-prolate (38.3 x 31.5 µm), range 30-42 x 25-34 µm. Anguloaperturate. Amb triangular. Colpi long, thin, running from pole to pole, membrane psilate. Apocolpium diameter not distinct and mesocolpium distance about 20 µm. Ora la-longate, small (1.5 x 5.0 µm). Exine about 2 µm thick. Sexine thinner than nexine, sexine pattern obscure.

Anatomy : Each cotyledon has two traces, while epicotyledonary leaf has one trace only with feebly splitting of cotyledonary xylem. Epicotyledonary traces die out in hypocotyl (Wright, 1904).

Wood is dirty white in colour which gets reddish tinged on exposure to air. Black heartwood is very small since central part generally rots in short duration. The timber consists high percentage of parenchymatous and tracheal elements. Growth rings indistinct. The vessels few, evenly distributed but with a tendency to be aligned radially in short or long radial multiples of 2-5; vessel lines distinct to inconspicuous.

The vessels of twigs are 0.34 mm long, having 0.04 mm radial and 0.07 mm tangential diameter. The vessels of sapwood are about 0.31 mm long, having 0.07 mm radial and 0.05 mm tangential diameter. The parenchyma is diffuse to diffuse-in-aggregates sometimes as closely placed thin lines or forming a network with the rays. The length of wood parenchyma cells in sapwood varies from 0.07 to 0.20 mm, with 0.02 mm radial diameter. The radial diameter of wood fibres in sapwood is 0.009 mm and in heartwood 0.010 mm. In some specimens of this species the wood parenchyma bands which are 2-cells in thickness often run together through a vertical distance upto about 0.8 mm and tangential bands of wood parenchyma are separated from one another radially by patches of fibres from 0.06 to 0.18 mm in thickness. In some other specimens some oblique bands of wood parenchyma are connected at the outer end to the median cells of a tangential band of parenchyma and to a medullary ray at a point opposite to another tangential line of parenchyma. The medullary rays are distinct, fine, closely



Distrib. Sketch Map – 10

● *Diospyros montana* Roxb.

spaced and uniformly distributed. The radial diameter of vertical medullary ray cells is 0.024 mm, tangential 0.02 mm, with vertical length 0.034 mm. The radial diameter of horizontal components is 0.07 mm, tangential diameter *ca* 0.01 mm, with vertical length 0.022 mm (Wright, 1904; Purkayastha, 1982). Nair & Mohan Ram (1989) reported absence of vestured pits and vestured vessel member walls in this taxon. Utsunomiya *et al.* (1998) have studied the tannin cells in the mesocarp of the fruits and reported their absence in this species.

Phytochemistry : The stem-bark of this species contains diospyrin $(C_{22}H_{14}O_6)_{11}$ and three tritepenes viz. lupeol, betulin and betulinic acid. Diospyrin contains two hydroxy and two C-methyl groups. On Zinc dust distillation it gives a crystalline hydrocarbon. Comparison of ultraviolet absorption spectra of diospyrin and its derivatives with those of the known binaphthyls suggested a 2, 2'- binaphthyl structure for diospyrin (Ganguly & Govindachari, 1966; Kapil & Dhar, 1961). Sidhu & Pardhasaradhi (1967a, 1967b) suggested that diospyrin dimethylether is a yellow compound and that the red compound which has been considered dimethylether by Kapil and Dhar (1961) and Ganguly and Govindachari (1966) is trimethylether. Fatty esters of α-amyrin, ursolic, betulic and oleanolic acids and lupeol and β-sitosterol have been isolated from fruit-pulp, betulinic acid from fruits and seeds, betulin, epiuvaol and a new triterpene characterized as urs-12-en-3α, 28 diol (I) along with lupeol, β-sitosterol, diospyrin, betulic acid and masterol from the leaves. The wood and bark have been found to contain 7 methyljugulone, mamegakinone, biramentacenone, isodiospyrin, 8'-hydroxydiospyrin, 3-5'-O-cyclodiospyrin, 3'-chloro-2'-hydroxydiospyrin, chromenone ester (II), chromenone acid (III), allobetulin and oxallobetulin. The seeds contain an oil which yields mixed fatty acids and unsaponifiable material. From saponifiable material, palmitic acid, stearic acid, oleic acid and linoleic acid have been isolated. The unsaponifiable material yields lupeol, β-sitosterol and stigmasterol. Recently, tetrahydrodiospyrin has also been isolated from the bark of this species (Rastogi & Mehrotra, 1993b). Narayan *et al.* (1978) have isolated diospyrin (I) from the leaves of this species. Earlier Cooke & Dowd (1952) also recorded the same content poisonous naphthaquinones from the leaves. Pardhasaradhi & Krishnakumari (1979) have also isolated tetrahydrodiospyrin- a reduced binaphthoquinone (3' 7'-dimethyl-5' 6' 7' 8'-tetrahydro-1' 5, 5'-trihydroxy (2, 2'-binaphthalene)-1, 4, 8'-trion) in addition to diospyrin and β-dihydrodiospyrin from the bark of this species. Recently, Hazra *et al.* (1984) have also isolated diospyrin, a bis-naphthoquinone derivative from the bark of this species.

Uses : Tender twigs and leaves are used as fodder. Fruits are poisonous, used to stupefy fishes, also in Thailand (Utsunomiya *et al.*, 1998). In Punjab, the paste of fruits is applied by water carriers (Bhistis) on the hands in case of boils. The gum, locally called "Kend ka Gand" is used to remove obstructions of the vision. A decoction of roots (*ca* 20 ml) is given thrice a day for seven days to cure small pox in Orissa (Singh & Dhar, 1993). In Andhra Pradesh, the Koyas crush the root-bark with *Curcuma longa* L. (Turmeric) and the filtrate is taken orally 2 spoonful twice a day to cure dysentery. At some places, the bark is mixed with pepper to cure dysentery. Jatapus and Savaras tribals use stem-bark and leaves as fish poison instead of fruits (Rao & Henry, 1996). The alcoholic extract of

stem-bark has been found to have antitumour potential to inhibit Ehrlich Ascites Carcinoma (E. A. C.) in Swiss albino mice. Studies have also been conducted on haematological parameters of the mice treated with crude extract with respect to the control. Thus, the species has anticancer potentiality (Hazra *et al.*, 1981). Recently, Hemadri & Rao (1984) have reported anti-jaundice potentiality of this species. Gautam & Purohit (1973) reported that petroleum ether and carbon tetrachloride extractives of leaves and seeds show antibacterial activity against *Bacillus subtilis*. Dhar *et al.* (1968) reported stem-bark to have antiprotozoal, antiviral and hypoglycaemic potential. Jain & Tarafdar (1970) have reported the plant to have medicinal potential for the treatment of fever, dysuria, gravel, neuralgia, pleurisy, pneumonia, monorrhagia and flooding, puerperal fever, diarrhoea and poison of spider bite. Wood is grey with darker streaks or patches, soft to moderately hard and durable. It is used for electric transmission poles and furniture and considered equal to Calamander in beauty. The wood is more commonly used for carpentry works and for the axles of carts and house posts. The natives of Mysore (Karnataka) have a superstition that if the wood is used in house-building, there will be quarrel among the inmates.

Exsicc.: ANDAMAN & NICOBAR : Andamans, 1916, *Parkinson* 1057 ♀ (DD); ANDHRA PRADESH : Krishna, G. Konduru, 14th May 1986, *P. Venkkana* 6087 ♀ (WALT); Adilabad, Boggula-raasi-Loddhi, 1st July 1987, *T. Ravishankar* 85244 ♀ (MH); Karimnagar, Near Mahadevpur on way to Kalleswar, 11th Feb. 1973, *S. L. Kapoor & Party* 70874 ♀ (LWG); Near village Kudurpalli, 9th Feb. 1973, *S. L. Kapoor & Party* 70747 ♀ (LWG); BIHAR : Rajgir hills, 12th March 1956, *G. Saran & Party* 25816 sterile (LWG); Sasaram, 17th Dec. 1957 *Kaul & Party* 46460 ♀ (LWG); CHHATTISGARH : Raipur, Gariaband, Jarjhara, 10th June 1972, *D. M. Verma* 17642 ♀ (BSA); Raigarh, Raunighat, 750 m, 3rd Oct. 1974, *N. C. Rathakrishnan* 21299 ♀ (BSA); Bhupdeopur, 250 m, 4th Feb. 1974, *N. C. Rathakrishnan* 19711 ♀ (BSA); Bastar, Abujhmarh, Konge, 27th Feb. 1985, *G. P. Roy & S. K. Dixit* 43587 ♀ (BSA); Rajnandgaon, Chichola, 20th Sept. 1976, *P. C. Pant* 25532 ♀ (BSA); Jagpani, 360 m, 31st Oct. 1974, *P. C. Pant* 21450 ♀ (BSA); Surguja, Sitachua, Chalgali, Pratapur, 26th Nov. 1999, *Vivek Kumar* 738 ♀ (BSD); DELHI : Gurgaon Road, 28 miles from Delhi, 5th April 1954, *Kaul & Party* 8338 ♀ (LWG); GOA : South Goa, Verhm hills, 1st Oct. 1972, *K. C. Sahni* 3731 ♀ (DD); Sanguem Range, Shigone, 26th March 1972, *K. N. Bahadur & R. C. Gaur* 2911 ♂ (DD); HIMACHAL PRADESH : Kangra, Near Ranital, 750 m, Oct. 1907, *R. N. Parker* Acc. No. 8280 ♀ (DD); Hamirpur, Nadaun, 8th Aug. 1977 *M. V. Vishwanathan* 61573 ♀ (BSD); Sirmaur, Renuka lake catchment area, 4th June 2000, *S. K. Srivastava* 96056 ♀ (BSD); JHARKHAND : West Singhbhum, Salai, Banki, 345 m, 2nd Jan. 1961, *G. V. S. Rao* 23102 ♀ (ASSAM); KERALA : Travancore, Pulyara, *T. F. Bourdillon* 827 ♂ (DD); MADHYA PRADESH : Rewa, Banglow No. 4, April 1967, *S. D. N. Tiwari* 20181 sterile (LWG); Forest near Govindgarh, Kaimur hills, 550 m, 25th April 1960, *K. M. Sebastine* 10048 ♂ (MH); 600 m, 25th April 1960, *K. M. Sebastine* 10040 ♂ (MH); Govindgarh-Jigna Road, 525 m, 26th June 1989, *R. Prasad* 43922 ♀ (BSA); Satna, Pattanala, 28th Dec. 1974, *R. M. Maurgain* 21737 ♀ (BSA); Guna, Bamore, 6th Oct. 1986, *R. M. Painuli* 7184 ♂ (LWG); Without locality, Without date, *K. M. Balapure*

Acc. No. 40403 ♀ (LWG); Dhar, Mandugarh, 22nd Dec. 1953, *Kaul & Party* 5658 ♀ (LWG); MAHARASHTRA : Ratnagiri, Khed Taluka, Yethalmachi, Near Vandra, 30th Nov. 1961, *K. P. Janardhanan* 76006 ♀ (BSI); Pune, J. N. Ayurvedic Medicinal Plants Garden, 14th May 1973, *K. S. Murthy* 1649 ♀ (RHMD); Matheran Road, 14th May 1973, *K. S. Murthy* 1649, 1653 ♀ (RHMD); Lonauli, 13th May 1903, *G. A. Gammie* 16308 ♀ (BSI); Raigarh, Khandala, Sakarpathar, 25th Dec. 1962, *S. R. Rolla* 85233 ♀ (BSI); Ambolighat, Temple point, 930 m, 4th Sept. 1968, *B. Gupta & Party* 1851/1140 ♀ (RHMD); Khandala-Pune, 14th March 1943, *H. Santapau* 1693 ♂ (DD); 30th Aug. 1942, *H. Santapau* 756 ♀ (DD); ORISSA : Mayurbhanj, Dorkuch, 14th Aug. 1939, *Without Collector* Acc. No. 85688 ♀ (DD); Ganjam, Bhicacola, March 1884, *J. S. Gamble* 13876 ♀ (DD); RAJASTHAN : Udaipur, 16 miles from Nathdwara, 8th April 1954, *Kaul & Party* 8559 ♂ (LWG); Dabok, 8th Aug. 1962, *N. Lal* 139 ♀ (LWG); TAMIL NADU : Dharmapuri, Denkanikotta, Semieri R. F. beyond pond, 1000 m, 2nd May 1979, *K. M. Matthew & N. Venugopal* 23264 ♀ (CAL); Harur-Dharampuri, 800 m, 25th Aug. 1978, *K. M. Matthew, Perumal & Manoharan* 16511 ♀ (CAL); Salem, Chinnar river bank, Hogainakkal, 250 m, 16th March 1965, *E. Vajravelu* 23579 ♀ (MH); Coimbatore, Simasamudram, 11th May 1914, *Without Collector* 10375 ♀ (MH); Tiruvannamalai, North Arcot, T. V. Malai base hills, 225 m, 22nd March 1978, *E. Vajravelu* 54546 ♀ (CAL); South Arcot, Gingu fort, 125 m, 9th Sept. 1977, *K. Ramamurthy* 51142 (MH); UTTRANCHAL : Tehri-Garhwal, Muni-ki-Reti, 300 m, 31st May 1979, *A. K. Goel* 67737 ♀ (BSD); Dehra Dun, Rajpur, 850 m, 21st April 1966, *U. C. Bhattacharyya* 28598 ♂ (BSD); Sahashtradhara, 23rd June 1964, *S. K. Malhotra* 31296 ♀ (BSD); Ranipur forest, 12th April 1996, *K. K. Singh & A. Prakash* 216321 ♀ (LWG); Kunnao F. R., R. N. P., 23rd Oct. 1996, *K. K. Singh & A. Prakash* 216935 ♀ (LWG); Mussoorie, 1500 m, 27th April 1957, *Y. K. Sarin & T. A. Rao* 2362 ♂ (BSD); Kutal village, 1050 m, 30th April 1961, *H. O. Saxena* 1897 ♀ (DD); Bindal, 12th July 1964, *C. R. Babu* 32224 ♀ (BSD); Raipur, 650 m, 21st April 1966, *U. C. Bhattacharyya* 28598 ♂ (BSD); 800 m, 17th April 1961, *U. C. Bhattacharyya* 14817 ♂ (BSD); Bhagwanpur village, 10th June 1958, *Y. K. Sarin* 5443 ♀ (BSD); Rishikesh, Dec. 1922, *B. L. Gupta* Acc. No. 31801 ♀ (DD); Jansar, Amlawa valley, 750 m, 16th June 1904, *U. N. Kanjilal* 1289 ♀ (DD); Nainital, Haldwani, Kamalnaganja, 16th June 1988, *U. Singh* 575 ♀ (BSD); Pauri, Bhalaon, Kota range, 16th June 2002, *Inayat* 25918 ♀ (DD); UTTAR PRADESH : Banda, Chitrakoot, Mandakini river bank, 14th Nov. 1957, *M. A. Rau* 3745 ♀ (BSD); Kanpur, Allen Reserve forest, 7th June 1958, *J. G. Srivastava & Party* 84873 ♀ (LWG); Lucknow, Mohanlalganj, 8th May 1958, *J. G. Srivastava* 46991 ♀ (LWG); Saharanpur, Shahjahanpur, Siwalik forest, April 1986, *Y. S. Murty & A. K. Goel* 2115 ♀ (BSD); Badshahi Bag, June 1983, *Y. S. Murty & A. K. Goel* 2112 ♀ (BSD); Gonda, Sangarha, 24th May 1900, *Inayat* 23705 ♂ (DD); Rai Bareli, Jail garden, 16th Dec. 1955, *Janki Prasad* 17239 ♂ (LWG); WEST BENGAL : Midnapore, Chilkigarh, 23rd May 1975, *S. Majhi* 1373 ♀ (CAL).

41. ***Diospyros multibracteata*** (Merr.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 77. 1937; Nair in Philipp. J. Biol. 5 (3) : 326. f. 1-7. 1976. *Maba euphlebia* Merr. in Philipp. J. Sci. Bot. 9

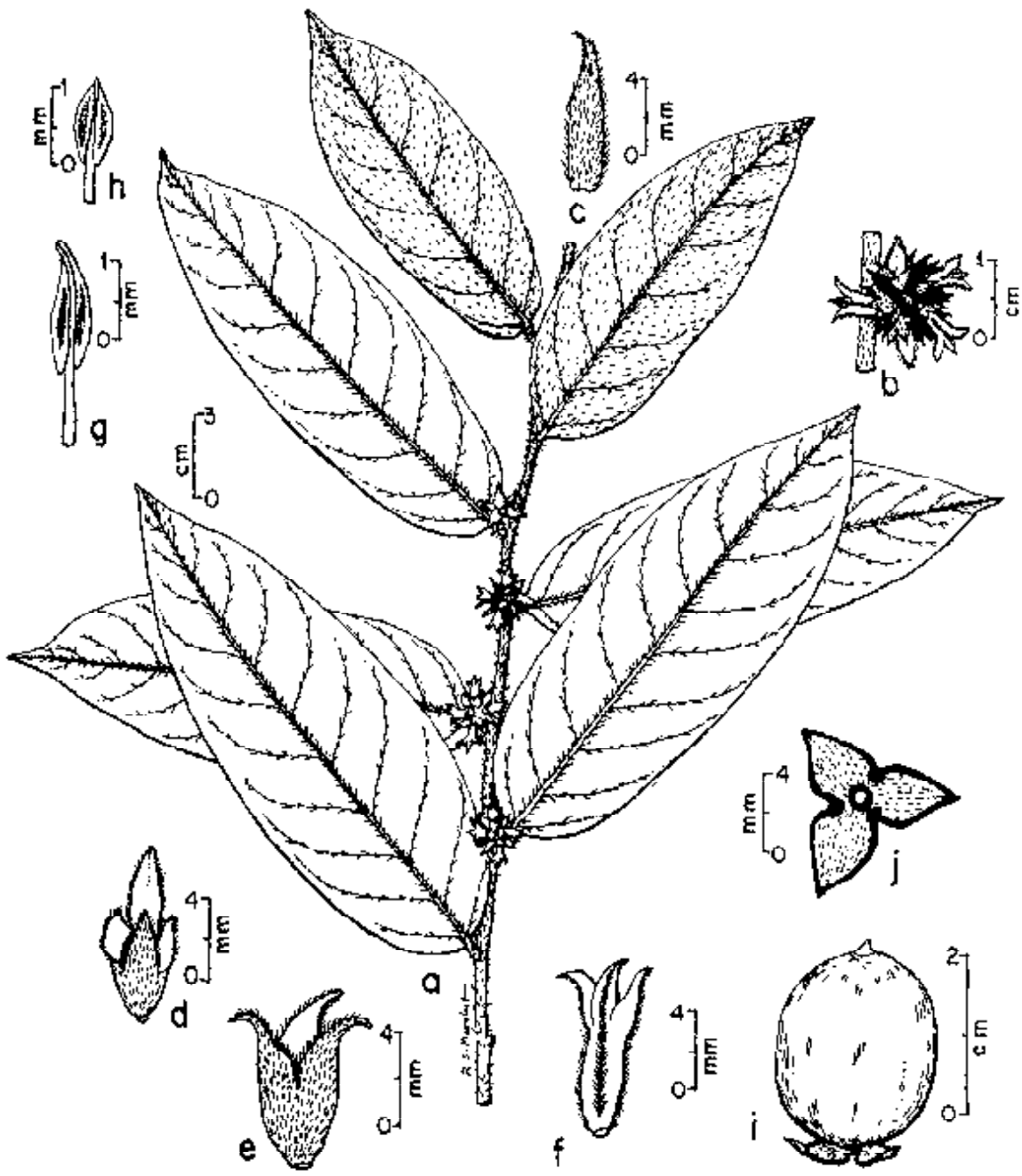


Fig.-39. ***Diospyros multibracteata*** (Merr.) Bakh.
Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. calyx, f. corolla, g-h. stamens.
Female : i. fruit with calyx, j. fruiting-calyx (ventral view).

(2) : 333. 1914 & Enum. Philipp. Flow. Pl. 3 : 289. 1923, non *Diospyros euphlebia* Merr. 1929. *M. multibracteata* Merr. in Philipp. J. Sci. Bot. 12 : 295. 1917 & Enum. Philipp. Flow. Pl. 3 : 289. 1923.

Dioecious, monoecious or polygamous shrubs or small trees, 3-4 m high; branches almost verticillate on main stem, with appressed pubescent branchlets. Leaves alternate, 10-21 x 3-7.5 cm, broadly elliptic-oblong, rounded to subcordate at base, slightly abruptly acuminate at apex, pellucid-punctate, pubescent when young, becoming glabrous with age except the nerves especially beneath, mature leaves glossy above; midrib canaliculate above, raised beneath, pubescent when young bothsides, becoming glabrous above on maturity; lateral nerves 7-10 pairs, distant, arcuate towards margins; petioles 3-4 mm long, *ca* 2 mm thick, densely pubescent, terete or subcanaliculate above and canal filled with the hairs. Flowers subsessile, in axillary, bracteate, more than 3-flowered cymose clusters on a short common peduncle, male and female or male and bisexual sometimes together. Bracts several, subtending each flower, 9-12 x 1.5-2 mm, linear-lanceolate, acuminate, pubescent outside, glabrous within, ciliate. Male flowers 7-9 mm long. Calyx 4-7 mm long, campanulate, divided upto the middle or little down, pubescent outside, glabrous within; lobes 3, ovate, 3-5 mm long, acuminate, ciliate, valvate. Corolla tubular, 6-9 mm long; tube slightly constricted towards apex; lobes 3, narrowly ovate, 3-4 mm long, acuminate, hairy outside on the thick keeled midrib which passes down to the tube, twisted to the right, yellowish-green. Stamens 12-14, inserted at the base of the corolla-tube in two rows, outer ones 2-3 mm long, inner ones 1-2 mm long; filaments subequal, upto 1 mm long, glabrous; anthers glabrous, connectives slightly produced into a neck. Pistillode absent. Bisexual or pistillate flowers clustered in the leaf axils, occasionally with male flowers, almost sessile, bracteate. Calyx and corolla of both like that of male flowers. Stamens in bisexual flowers or staminodes in pistillate flowers 12-20, of varying sizes, glabrous and like male flowers. Ovary *ca* 2 x 1 mm, oblong, 3 to 5-celled, cells 1-ovuled, glabrous; style short, stout; stigma irregularly 3-lobed. Fruits 2-2.5 x 1.5-2 cm, ovoid-oblong, slightly mucronate at apex, glabrous, red when ripe, 3 to 5-celled, cells 1-seeded. Fruiting-calyx flat, discoid, fruit seated on the disc, no tube, tube deeply partite, 1-1.5 cm across; lobes 6-7 mm long, ovate, acuminate, glabrous, horizontally spreading, not touching the fruit, margins sometimes dark black. Seeds ellipsoid, flat to concave on one side and rounded at other side, *ca* 2 x 1 cm; testa hard, shiny, brown; albumen equable (**Fig.-39; Plate 15/1**).

Fl. & Fr.: December – May.

Ecol.: Rare, in tropical rain forests.

Distrib.: Native of Philippines; recently collected from Andaman & Nicobar Islands in India (**Map-11**).

Notes: This species shows disjunct distribution as it occurs in Philippines and Andaman and Nicobar Islands and nowhere in between.

Exsicc.: ANDAMAN & NICOBAR : North Nicobar, Arong, Car Nicobar, Sea level, 31st April 1975, *N. G. Nair* 2629 polygamous (PBL); 27th Feb. 1976, *N. G. Nair* 3563 polygamous (PBL).

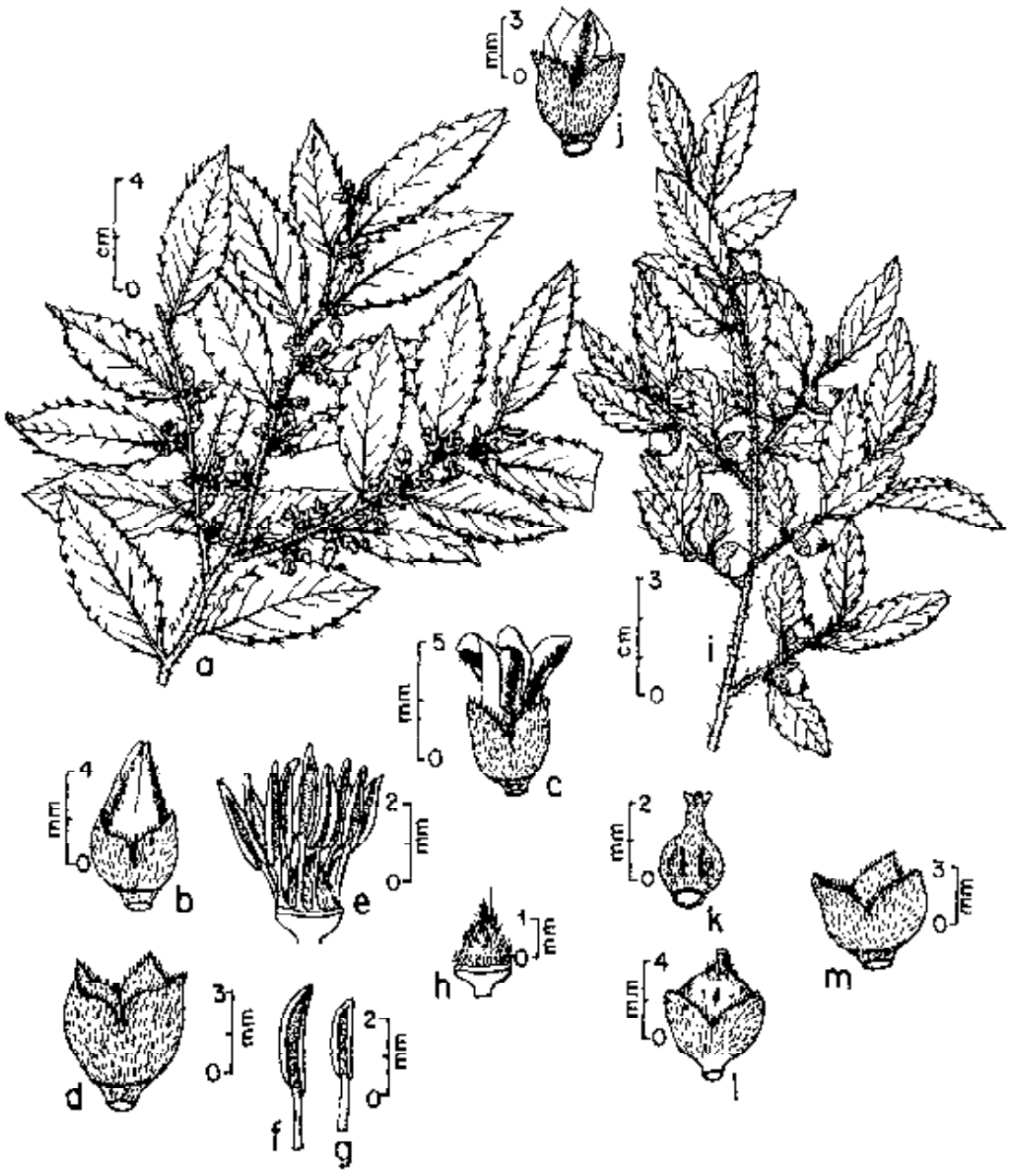


Fig.-40. ***Diospyros neilgerrensis*** (Wight) Kosterm.

Male : a. habit, b. flower-bud, c. flower, d. calyx, e. stamens borne on torus, f-g. stamens, h. pistillode.

Female : i. habit, j. flower, k. gynoecium, l. fruit enclosed within calyx, m. fruiting-calyx.

42. ***Diospyros neilgerrensis*** (Wight) Kosterm. in Ceylon J. Bot. (Biol. Sci.) 12 (2) : 106. 1977. *Maba neilgerrensis* Wight, Ic. Ind. Pl. Or. 4 : 10. t. 1228, 1229. 1848. *M. angustifolia* Miq. in Anal. Bot. Ind. 3 : 13. 1852. *M. nigrescens* Dalz. in Dalz. & Gibs. Bombay Fl. 142. 1861; Clarke in Hook. f. Fl. Brit. India 3 : 551 1882. *M. buxifolia sensu* Clarke in Hook. f. Fl. Brit. India 3 : 551 1882, *pro parte*, non Pers. 1807. *Diospyros ferrea* (Willd.) Bakh. var. *neilgerrensis* (Wight) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 57, 62. 1937. *D. ferrea* (Willd.) Bakh. var. *angustifolia* (Miq.) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (2) : 57. 1937. *D. nigrescens* (Dalz.) Saldanha in Saldanha & Nicolson, Fl. Hassan Dist. 197. 1976. *D. angustifolia* (Miq.) Kosterm. in Ceylon J. Sci. (Biol. Sci.) 12 (2) : 106. 1977 non Lodd. ex Loud. 1838, nec. Audib. ex Spach 1838.

Vernacular names : *Kan.*: Karimarlu, Sunnala, Ruktroora, Karimolu; *Mar.*: Kari-Kila-Jhid; *Tam.*: Eruvallo, Humbilli, Irampalai, Iruvalli, Juvarai, Irumbali, Thuvarai, Trumbilli, Irumalli, Kulumayamaram, Kuruvilichi, Sirumolaya, Kariamarum, Kanasthrimaram; *Tel.*: Alli, Guakoli, Chinna-ulinji, Uti, Chettu, Yerruti.

Shrubs or small trees, 5-10 m high, with hairy young branchlets with short and long hairs, becoming glabrous with age. Leaves alternate, 2-7.5 x 1-3 cm, elliptic or elliptic-lanceolate, chartaceous, obtuse or obtusely somewhat acuminate at apex, cuneate at base, margins entire, thickened, undulating in dry specimens, very sparsely ciliate with long hairs, older ones glabrous on both surfaces except the midrib which bears few scattered long hairs beneath and rather dense short hairs above in the lower region; midrib subcanaliculate above, glabrous except in basal part near the petiole, raised beneath with few scattered long hairs; lateral nerves not conspicuous as they merge with reticulate venation; petioles 2-5 mm long, hairy, canaliculate above and rounded beneath. Male flowers sessile, usually in 3-flowered, axillary, pedunculate, hairy cymes, sometimes cymes 1-flowered due to fall of lateral ones. Flower-buds ovoid, acuminate. Calyx 4-5 mm long, campanulate, pubescent bothsides, divided half way down, 3-lobed; lobes ovate, subacute, ciliate, valvate. Corolla tubular, 6-8 mm long, hairy outside along the middle line of lobes, glabrous within; lobes 3, almost oblong, contorted. Stamens 9-12, hypogynous, seated on the torus, neither united in pairs nor attached to the corolla- tube, subequal; filaments 2-3 mm long, glabrous; anthers 1.5-2.5 mm long, linear, obtusely narrowed at apex, not apiculate, connectives not produced, glabrous. Pistillode densely hairy, the central hairs about as long as filaments. Female flowers subsessile, axillary, solitary, 3-merous. Calyx campanulate, 5-8 mm long, divided half way down, hairy bothsides; lobes ovate, subacute, valvate. Corolla tubular, 7-10 mm long, hairy along the middle line of lobes outside, glabrous within; lobes 3, ovate, acute, contorted. Staminodes absent. Ovary globose-trigonous, *ca* 1.5 mm in diam., densly silky hairy, 1 to 3-celled, cells 2-ovuled; style 1, *ca* 1 mm long, hairy at base, glabrous above; stigma 3-lobed. Fruits 5-7 mm in diam., globose, apiculate at apex by the remains of styles, silky hairy when young, becoming glabrous on maturity except in the styler region in upper part. Fruiting-calyx cupuliform, enclosing the lower part of the fruit, pubescent bothsides; lobes 3, erect, touching the fruit. Seeds 1-3, oblong, glabrous; albumen equable (Fig.-40; Plate 15/2 & 3).

Distrib. Sketch Map – 11

● *Diospyros multibracteata* (Merr.) Bakh.;

▲ *Diospyros neilgherrensis* (Wight) Kosterm.

Holotype : Peninsular Indiae Orientalis, *Wight* 1730 ♀ (K).

Fl. & Fr.: June – September, sometimes most part of the year.

Ecol.: Usually found in the forests along the hills, upto 1500 m; rarely grows along the outer border of forests in the coastal areas especially in the regions which regularly return to a period of drought.

Distrib.: Endemic to India, confined to Maharashtra, Goa, Daman & Diu, Karnataka, Andhra Pradesh, Tamil Nadu and Kerala (**Map-11**).

Pollen : Pollen grains 3-colporate, prolate- spheroidal (35 x 34 µm). Colpi long, streaky, with psilate membrane. Ora la-longate, margins irregular and membrane psilate. Sexine as thick as nexine and sexine pattern obscure (Sharma & Gupta, 1979).

Notes : *Maba angustifolia* Miq. (1852) and *M. nigrescens* Dalz. (1861) have been considered conspecific by most of the workers. Bakhuizen (1937) reduced *M. angustifolia* Miq. to the variety of *D. ferrea* (Willd.) Bakh. and Kostermans (1977a) transferred this taxon to *Diospyros* L. at specific level as *D. angustifolia* (Miq.) Kosterm. which is illegimate being later homonym of Lodd. ex Loud (1838) and Audib. ex Spach (1838). As such, Saldanha proposed new combination under *Diospyros* L. as *D. nigrescens* (Dalz.) Saldanha based on next available specific name *Maba nigrescens* Dalz. Perusal of protologue of *Maba nigrescens* Dalz. and type material in Kew herbarium revealed it difficult to distinguish it from *D. neilgerrensis* (Wight) Kosterm. However, Bakhuizen (1937) has made an attempt to distinguish *D. ferrea* (Willd.) Bakh. var. *angustifolia* (Miq.) Bakh. from its allied var. *neilgerrensis* (Wight) Bakh. by comparatively larger leaves in former. Present study revealed that the characters used by Bakhuizen (1937) and other workers to distinguish two taxa do not hold good and the Indian material identified as *D. nigrescens* (Dalz.) Saldanha, *D. neilgerrensis* (Wight) Kosterm. and *D. angustifolia* (Miq.) Kosterm. are the same. As such, I propose to merge all these taxa under *D. neilgerrensis* (Wight) Kosterm. Hiern (1873) and Bakhuizen (1937) have wrongly spelt the specific epithet as *neilgherrensis*.

Exsicc.: GOA : North Goa, Colem Range, Anmod Molem, 15th March 1971, *K. N. Bahadur & R. C. Gaur* 2395 ♀ (DD); Anmod, 28th Sept. 1972, *K. C. Sahni* 3391 ♀ (DD); KARNATAKA : Belgaum, Vingurla Road, 26th April 1902, *G. A. Gammie* 15002 ♀ (BSI); Mysore, Balehalli, Agumbe, 19th May 1960, *R. S. Raghavan* 62685 ♀ (CAL); Varahi-Hulical, 24th March 1964, *R. S. Raghavan* 97166 ♂ (CAL); Western Ghats, Castle Rock, May 1917, *L. J. Sedgwick* 2460 ♀ (CAL); South Kanara, Subramanya, 18th May 1979, *B. G. Kulkarni* 155010 ♀ (BSI); North Kanara, Ainshi, June 1985, *W. A. Talbot s.n.* ♀ (DD); Shimoga, Jog, 16th April 1950, *A. R. Braganza* 57 ♀ (DD); Jog fall, 28th April 1939, *N. L. Bor* 11368 ♀ (DD); 1st May 1939, *N. L. Bor* 11334 ♀ (DD); MAHARASHTRA : Ratnagiri, Amberi, 1300 m, 8th May 1994, *Jony Augustine* 13768 ♀ (KFRI); Ramghat forest, 6 miles from Chankul, 1st May 1966, *B. G. Kulkarni* 100058 ♂ (BSI); Bombay, Devimani, 29th April 1939, *N. L. Bor* 11301 sterile (DD); TAMIL NADU : Coimbatore, Tadagam hills, 1200 m, 26th April 1911, *C. E. C. Fischer* 2681

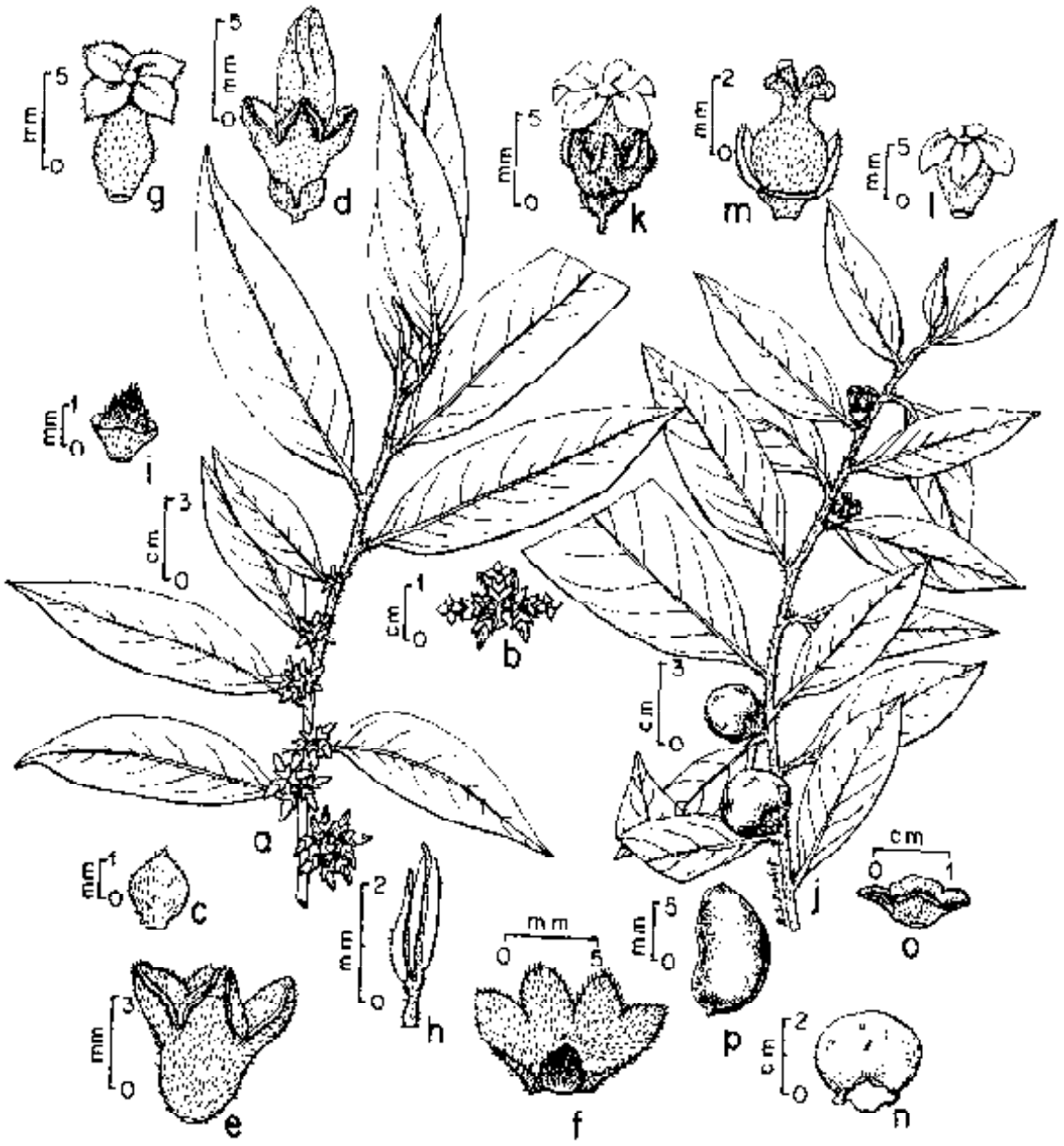


Fig.-41. ***Diospyros nilagirica*** Bedd.

Male : a. habit, b. inflorescence, c. bract, d. flower-bud, e. calyx, f. calyx within with pistillode, g. corolla, h. stamens, i. pistillode. *Female* : j. habit, k. flower with bracts, l. corolla, m. gynoecium, n. fruit with calyx, o. fruiting-calyx, p. seed.

♀ (MH); Ramanathapuram, On way to Deviar Estate, Sethur hills, 800 m, 10th June 1979, *S. R. Srinivasan* 61499 ♀ (MH); Nilgiri, Bokkapuram R. F., 1400 m, 17th April 1971, *N. C. Rathakrishnan* 37936 ♂ (MH); Madurai, Thandikudi-Kodaikanal, 1500 m, 27th April 1965, *K. Ramamurthy* 23641 ♂ (MH).

43. ***Diospyros nilagirica*** Bedd. Ic. Pl. Ind. Or. 7 : 27. t. 136. 1871; Clarke in Hook. f. Fl. Brit. India 3 : 566. 1882. *D. hirsuta* L. f. forma *nilagirica* (Bedd.) Hiern in Trans. Cambr. Philos. Soc. 12 : 164. 1873.

English name : Ebony.

Vernacular names : *Mal.*: Karinchora, Karinthuvara; *Tam.*: Karu.

Large trees, upto 25 m high, with rufous tomentose branchlets. Leaves alternate, 6.5-15 x 2-6 cm, elliptic, bluntly acuminate at apex, cuneately narrowed at base, coriaceous, mature ones glabrous and shining above, glabrous beneath except rarely on the midrib, youngest ones densely rufous hairy, margins slightly revolute in dry specimens; midrib glabrous and canaliculate above, glabrous or slightly hairy and raised beneath; lateral nerves 6-9 pairs, arcuating towards apex, rather prominent beneath; petioles 5-10 mm long, canaliculate above, rounded beneath, rufous pubescent. Male flowers in axillary, subsessile, many-flowered, congested and densely rufous hairy, bracteate cymes. Bracts ovate-suborbiculate, abruptly acute, densely rufous tomentose bothsides, 2 subtending each flower. Calyx campanulate, 4-6 mm long, 4-lobed, divided upto the middle, densely rufous hairy bothsides; lobes ovate, obtuse, margins reflexed, valvate. Corolla tubular, 6 8 mm long, hairy outside, glabrous within, 4-lobed; lobes rounded, contorted. Stamens 16, united in pairs, subequal in each pair, inserted at the base of corolla-tube; filaments 1-2 mm long, often hairy; anthers 2-3 mm long, glabrous or hairy on the back along middle line, apiculate due to produced connectives. Pistillode small, ovoid, hairy. Female flowers solitary or geminate, sessile, axillary. Calyx and corolla as in males but slightly larger. Staminodes 8, alternately longer. Ovary globose, hairy, 8-celled, cells 1-ovuled; styles 4, hairy, much reflexed; stigmas dilated. Fruits depressed globose, 2-3 cm in diam., glabrous on maturity, hairy when young. Fruiting-calyx bowl-shaped, pubescent outside; lobes with outwardly rolled margins and reflexed forming a circular mouth of the bowl with thickened rim, fruit seated in the cavity of bowl. Seeds 8, oblong-semilunar, 10-12 x 6-8 mm, smooth, shining, light brown; albumen equable (**Fig.-41; Plate 15/4 & 16/1**).

Holotype : India : Nilgiris, Sispara-ghat, *Beddome s. n.* (BM).

Fl. & Fr.: April – February.

Ecol.: Found on Nilgiris and Pulney hills in evergreen forests, between 900-2200 m. Occasionally metwith along the margins of sholas.

Distrib.: Considered endemic to India, confined to Karnataka, Tamil Nadu and Kerala. However, Hiern (1873) has recorded its occurrence at Singapore (*Wallich* 4127) and Molucca (*Maingay* 970, 973; Griffith 3637); probably cultivated outside India (**Map-12**).

Pollen : Pollen grains 3-colporate, sub-prolate (35 x 28 µm). Amb sub-circular. Colpi long, thin, running from pole to pole, margins uneven with psilate membrane. Maximum width of colpus about 1.5 µm. Mesocolpium 16 µm. Ora la-longate, with psilate membrane. Exine about 2 µm thick. Sexine as thick as nexine and sexine pattern psilate (Sharma & Gupta, 1979).

Anatomy : The wood is diffuse-porous. Pores scanty, moderate-sized, often subdivided into 3 or 4 and then in radial or oblique strings. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The transverse bars prominent, combined into narrow concentric wavy lines. The heartwood and sapwood are indistinct, straight-grained and fine-textured. The timber is susceptible to dry wood borer (Gamble, 1881; Wright, 1904; Purkayastha, 1982).

Exsicc.: KARNATAKA : Kodagu, Gallibedu, Mercara taluk, *J. P. Pascal* 859 (HIFP); KERALA : Travancore, *T. F. Bourdillon* 169 ♀ (K); Panchanpallam, 1300 m, 21st April 1994, *Jony Augustine* 13567 ♀ (KFRI); Calicut, Nilambur, Karuvaralaund, 27th Feb. 1983, *P. Mathew* 33822 sterile (CALI); Palghat, Kudam area, 850 m, 28th April 1979, *E. Vajravelu* 62943 ♂ (MH); Palghat R. F., Aug. 1926, *J. S. Gamble* 6406 (DD); Silent Valley, Sispara, 2200 m, 8th March 1982, *C. S. Kumar* 10174 ♂ (CALI); Quilon, Pamba Dam to Kakki Dam, 1000 m, 13th March 1980, *K. Vivekananthan* 66213 ♂ (MH); Kottayam, Above Kakkada R. F., Ranni valley, 13th March 1980, *C. E. Ridsdale* 604 ♂ (L); Peermade, April 1894, *T. F. Bourdillon* 170 ♀ (DD).

44. ***Diospyros oocarpa*** Thw. Enum. Pl. Zeyl. 180. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 171. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 560. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 12. 1981. *D. arnottiana* Miq. ex Thw. Enum. Pl. Zeyl. 423. 1860.

Vernacular names : *Kan.*: Kalu-kadumberiya; *Tam.*: Vellei-karankali, Vellaikkarungali, Vellaikarunkkali.

Trees, upto 30 m high, with pubescent branchlets becoming soon glabrescent, unarmed. Leaves alternate, 5-11.5 x 2.5-5 cm, oblong-broadly elliptic, cuneate at base, obtusely acuminate at apex, glabrous bothsides except the midrib and lateral nerves especially beneath; midrib subcanaliculate above, raised beneath, thinly pubescent; lateral veins 8-10 pairs, prominent bothsides, arcuating towards apex; petioles 4-10 mm long, flat or subcanaliculate above, rounded beneath, pubescent. Male flowers in 3 to 7-flowered, axillary, densely fulvous silky, bracteate cymes. Flower-buds 7-8 mm long, narrowly ovate, pointed at apex, densely ferruginously pubescent. Bracts 1.5-2 mm long and about as wide, concave-rounded, obtuse, pubescent on dorsal surface, glabrous ventrally, each subtending a flower. Calyx *ca* 4 mm long, tubular, almost truncate at mouth with usually 3 or rarely 4 (Hiern, 1873) small teeth, densely pubescent outside, glabrous within; lobes broadly triangular, valvate. Corolla tubular,

7-12 mm long, sericeous outside, glabrous within, tube constricted below the lobes; lobes usually 3 or rarely 4 (Hiern, 1873), ovate, obtuse, reflexed, densely pubescent outside, one of the lobe is completely enclosed by the other in bud and rest imbricating dextrorsely or sinistrosely or contorted. Stamens 9-14, inserted at the base of corolla-tube or epipetalous and hypogynous, free or some in pairs, arranged in 2-3 rows, outer ones longest and inner ones smallest; filaments 0.5-2 mm long, glabrous; anthers 1-1.5 mm long, ovate, hastate at base, apiculate at apex with a tuft of hairs at the tip, glabrous or sometimes pubescent along the sutures, dehiscing along the longitudinal slit. Pistillode hairy. Female flowers usually solitary, sometimes 1 to 3-together, axillary; pedicels 4-5 mm long, ferruginously hairy, thickened upwards, no distinct articulation with the flowers. Bracts 2 or more, imbricating at the base of pedicels, 2-2.5 mm long, broadly ovate to suborbicular, concave and glabrous within and densely hairy outside. Calyx campanulate or bell-shaped, 3-4 mm long, densely hairy outside, glabrous within, mouth almost truncate, about as wide as calyx-tube; lobes usually 3 or rarely 4 (Hiern, 1873), indistinct, valvate. Corolla tubular, 9-13 mm long, densely hairy outside, glabrous within; lobes usually 3 or rarely 4 (Hiern, 1873), 3-4 mm long, ovate, reflexed, aestivation as in males. Staminodes 3, with *ca* 2 mm long, glabrous filaments and *ca* 1 mm long, pubescent anthers. Ovary globose-ovoid, densely ferruginously hairy, usually 6-celled, rarely 8-celled (Hiern, 1873), cells 1-ovuled; style 1 or rarely 2; stigmas 1-3. Mature fruits *ca* 3.5 x 2.3 cm, oblong-ovoid, young ones cylindrical, longitudinally grooved, 1-seeded, clothed with appressed ferruginous hairs when young, becoming glabrescent with age. Young fruiting-calyx bell-shaped, 4-5 mm long, with about as wide truncate mouth, densely ferruginously hairy outside, glabrous within; lobes 3, broad, not conspicuous, tube appears truncate, lower part of fruit enclosed within the tube. Seeds flattened, elliptic, with two longitudinal grooves; cotyledons narrow, elliptic; testa brown, glossy; albumen equable. Mature fruits were not available to me and description has been borrowed from the literature cited (**Fig. 42; Plate 16/2 & 3**).

Holotype : Ceylon : Kornegalle, *Thwaites* 1914 (PDA).

Chr. No.: 2n=30 (Chatterji, 1964).

Fl. & Fr.: February – December.

Ecol.: In dry evergreen forests in semi-arid zones, upto 1000 m. The germination of seeds is epigeal and cotyledons get detached early.

Distrib.: Confined to southern parts of India, chiefly to Maharashtra, Goa, Karnataka, Kerala, Tamil Nadu and Andaman & Nicobar Islands. It extends further southwards to Sri Lanka – its native home (**Map-12**).

Pollen : Grains 3-zonocolporate; endocolpium lo-longate, 3 x 1 µm. Exine surface psilate. Size 30-34 x 22-26 µm (Nair & Kothari, 1985).

Anatomy : There are three traces in each cotyledon and xylem splits into 8-13 strands. Each epicotyledonary leaf possesses one trace, continued below cotyledonary node (Wright, 1904). The heartwood in young trees is small, black or brown and sapwood is of a faint red tinge. However, the

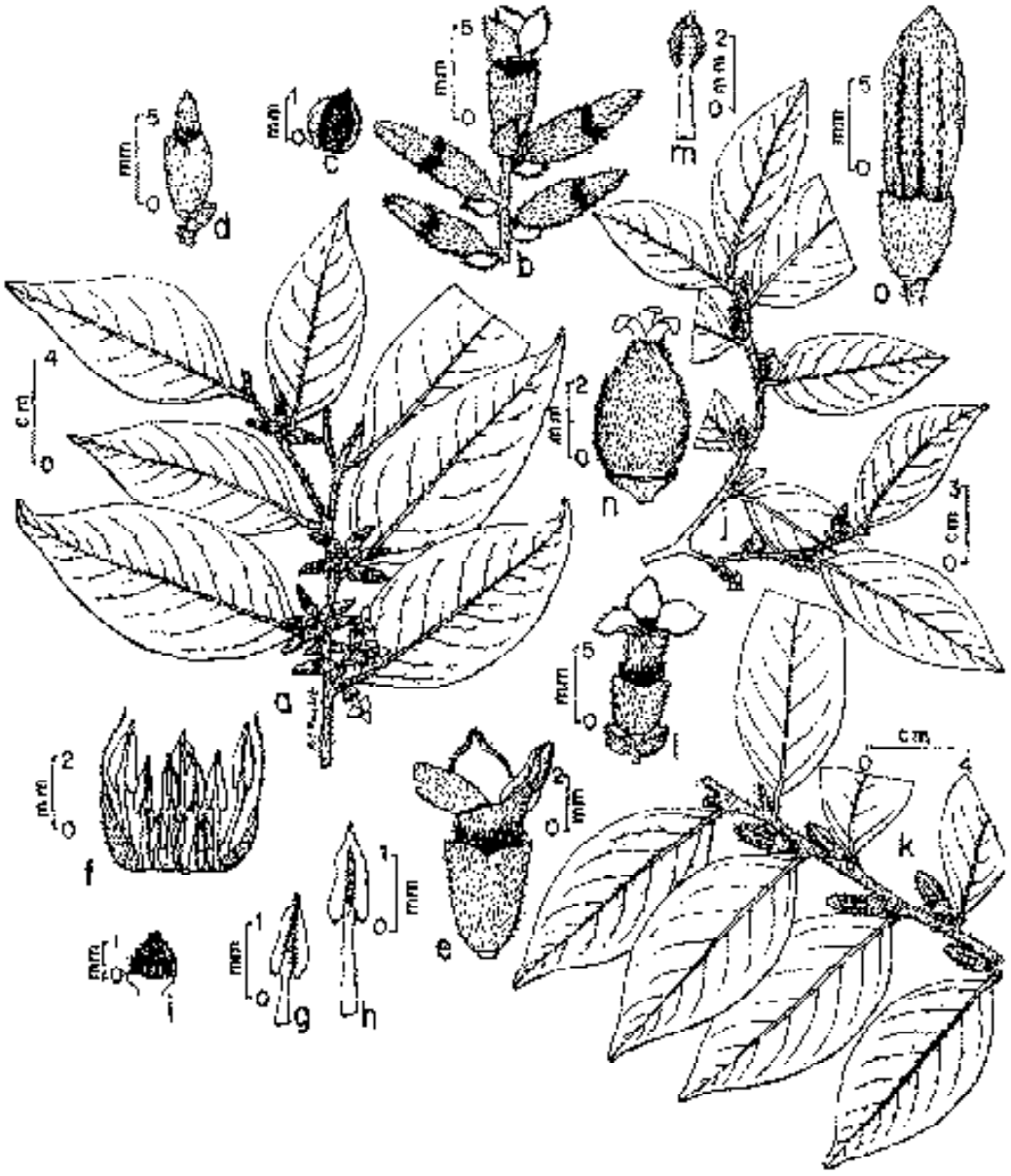


Fig. 42. ***Diospyros ocarpa*** Thw.

Male : a. habit, b. inflorescence, c. bract, d. flower-bud with bract, e. flower, f. corolla within with stamens, g-h. stamens, i. pistillode.

Female : j-k. habit, l. flower, m. staminode, n. gynoecium, o. young fruit with calyx.

large trees possess coloured heartwood of considerable size, irregular in outline and presents a beautiful alternations of black and brown layers. The sapwood of large trees possesses irregular dark lines. The coloured material occurs in all elements of sapwood except the fibres. In the heartwood all elements, including fibres, are filled with brown or black contents. Anatomically the timber is characterized by abundance of closely set fibres, the large tracheal elements and low percentage of medullary ray cells. The differentiation is very irregular. Rings of growth are very inconspicuous (Wright, 1904).

The length of vessels of twigs is about 0.23 mm, with radial diameter *ca* 0.027 mm and tangential diameter *ca* 0.025 mm. The sapwood, however, bears 0.42 mm long vessels. The tangential and radial diameter of latter are 0.07 mm and 0.06 mm respectively. The length of wood parenchyma cells in sapwood varies from 0.06 to 0.13 mm, with 0.013 mm radial diameter. The radial diameter of wood fibres in sapwood is about 0.010 mm and in heartwood *ca* 0.009 mm. The diameter of vertical medullary ray cells is 0.015 mm radially and 0.014 mm tangentially, with 0.05 mm vertical length. The radial diameter of horizontal components is 0.04 mm and tangential is *ca* 0.012 mm, with 0.018 mm vertical length (Wright, 1904).

Uses : The timber of young trees is often used for furniture and cabinet work and considered equal to Calamander for ornamental purposes. Andaman Marble wood is commonly produced by *D. kurzii* Hiern, but Parkinson (1923) refers it to *D. oocarpa* Thw.

Exsicc.: GOA : Valpoi, Kodar, 12th March 1971, *K. N. Bahadur & R. C. Gaur* 1439 sterile (DD); KARNATAKA : North Kanara, 25th Feb. 1892, *W. A. Talbot* 2724 ♂ (BSI); June 1910, *W. A. Talbot* 1232 ♀ (DD); Kanara-West division, Aug. 1961, *A. Krishnaswamy* Acc. No. 135535 ♀ (DD); South Kanara, Sitanadi, 6th March 1963, *R. K. Arora* 2975 ♀ (CAL); Kodagu, Coorg, Watekolle R. F., Makulta-Virajpet road, 21st Feb. 1984, *E. Vajravelu* 77818 ♂ 77819 ♀ (MH); Dharwar, Devimani, May 1939, *N. L. Bor* 11588 ♀ (DD); 21st April 1950, *K. M. Vaid* 96 ♀ (DD); KERALA : Travancore, Mercheston, 15th May 1896, *T. F. Bourdillon* 884 ♀ (DD); MAHARASHTRA : Ratnagiri, Girbyachi Rai, Near Naradave, 17th Feb. 1970, *B. G. Kulkarni* 120138 ♂ (BSI); TAMIL NADU : Tirunelveli, Kannikatti, 750 m, 21st Feb. 1913, *D. Hoopper & M. S. Ramaswami* 39430 sterile (CAL).

45. ***Diospyros ovalifolia*** Wight, Ic. Pl. Ind. Or. 4 (1) : 10. t. 1227. 1848; Hiern in Trans. Cambr. Philos. Soc. 12 : 237. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 557. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 15. 1981, non *Maba ovalifolia* (Thw.) Hiern 1873.

English name : Bastard Ebony.

Vernacular names : *Tam.*: Vedikkanru, Vedukunari; *Tel.*: Kukkatumiki.

Dioecious trees, upto 15 m high, glabrous except with few scattered hairs on very young branchlets, petiole and inflorescence. Bark lenticelled, with black ridges and brown fissures striped longitudinally in old trees. Leaves alternate, 4-12.5 x 2.2-6.5 cm, obovate, oblong, obovate-oblong or

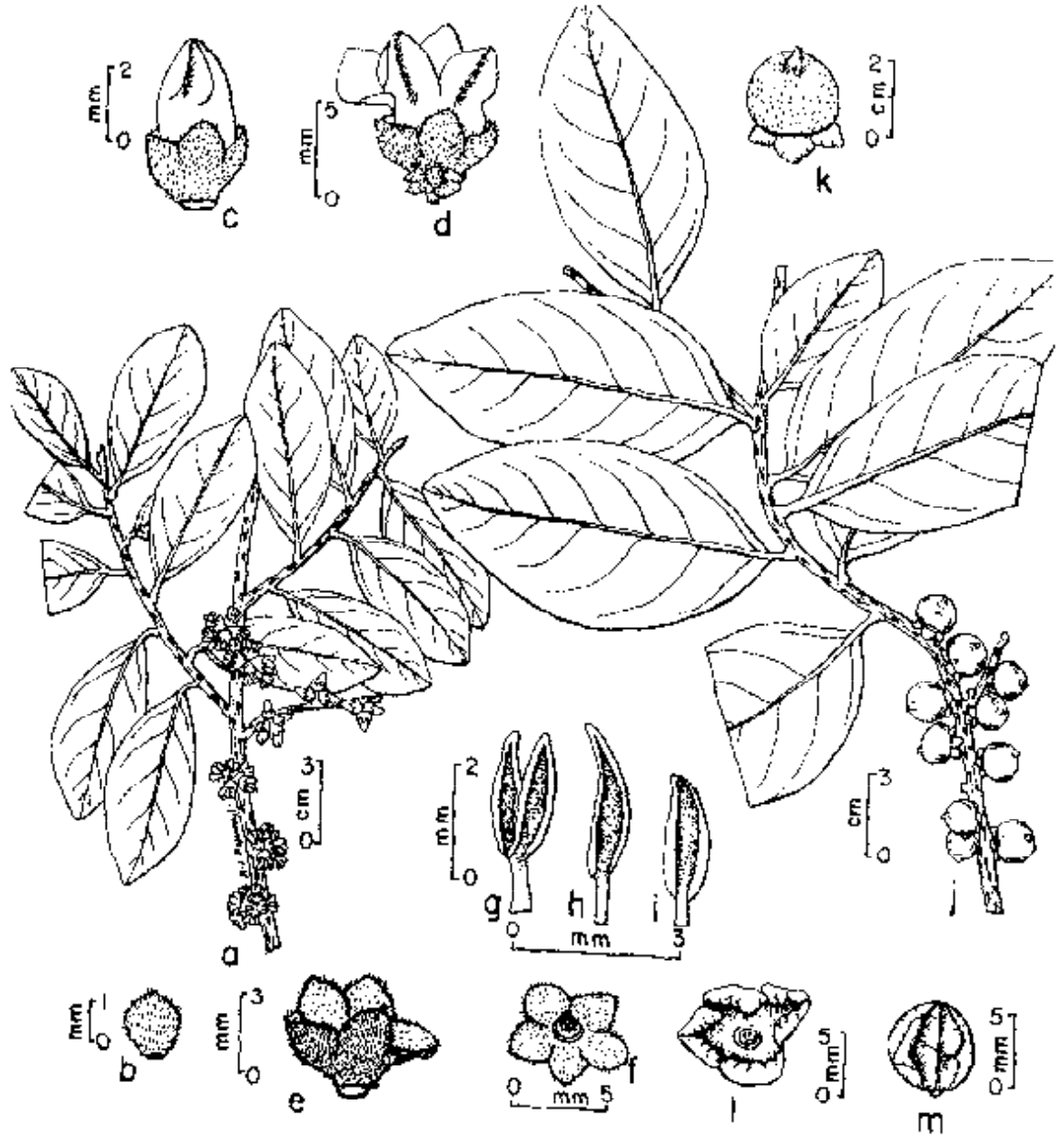


Fig.-43. ***Diospyros ovalifolia*** Wight

Male : a. habit, b. bract, c. flower-bud, d. flower with bracts, e. calyx, f. calyx within with pistillode (top view), g-i. stamens.

Female : j. habit, k. fruit with calyx, l. fruiting-calyx, m. seed.

elliptic, obtuse or rounded at apex, subcuneate or subrounded at base, thinly coriaceous, glabrous; midrib glabrous and canaliculate above, raised and glabrous or with few scattered hairs beneath, reddish; lateral nerves 6-9 pairs, rather bold than intermediate reticulation, arcuate towards apex; petioles 4-10 mm long, glabrous or thinly hairy. Male flowers yellow, in bracteate, sessile cymose clusters of 3-7 flowers on woody twigs in the axils of leaves or fallen leaves. Flower-buds ovate. Bracts rhomboid-ovate, obtuse, 1.5-2 mm long, densely hairy bothsides, closely imbricated forming a basal involucre. Calyx openly campanulate, 3-4 mm long, with wide mouth upto 7 mm, densely adpressed pilose bothsides, divided about halfway down; lobes 4-5, orbicular or deltoid, thick, imbricate. Corolla urceolate, 5-8 mm long, divided halfway down, glabrous bothsides except along the middle line of lobes; lobes 4-5, oblong-suborbicular, obtuse, spreading or recurved, hairy along the middle line outside, contorted. Stamens 15 (13-15-20, Hiern, 1873), subequal, inserted at the base of corolla-tube, paired or not, glabrous; filaments upto 1 mm long, much shorter than anthers; anthers 2-2.5 mm long, glabrous, obtuse or narrowed at apex like a beak, not apiculate due to produced connectives, almost flat in bud. Pistillode a small hairy disc. Female flowers solitary or in clusters of 2-6 (3-9, Kostermans, 1981) in leaf axils or on bare twigs. Bracts 2-3, deciduous. Calyx and corolla as in male flowers but little larger. Staminodes usually 4 or rarely 1-7 or absent (Hiern, 1873; Clarke, 1882). Ovary conical, densely hairy or pubescent, usually 4-celled or rarely 6-celled (Hiern, 1873), cells 1-ovuled; stigmas 2-4, reniform. Fruits globose, 1-2 cm in diam., subsessile, 1 to 3-together, borne on old branches with fallen leaves, apiculate at apex with style remains, pubescent when young and becoming glabrate on maturity except in lower part, 1-seeded. Fruiting-calyx densely hairy bothsides, enlarged, 10-13 mm in diam., tube almost flattened and disciform, fruit seated on the disc; lobes thick but not dilated, strongly reflexed, margins rolled outwards. Seeds ca 9 x 5-7 mm, usually somewhat globose or wedge-shaped, smooth, brown, shining; cotyledons ovate, rounded at the base and apex; albumen equable; testa prominently veined **(Fig.-43; Plate 16/4 & 17/1)**.

Holotype : India : Tamil Nadu, Coimbatore, *Wight* 1720 (K).

Fl. & Fr.: Throughout the year.

Ecol.- In dry and moist deciduous forests, upto 1600 m. The seeds take much longer period (upto 9 months) in germination due to hard testa and horny endosperm. In this species, the testa do not split at all and as such cotyledons do not find sufficient exist except small circular micropylar opening. The seedlings are glabrous. Further, the flowering starts quite late in this species after the tree has attained considerable dimension.

Distrib.: The species finds distribution in southern parts of India, especially in Andhra Pradesh, Karnataka, Kerala and Tamil Nadu, sometimes in Assam and Madhya Pradesh. It extends further southwards to Sri Lanka and eastwards to Malaysian Islands **(Map-12)**.

Anatomy : Vascular traces two in each cotyledon which do not split to any great extent at the node and give a 4-cornered appearance to the vascular cylinder in hypocotyl. Epicotyledonary traces are solitary in each leaf. In the apex of the primary root there are only eight strands, developed by splitting

Distrib. Sketch Map – 12

● *Diospyros nilagirica* Bedd.;

▲ *Diospyros aocarpa* Thw.; ■ *Diospyros ovalifolia* Wight

of four cotyledonary strands or may consist of two epicotyledonary and six cotyledonary strands (Wright, 1904).

Timber of young trees has small brown heartwood and pale pinkish sapwood. However, mature timber has black heartwood with alternating black and brown layers and sapwood with black lines. The wood has high percent of tracheal elements and small quantity of gum-resin (Wright, 1904).

The size of vessels in twigs is about 0.20 mm, with 0.024 mm radial and 0.024 mm tangential diameter. The sapwood, however, bears vessels of 0.40 mm length, with 0.05 mm radial and tangential diameter. The length of wood parenchyma cells in sapwood varies from 0.09 to 0.13 mm, with 0.011 mm radial diameter. The radial diameter of wood fibres in sapwood is 0.008 mm and in heartwood 0.0075 mm. The radial diameter of vertical medullary ray cells is 0.018 mm and tangential *ca* 0.016 mm, with vertical length *ca* 0.06 mm. In horizontal components the radial diameter is 0.07 mm and tangential *ca* 0.02 mm, with 0.09 mm vertical length (Wright, 1904).

Uses : The ripe fruits are edible. Leaves are used medicinally for gonorrhoea, blood poison etc. They are also used as fish poison (Nayar *et al.*, 1989). Timber is used for furniture and building construction.

Exsicc.: ASSAM : Sibsagar, Barpather, 81 m, 23rd April 1914, *U. N. Kanjilal* 3880 sterile (CAL); KERALA : Travancore, Arienkavoo, *T. F. Bourdillon* 6889 ♀ (DD); MADHYA PRADESH : Bhupdeopur forest area, 1st Feb. 1986, *Peerzada* Acc. No. 2028020 (LWG); TAMIL NADU : Tiruvallur, Madras, Top slip, Oct. 1838, *D. F. O.* 310 ♀ (DD); Nov. 1937, *N. L. Bor* 7945 ♀ (DD); Nilgiri, Ronning-town forest, 500 m, 25th June 1974, *E. Vajravelu* 44947 sterile (RHMD); Coimbatore, Kurudimalai, North slope, 1000 m, 6th July 1971, *M. V. Viswanathan* 1001 ♀ (MH); 700 m, 5th April 1960, *B. V. Shetty* 10217 ♂ (MH); Tirunelveli, Kottabomman, Kollimalai Estate, Sivagiri hills, 1000 m, 22nd April 1989, *S. R. Srinivasan* 89541 B& (MH); Melnilidanallur, 1600 m, 6th May 1994, *Jony Augustine* 13738 ♂ (KFRI).

46. ***Diospyros paniculata*** Dalz. in Hook. Kew J. Bot. 4 : 109. 1852, non King & Gamble 1905; Hiern in Trans. Cambr. Philos. Soc. 12 : 190. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 570. 1882; Jayaraman in Bull. Bot. Surv. India 34 (1-4) : 230. 1992.

English name : Ebony.

Vernacular names : *Kan.*: Kuri-koomar; *Mal.*: Kari, Karivella, Illakatta, Karumaram, Kakka-Karimaram, Panicha, Karimaran; *Sans.*: Thinduka; *Tam.*: Karinthovarai, Karunduvarai; *Tel.*: Vasa, Vadaja.

Trees, 10-15 m high, with finely pubescent and nigro-pilose young branches becoming glabrate with age; branches somewhat angular or ribbed. Leaves alternate, 6-19 (-27) x 3-8 cm, broadly oblong or lanceolate or sometimes obovate-oblong, rounded or narrowed at the base, acute, obtuse, rounded or acuminate at apex, subcoriaceous, glabrous, shining; midrib flat to canaliculate and glabrous above, prominently raised and glabrous or finely pubescent beneath; lateral nerves 6-10 pairs, prominent

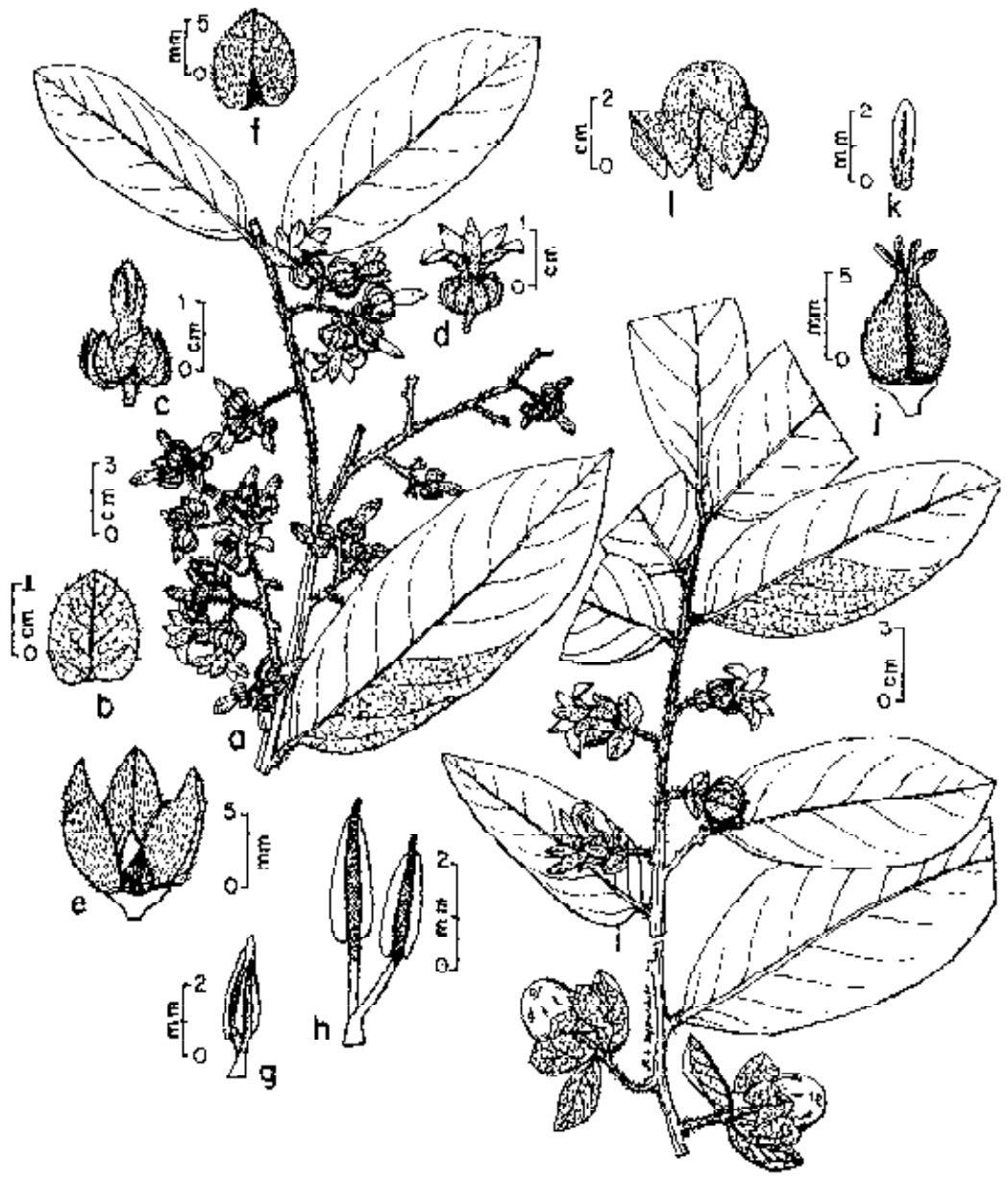


Fig.-44. ***Diospyros paniculata*** Dalz.

Male : a. habit, b. bract, c. flower-bud, d. flower, e. calyx within with pistillode, f. calyx-lobe, g-h. stamens.

Female : i. habit, j. gynoecium, k. stigma, l. fruit with calyx.

beneath, highly reticulated between the nerves; petioles 4-10 mm long, pubescent and nigro-pilose, flat or canaliculate above, rounded beneath. Male flowers in lax, few-flowered, pubescent, bracteate, long-peduncled, paniculate cymes borne in the axils of fallen leaves; peduncles 1-5 cm long, pubescent and nigro-pilose; pedicels 5-15 mm long, pubescent and nigro-pilose. Bracts sessile, ovate-suborbicular, obtuse, foliaceous, 7-15 x 6-12 mm, membranous, glabrous or with few scattered stiff hairs on dorsal surface and on the margins, reticulately veined, deciduous. Calyx openly campanulate, upto 10 x 13 mm, deeply 5-lobed nearly to the base, puboscent and sparsely nigro-pilose bothsides; tube *ca* 1 mm long; lobes broadly ovate-suborbicular, 5-10 x 5-7 mm, foliaceous, obtuse at apex, subcordate at base, midrib raised on dorsal surface and grooved ventrally especially in basal region, reticulately veined, margins widely reflexed, imbricate in bud. Corolla 10-15 mm long, tubular, somewhat pentagonal, velvety outside, glabrous within; tube narrowed at the junction with lobes; lobes 5, broadly oblong, spreading or reflexed, thinly pubescent within in upper half, velvety outside, contorted. Stamens 15 or 20, inserted at the base of corolla-tube or hypogynous and seated on the torus, paired, inner ones rather short; filaments 1-2 mm long, glabrous; anthers 2.5-3 mm long, distinctly apiculate at apex due to produced connectives, glabrous. Pistillode represented by a tuft of hairs, inconspicuous. Female flowers axilliary, solitary or in 2 to 5-flowered cymes; peduncles/pedicels *ca* 2 cm long in flower, enlarging upto 4 cm in fruit, ribbed, pubescent and nigro-pilose. Bracts sessile, ovate-suborbicular, 1-1.5 x 0.7-1.3 cm, paired, glabrous, deciduous, inserted at about middle of the peduncle/pedicel. Calyx thinly pubescent bothsides, otherwise as in males but little larger. Corolla as in males; lobes 5, contorted. Staminodes absent. Ovary ovoid, clothed with fuliginous and ferruginous hairs and glands, 4-celled, cells 1-ovuled; styles 2, short, stout and hairy; stigmas 4, ligulate, hairy on inner face. Fruits 2-4 x 3 cm, ovoid, hirsute when young, becoming glabrate with age, crowned with remains of styles. Fruiting-calyx accrescent, much enlarged, plicate, umblicate below, enclosing half or more than half lower part of the fruit, tube flattened and reflexed, as such the lobes are also pushed downwards, then lobes bend upwards about in the middle and become erect enclosing the fruit, the lower part of the lobes become hastate forming 5 distinct processes and distinct auricled base in the middle of each lobe; lobes 5, foliaceous, almost suborbicular, imbricated at base, almost glabrous, distinctly veined. Albumen equable (Fig.-**44; Plate 17/2 & 3**).

Holotype : India : Maharashtra, Syhadree Mts. Chorla Ghat, 600-900 m, *Dalzell s. n.* (K).

Fl. & Fr.: April – September.

Ecol.: Rare, found in broad-leaved wet forests on the hills and in valleys, upto 1200 m. The plants may be propagated through seeds and vegetative methods (Prajapati *et al.*, 2003). The important insect pests are borer *Platypus latifinis, P. uncinatus* and *Xyleborus testaceus,* which are reported on this species.

Distrib.: Considered endemic to India, confined to Chhattisgarh, Maharashtra, Goa, Karnataka, Kerala and Tamil Nadu. Recently, it has extended to West Bengal (Jayaraman, 1992). King & Gamble

(1905) reported this taxon from Malayan peninsula (Perak). If identity of specimens from Perak is correct, it is a case of disjunct distribution (**Map-13**).

Anatomy : The wood is diffuse-porous. Pores very scanty, moderate-sized or large, faintly obliquely echeloned. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained, fine-textured. The timber is susceptible to dry wood borer (Gamble, 1881; Wright, 1904; Purkayastha, 1982).

Uses : The powdered bark is useful in rheumatism and ulcers. The decoction of the fruits is given in gonorrhoea, biliousness and in cases of blood poisoning. The fruits are dried, powdered and applied to heal burns. The leaves are used as fish poison. Wood is white, with iron-grey heartwood, streaked with darker lines and soft. It is suitable for match boxes and sometimes used for house building.

Exsicc.: CHHATTISGARH : Bastar, Konpagaon, 550 m, 21st Jan. 1972, *C. R. Das* 15090 ♀ (BSA); GOA : Vergni hill top, 7th May 1976, *Peerzada* 94969 ♀ (LWG); KARNATAKA : North Kanara, 25th Jan. 1893, *W. A. Talbot* 2865 ♂ (BSI); KERALA : Trivandrum, Agasthyamalai, 1000-1200 m, 1st April 1989, *N. Mohanan* 5506 ♂ (TBGT); Bomaccord, 700-750 m, 17th May 1988, *N. Mohanan* 9877 ♀ (TBGT); Koruttiode, 200 m, 4th Aug. 1993, *Jony Augustine* 12221 ♀ (KFRI); Quilon, Ariankavu Reserve, Tenmalai side, Opp. to Tenmalai Rly. Station, 6th Feb. 1961, *Without Collector* 63391 ♂ (BSI); Way to Kallar Estate, 1200 m, 6th Sept. 1977, *N. C. Nair* 50926 ♀ (MH); Pathanamthitta, Sabarimala-Pamba, 600 m, 14th April 1978, *C. N. Mohanan* 55505 ♀ (MH); Pamba-Sabarimala R. F., Near Bus Stand, 24th April 1984, *E. Vajravelu* 80579 ♀ (MH); Palghat, Kaikatty to Pothundy, 725 m, 28th Feb. 1975, *E. Vajravelu* 45791 ♂ (MH); Chenal-Nair, 25th Feb. 1928, *E. V. P. Pillai* Acc. No. 45432 (DD); Cannanore, Nedumpoyil, 550 m, 27th Feb. 1979, *V. S. Ramachandran* 61966 ♂ (MH); Travancore, Hill slopes, 900 m, *T. F. Bourdillon* 156 sterile (DD); MAHARASHTRA : Kodkani, May 1939, *N. L. Bor* 11226 ♀ (DD).

47. ***Diospyros peregrina*** (Gaertn.) Gurke in Engl. & Prantl., Nat. Pflanzenfam. 4 (1) : 164. t. 87. 1891. *Embryopteris peregrina* Gaertn. Fruct. Sem. Pl. 1 : 145. f. 29. 1788. *Garcinia malabarica* Desr. in Lam. Encycl. Meth. Bot. 3 (2) : 701. 1792. *Embryopteris glutinifera* Roxb. Pl. Cor. 1 : 49. t. 70. 1795. *Diospyros embryopteris* Pers. Syn. Pl. 2 : 624. 1807, *pro parte*, non Spreng. 1825, nec Boj. 1837, nec Fernand.-Villar 1880, A. DC. in DC. Prodr., 8 : 235. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 257. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 556. 1882. *D. glutinifera* (Roxb.) Ham. in Trans. Linn. Soc. 15 (4) : 109. 1825. *D. glutinigera* Weinmann in Regensb. Fl. 8 : 54. 1825. *D. glutinosa* Koenig ex Roxb. Fl. Ind. 2 : 533. 1832. *D. malabarica* (Desr.) Kostel. Allg. Med. – Pharm. Fl. 3 : 109. 1834; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 325. 1938; Kostermans, Rev. Handb. Fl. Ceylon 3 : 27. 1981. *D. biflora* Blanco, Fl. Filip. 303. 1837. *Embryopteris gelatinifera* G. Don, Gen.

Syst. Gard. Bot. 4 : 41 1837. *Diospyros citrifolia* Wall. ex A. DC. in DC. Prodr. 8 : 235. 1844. *D. melanoxylon* Hassk. Cat. Pl. Hort. Bot. Borog. 2 : 159. 1844, non Roxb. 1795, nec Blume 1825. *Embryopteris globularia* Roxb. ex Miq. Fl. Ind. Bat. 2 : 1048. 1856. *Garcinia malabua* Lam. ex Hassk. Nachtr. Verbess. Hort. Malab. Clavis Nova II, in Regensb. Fl. 20 (Neue Reihe) : 74. 1862. *Diospyros globularia* (Roxb. ex Miq.) Koord. & Val. Bijdr. Booms. Java 1 : 43. 1898. *D. malabarica* (Desr.) Kostel. forma *pallida* Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 329. 1938.

English names : Riber Ebony, Indian Persimmon, Wild Mangosteen, Malabar Ebony, Gaub tree.

Vernacular names : *Asm.:* Kendu; *Beng.:* Gab, Makurkendi, Kalatendu; *Guj.:* Timru, Zeeberwo; *Hindi:* Gale, Gandphanas, Gab, Banda, Tendu, Tirkakaya, Fendu, Kalatendu, Makadtendu, Makartendu, Makurkendi, Kusi; *Kan.:* Antina, Banda-kakutupare, Kusure, Higebanda, Holletupra, Kusharta, Hige, Bandadamra, Bantha, Kakadhupada, Holletupra, Tumakimara, Higebuntha, Huli, Tumri, Gavandu, Tapasi, Hagna, Tupure; *Mal.:* Panachi, Vananci, Temburni, Timbvini, Panichi, Panicha, Panachimaram, Vananji; *Mar.:* Gab, Kusi, Tendu, Tamburni, Timburi, Temburni, Timbvini, Timbru, Timar, Zeeberwo; *Or.:* Gusvakendu, Garatiril, Kol, Titia, Dusarakhendu, Dhusaro-kendu, Makar-kendu, Makara, Kari-kendu, Pakhivari-kendu; *Sans.:* Anilsara, Dantasatha, Tinduka, Thinduka, Tinduki, Kalaskandha, Shitisarka; *Tam.:* Kavikattai, Kattatti, Karunthali, Panichika, Paniccai, Panicika, Tumbilik-kay, Tuvarai, Tumika, Tumbika, Panichchai; *Tel.:* Elosu, Eitummika, Gabu, Tumil, Nitta-tumma, Tumikichettu, Tumika, Nititumiki, Tinduki, Tumikio, Nititunika, Muttiatumiki; *Urdu:* Tindu.

Medium-sized, dioecious or polygamous, evergreen trees, upto 10 m high, with scaly, blackish rust-coloured bark; branches glabrous, longitudinally striated or wrinkled; vegetative buds pubescent. Leaves alternate, 7-30 x 1.8-10 cm, linear-oblong to broadly oblong, apex acute to subacuminate or obtuse, rounded or subcuneate at base, rather thick, coriaceous, glabrous, margins entire and flat; midrib canaliculate above, raised beneath; lateral veins several pairs, arcuate towards apex, reticulate venation prominent; petioles 5-20 mm long, glabrous, canaliculate above, rounded beneath. Stipules solitary, sheath-like, bursting with the expansion of leaves, caducous. Male flowers white, in 3 to 7-flowered, bracteate, axillary, peduncled, thinly puberulous cymes; main peduncle upto 2 cm long. Bracts acuminate, small, deciduous. Calyx 4-6 x 8-10 mm, broadly cup-shaped, silky pubescent outside, glabrous within; lobes 4, broadly triangular, divided less than half way down, obtuse, pubescent, valvate. Corolla urceolate, glabrous or with patches of hairs outside particularly on the lobes, glabrous within; lobes 4, suborbicular, notched at apex, contorted. Stamens usually 40, sometimes 30 or 24 to 64 or more (Hiern, 1873; Bakhuizen, 1938), inserted at the base of corolla-tube, united in pairs at the base of filaments; filaments *ca* 1 mm long, pilose at apex; anthers linear, 4-5 mm long, subequal in size or unequal in some pairs, hairy on the front and back, winged on the margins, connectives very shortly produced into apiculate tip. Pistillode absent or rudimentary. Female flowers comparatively larger than males, axillary, usually solitary or rarely in 1 to 5-flowered, pedunculate, bracteate cymes (Hiern, 1873); peduncles/ pedicels articulated with the flowers, upto 1.5 cm long, densely silky pubescent. Flower-buds ovate, completely enclosed within the calyx, pubescent. Calyx cup-shaped, 8-10 x 6-8 mm in young buds,

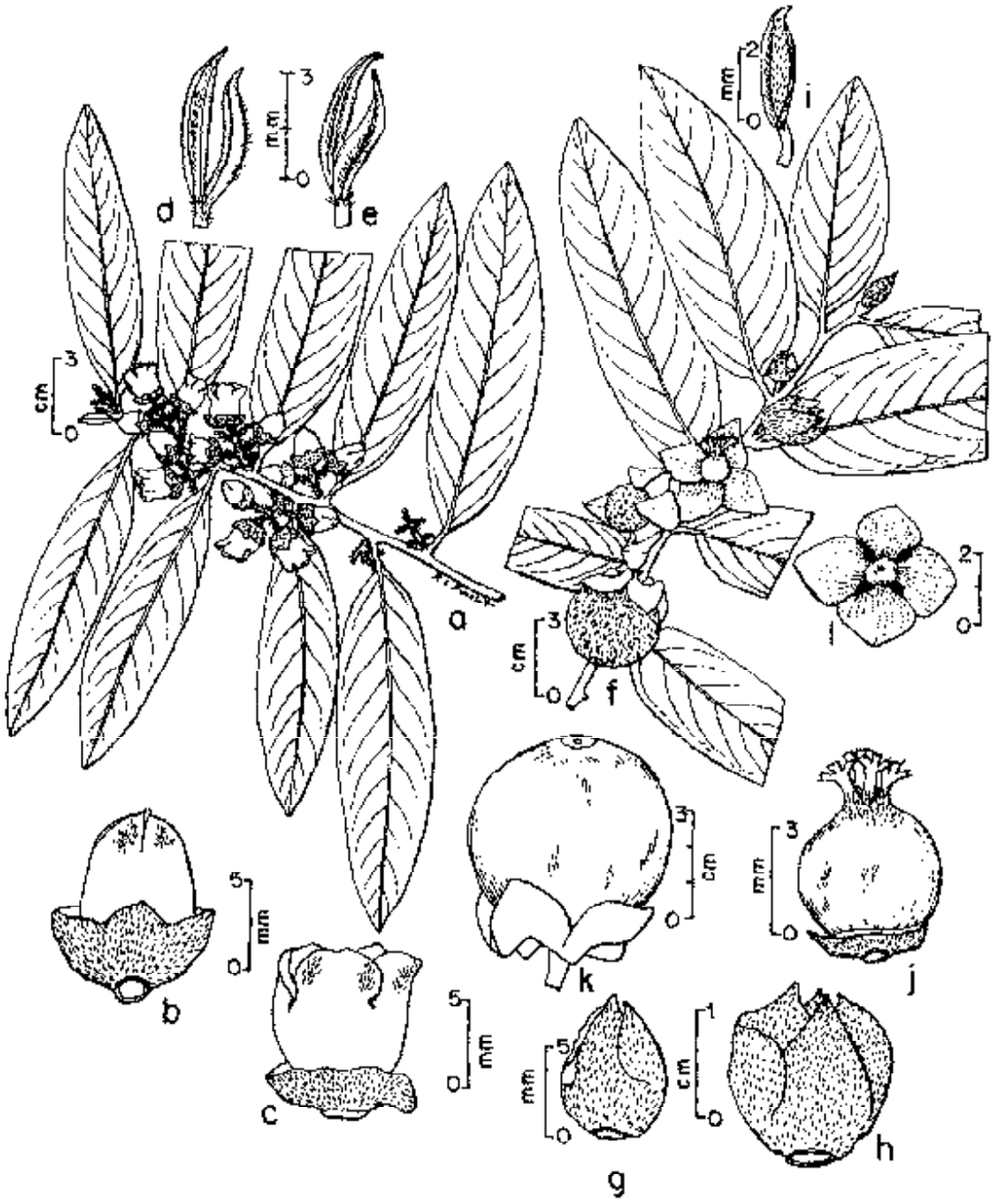


Fig.-45. ***Diospyros peregrina*** (Gaertn.) Gurke

Male : a. habit, b. flower-bud, c. flower, d-e. stamens.

Female : f. habit, g-h. flower-buds, i. staminode, j. gynoecium, k. fruit with calyx, l. fruiting-calyx in young stage.

gradually enlarges with age, 4-lobed, divided 2/3rd down or nearly to the base, pubescent bothsides; lobes broadly ovate, abruptly obtusely acuminate, imbricate. Corolla urceolate, pubescent outside, glabrous within; lobes 4, suborbicular, notched at apex, contorted. Staminodes usually 5, alternating with the corolla-lobes, hairy on the connectives on both faces, rarely upto 12 in number (Hiern, 1873; Bakhuizen, 1938). Ovary globose, glabrous or with a basal ring of hairs, 8-celled, cells 1-ovuled; styles 4, stout, pilose at base, spreading; stigmas usually 3-cleft. Fruits globose, of the size of a middle-sized apple, 4-6 cm in diam., clothed with rusty farina and glandular papillae when young, becoming glabrate with age, pulpy. Fruiting calyx 4-6 cm in diam., flat, 4-angular-discoid, no distinct tube, deeply 4-lobed; lobes ovate-triangular, foliaceous, spreading horizontally or become erect from the point of fusion with the tube forming the base auricled or subcordate and clasping the fruit base, sinistrorsely imbricate. Seeds 4-8, reniform or elliptical-wedge-shaped; endosperm equable; testa not striated **(Fig.-45; Plate 17/4 & 18/1 & 2).**

Holotype : *Panitsjika maram* Rheede, Hort. Mal. 3 : t. 41 1682.

Chr. No.: 2n=30 (Pathak *et al.*, 1949; Nanda, 1962; Chatterji, 1964); n=15 (Bir *et al.*, 1980).

Fl. & Fr.: February September.

Ecol.: Found in the forests in wet places and along the rivers and streams, upto 1800 m; sometimes cultivated. The plants may be propagated through seeds and vegetative methods (Prajapati *et al.*, 2003). The fresh seeds germinate in rainy season. Storage of seeds leads to the loss of viability. The germination is epigeal and cotyledons are detached early, never green and photosynthetic. The seedlings thrive well in dense shade on moist, ordinary loam soil. They are sensitive of drought and frost. Growth of seedlings is slow in first three years, but afterwards it grows at a much faster rate than other species of *Diospyros* L. The flowering starts quite late after the tree has attained considerable dimension. The plants have potential for avenue and may be grown along the roads for this purpose in public parks.

Defoliator *Myllocerus stulifer* and borer *Stromatium barbatum* are the main insect pests associated with this species. However, *Diplodia embryopteridis* also affects fruits and *Centhospora diospyri* and *Phyllosticta diospyri* have been recorded on the leaves. Meyrick (1907) recorded that larvae of *Conopomorpha isochorda* also mines in young leaves of this species. The leaves of this species are also infected by the pathogen *Discosia poonensis* which produces brownish necrotic spots on the leaves (Naphade, 1970). However, Tandon & Lal (1964) found the leaves and fruits of this taxon severely attacked by pathogen *Pestalotia bicolor*.

Distrib.: This species finds rather wide distribution in India, chiefly in south, central and eastern parts, particularly in the States of Punjab, Uttranchal, Delhi, Uttar Pradesh, Chhattisgarh, Jharkhand, West Bengal, Orissa, Maharashtra, Goa, Kerala, Tamil Nadu, Andhra Pradesh and Meghalaya. It is

also reported from Nepal, Sri Lanka, Myanmar, Thailand (Siam), Laos, Cambodia, Vietnam, W. Malaysia, Sumatra, Java, Timor and Celebes (**Map-13**).

Pollen: Grains 3-zonocolporate; endocolpium la-longate, kidney-shaped, 7 x 14 µm. Exine surface psilate. Size 35-42 x 29-35 µm (Nair & Kothari, 1985).

Anatomy : Each cotyledon has three vascular traces and cotyledons get detached soon. The xylem and phloem of the median trace are abortive and epicotyledonary traces are continued through the hypocotyl into the primary root (Wright, 1904).

The petiole at distal end exhibit a solitary, concentric, concave vascular strand with deeply incurved ends. The secondary phloem of the stem is devoid of fibres, but stone cells are present. Pith characteristically includes groups of large stone-cells. Vessels follow a vague radial or oblique pattern in the wood (Metcalfe & Chalk, 1950).

The wood is usually diffuse-porous, hard and heavy. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained and fine-textured. The heartwood is sometimes variegated with black and brown and is as pretty as Calamander, but rots soon. The timber is susceptible to dry wood borer (Wright, 1904; Purkayastha, 1982).

Timber is usually white with occasional black strands. Black heartwood is very small, even in the center of very old trees. The vessels of twigs are 0.31 mm long, having 0.04 mm radial and tangential diameter. The sapwood, however, bears 0.43 mm long vessels, having 0.14 mm and 0.09 mm radial and tangential diameter. It is interesting to record that the radial and tangential diameter of vessels are identical in the twigs. The tracheids are occasionally found with fibres. The length of wood parenchyma cells in sapwood varies from 0.09 to 0.13 mm, with 0.01 mm radial diameter. The radial diameter of wood fibres in sapwood and heartwood is 0.009 mm. The radial diameter of vertical medullary ray cells is 0.025 mm and tangential 0.012 mm, with vertical length 0.070 mm. The radial diameter of horizontal components is 0.07 mm and tangential 0.009 mm, with vertical length 0.032 mm (Wright, 1904).

Phytochemistry : The stem contains aliphatic ketol which has been characterized as nonadecan – 7 – OL – 2 – one (Chauhan & Kumari, 1980; Rastogi & Mehrotra, 1993c). Unripe fruits, flowers and bark contain a large quantity of pectin and tannin (Biswas, 1944). Fruits contain about 12.8 per cent astringent acid closely related to gallo-tannic acid. β-sitosterol, betulin, oleanolic acid and myricyl alcohol have been isolated from the leaves. The bark yields betulinic acid and saponin (Rastogi & Mehrotra, 1993a). Recently, Gupta & Tiwari (1964) have also isolated myricyl alcohol, betulin, β-sitosterol, betulinic acid and oleanolic acid from the bark. Betulinic acid from seeds and fruit pulp; gallic acid, hexacosane, β-sitosterol, betulin, lupeol, β-D-glucoside of β-sitosterol, sallic acid, hexacosanol

and marsformosanone-a triterpene ketone from fruit pulp (Bhaumik *et al.*, 1981; Misra *et al.*, 1971); a new leucoanthocyanin characterized as leucopelargonidin-3-O-α-L-rhamnopyranoside (I) from stem (Chauhan & Kumari, 1978); a new dihydroflavonol glycoside (II) (5, 7 3, 5'-tetrahydroxy-3'-methoxy flavonol-4'-O-α-L-rhamnopyranoside) from roots have also been isolated during recent years (Chauhan *et al.*, 1979; Rastogi & Mehrotra, 1993b). Jain & Yadava (1996) have recently isolated a new chromenoflavone from the fruits. A new glycoside 5, 7, 3' 4'-tetrahydroxyflavanone-3-O-β-D-glucopyranosyl (1→4)-α-L-rhamnopyranoside (I) has been recently isolated from the roots (Rastogi & Mehrotra, 1993c). Asolkar *et al.* (1992) have also reported myricyl alcohol and saponin from the bark and β-sitosterol and leucoanthocynin from the stem.

Uses : The ripe fruits are sweet and sometimes eaten. The high percentage of tannins make them astringent, yet, the poorer classes of the society like them very much and collect during February-September. It is considered as one of the important famine foods, but is said to produce great thirst. I found that it causes burning sensation in the throat. The tender leaves are cooked as vegetable in Madhya Pradesh during famine.

Varier (1994) has reported leaves as diuretic, carminative, laxative, ophthalmic and styptic and useful in strangury, dyspepsia, flatulence, scotoma, nyctalopia, ophthalmia, epistaxis, haemoptysis, burns, tubercular glands, scabies and wounds. The juice of unripe fruits is considered as valuable astringent and useful in haemorrhage from internal organs, diarrhoea and chronic dysentery. The extract of fruits is mixed with water and injected in the vagina to cure leucorrhoea. Sometimes the seeds are eaten for this purpose. The pulp of the fruits is applied locally by Jatapus tribe in Andhra Pradesh to bruises, wounds, ulcers and sprains. The juice of the unripe fruits also makes an excellent application on fresh wounds owing to its high tannin content. The alcoholic extract of the fruits is used as a mouthwash for aphthae, stomatitis and sore-throat. In Madhya Pradesh, the unripe fruits and their extract is employed in treating diarrhoea (Jain, 1965). The fruits have also been found very effective in the treatment of irritating cough. Varier (1994) has reported fruits as bitter, acrid, cooling, digestive, carminative and oleaginous and useful in pharyngodynia and vitiated conditions of *pitta* and *vata*. The pharmacological studies carried out at K. G. Medical College, Lucknow revealed that plant has anti-stress effect (Med. Aromat. Plants Abstr. 5 (2) : 164. 1983). The oil extracted from the seeds is used with success in diarrhoea and dysentery (Jayaweera, 1980). It is considered laxative and also used for burning and in painting (Rao, 1914). The fresh seeds are also used as such in diarrhoea as an astringent. The flowers and fruits are aphrodisiac and oleaginous; they are also given in hiccup of children (Agharkar, 1991). Varier (1994) has reported flowers useful in leucorrhoea, urethrorrhoea, splenomegaly, nyctalopia, anaemia and scabies. Flowers and fruits are also used to cure biliousness, leprosy, diseases of the blood, urine discharge and stones in the urinary tract (Kirtikar & Basu, 1935). The bark possesses antidysenteric properties (Chopra *et al.*, 1958). The bark is made into a paste and applied to boils and tumours. Infusion of bark is given to cure intermittent fevers and as an antidote in snake-bite (Nadkarni, 1976). Latex from the bark is used to cure chickle gums in lower gangetic plains. The alcoholic extract of

stem-bark has been found to have anti-protozoal activity against *Entamoeba histolytica*, antiviral activity against Ranikhet disease virus and hypoglycaemic activity in albino rats (Dhar *et al.*, 1968). Bark is also considered good for dysentery (Agharkar, 1991). Bark is powdered and boiled in oil and applied to eczema in children (Rao, 1914). Varier (1994) has reported multiple properties of bark viz. astringent, acrid, cooling, anti-inflammatory, constipating, depurative and febrifugal; it is found useful in vitiated conditions of *pitta*, burning sensation, inflammations, diarrhoea, dysentery, leprosy, skin diseases, pruritus, dyspepsia, haemorrhages, burns, diabetes, fever, spermatorrhoea and vaginal disorders. The wood is believed to cure biliousness. Recently, the medicinal uses of different parts of this species have been compiled by Jain & Tarafdar (1970) in details as for cholera, dysentery, menorrhagia, diarrhoea, bleeding gums, fever, atrophy, tumours, sores, fistula, syphilis, carbuncle, dysuria, gravel, dry cough and bronchitis, neuralgia, pleurisy, pneumonia, blood and mucus in bowel excretion etc.

In Bengal, the viscid mucous of the young fruits, which contains high percentage of tannin, is applied to the bottom of the boats and on the fishing nets to make them more durable. For this, the fruits are beaten and the juice so expressed is boiled and mixed with powdered charcoal and applied once a year to the boats. The tannin obtained from the fruits is used in dyeing and tanning. Fruit is also used in pyrotechnics. Pulp is used as a glue in book binding since it is a good insect repellent (Secoy & Smith, 1983). Plants yield a good quality of gum (Jayaraman, 1996).

The wood is called Bombay ebony or Ceylon ebony and is usually used for masts of ships. It is also suitable for building construction, well construction and boat making. The wood provides good charcoal.

Notes : Besides forma *typica*, Bakhuizen (1938) has recognized two forma under this species viz. forma *atrata* (Thw.) Bakh. and forma *pallida* Bakh. The latter has been merged under proper species in the present work and former has been raised to specific level, following the concept of Alston (1931).

Exsicc.: ANDHRA PRADESH : Visakhapatnam, Madugula to Tacheru, Near Kunchuraigummagedda, 500 m, 10th April 1976, *G. V. Subbarao* 47271 ♀ (MH, CAL); CHHATTISGARH : Bilaspur, Korba, 18th April 1965, *G. Panigrahi & C. M. Arora* 8703 ♂ (CAL); Raipur, Deodhara, 12th Oct. 1976, *D. M. Verma* 25730 ♀ (BSA); Bastar, Abujhmarh, Badgaon, 25th May 1983, *G. P. Roy* 34040 ♀ (BSA); Bhairam Baba Temple; 23rd Jan. 1977, *B. G. Gupta & Party* 6317 ♀ (RHMD); Chitrakut, 520 m, 23rd Dec. 1971, *C. R. Das* 14846 ♀ (BSA); 20th Feb. 1963, *G. Panigrahi* 1187 ♀ (BSA); DELHI : Budha Jayanti Park, 18th May 1993, *B. D. Naithani* 83561 ♀ (BSD), GOA : Bercem, 2nd Oct. 1973, *K. C. Sahni* 3735 ♀ (DD); JHARKHAND : Chota Nagpur, Saranada, Jan. 1881, *J. S. Gamble* 9099 ♀ (DD); Dumroon, 17th Oct. 1959, *Hira Lal* 62006 ♀ (LWG); KERALA : Calicut, University campus, 10th Feb. 1972, *V. V. Sivarajan* 1671 ♂ (CAL); MAHARASHTRA : Pune, Botanical Survey of India campus, 12th Feb. 1961, *John Cherian* 68241 ♂ (BSI); Chandrapur, Chanda, Bhamragarh Forest Rest House, 26th April 1964, *R. S. Rao* 96571 sterile (BSI); MEGHALAYA : Mahendraganj, Garo hills, 21st April 1940, *P. R. Dutta* 19218 ♂ (ASSAM); Without locality, April 1893, *Dr. King's Collector* Acc. No. 260

(DD); ORISSA : Barheipani Water fall in the valley, 21st Feb. 1958, *G. Panigrahi* 12697 ♀ (ASSAM); Malkangiri, Dandakoranya, Goiparvatham, 210-300 m, 19th May 1959, *R. S. Rao* 18439 ♀ (ASSAM); Bolimella, 180-510 m, 23rd May 1959, *R. S. Rao* 18534 ♀ (ASSAM); Gajapati, Mahendragiri, Sobakota, 14th March 1959, *G. Saran & Party* 58686 ♀ (LWG); Koraput, Ghatvan, 13th March 1964, *S. L. Kapoor* 69255 ♀ (LWG); PUNJAB : Ferozpur, Cantt. area, Municipal Garden, Oct. 1980, *DFO Ferozpur* Acc. No. 152674 ♀ (DD); TAMIL NADU : Nilgiri, Ronnington forest, 25th June 1974, *E. Vajravelu* 44944 ♀ (RHMD); Moyar river bank, 550 m, 19th April 1971, *N. C. Rathakrishnan* 37957 ♂ (MH); Towards Kutrapatti, Moyar river, 450 m, 12th March 1972, *G. V. Subbarao* 40180 ♂ (MH); UTTRANCHAL : Dehradun, Gola Thappar, 450 m, 4th July 1969, *C. M. Arora* 38873 ♀ (BSD); 8th Feb. 1995, *B. P. Uniyal & D. Basu* 90905 ♀ (BSD); Rispana, 15th May 1965, *C. R. Babu* 34965 ♀ (BSD); Raipur Road, Near BSI office, 800 m, 15th June 1957, *T. A. Rao* 2708 ♀ (BSD); 700 m, Feb. 1957, *T. A. Rao* 1737 ♀, 1737A ♀ (BSD); Rangers college, April 1937, *M. B. Raizada* Acc. No. 74240 ♀ (DD); Khaire, 1st Feb. 1907, *J. H. Lace* 3081 ♀ (DD); Botanic Garden, New forest, 28th June 1957, *K. M. Balapure* Acc. No. 123422 ♀ (DD); UTTAR PRADESH : Lower Gangetic Plain, Kistopore near Dankuni, 27th June 1974, *B. G. Gupta & Party* 5549 ♀ (RHMD); Lucknow, NBRI, 18th May 1954, *G. S. Bhatnagar* 7831 ♀ (LWG); 1st June 1965 and 14th June 1965, *M. Aslam & Puttilal* 20250 ♀ (LWG); 2nd June 1958, *K. M. Balapure* 51695 ♀ (LWG); Kanpur, *S. K. Bose* Acc. No. 15698 ♀ (LWG); WEST BENGAL : Bankura, Dhansimla, Thawar-Sonamukhi, 16th March 1966, *M. N. Sanyal* 1002 sterile (CAL); Nadia, Burdwan, Around city, 14th June 1965, *A. K. Dutt* 855 ♀ (CAL); Howrah, Andul, 17th April 1963, *S. S. R. Bennet* 96 ♂ (CAL); Indian Botanic Garden, 13th June 2002, *V. Singh* 10292 ♀ (BSJO); South 24 Parganas, Sunderbans, Khulua circle, 10th July 1903, *J. H. Lace* 2634 ♀ (DD).

48. ***Diospyros pilosanthera*** Blanco var. ***helferi*** (Clarke) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 246. 1938. *D. helferi* Clarke in Hook. f. Fl. Brit. India 3 : 569. 1882.

English name : Camagaon Ebony.

Trees, upto 20 m high; branchlets terete, pubescent or rufous tomentose when young, glabrescent with age, sparsely lenticelled. Leaves alternate, bifarious, elliptic-oblong, 13-19 x 4-8.5 cm, rounded or obtusely cuneate at base, shortly decurrent into the petioles, rounded or shortly obtusely subacuminate at apex, some leaves much shorter, *ca* 4 x 3.5 cm, obovate with emarginate or rounded apex or ovate with obtuse apex, very young ones rufous-tomentose especially beneath, gradually glabrescent with age except midrib, coriaceous or chartaceous, margins recurved; midrib canaliculate and pubescent above, raised and pubescent beneath; lateral veins 7-15 pairs, subhorizontal, reticulation considerably prominent bothsides; petioles semiterete, canaliculate above, rounded beneath, pubescent or glabrous with age, upto 12 mm long. Male flowers in dense, axillary, bracteate, rufous-tomentose cymes on young branches; peduncles upto 5 mm long; pedicels upto 2 mm long, articulated with the flowers. Bracts 2-5 x 1.5-2.5 mm, ovate-oblong, boat-shaped, concave on ventral side, acuminate at apex, tomentose outside, glabrous within. Calyx campanulate, villous bothsides; tube 2-3 mm long, glabrous within at the base only; lobes 5 (rarely 6 – Bakhuizen, 1938), 3-4 mm long, always longer than tube, divided below the middle,

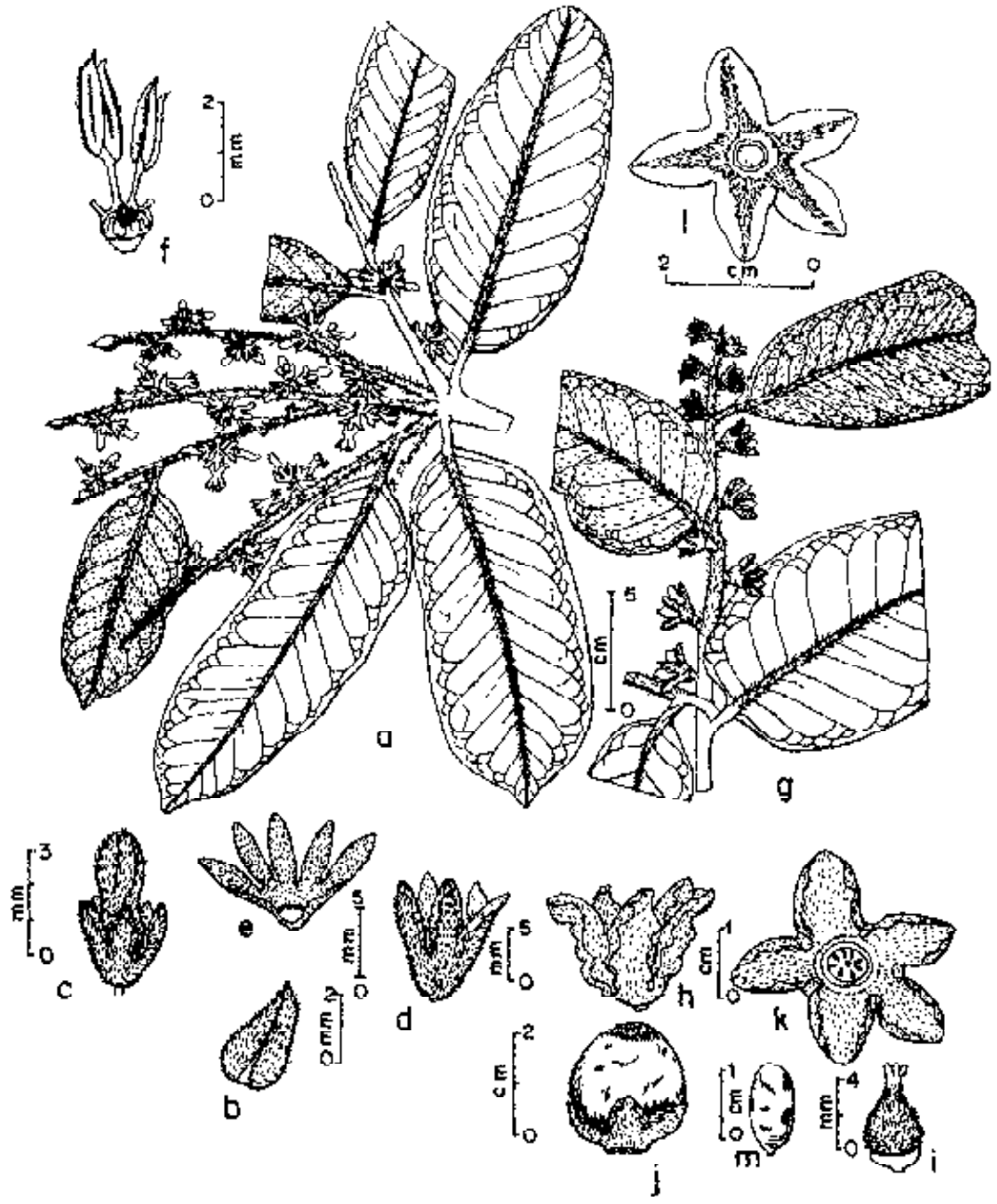


Fig. 46. ***Diospyros pilosanthera*** Blanco var. ***helferi*** (Clarke) Bakh.
Male : a. habit, b. bract, c. flower-bud, d. calyx, e. calyx within, f. stamens.
Female : g. habit, h. calyx, i. gynoecium, j. fruit with calyx,
k. fruiting-calyx (dorsal view), l. fruiting-calyx (ventral view), m. seed.

oblong, obtuse or rounded at apex, erecto-patent, margins somewhat undulating and recurved, valvate, with distinct sinus between the lobes, rather thinly tomentose within. Corolla tubular, densely rufous-tomentose outside; tube glabrous within, constricted at the apex below the lobes; lobes 5 (rarely 6 Bakhuizen, 1938), elliptic, glabrous within except at the apex, contorted. Stamens 15-18 (sometimes 12-15 or 8-10 – Bakhuizen, 1938), inserted on the torus in one row, paired, connate at base; filaments 1-1.5 mm long, glabrous; anthers subequal or some unequal, 1.5-3 mm long, linear-lanceolate, acuminate or apiculate due to produced connectives, connectives pubescent on one face. Pistillode hirsute. Female flowers sessile or subsessile, axillary, usually solitary or sometimes in fascicles of 1 to 3-flowers; pedicels 2-4 mm long, tomentose, articulated with the flowers. Calyx campanulate, tomentose bothsides; tube 2-3 mm long, glabrous within at the base only; lobes 5, ovate-oblong, divided below the middle, rounded and/or apiculate at apex, erecto-patent, margins strongly undulating and reflexed, appearing almost curled, valvate, with distinct sinus between the lobes. Corolla salver-shaped, with long tube and wide mouth, tomentose outside, glabrous within; lobes 5, contorted. Staminodes 4-6. Ovary ovoid-globose, densely tomentose, 8 to 10-celled, cells 1-ovuled; styles 4-5, short, united at base, tomentose; stigmas glabrous. Fruits ovoid or subglobose, rufous tomentose when young, becoming glabrate with age except at apex and base, 2-2.5 cm in diameter. Fruiting-calyx distinctly accrescent, foliaceous but smaller than fruits, plicate, auriculated at base, clasping the base of fruit, with a central ring of dense hairs on ventral side; lobes erecto-patent in early stage, spreading horizontally in fully mature fruits, 1-2.5 x 1-2 cm, with a line of dense hairs in the middle on ventral side, tomentose on dorsal side, margins undulating and reflexed. Seeds oblong, 12-13 x 5-6 mm, sub-flattened on lateral faces, brownish-black; albumen equable (**Fig.-46; Plate 18/3 & 4**).

Holotype : Tenasserim, *Helfer* 3632 (K).

Fl. & Fr.: March – September.

Ecol.: Rare, found in wet evergreen forests of Andamans.

Distrib.: In India, this species is restricted to Andaman and Nicobar Islands. Eastwards it extends to Myanmar (native home), Singapore, Thailand (Siam), Cambodia, Laos, Vietnam and Malay peninsula (**Map-13**).

Anatomy : Sapwood is pink or reddish and heartwood black with brownish or reddish streaks.

Notes : This species is highly polymorphic and resembles closely to *D. polyalthioides* Korth ex Hiern. Bakhuizen (1938), though recognized three varieties under this species, but was not sure since they are not clearly definable. Since I don't have enough material from other countries, it is difficult to verify the observations of Bakhuizen (1938) in the present study.

Exsicc.: MALAY PENINSULA : Welesley, Lovah, March 1892, *Curtis* 2596 ♀ (CAL); Perlis, Kaeiga, March 1910, *Without Collector* Acc. No. 282761 ♀ (CAL); Kedah, Jaunkawi, Jan. 1897, *Hooker* 327 ♂ Acc. No. 282765 (CAL); Pola Laukani, June 1890, *Lobentis* 2596 ♀, Acc. No. 282768 (CAL). No specimen from India was available and the species has been included on the authority of Clarke (1882).

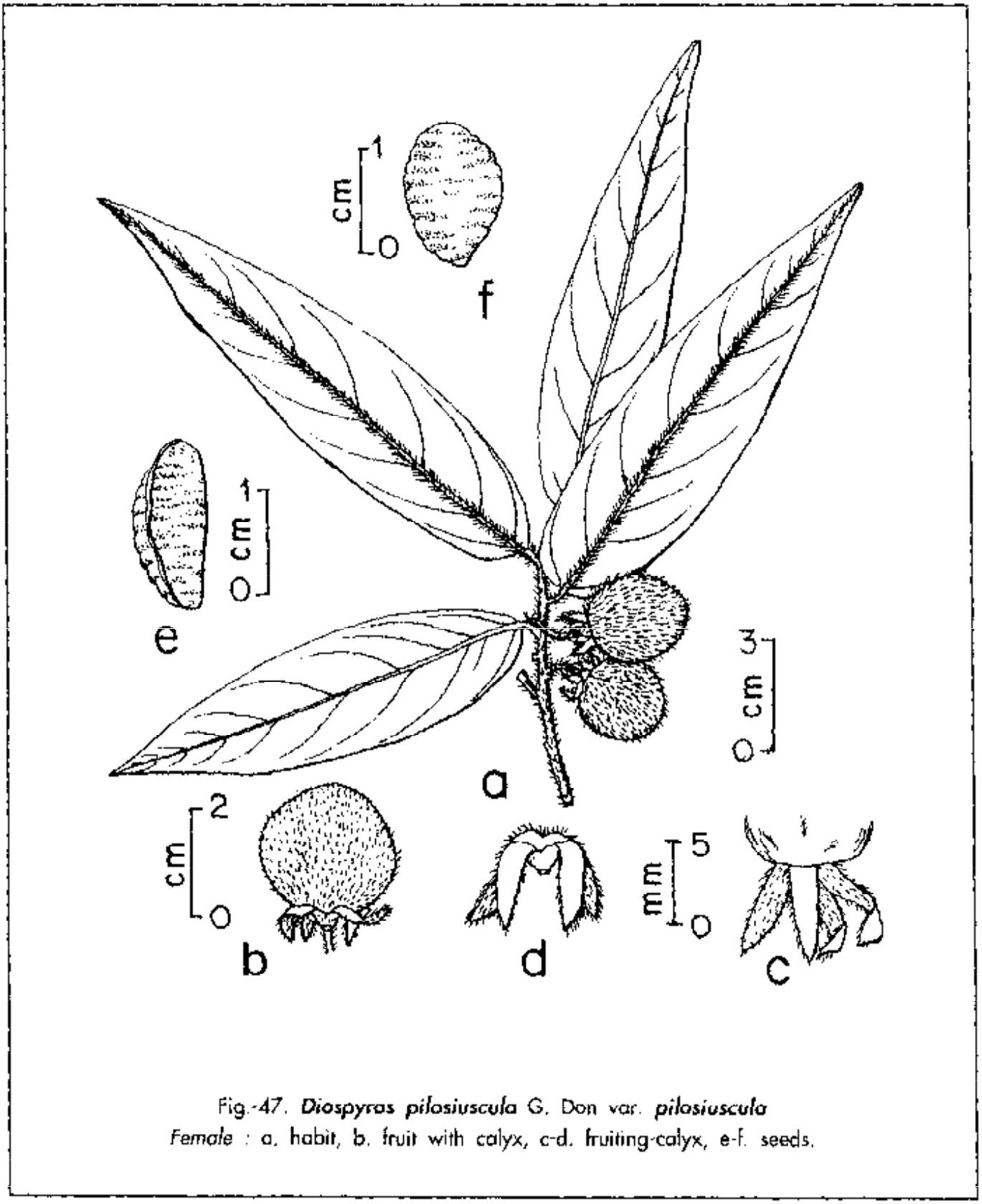


Fig.-47. ***Diospyros pilosiuscula*** G. Don var. ***pilosiuscula***
Female : a. habit, b. fruit with calyx, c-d. fruiting-calyx, e-f. seeds.

49. ***Diospyros pilosiuscula*** G. Don, Gen. Hist. Dichl. Pl. 4 : 39. 1837. *Gunisanthus pilosulus* A. DC. in DC. Prodr. 8 : 220. 1844. *D. pilosula* (A. DC.) Wall. ex Hiern in Trans. Cambr. Philos. Soc. 12 : 188. 1873, non *D. pilosella* H. Lecomte 1928; Clarke in Hook. f. Fl. Brit. India 3 : 554. 1882.

var. ***pilosiuscula***

English name : Ebony.

Vernacular name : *Nag.*: Lang-poi-Ching, Gjut.

Small trees or large shrubs, with smooth blackish bark which is reddish-brown inside and terete, fulvo-pubescent young branches. Leaves alternate, bifarious, 8-17.5 x 1.5-4.5 cm, oblong or lanceolate, abruptly or long acuminate at apex, rounded or cuneate at base, thinly coriaceous, glabrous except the midrib beneath; midrib raised and appressed hairy beneath, canaliculate and thinly pubescent to glabrous above; lateral nerves *ca* 8 pairs or more, oblique towards apex, prominent beneath; petioles 5-7 mm long, terete, pubescent. Male flowers in 3 to 4-flowered, lax, pilose, subracemose cymes borne on young shoots; pedicels 7-10 mm long. Bracts *ca* 5 mm long, ovate, hairy outside, ciliate, deciduous. Calyx campanulate, pubescent outside, glabrous within; lobes 4, lanceolate, ciliate, acute, valvate. Corolla tubular, with 6-8 mm long tube, pilose outside, glabrous within; lobes 4, lanceolate, longer than tube, acute, contorted. Stamens 12, glabrous, unequal, inserted on the torus; filaments often geniculate. Female flowers solitary, axillary, borne on young shoots, ebracteate; pedicels pubescent, terete, articulated at the apex with flowers. Calyx campanulate, pubescent outside, glabrous within; lobes 4, lanceolate, 6-8 mm long, acute, spreading, ciliate, valvate. Corolla tubular, little larger than males, silky outside, glabrous within, deeply 4-lobed; lobes lanceolate, contorted. Staminodes absent. Ovary globose, densely hairy, 4-celled, cells 1-ovuled; style 1, short, covered by the hairs of ovary; stigmas 2, glabrous. Fruits 1.5-2 cm in diam., globose, densely rufous hairy when young, becoming glabrescent with age; fruiting-pedicels 6-10 mm long, pubescent. Fruiting-calyx deeply lobed, without conspicuous tube at base, fruit seated on a very small disc of flat tube; lobes flattened, lanceolate, enlarged, pilose outside, glabrous within, long ciliate, rigid, reflexed, not touching the fruit, without dilated margins, not veined. Albumen equable (**Fig.-47; Plate 19/1**).

Fl. & Fr.: January – June or further late.

Ecol.: Found in tropical rain forests, particularly on Khasia and Jaintia hills, upto 1000 m.

Distrib.: This species finds distribution in eastern India from W. Bengal to Assam, Manipur, Meghalaya, Nagaland and Andaman and Nicobar Islands. It also extends to Myanmar (native home) through Bangladesh (**Map-13**).

Anatomy : The wood is diffuse-porous. Pores very small, scanty, often in short radial lines between the closely packed medullary rays. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network

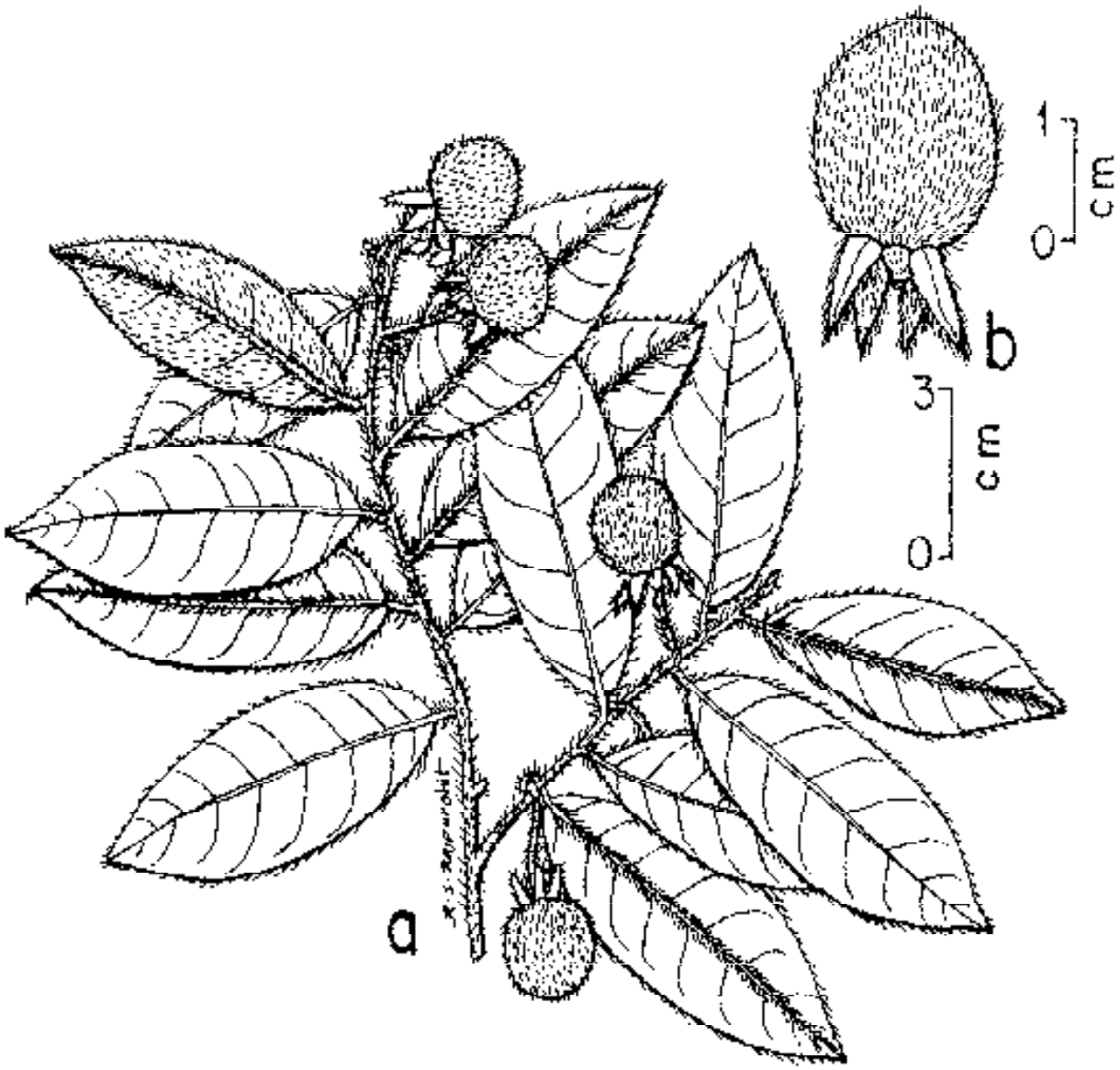


Fig. 48. ***Diospyros pilosiuscula*** G. Don *var.* ***andamanensis*** (Jayaraman & Nayar) Singh
Female : a. habit, b. fruit with calyx.

with rays. Rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained and fine-textured. The timber is susceptible to dry wood borer (Gamble, 1881; Wright, 1904; Purkayastha, 1982).

Uses : Wood is used locally for making axe handles. However, it may be successfully used for flutes and other wind instruments and for ear-rings, carved images and picture frames. The bark and fruits yield a beautiful black dye.

Notes : During present study, I could examine only female specimens in fruiting state and description of flowers provided herewith has been borrowed from the literature cited.

Exsicc.: ANDAMAN & NICOBAR : North Andamans, Lekmipur, 20 m, 23rd Nov. 1976, *N. G. Nair* 4879 ♀ (PBL); Andamans, July 1915, *C. E. Parkinson* 656 ♀ (DD); ASSAM : North Cachar hills, Above Jatingu, 690 m, 11th May 1915, *U. N. Kanjilal* 5668 sterile (ASSAM); 900 m, 11th May 1915, *U. N. Kanjilal* 5676 sterile (DD); MEGHALAYA : Khasia & Jaintia hills, Dawki, 28th July 1939, *R. N. De* 18609 ♀ (ASSAM); Mawlong, 19 m, 30th Nov. 1915, *U. N. Kanjilal* 6280 sterile (ASSAM).

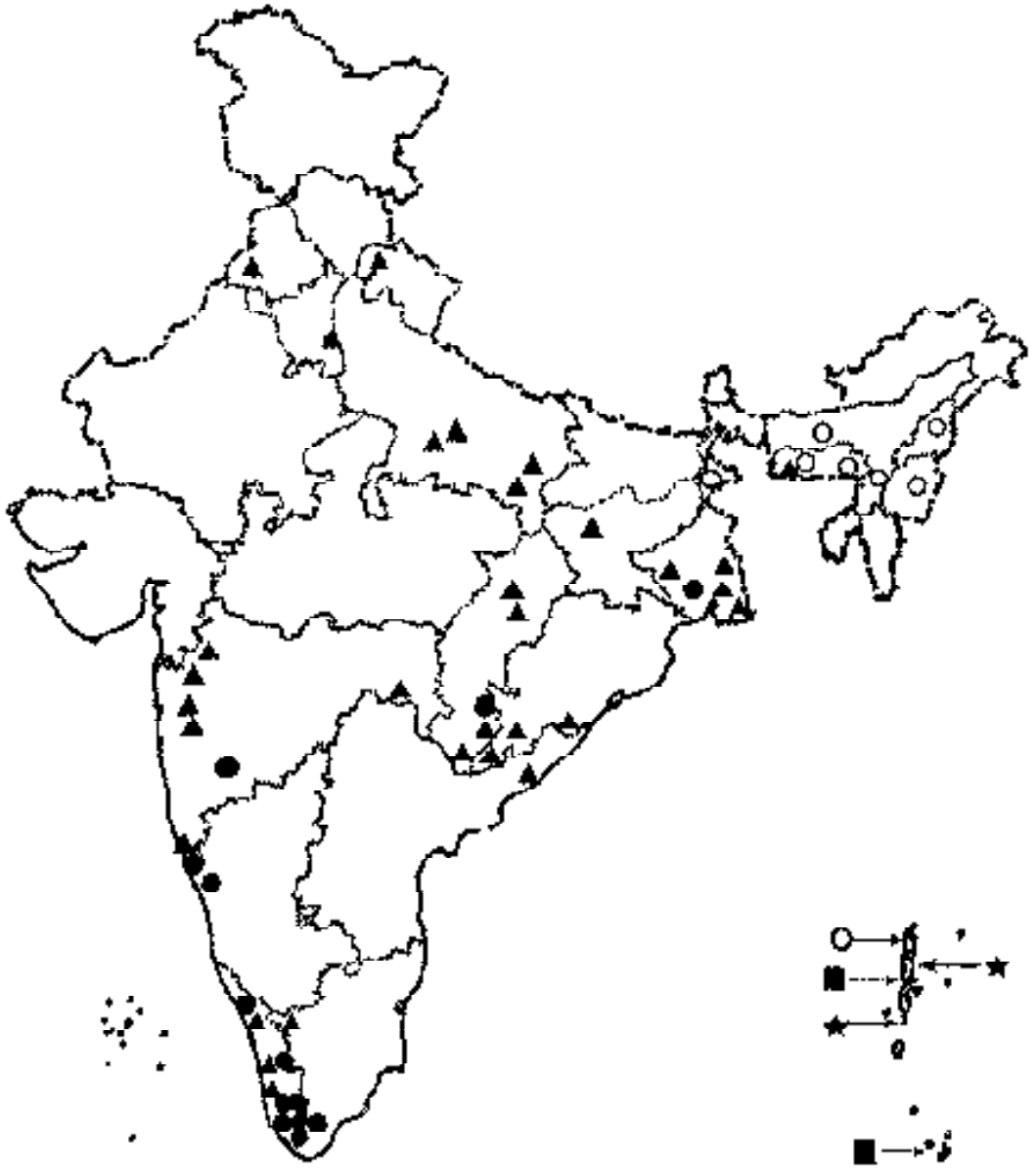
50. ***Diospyros pilosiuscula*** G. Don var. ***andamanensis*** (Jayaraman & Nayar) Singh, V. comb. nov. *D. pilosula* (A. DC.) Wall. ex Hiern var. *andamanensis* Jayaraman & Nayar in Bull. Bot. Surv. India 34 (1-4) : 180. 1992.

Trees or shrubs; branchlets pilose with long, fine, fulvous, spreading hairs, becoming glabrescent with age. Leaves alternate, ovate-oblong or broadly elliptic-lanceolate, 1.5-7 x 1.5-3 cm, rounded at base, acute or abruptly subacuminate to mucronate at apex, glabrous above, hairy beneath when young, becoming glabrous with age except midrib, ciliate-margined when young; midrib canaliculate and glabrous to pubescent above, raised and hairy beneath; lateral nerves 6-10 pairs, obliquely almost parallel towards margins, inconspicuous; petioles 2-5 mm long, terete, fulvous hairy. Male flowers in lax, pilose, depauperate subracemose cymes, 4-merous, pedicellate and like typical variety. Female flowers axillary, solitary, 4-merous and like typical variety. Fruits subglobose, 1.5-2.5 cm in diam., fulvous hairy when young, becoming glabrous with age; fruiting-pedicels 2-2.5 cm long, wiry, pilose. Fruiting-calyx 4-lobed; lobes elliptic-oblong, pilose outside, long ciliate, reflexed. Seeds 10-14 x 7-8 mm, oval and turgid or oblong with two flat faces, black, testa transversally wrinkled; albumen equable (**Fig.-48; Plate 19/2**).

Holotype : Andaman & Nicobar Islands, Middle Andaman, Jirkatang, Sea level, 16th Aug. 1976, *N. Bhargava & P. Chakraborty* 3771 (PBL).

Fl. & Fr.: May – October.

Ecol.: Rarely found in wet evergreen forests, upto 100 m.



Distrib. Sketch Map – 13

● *Diospyros paniculata* Dalz.; ▲ *Diospyros peregrina* (Gaertn.) Gurke;
■ *Diospyros pilosanthera* Blanco var. *helferi* (Clarke) Bakh.;
○ *Diospyros pilosiuscula* G. Don var. *pilosiuscula*,
★ *Diospyros pilosiuscula* G. Don var. *andamanensis* (Jayaraman & Nayar) Singh.

Distrib. : Endemic to India, confined to Andaman & Nicobar Islands (Map-13).

Phytochemistry: Jayaraman & Nayar (1992) have studied flavonoid pattern of proper species and the variety *andamanensis* (Jayaraman & Nayar) Singh. They found that two elements show distinct pattern of distribution of flavonoid spots in the chromatogram.

Notes : The variety differs from the proper species by its more pilose habit, smaller leaves and venation pattern, smaller petioles, longer fruiting-pedicels and in the distribution pattern of flavonoid spots, besides range of distribution. Apparently, this variety is sometimes confused for *D. saldanhae* Kosterm. and *D. pruriens* Dalz.

Exsicc.: ANDAMAN & NICOBAR : Middle Andamans, 5 km towards south-east, Sea level, 28th July 1975, *N. Bhargava* 2827 ♀ (Paratype-PBL); South Andaman, *Kurz* 281921, 281922, 281924 (paratypes-CAL); Towards C. D. camp from Poona-nallah, Sea level, 7th Sept. 1982, *D. K. Hore* 9139 ♀ (PBL); Inanganj hill jungle, 7th May 1892, *King's Collector* 281925 (paratype-CAL); Dhandikhari hill jungle, 24th June 1893, *King's Collector* 281889 (paratype-CAL); Jusonabad, 2nd Sept. 1893, *King's Collector* 281888 (paratype-CAL); Jirkatang, 16th July 1976, *N. Bhargava & P. Chakraborty* 3771 ♀ (PBL).

51. ***Diospyros pruriens*** Dalz. in Kew J. Bot. 4 : 110. 1852; Hiern in Trans. Cambr. Philos. Soc. 12 : 185. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 553. 1882.

Vernacular name : *Kan.*: Karimarlu.

Medium-sized trees; young branches terete, densely fulvous pilose with upto 5 mm long, spreading hairs having stinging properties. Leaves spirally arranged, 2.7-9.5 x 1.5-4 cm, usually broader in upper half, oblong-elliptic, slightly narrowed and rounded at base or rarely some leaves subcordate, ciliate-margined, obtusely acuminate at apex, young ones fulvous-pilose beneath, glabrous above, becoming glabrous bothsides with age except the midrib on bothsides and margins, chartaceous or scarcely coriaceous; midrib densely hairy and raised beneath, canaliculate above and canal filled with hairs; lateral nerves 6-10 pairs, obliquely facing towards apex, not prominent especially on the upper surface; petioles upto 4 mm long, terete, densely pilose. Male flowers pedicellate, usually solitary, rarely 2-together on a common peduncle, pedicellate, in the axils of upper leaves. Bracts small, ovate or rounded, hairy outside, glabrous within, caducous. Calyx 8-10 mm long, about as long as corolla-tube, densely pilose outside, glabrous within, deeply 4-lobed nearly to the base, tube upto 2 mm long; lobes 6-8 x 2-3 mm, subequal, elliptic-oblong, obtuse, ciliate, densely pilose outside, thinly pubescent within, imbricate in bud, distinctly nerved. Corolla tubular, densely pilose outside, glabrous within; tube 8-10 mm long, cylindrical, slightly broader at mouth; lobes 4, 7-9 mm long, about as long as tube, elliptic-oblong, spreading, ciliate, sinistrorsely imbricate. Stamens 13-14, hypogynous, seated on the torus, unequal-sized, shorter than corolla-tube, glabrous; filaments about as long as anthers; anthers ovate-oblong, 2-3 mm long in bud, glabrous, acute at apex, not apiculate. Pistillode hairy. Female flowers solitary, axillary, on young branchlets; pedicels 8-12 mm long, terete, pilose. Bracts absent.

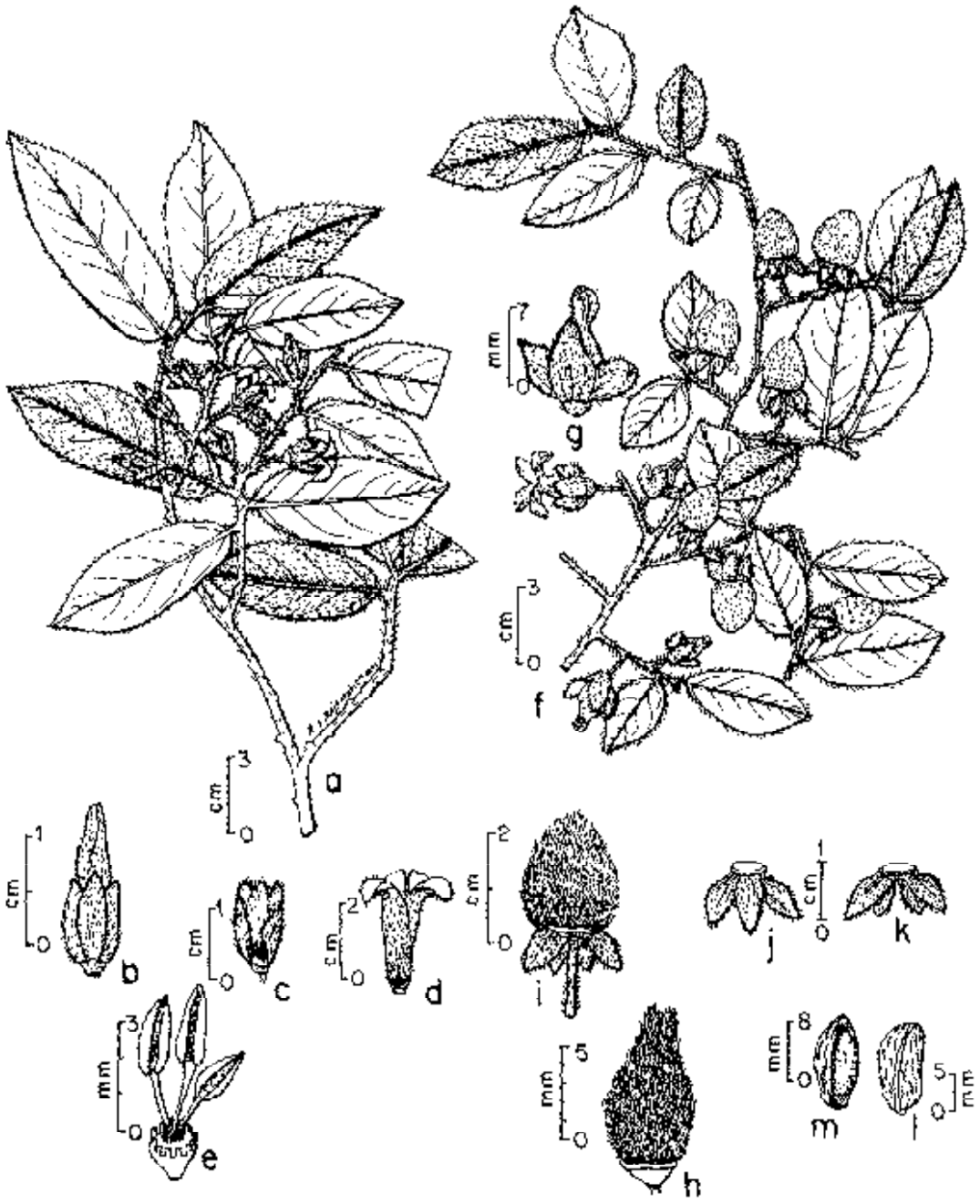


Fig.-49. ***Diospyros pruriens*** Dalz.

Male : a. habit, b. flower-bud, c. calyx within with pistillode, d. corolla, e. stamens borne on torus and pistillode.

Female : f. habit, g. flower-bud, h. gynoecium, i. fruit with calyx, j-k. fruiting-calyx, l-m. seeds.

Calyx deeply 4-lobed nearly to the base, 10-12 mm long, densely hairy outside and thinly so within, tube *ca* 1 mm long; lobes broadly lanceolate, 9-10 x 4-5 mm, subacute, ciliate, distinctly nerved, nerves many from the base and converging towards apex, imbricate in bud. Corolla tubular, 12-15 mm long, hairy outside, pubescent within; tube 7-8 mm long, gibbosely oval, constricted at apex; lobes 4, ovate-oblong, 5-7 mm long, obtuse, ciliate, contorted. Staminodes 4, inserted at the base of corolla-tube, glabrous. Ovary ovoid, ferruginously hirsute with long hairs, 4 celled, 1 ovuled in each cell; styles 2, short, stout, densely hairy with long hairs and concealed within hairs; stigmas 2-lobed, hairy and concealed in the hairs of ovary. Fruits 1.5-2 x 1.2-1.5 cm, ovoid-conical, densely clothed with fulvous hairs having stinging properties. Fruiting-calyx deeply lobed, without tube at base, fruit seated on the disc formed by tube and torus; lobes flattened, 7-10 x 3-4 mm, oblong-elliptic, not enlarged, reflexed or spreading, hairy bothsides, ciliate, obtuse. Seeds 4, oblong, 10-13 x 5-7 mm, convex on one face with a longitudinal middle line, flat on the other faces, black, glabrous, testa somewhat longitudinally wrinkled; albumen equable **(Fig. 49; Plate 19/3)**.

Holotype : India : Maharashtra, Chorla Ghat, *Dalzell s. n.* (K).

Fl. & Fr.: March – August.

Ecol.: Common in the forests of South India, upto 1100 m. The germination of seeds is epigeal and cotyledons are detached early. At the time of germination, the testa of the seeds does not split and cotyledons make their way through small circular micropylar opening. As such, the germination is delayed in this species. The flowering starts at young age. This species hardly develops into a large tree.

Distrib.: This species commonly occurs in Goa, Maharashtra, Karnataka, Tamil Nadu and Kerala in India and extends further southwards to Sri Lanka **(Map-14)**.

Anatomy : Each cotyledon has three traces and xylem and phloem persist in all traces contrary to other species of *Diospyros* L. where xylem and phloem of medium trace are abortive. The epicotyledonary leaf possesses one trace which continues into root, but not into apical part (Wright, 1904).

The timber is heavy, compact, white, tinged with yellow, turning to red on exposure. It has low percentage of tracheal elements and high per cent wood fibres. The vessels of twigs are 0.26 mm long, with 0.038 and 0.04 mm radial and tangential diameter. The sapwood, however, bears *ca* 0.44 mm long vessels, with 0.11 mm radial and 0.10 tangential diameter. Thus, the radial and tangential diameter of vessels in sapwood is almost equal. The length of wood parenchyma cells in sapwood varies from 0.08 to 0.14 mm, with 0.015 mm radial diameter. The radial diameter of medullary ray cells is 0.02 mm and tangential 0.018 mm, with vertical length 0.05 mm. The radial diameter of horizontal components is 0.038 mm and tangential 0.010 mm, with vertical length 0.025 mm. The medullary rays occur as radial rows of cells throughout the secondary xylem. In majority of the species there is only one cell in tangential width, but it is interesting to record two or three cells in width. In this respect, it shows close affinity with *D. crumenata* Thw., *D. racemosa* Roxb. and *D. insignis* Thw. (Wright, 1904).

Exsicc.: GOA : North Goa, Mollem, Moist forest, 1st May 1976, *Peerzada* 94945 ♀ (LWG); Mollem-Awadam, 16th March 1971, *K. N. Bahadur & R. C. Gaur* 2659 ♀ (DD); South Goa, Sanguem Range, Shigone, 26th March 1972, *K. N. Bahadur & R. C. Gaur* 2913 ♀ (DD); KARNATAKA : Kodalu, Coorg, Sampaje, Bhimanagundi, 14th March 1960, *R. K. Arora* 61676 sterile (BSI); Mysore, Hulical-shar, *R. S. Raghavan* 97140 ♀ (CAL); Shimoga, Hulical Range, 23rd May 1962, *R. S. Raghavan* 80934 ♀ (CAL); KERALA : Kasaragod, Maloth, 500 m, 10th May 1982, *V. J. Nair* 73806 ♀ (MH); Palghat, Silent valley, Lower reach of Kunthipuzha, 1100 m, 18th Feb. 1982, *C. S. Kumar* 10160 ♂ (CAL); MAHARASHTRA : Bombay, 5th March 1896, *W. A. Talbot* 3607 sterile (BSI); WITHOUT LOCALITY : Herb. Hort. Bot. Calcuttensis, Herb. of N. Dalzell Bombay; purchased 1878, Acc. No. 281905 ♀ (CAL).

52. ***Diospyros pyrrhocarpa*** Miq. Fl. Ind. Bat. Suppl. Sumatra 250, 583. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 266. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 571. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 305. 1938. *D. reflexa* King & Gamble in J. As. Soc. Bengal 74 (2) : 227. 1905. *D. ahernii* Merr. in Phil. J. Sci. Bot. 4 : 305. 1909.

English name : Ebony.

Large trees, upto 40 m high, young branches and buds pubescent to velvety. Leaves alternate, bifarious, 10-30 x 4-10 cm, ovate or elliptic-oblong to elliptic-lanceolate, obtuse to rounded or rarely cuneate to acute at base, distinctly acuminate at apex, acumen 1-2.5 cm long, margins reflexed, coriaceous, rugose or glabrous except the nerves beneath, basal glands 1-4; midrib canaliculate above; lateral nerves 6-7 pairs, dense and regular; petioles half terete, canaliculate or depressed above, upto 1.5 cm long. Male flowers subsessile, in dense, shortly pedunculate cymes scattered in the axils of leaves on young branches; peduncles *ca* 1 cm long. Bracts ovate, concave, obtuse, 5-7 x 4-5 mm, pubescent. Calyx campanulate, hairy bothsides, 5-7 mm long; tube thickened, woody; lobes 4-5, longer than tube, ovate or subdeltoid, erecto-patent, pubescent, dilated and coriaceous on the margins, thickened at the center, valvate. Corolla salver-shaped, 1.5-2 cm long; tube longer than calyx, densely tomentose outside, glabrous within; lobes 4-5, longer than tube, obtuse, densely villous, imbricate. Stamens 12-15, unequal in size, some connate in pairs, others free, hypogynous, inserted on the torus; anthers linear, acute or acuminate, hairy at top. Pistillode densely hirsute. Female flowers solitary, axillary, pedicellate, borne on young branches. Calyx as in males but larger, margins of lobes revolute. Corolla tubular, tomentose bothsides; lobes 4-5, longer than tube, elliptic-oblong or oblong-lanceolate, obtuse or rounded, contorted. Staminodes 4-5, inserted at the base of corolla-tube, glabrous. Ovary ovoid, rufous hairy, 8 to 10-celled, cells 1-ovuled; style short, 4 to 5-lobed at apex, pubescent; stigmas 2-fid. Fruits pedicellate, depressed globose, rufous hairy, 5-6 cm in diam.; pedicels *ca* 7 mm long. Fruiting-calyx accrescent, 3-4 cm in diam., constricted at base; lobes reflexed, velutinous bothsides, 1-2 x 1-1.2 cm. Seeds ellipsoid, plano-convex, 2-3.5 x 1-1.5 cm; albumen equable; hollow of embryo reaching the testa in transverse section of the seed (**Plate 19/4**).

Isotype : West Sumatra, Priaman, *Diepenhorst* 2351 (L).

Fl. & Fr.: April – October.

Ecol.: Rare, in the deciduous forests in high rainfall areas.

Distrib.: This species finds distribution in Andaman & Nicobar Islands and Meghalaya in India. However, its chief centers of distribution are Myanmar, Molucca, Singapore, Thailand (Siam), Sumatra (native home), Java, Malaya, Borneo and Philippines **(Map-14)**.

Pollen : Pollen grains 3-colporate, sub-prolate (45 x 38.7 µm), range 37.5-45 x 25-35 µm. Colpi long, thin (streaky), about 1 µm in width, membrane psilate. Apocolpium diameter about 6.0 µm and mesocolpium about 17 µm. Ora la-longate (2.5 x 10 µm), with psilate membrane. Exine about 2.5 µm thick. Sexine thinner than nexine and sexine pattern obscure to psilate (Sharma & Gupta, 1979).

Anatomy : The wood is diffuse-porous, light pink to greyish, moderately hard, straight-grained and fine-textured. Pores small, scanty, in short radial lines. The heartwood and sapwood are indistinct. Growth rings indistinct. Vessels very small, 3-12 per sq. mm, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct to inconspicuous. Parenchyma distinct, diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine to very fine, closely spaced and uniformly distributed. The timber is susceptible to dry wood borer (Gamble, 1881; Wright, 1904; Purkayastha, 1982).

Uses : The natives in Myanmar extract a red dye from this plant and polish fishing nets. Chinese are said to coat their umbrellas with this red dye to render them water proof. For this, the fruit extract is generally mixed with sulphate of iron and dye so obtained is used for above mentioned purposes as well as for dyeing raincoats (Maheshwari & Singh, 1965). The hollowed trunk is used for proas in Sumatra. No such uses are on record from India. Though the timber is susceptible to dry wood borers and not durable in contact with ground, yet it is used for construction purposes, poles, hammer and axe handles and for furniture in India. Branches are used for making walking sticks. The mature fruits are orange when ripe and much relished by the tribal communities of islands of Andaman and Nicobar, in Myanmar and Philippines.

Notes : Ramesh & Franceschi (1993), while describing a new species of *Diospyros* L. viz. *D. pyrrhocarpoides* Ramesh & Franceschi, from Western Ghats of India, had an opportunity to examine isotype of *D. pyrrhocarpa* Miq. and some other authentic herbarium specimens at K, L, CAL and P. They pointed out that in the recent monographs, particularly in Bakhuizen's (1936-1955) work on Malaysian *Ebenaceae*, the description of *D. pyrrhocarpa* Miq. is a mixture as it contains some other element also besides latter. As such, a taxonomic contamination is prevailing in the recent literature as regard to the delimitations of *D. pyrrhocarpa* Miq. However, from the contaminated herbarium material of the latter, *D. pyrrhocarpa* Miq. may be isolated on the basis of following characters :

Young branchlets hairy; leaves distinctly acuminate with acumen 1-2.5 cm long; secondary nerves 6-7 pairs; indumentum dark brown; male flowers scattered on the whole length of young branches; calyx and corolla-lobes longer than tube; anthers hairy at top; fruits develop on a distinct, *ca* 7 mm long

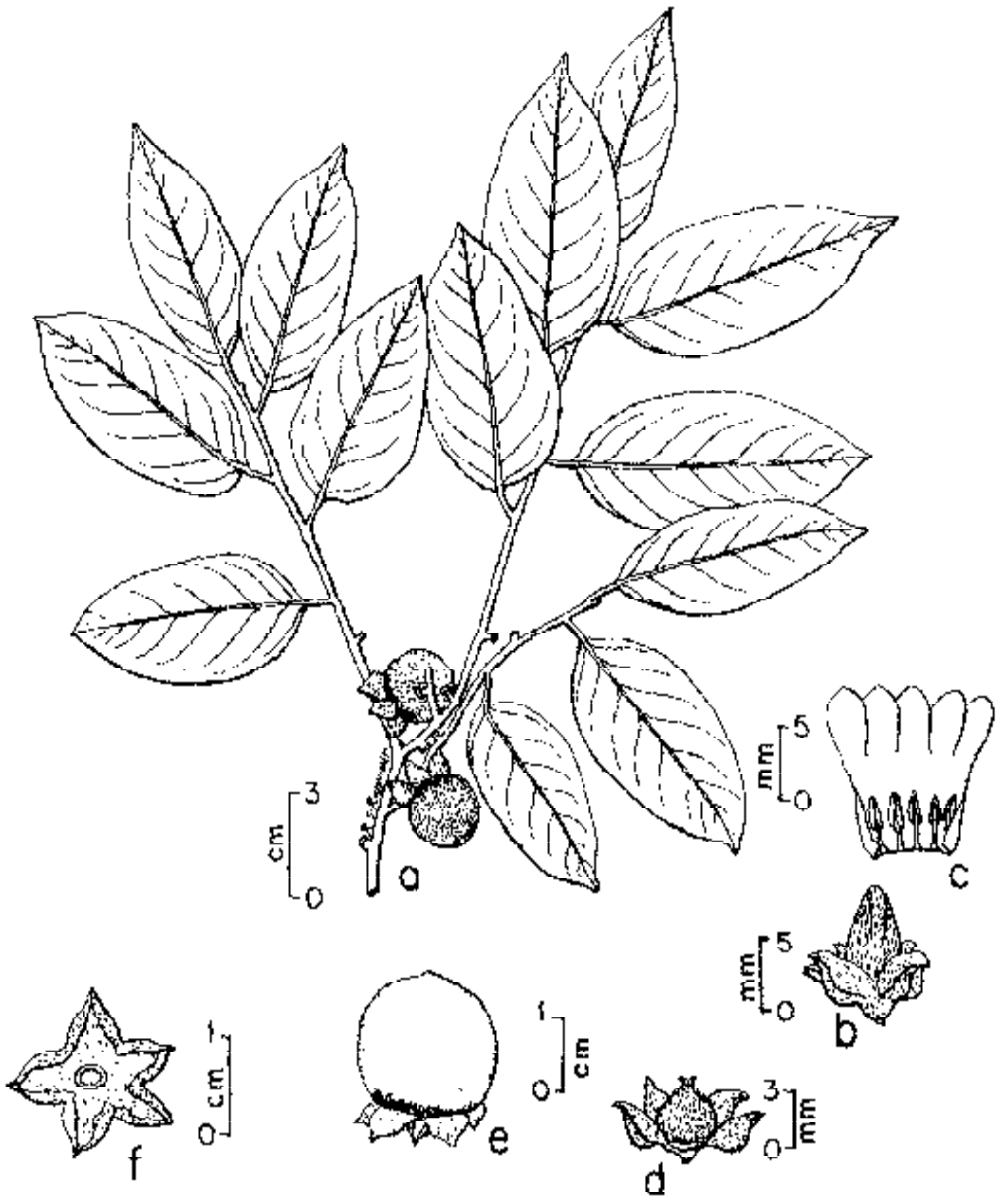


Fig.-50. ***Diospyros pyrrhocarpoides*** Ramesh & Franceschi
Female : a. habit, b. flower-bud, c. corolla within with staminodes, d. gynoecium with calyx, e. fruit with calyx, f. fruiting-calyx (dorsal view).

pedicel. On the basis of these characters, this species may also be separated from its most closely allied species *D. pyrrhocarpoides* Ramesh & Franceschi.

Further, Kurz (1877) has recognized a variety *andamanica* Kurz under this species, characterized with oblong to narrowly oblong leaves, faint lateral veins and more lax reticulation from Andamans. Recently, Ramesh & Franceschi (1993) have pointed out that variety *andamanica* Kurz is conspecific to *D. pyrrhocarpoides* Ramesh & Franceschi. I do not have material of var. *andamanica* Kurz at present in hand to assess the findings of Ramesh & Franceschi (1993) and, therefore, have followed their concept in respect of *D. pyrrhocarpa* Miq., its variety *andamanica* Kurz and *D. pyrrhocarpoides* Ramesh & Franceschi.

Exsicc.: ANDAMAN & NICOBAR : Andamans, Betapur valley, 24th March 1916, *C. E. Parkinson* 1130 ♀ (DD); Long Islands, 19th Feb. 1916, *C. E. Parkinson* 1012 ♂ (DD); 1st July, 1915, *C. E. Parkinson* 652 ♂ (DD); July 1915, *C. E. Parkinson* 652A ♂ 652B ♀ (DD); July 1915, *C. E. Parkinson* 666 ♀ (DD); Middle Andamans, 17th March 1913, *C. E. Parkinson* 42 ♂ (DD); MEGHALAYA : Khasia hills, *Simon* 902.154-12 sterile (HLB), *Jenkins* 902.154-13 sterile (HLB). I have not examined last two specimens, but have included in this work based on Bakhuizen's (1938) observations.

53. ***Diospyros pyrrhocarpoides*** Ramesh & Franceschi in Blumea 38 (1) : 133. f. 2. 1993. *D. pyrrhocarpa* Miq. var. *andamanica* Kurz, For. Fl. Brit. Burma 2 : 137. 1877; Clarke in Hook. f. Fl. Brit. India 3 : 572. 1882, non *D. andamanica* (Kurz) Bakh. 1937.

Dioecious trees, upto 15 m high, with totally glabrous branches. Leaves alternate, broadly elliptic-oblong to oblong-lanceolate, 6.5-9 x 2.5-4.5 cm, bluntly acuminate at apex, acumen upto 6 mm long, rounded and slightly decurrent at base, glabrous bothsides, subcoriaceous; midrib canaliculate above, raised beneath, glabrous bothsides; lateral nerves 8-11 pairs, prominent bothsides, arcuating towards apex, tertiary nerves finely reticulate and prominent bothsides; petioles 0.6-1 cm long (upto 2 cm – Ramesh & Franceschi, 1993), canaliculate above, rounded beneath, glabrous. Male flowers subsessile, in 3 to 4-flowered, golden-brown pubescent cymes borne towards the base of new shoots. Calyx campanulate, 5-5.5 mm long, tomentose bothsides; lobes 5, 2-2.5 mm long, shorter than tube, triangular, acute, margins slightly reflexed, valvate. Corolla tubular, creamy white; tube 5-6 mm long, tomentose outside, glabrous within; lobes 5, broadly ovate, shorter than tube, *ca* 3 mm long, acute, spreading-recurved, tomentose bothsides, contorted. Stamens *ca* 20, 2.5-3 mm long, inserted on the torus, hypogynous; anthers apiculate, glabrous. Pistillode hairy, *ca* 1 mm across. Female flowers sessile, solitary, axillary, borne near the base of young shoots. Calyx campanulate, 6-7 mm long, tomentose bothsides; lobes 5, ovate, 3-4 mm long, longitudinally folded outside and slightly reflexed, valvate. Corolla tubular, creamy white; tube *ca* 3 mm long, tomentose outside, glabrous within; lobes 5, ovate, bluntly acute, contorted. Staminodes 5, adnate to the base of corolla-tube. Ovary globose, tomentose, *ca* 3 mm across, 4-celled, cells 1-ovuled; stigma subsessile, 2-lobed. Fruits globose, 1.5-2 cm in diam. (upto 3 cm – Ramesh & Franceschi, 1993), sessile or subsessile, densely brown tomentose when

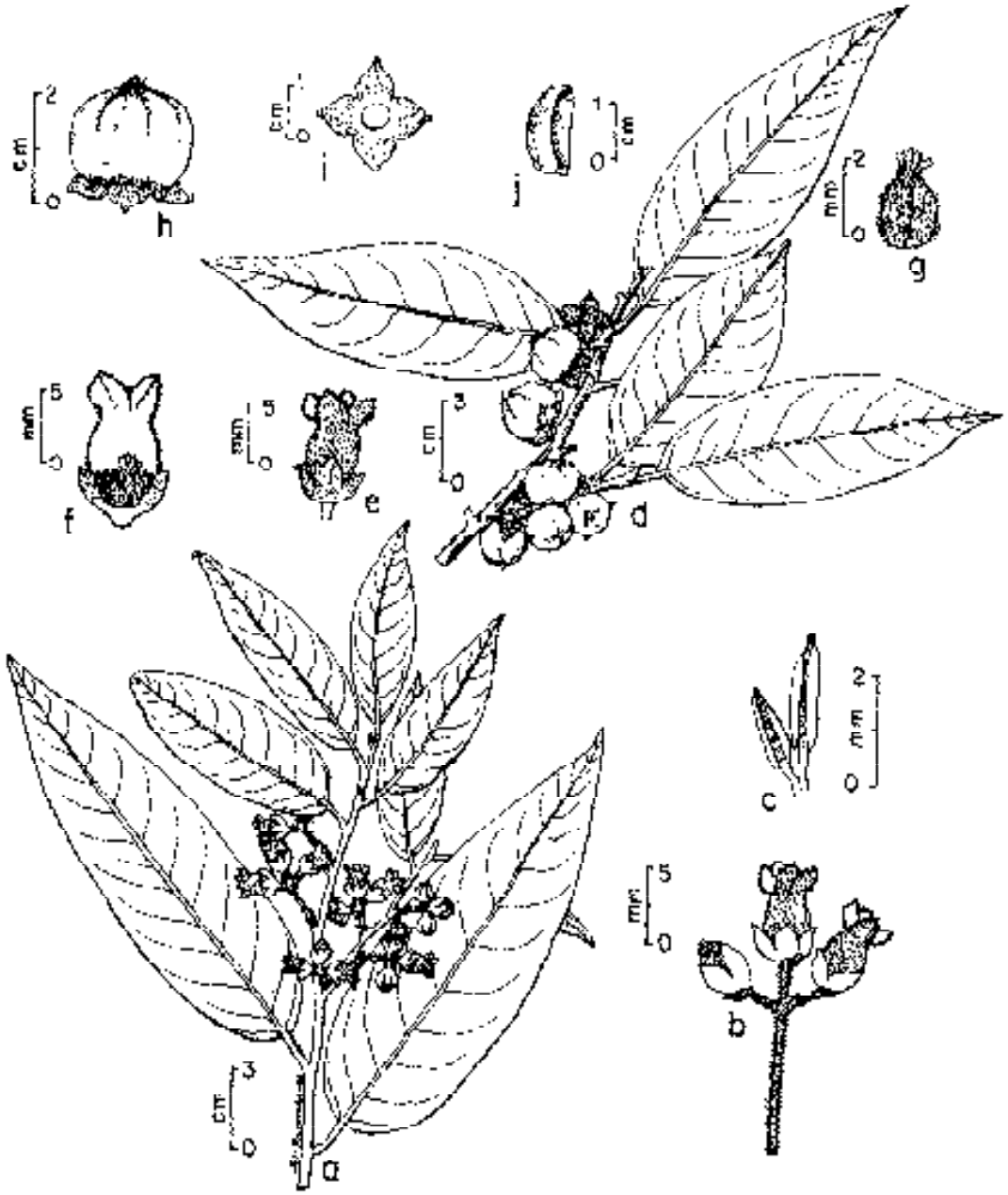


Fig.-51. ***Diospyros racemosa*** Roxb.
Male : a. habit, b. inflorescence, c. stamens.
Female : d. habit, e. flower, f. L. S. of flower, g. gynoecium, h. fruit with calyx, i. fruiting-calyx, j. seed.

young, glabrous with age except at the base. Fruiting-calyx accrescent, tube flat and disciform, fruit seated on the disc and torus; lobes strongly reflexed, slightly longitudinally folded outside and becoming concave with pointed apex, pubescent bothsides, rather thick. Albumen equable (**Fig.-50; Plate 20/1**).

Holotype : India : Karnataka, Hassan, Bisle R. F., *Franceschi* 484 ♂ (HIFP).

Fl. & Fr.: April – October.

Ecol.: Found in wet evergreen forests, upto 600 m, particularly in Western Ghats and Andaman & Nicobar Islands.

Distrib.: Endemic to India, confined to Karnataka, Kerala and Andamans & Nicobar Islands (**Map-14**).

Notes : This taxon shows close affinity with *D. pyrrhocarpa* Miq. in having fine prominent reticulation, indumentum covering inflorescence and fruits and folded reflexed fruiting calyx-lobes. However, the reticulation is strong and fruits are depressed globose and distinctly pedicellate in *D. pyrrhocarpa* Miq.

Exsicc.: ANDAMAN & NICOBAR : Andaman, Long Island, *Parkinson 5*, 1666 (CAL-Paratype); Middle Andaman, 17th March 1913, *C. E. Parkinson* 42 (K, CAL); KARNATAKA : Shimoga, Jog, *Hall & McCann* 34848 (BLAT-Paratype); Hassan, Bisle Ghat, *Saldanha* 13202, 16025 (JCB, K-Paratypes); Kodagu, Kadamakkal R. F., *Ramesh* 193 ♀ (HIFP-Paratype), *Franceschi* 479 ♀ (HIFP-Paratype); KERALA : Quilon, Chendurney Sanctuary, *Ramesh & Franceschi* 495 (HIFP-Paratype); Palghat, Mandampatty, 550 m, 12th April 1978, *N. C. Nair 56767* ♀ (MH-Paratype), *Vajravelu* 60628 (MH-Paratype).

54. ***Diospyros racemosa*** Roxb. Fl. Ind. 2 : 536. 1824. *D. toposia* Buch.-Ham. in Trans. Linn. Soc. London 15 : 115. 1827; A. DC. in DC. Prodr. 8 : 237. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 263. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 556. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 298. 1938; Kostermans, Rev. Handb. Fl. Ceylon 3 : 22. 1981. *D. lanceolata* Roxb. ex Wall. Cat. No. 4122. 1831, *nom. nud.*, non Poir 1804, nec Lesq. ex Schimp. 1872. *D. incisa* Ham. ex Wall. Cat. No. 4122. 1831, *nom. nud. Embryopteris racemosa* (Roxb.) G. Don, Gen. Hist. Dichl. Pl. 4 : 41 1837. *Diospyros ebenum* non Koen. forma *grandiflora* Hochr. in Bull. Inst. Bot. Buitenz. 22 : 62. 1905. *D. foveo-reticulata* Merr. in Phil. J. Sci. Bot. 4 : 308. 1909. *D. collinsae* Craib. in Kew Bull. Add. Ser. 11 : 302. 1920.

Vernacular names : *Asm.*: Gulal, Goolul, Thing-bong; *Beng.*: Toposi, Gulal, Goolul; *Kh.*: Dieng-seit-langkait; *Tam.*: Karunduvarai, Tuvarai, Thoveri, Vellaithoveri.

Dioecious trees, upto 20 m high, with terete, glabrous branches. Bark black or dark grey, smooth, hardly peeling off. Leaves alternate, 7-20 x 2.4-7.5 cm, oblong, ovate-oblong or elliptic-lanceolate, gradually narrowed towards apex, acuminate, cuneately narrowed or rounded at base, coriaceous,

glabrous bothsides, shining above; midrib canaliculate above and raised beneath, glabrous bothsides; lateral veins *ca* 10 pairs or more, rather prominent beneath than above, reticulate venation closely combiform and prominent bothsides; petioles 7-15 mm long, canaliculate above, rounded beneath, glabrous. Male flowers yellow, in axillary, pubescent, 3 flowered or in cultivated plants 3 to 12-flowered cymes on lower part of leafless branches or in the axils of lower leaves; main peduncles upto 1.5 cm long; pedicels upto 5 mm long, shorter than calyx. Flower-buds globose. Bracts at the top of peduncles or say at the base of pedicels, hood-shaped, acute, pubescent or hairy, caducous, sometimes small bracteoles developed at the apex of pedicels subtending the flowers. Calyx campanulate, 5-6 mm long; tube glabrous, deeply irregularly 4-lobed; lobes unequal, ovate, acute, spathaceo-valvate, with few inconspicuous scattered setae outside. Corolla urceolate, pubescent outside, glabrous within except a few hairs along the middle line of lobes; lobes 4, contorted. Stamens usually 32, rarely 18 to 33, in pairs of unequal length, seated on torus, hypogynous; filaments short, glabrous; anthers *ca* 2 mm long, glabrous, shortly apiculate. Pistillode inconspicuous. Female flowers usually solitary, axillary or rarely in cymes on lower part of young shoots; peduncles (if any) upto 10 mm long; pedicels upto 8 mm long, pubescent, sometimes peduncle (if present) or pedicel shortly adnate to the branch and inflorescence appears supra-axillary. Bracts borne at the top of pedicels, caducous. Calyx as in males but little larger and hairy bothsides. Corolla tubular-urceolate, pubescent or hairy outside, 4-lobed at apex; lobes shorter than tube, ovate, acute, glabrous within except a middle line of hairs, contorted. Staminodes 12-16, glabrous. Ovary densely pubescent or hairy, 4-celled (rarely 6-celled-Hiern, 1873; Kostermans, 1981), cells 1-ovuled; style short, inconspicuous; stigmas 4, pubescent, slightly notched at apex. Fruits 1.5-2.5 cm in diam., globose, glandular and villous when young, becoming glabrous and rough with age except at the base and apiculate apex; fruiting-pedicels upto 8 mm long, almost glabrous. Fruiting-calyx accrescent, *ca* 1.5 cm in diam., tube flattened forming a disc with torus and lobes, fruit seated on the disc; lobes ovate, abruptly obtusely subacuminate, spreading horizontally or slightly reflexed, villous within and almost glabrous outside. Seeds usually 4, rarely reduced to 1, oval-elliptic or wedge-shaped, upto 2 x 1 cm, lateral faces flat; albumen equable, cartilaginous (**Fig.-51; Plate 20/2 & 3**).

Holotype : Roxburgh's plate as reproduced by Wight, Ic. t. 416 (K).

Fl. & Fr.: March – November.

Ecol.: In moist evergreen forests, upto 1000 m. The germination of seeds in epigeal and cotyledons get detached at an early stage.

Distrib.: In India, this species finds distribution in W. Bengal and North-Eastern States, particularly Arunachal Pradesh, Assam, Tripura and Meghalaya. It further extends eastwards to Bangladesh, Myanmar, Thailand, Malaya, Philippines, Borneo, Timor and southwards to Sri Lanka (**Map-14**).

Anatomy : There are three traces in each cotyledon and 1 trace in each epicotyledonary leaf. The cotyledonary xylem splits to form 10-15 groups, but epicotyledonary traces are not well developed to trace the courses (Wright, 1904).

Timber is red when fresh, deepening to reddish brown on exposure; usually numerous black strands are irregularly distributed throughout the brown wood. Black heartwood is scanty. The tracheal elements contain abundant gummy, yellow to brown deposits. Contents in parenchyma are brown and granular. The length of vessels in twigs is 0.27 mm, with 0.027 mm radial and 0.03 mm tangential diameter. The length of vessels of sapwood is about 0.30 mm, having 0.09 mm radial and 0.06 mm tangential diameter. The length of wood parenchyma cells in sapwood varies from 0.06 to 0.15 mm, with 0.013 mm radial diameter. The radial diameter of wood fibres in sapwood and heartwood is 0.010 mm. The radial and tangential diameter of vertical medullary ray cells is 0.02 mm, with vertical length *ca* 0.09 mm. In horizontal components, the radial diameter is 0.05 mm and tangential 0.01 mm, with vertical length *ca* 0.035 mm. The medullary rays occur as radial rows of cells throughout the secondary xylem. In most of species there is only one cell in tangential width, but it is interesting to note two or three cells in tangential width in this species. In this character the species shows close affinity with *D. crumenata* Thw., *D. insignis* Thw. and *D. pruriens* Dalz. (Wright, 1904).

Uses : The ripe fruits are steeped in water and afterwards eaten in north-east India. They are used to stupefy fishes in Thailand (Utsunomiya *et al.*, 1998). The gummy extract exuding from the cuts on the trees is used against toothache. It is also reputed to be efficacious for skin diseases. The wood is used for ornamental works.

Notes : The calyx of this species is very characteristic being closed in bud with connate lobes, afterwards irregularly splitting from apex in unequal lobes. Hiern (1873) and Bakhuizen (1938) missed that the name *D. racemosa* Roxb. (1824) has priority on *D. toposia* Buch.-Ham. (1827) as it was published in first edition of Flora Indica by Roxburgh in 1824 and subsequently in Carey edition in 1832.

Exsicc.: ASSAM : Cachar, Mynadhar, 30 m, 18th May 1915, *U. N. Kanjilal* 6885 ♂ (ASSAM); Katakhal Reserve, 15th Dec. 1914, *U. N. Kanjilal* 4873 sterile (DD); Cachar hills, March 1875, *Without Collector* 9 ♀, Acc. No. 41856 (ASSAM); North Cachar hills, Hot spring, 150 m, 4th Feb. 1915, *U. N. Kanjilal s.n.*, Acc. No. 17609 ♀ (ASSAM); MEGHALAYA : Khasia & Jaintia hills, Nongla, 60 m, 11th Dec. 1915, *U. N. Kanjilal* 6360 sterile (DD); West Garo hills, Tura peak forest, 18th April 1987 *Ved Prakash* 15990 ♀ (RHMD); 8th June 1937, *DFO Garo hills* 14017 ♀ (ASSAM); Garo hills, 45 miles on Songeon Road, 23rd March 1915, *U. N. Kanjilal* 5353 sterile (DD); TRIPURA : North Tripura, Phuldungsei, Ananda Bazaar, 660 m, 1st Feb. 1962, *D. B. Deb* 27342 ♀ (CAL); WITHOUT LOCALITY : 20th Jan. 1884, *Paull s.n.*, Acc. No. 282151 ♀ (CAL).

55. ***Diospyros ramiflora*** Roxb. Fl. Ind. 2 : 535. 1832; A. DC. in DC. Prodr. 8 233. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 235. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 569 1882.

Vernacular names : *Asm.*: Theikum; *Beng.*: Oori-gaub, Goolul; *Mal.*: Therikka; *Tam.*: Karumchatthi.

Large, dioecious trees, with straight trunk and glabrous branches. Leaves alternate, 10-25 x 2.5-7.5 cm, elliptic or oblong, gradually tapering at apex, long acuminate, base cuneate or subrounded and slightly decurrent with petiole, coriaceous, shining, margins entire, sometimes undulating in dry specimens, glabrous bothsides; midrib flat or subcanaliculate above, raised beneath, glabrous bothsides, lateral nerves 9-12 pairs, strongly arcuating towards apex, not conspicuous, tertiary venation loose, irregular and delicate; petioles 5-8 mm long, canaliculate above, rounded beneath, glabrous. Flowers usually pentamerous in Indian material, rarely tetramerous or hexamerous (Hiern, 1873). Male flowers in small, rusty pubescent fascicles on rather woody branches and/or in 1.5-2.5 cm long, pubescent, bracteate racemes on lower part of leafless young branches or in the axils of leaves. Bracts oblong, 2-2.5 x 1-1.5 mm, obtuse, densely pubescent bothsides, subtending the flowers. Calyx oblong-campanulate, pentagonal, pubescent bothsides, 5-lobed, divided less than half way down; tube 4-5 mm long; lobes *ca* 2 mm long, triangular, acute, valvate. Corolla white, 7-9 mm long, oblong-tubular; tube about as long as calyx-tube, densely villous outside, glabrous within; lobes 5, broadly oblong, hairy bothsides, contorted. Stamens 16, hypogynous, seated on torus, in two rows, subequal in size, paired; filaments short, 1-1.5 mm long, about half the length of anthers, glabrous; anthers linear, 2-3 mm long, pubescent on lateral sides, connectives produced, apiculate, with a tuft of hairs at tip. Pistillode a tuft of hairs surrounded by two rows of stamens. Female flowers usually in small, pubescent, pedicellate fascicles on woody or young branches or rarely in racemes or panicles. Calyx oblong-campanulate, pubescent bothsides; tube 5-7 mm long, somewhat inflated, 5-lobed, divided less than half way down like males; lobes deltoid, 2.5-3.5 mm long, acute, valvate. Corolla shortly tubular, 9-12 mm long, white, hairy outside; tube glabrous within; lobes 5, oblong-ovate, about one-fourth as long as tube, hairy bothsides, contorted. Staminodes usually 10 (12 in hexamerous flowers), in one row, shorter than corolla-tube, glabrous. Ovary ovoid-conical, ferruginously hairy, usually 10-celled (12-celled in hexamerous flowers), cells 1-ovuled; style 1, short, hairy; stigmas 5 (6 in hexamerous flowers). Fruits globose, 6-7.5 cm in diam., young ones hairy, becoming glabrous and rather scabrous on maturity. Fruiting-calyx accrescent, 3-3.5 cm in diam., tube flat and disciform, fruit seated on the disc; lobes small, triangular, horizontally spreading and as such the flat disc appears pentagonal. Seeds as many as locules in the fruit (usually 10), oblong, 10-12 x 7-8 mm, glabrous, with distinct transverse lines on the testa; albumen ruminate (**Fig.-52; Plate 20/4 & 21/1**).

Holotype : Roxburgh's plate as reproduced in Wight, Ic. t. 189 (K).

Fl. & Fr.: February – June.

Ecol.: Rare, found in subtropical forests, upto 1500 m. The plants attain great size on the Eastern Himalaya. The fruits take almost an year to ripen from its blooming period.

Distrib.: This species finds restricted distribution in India from W. Bengal to Assam, Mizoram and Andaman & Nicobar Islands. Further east, it is reported from Bangladesh and Myanmar (**Map-14**).

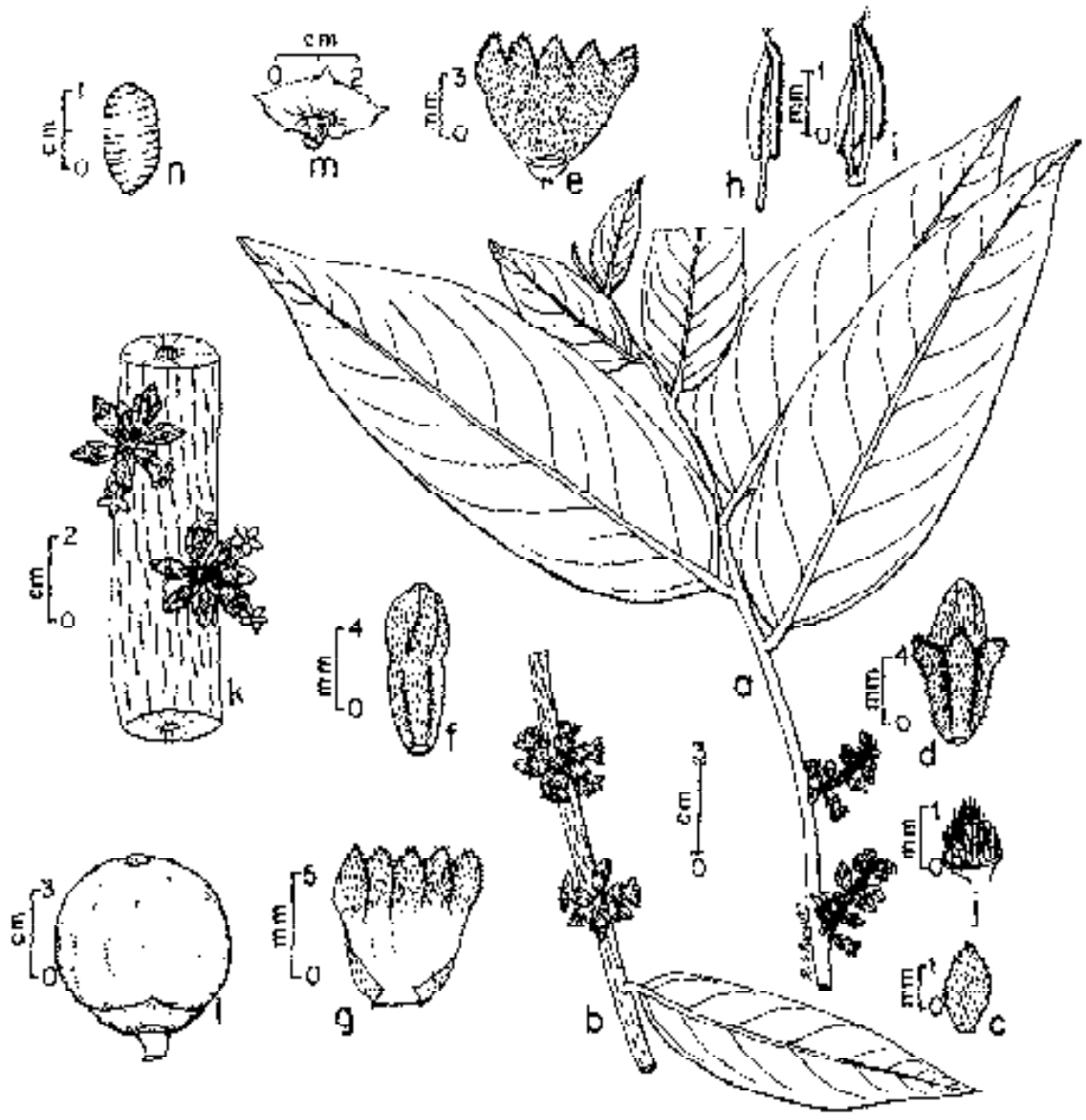
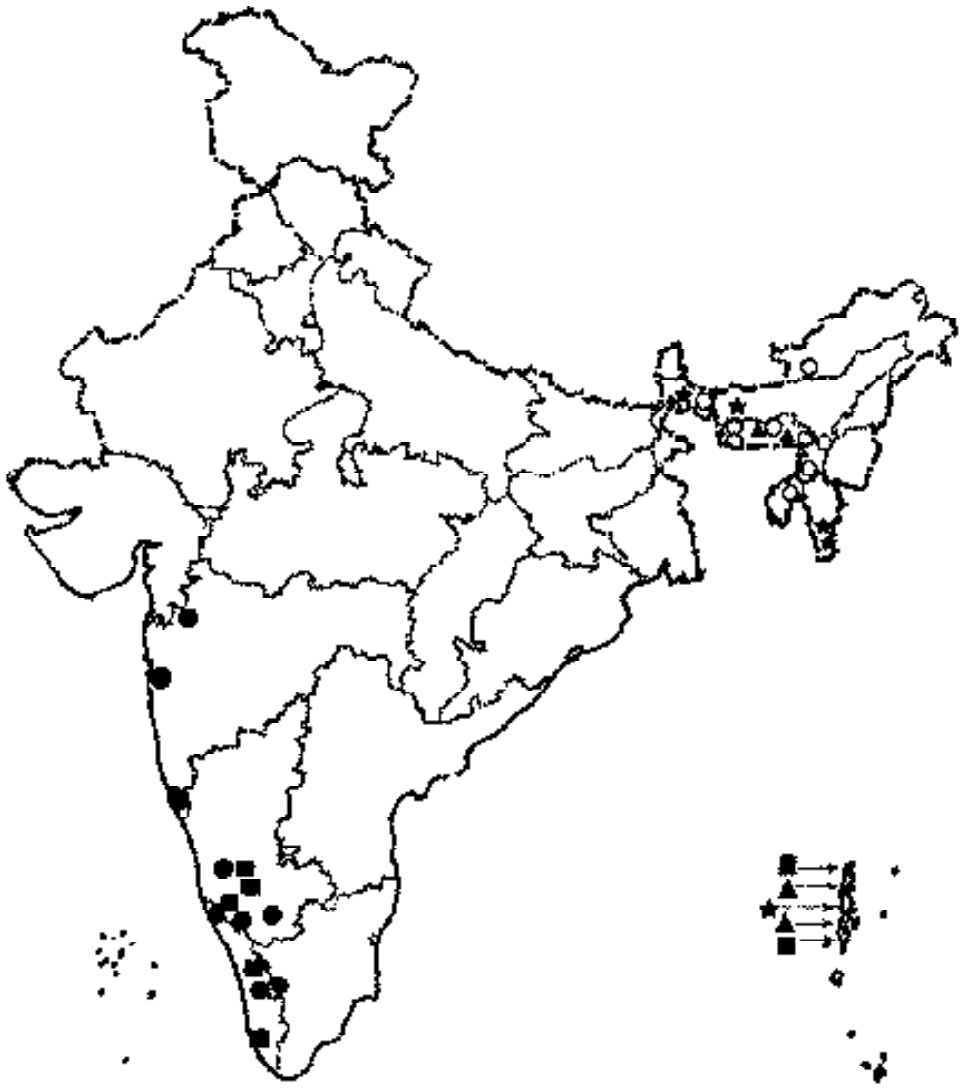


Fig.-52. ***Diospyros ramiflora*** Roxb.
Male : a-b. habit, c. bract, d. flower-bud, e. calyx within, f. corolla in bud, g. corolla within, h-i. stamens, j. pistillode.
Female : k. inflorescence borne on old wood, l. fruit with calyx, m. fruiting-calyx, n. seed.



Distrib. Sketch Map – 14

● *Diospyros pruriens* Dalz.; ▲ *Diospyros pyrrhocarpa* Miq.;
■ *Diospyros pyrrhocarpoides* Ramesh & Franceschi;
○ *Diospyros racemosa* Roxb.; ★ *Diospyros ramiflora* Roxb.

Uses : The wood is strong and hard, used for furniture and building construction. The ripe fruits are orange, with yellowish, sweet, edible pulp which is much relished by Khasia tribals in north-east.

Notes : Hiern (1873) has described tetramerous, pentamerous and hexamerous flowers in this species. The Indian specimens examined by me are invariably pentamerous.

Exsicc.: ANDAMAN & NICOBAR : Middle Andamans, Near town, Sea level, 28th July 1972, *N. Bhargava* 2824 ♀ (PBL, probably belongs here); MIZORAM : Lushai hills, 120 m, 27th Nov. 1914, *U. N. Kanjilal* 4761 ♀ (DD); WITHOUT LOCALITY : *H. B. K. s.n.*, Acc. No. 282817 ♂ (CAL).

56. ***Diospyros ridleyi*** Bakh. in Gard. Bull. Str. Settl. 7 : 183. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 354. 1938. *D. dajakensis* Bakh. in Gard. Bull. Str. Settl. 7 : 168. 1933 & Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 321. 1938.

Vernacular name : *Hindi* : Tendu.

Dioecious trees, upto 15 m high, with terete, sparsely lenticelled and glabrous branches. Leaves alternate, bifarious, oblong-lanceolate or elliptic-oblong, 5-20 x 2.5-8 cm, cuneate or subrounded at base and slightly decurrent with petiole, obtusely subacuminate at apex, glabrous bothsides, coriaceous; midrib canaliculate above, raised beneath, glabrous bothsides; lateral nerves 7-10 pairs, not prominent, usually mixed with reticulation; petioles 5-10 mm long, canaliculate above, rounded beneath, glabrous. Male flowers in axillary, 1 to 3-flowered, rufous-tomentose, bracteate cymes; peduncles *ca* 5 mm long, rufous-tomentose. Bracts ovate, tomentose bothsides. Calyx urceolate; tube 5-6 mm long, 2-3 mm wide at mouth, tomentose bothsides, usually 4 (-5) dentate; lobes tomentose bothsides, valvate. Corolla tubular; tube longer than calyx, rufous sericeous outside, glabrous within; lobes usually 4 (-5), tomentose bothsides, contorted. Stamens 12, unequal, inserted on the torus; filaments glabrous; anthers linear-lanceolate, 3-4 mm long, acute, not apiculate, glabrous. Pistillode rudimentary. Female flowers axillary, solitary, subsessile. Calyx and corolla as in males but little larger. Ovary 8 or 10-celled, hairy, cells 1-ovuled. Fruits ovoid-globose or depressed globose, 5-8 cm in diam., glabrous on maturity, apiculate due to style remains; fruiting-pedicels 2-3 mm long, thick. Fruiting-calyx enlarged, usually 4 (-5)-gonous, 3-3.5 cm in diam. diagonally, 5-8 mm thick, flat, woody, rufous tomentose outside, sericeous within; lobes triangular, acute, 5-7 mm long and 1.5-2 cm broad at base, thick, margins coriaceous. Seeds 8-10, elliptic-oblong, compressed, 2.5-3.5 x 1.5-2 cm, *ca* 1 cm thick, testa coriaceous, blackish; albumen ruminate (**Fig.-53; Plate 21/2**).

Holotype : Malayan Peninsula, Johore, Johore Bahru, 1889, *H. N. Ridley s.n.* ♂ Acc. no. 40455 (SING).

Fl. & Fr.: Most part of the year.

Ecol.: Rare, found in loamy soils in inland forests along streams, upto 100 m.

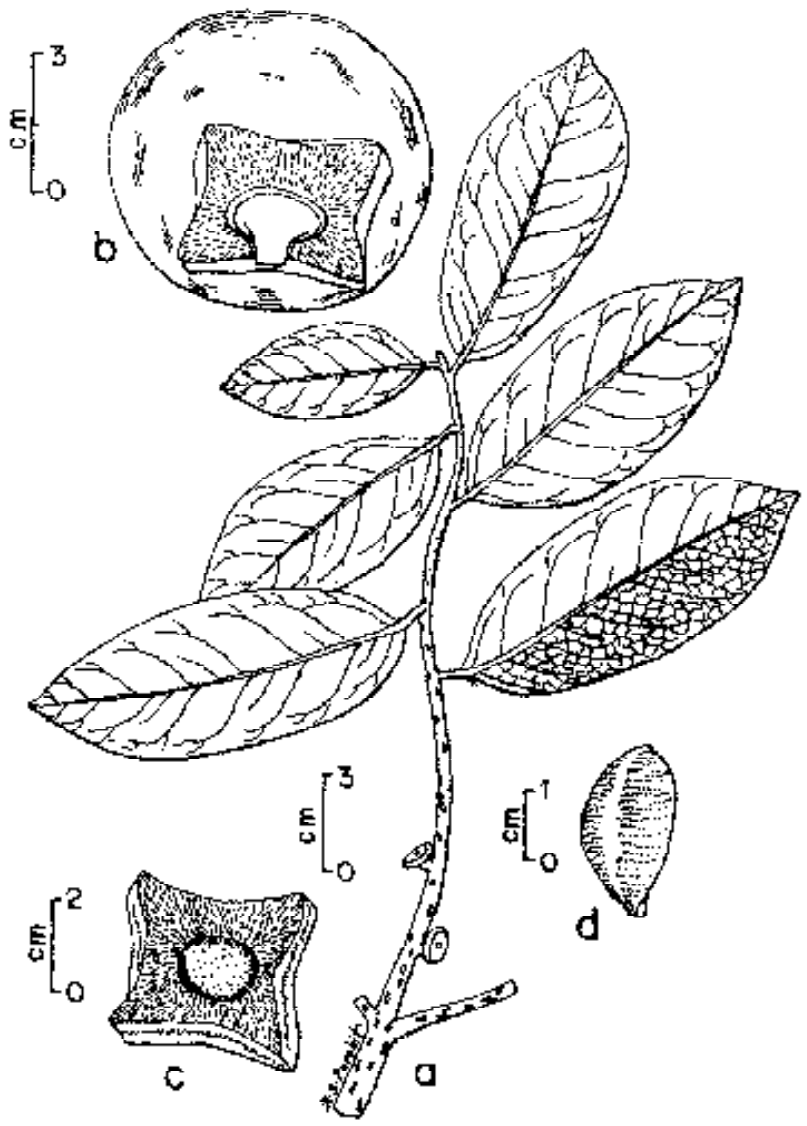


Fig.-53. ***Diospyros ridleyi*** Bakh.
Female : a. habit, b. fruit with calyx, c. fruiting-calyx, d. seed.

Distrib.: This species is a native of Malayan peninsula and finds very restricted distribution in Andaman and Nicobar Islands of the country. Sofar, it was considered endemic to Malaya (**Map-15**).

Uses : Fruits are eaten in the Middle Andamans.

Notes : The flat, thick, woody, shortly 4-lobed, densely pubescent fruiting-calyx of the species is characteristic to distinguish it from other related taxa like Sri Lankan *D. quaesita* Thw. and Malaysian *D. sundaica* Bakh. Further, the male plants were not available to me during the course of pesent study and the characters have been borrowed from the protologue.

Exsicc.: ANDAMAN & NICOBAR : North Andamans, Sitanagar forest, 15th May 1982, *M. K. V. Rao* 9041 ♀ (PBL); Lamia Bay to Kalipur, 50 m, 1st April 1977, *N. P. Balakrishnan* 5440 ♀ (PBL); Lekmipur, 24th Nov. 1976, *N. G. Nair* 4899 ♀ (PBL); Middle Andamans, Bakultala, 20th Jan. 1994, *Marcel Tigga* 16604 ♀ (PBL); South Andaman, Ograbraj, 50 m, 7th March 1974, *N. P. Balakrishnan* 880 ♂ (PBL).

57. ***Diospyros sahayadryensis*** Daniel & Vajravelu in J. Econ. Taxon. Bot. 3 (2) : 675. 1982. *Holochilus micranthus* Dalz. in Hook. Kew J. Bot. 4 : 291. 1852, non *Diospyros micrantha* Sandwith 1950. *Maba micrantha* (Dalz.) Hiern in Trans. Cambr. Philos. Soc. 12 : 133. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 552. 1882.

Medium-sized, dioecious trees, with glabrous branchlets. Leaves alternate, 10-14.5 x 4.5-6 cm, somewhat ovate with wider base or elliptic to oblong, obtusely acuminate at apex, subrounded or attenuated at base, coriaceous, glabrous; midrib flat above, not canaliculate, raised beneath, glabrous; lateral veins more than 6 pairs, close, indistinct, arcuating towards apex; petioles 8-10 mm long, almost 4-gonous, obscurely rusty puberulous when young, glabrous with age. Male flowers sessile, in 3 to 5-flowered, sericeous, axillary clusters; epicalyx or scales (probably bracts) *ca* 3 mm long, sericeous. Calyx *ca* 5 mm long, campanulate, pubescent outside, glabrous within, minutely 3-toothed or almost truncate; teeth valvate. Corolla 6-7 mm long, urceolate, 3-lobed; lobes contorted. Stamens 12-14, inserted at the base of corolla-tube. Female flowers subsessile, axillary, solitary; pedicels 1-2 mm long, sericeous, with bifarious scales (bracts) at the base of calyx. Calyx 3-4 mm long, tubular-campanulate, 3-toothed or almost truncate, pubescent outside, glabrous within; teeth valvate. Corolla 1-1.2 cm long, tubular, 3-lobed, divided up to the middle; lobes ovate, obtuse, spreading, contorted. Staminodes 6, inserted at the base of corolla-tube; filaments double the length of barren anthers. Ovary hemispheric, glabrous, 6-celled, each cell 1-ovuled; styles 3, rather thick, obtuse. Fruits *ca* 2.5 x 0.8 cm, cylindric-oblong, glabrous, 6-seeded; fruiting-pedicels upto 3 mm long, sericeous, with scars of fallen scales. Fruiting-calyx funnel-shaped, truncate at apex, dry, hard, sericeous outside, glabrous within, enclosing lower part of the fruit. Albumen equable (**Fig.-54; Plate 21/3**).

Holotype : India : Maharashtra, Southern Ghats, Sahayadri hills, *Dalzell s. n.* ♀ (K).

Fl. & Fr.: February - August.

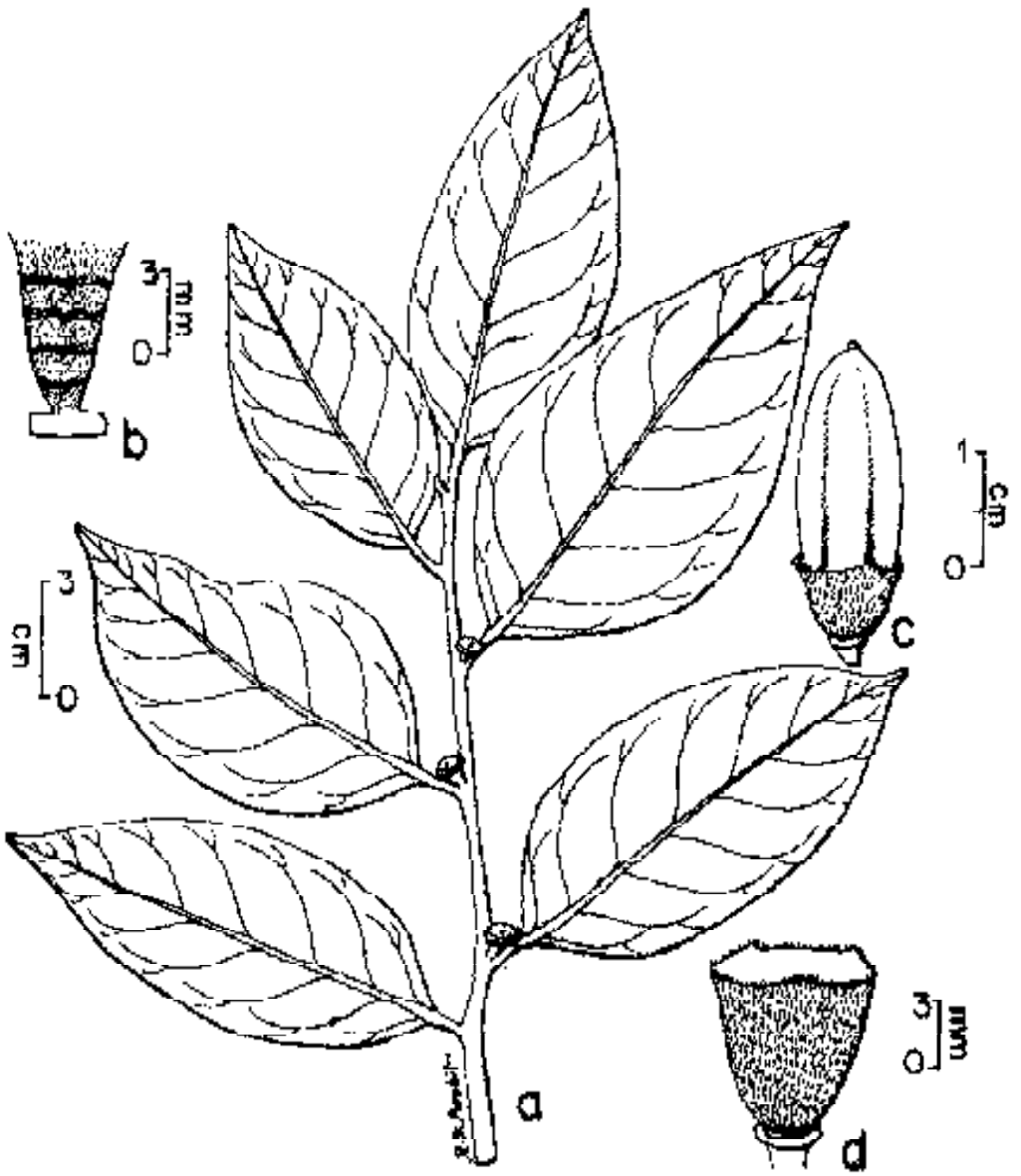


Fig.-54. ***Diospyros sahayadryensis*** Daniel & Vajravelu
Female : a. habit, b. scars of fallen scales on fruiting peduncle, c. fruit with calyx, d. fruiting-calyx.

Ecol.: Rare, in semi-evergreen forests on the hills, upto 2000 m.

Distrib.: Endemic to India, confined to Maharashtra and Karnataka (**Map-15**).

Exsicc.: KARNATAKA : North Kanara, Anshi, 450 m, May 1919, *T. R. Bell 5967* ♀ (CAL).

58. ***Diospyros saldanhae*** Kosterm. in J. Bombay Nat. Hist. Soc. 74 (2) : 326. 1977.

Trees, 8-10 m high; branches and branchlets densely tomentose with rather soft and short hairs and scattered, long and stiff hairs. Leaves spirally arranged, 4.5-14 x 2.3-5.8 cm, ovate-oblong, oblong or subobovate-oblong broader in upper half, abruptly subacuminate with obtuse or acute tip, subcordate at base, coriaceous, densely hairy with long hairs beneath especially on veins, upper surface almost glabrous or with few scattered hairs, becoming glabrate with age on bothsides except midrib, ciliate-margined; midrib raised beneath, canaliculate above, hairy bothsides; lateral nerves not much prominent, upto 10 pairs or more, facing obliquely forward towards margins, reticulation more prominent beneath than upper surface; petioles not exceeding 5 mm in length, thick, terete, densely tomentose. Male flowers not seen. Female flowers solitary, axillary, on young branchlets; pedicels upto 4 mm long, densely tomentose. Calyx campanulate, upto 12 mm long, densely tomentose outside, deeply 4-lobed nearly to the base; tube upto 2 mm long, glabrous within; lobes elliptic-oblong, 6-9 x 3-5 mm, obtuse, densely hairy outside, glabrous or with few scattered hairs within, ciliate with long hairs, spreading, contorted in bud. Corolla tubular, about as long as calyx or little longer, hairy outside, glabrous within, tube slightly constricted below the lobes; lobes 4, about as long as tube, ovate-oblong, obtuse, contorted. Staminodes 4, inserted at the base of corolla-tube, glabrous; filaments about twice as long as sterile anthers. Ovary ovate-conical, densely covered with long hairs, 4-celled, cells 1-ovuled; style 1, *ca* 2 mm long, densely hairy and hidden in the hairy mass of ovary; stigmas 2, projecting above the mass of hairs of ovary, 2-lobed at apex, thinly pubescent on outer face only. Fruits subovoid-globose, 1.2-2.5 cm in diam., densely tomentose, apiculate at tip by style remains; fruiting-pedicels 2-3 mm long, thick, densely pilose. Fruiting-calyx not enlarged, tube flattened and disciform; lobes oblong-ovate, 6-9 mm long, obtuse, hairy outside, glabrous within, spreading horizontally, fruit seated on the disciform platform formed by disc, lobes and torus. Seeds 3 or rarely 4, narrowly pear-shaped, slightly pointed, smooth, upto 15 mm long; albumen equable (Fig.-**55**; **Plate 21/4**).

Holotype : India : Karnataka, Hassan, Along a stream between Devalkere and Devarunde, May 1970, *Nicolson, Saldanha & Ramamoorthy,* HFP62 ♀ (JCB).

Fl. & Fr.: January – July.

Ecol.: Along the streams in the forests.

Distrib.: Endemic to India, confined to Goa, Karnataka and Kerala, upto 1000 m (**Map-15**).

Notes : This species is closely related to *D. pruriens* Dalz. to the extent that in Indian herbaria the specimens of two taxa have been mixed up. Kostermans (1977c) distinguished *D. saldanhae* Kosterm. from *D. pruriens* Dalz. by its broader leaves with subcordate base, shorter hairs of two kinds, short pedicels and larger fruits. He could examine only fruiting specimens while describing the species. The

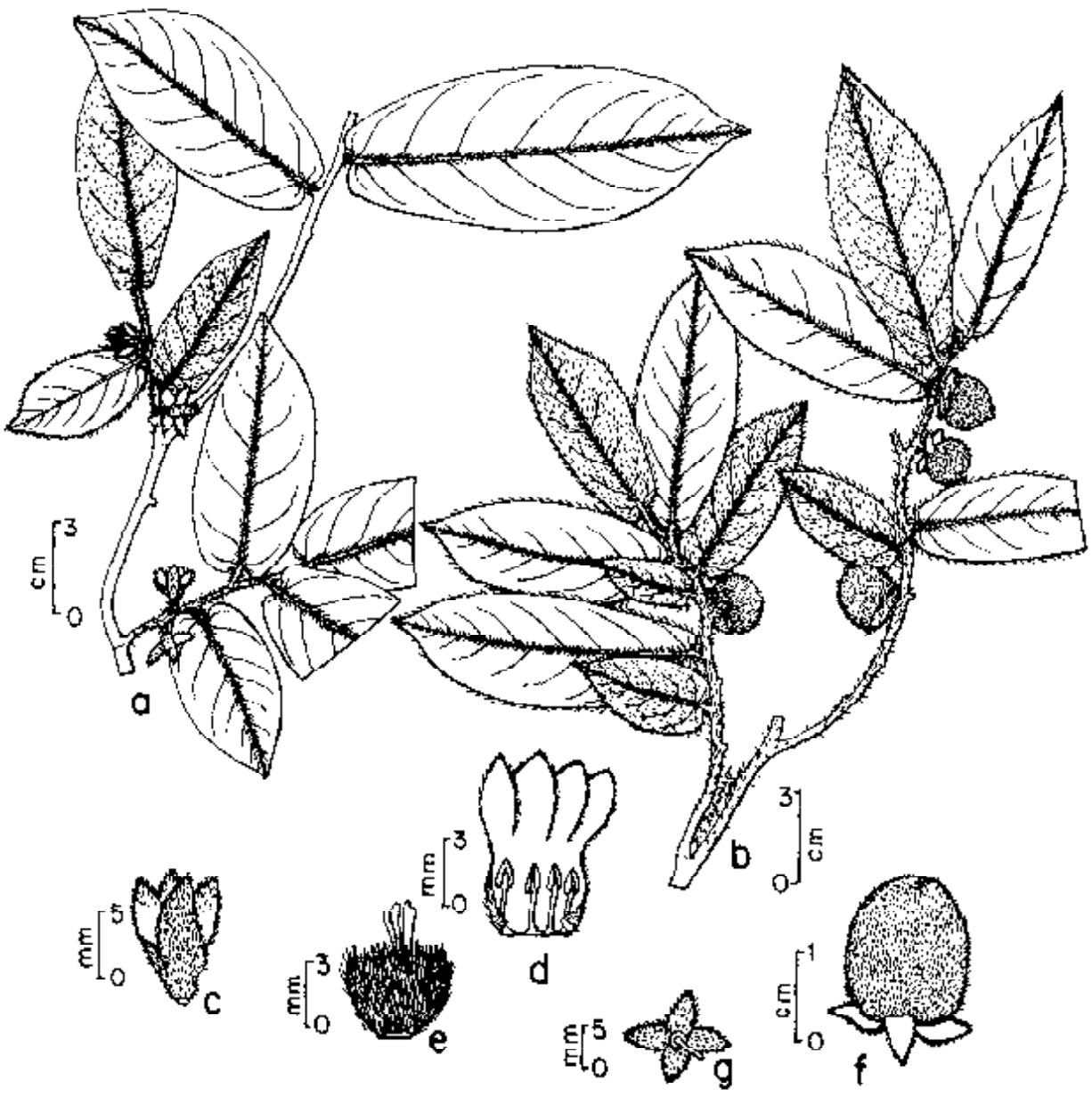


Fig.-55. ***Diospyros saldanhae*** Kosterm.

Female : a-b. habit, c. calyx, d. corolla within with staminodes, e. gynoecium, f. fruit with calyx, g. fruiting-calyx (dorsal view).

present study revealed that besides the characters used by Kostermans, two taxa may be well distinguished as under :

Leaves smaller, not exceeding 9.5 x 4 cm, usually rounded at base; petioles not thick. Female pedicels 8-12 mm long. Calyx-lobes distinctly nerved, imbricate in bud. Stigmas hairy and concealed in the hairs of the ovary, lobes at apex not distinct or absent. *D. pruriens*

Leaves rather large, atleast some upto 14 x 5.8 cm, usually subcordate at base; petioles rather thick. Female pedicels upto 4 mm long. Calyx-lobes not nerved, distinctly contorted in bud. Stigmas glabrous on inner face, pubescent on outer face, projecting above the hairs of ovary, 2-lobed at apex. *D. saldanhae*

During present study, I also could not come across any male plant. The source of pollen material for the female counterpart for producing fruits and seeds is not yet known. It's close affinity with *D. pruriens* Dalz., however, indicates possibility of being pollinated through the male plant of latter, which is, however, yet to be confirmed through the studies on its reproductive biology.

Exsicc.: KARNATAKA : Hassan, Along a stream between Devalkere and Devarunde, May 1969, *Saldanha* 13709 ♀ (JCB-Paratype); KERALA : Cannanore, Tirunalli, 825 m, 17th Nov. 1978, *V. S. Ramachandran* 58781 ♀ (CAL); Theevthundomalai-Chandanathode, 875 m, 24th Feb. 1979, *V. S. Ramachandran* 61385 ♀ (MH); Chandanathode, 840 m, 20th March 1980, *V. S. Ramachandran* 66832 ♀ (MH); Palghat, Poovanchalai, 850 m, 29th April 1980, *V. J. Nair* 67390 ♀ (MH, CAL); Malappuram, Nilambur, Karuvarakundu, 16th June 1982, *P. Mathew* 33369 sterile (CAL).

59. ***Diospyros stricta*** Roxb. Fl. Ind. 2 : 539. 1832, non Hort. ex Loud. 1842, nec Bl. ex Teysm & Binnend. 1855; A. DC. in DC. Prodr. 8 : 232. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 201. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 563. 1882.

Small, conical trees like firs, with straight trunk; branches terete, subtomentose, becoming glabrescent with age. Leaves alternate, 2.5-11 x 1-3 cm, lanceolate or ovato-lanceolate, ovate-lanceolate ones rather smaller in lower part of branches, long acuminate at apex, obtuse at base in lanceolate leaves and rounded in ovate ones, sub-membranous, hairy beneath when young and becoming glabrous with age except midrib and lateral veins, glabrous above except midrib, ciliate when young; midrib flat or subcanaliculate above in lower region and glabrous or filled with short hairs, raised and hairy beneath; lateral veins 8-10 pairs, arcuating towards apex, not conspicuous, reticulation very lax between the lateral veins; petioles 3-5 mm long, pubescent, terete or flat above and rounded beneath, neither grooved nor depressed above. Male flowers subsessile, arranged in pubescent, bracteate, cymose clusters of 1-3 flowers subspicately along an axillary, 5-7 mm long peduncle. Bracts ovate-suborbicular, 3-5 x 2-3 mm, boat-shaped, acute, pubescent outside, glabrous within, ciliate, with distinct midrib on dorsal surface, enclosing the flower-buds. Calyx campanulate, tawny hirsute outside, glabrous within, deeply 4-lobed; lobes ovate, apiculate, hirsute outside, glabrous inside, ciliate, imbricate. Corolla tubular, 5-8 mm long, salver-shaped, tawny hirsute outside, glabrous within, tube narrowed upwards; lobes 4, ovate,

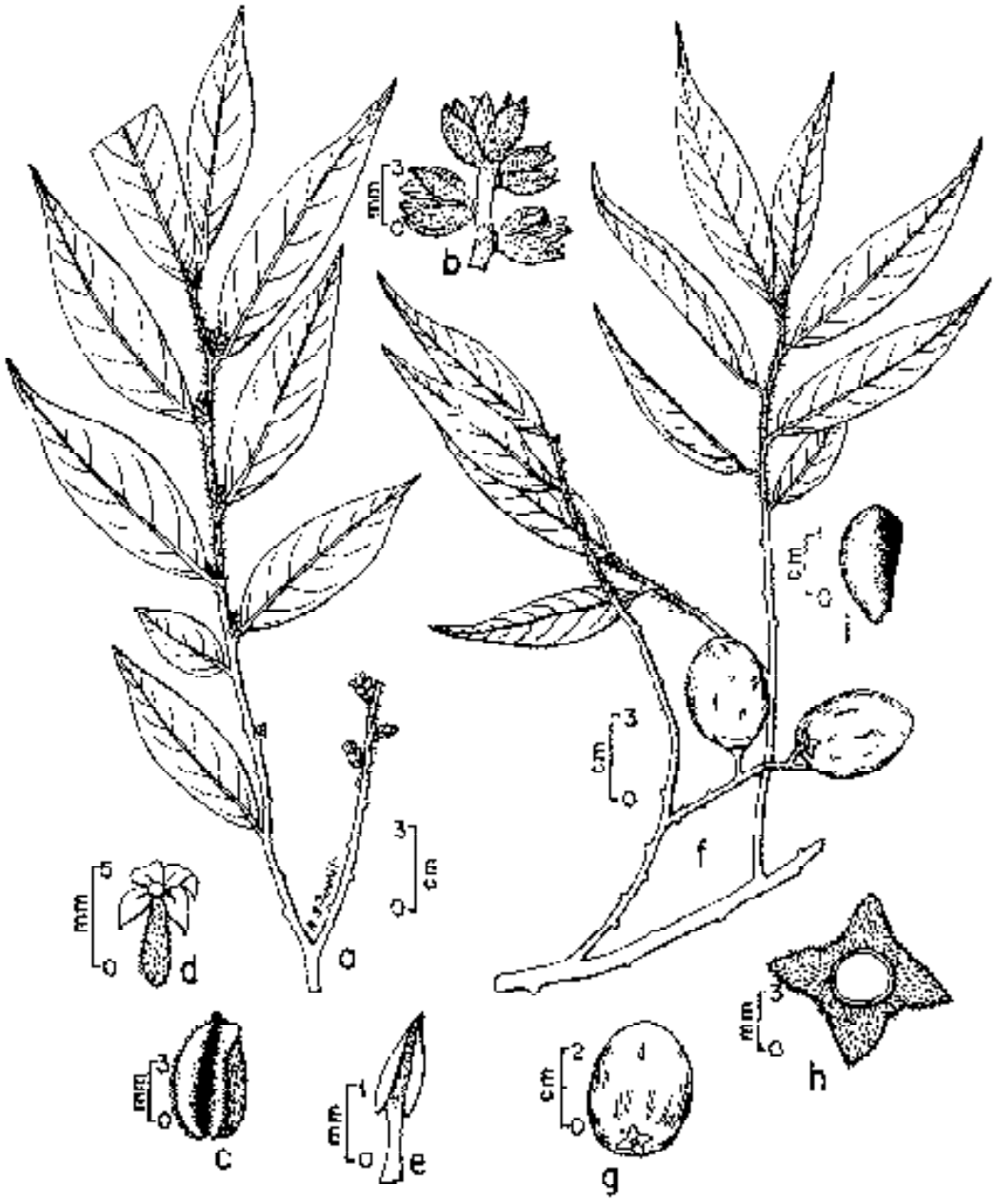


Fig.-56. ***Diospyros stricta*** Roxb.

Male : a. habit, b. inflorescence, c. bract, d. corolla, e. stamen.

Female : f. habit, g. fruit with calyx, h. fruiting-calyx, i. seed.

erect or reflexed, tomentose outside, glabrous within, contorted. Stamens usually 16, rarely 14, glabrous, free, about half of the length of corolla-tube, some inserted at the base of corolla-tube in one row, others borne on torus; filaments shorter or about as long as anthers; anthers glabrous, acute at apex. Pistillode absent or inconspicuous. Female flowers solitary, axillary, on erect pedicels thickened upwards. Calyx and corolla as in males but little larger. Ovary glabrous, 4-celled, cells 1-ovuled. Fruits ovoid, 2.5-3.5 x 1.5-2.5 cm, glabrous. Fruiting-calyx small, 8-10 mm in diam., not much enlarged, flat, disciform, with horizontally spreading lobes, fruit seated on small disc. Seeds solitary, oblong, 2 x 1 cm, glabrous, blackish; albumen equable (Fig.-**56; Plate 22/1 & 2**).

Holotype : Roxburgh's Plate No. 2507 (K).

Fl. & Fr.: March – September.

Ecol.: Rare, found in the rain forests, upto 1000 m.

Distrib.: In India, the species finds distribution in Uttar Pradesh, W. Bengal, Assam, Tripura and Meghalaya. It is also reported from Bangladesh (**Map-15**).

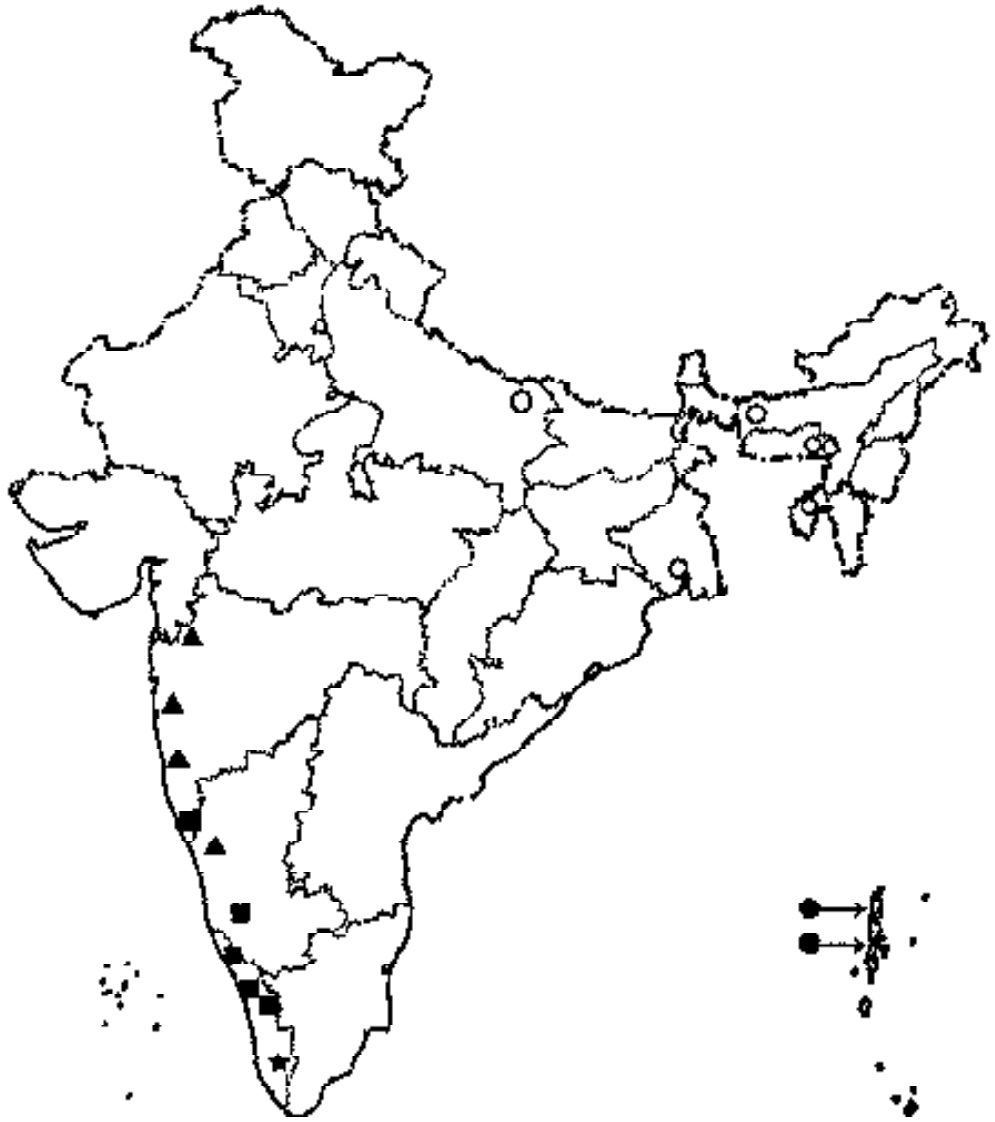
Uses : Timber is used in building construction.

Exsicc.: MEGHALAYA : Khasia & Jaintia hills, Pongtùm forest, 5th Nov. 1938, *S. R. Sharma* 17974 ♂ (ASSAM); Dawki forest, 1st May 1943, *G. K. Deka* 13 ♀ (DD); Near Dawki Dak Banglow, 1st May 1943, *G. K. Deka* 21697 ♀ (ASSAM); TRIPURA : Damcherra, 30 m, 19th Jan. 1962, *D. B. Deb* 26819 ♂ (ASSAM); WEST BENGAL : Howrah, Royal Botanic Garden (IBG), 15th Aug. 1902, *Without Collector s.n.* ♂ (BSI); WITHOUT LOCALITY : Herb. Sulp. Kurz, *HBC* Acc. No. 282543 ♂ (CAL). Also examined East Bengal (Bangladesh), *Griffith* 3624 ♀ (K).

60. ***Diospyros sulcata*** Bourd. Forest Trees Travancore 255. 1908, non Kostermans 1977; Gamble, Fl. Madras 2 (5) : 777. 1922.

Vernacular name : *Mal.*: Kari.

Trees, upto 10 m high, with blackish grey, smooth bark. Leaves alternate, 15-23 x 5-10 cm, oblong or oblong-lanceolate, abruptly acuminate at apex, tapering at base, coriaceous, glabrous bothsides, pellucid on the veins; petioles 0.8-2.5 cm long. Male flowers sessile, in tomentose, many-flowered axillary clusters or in the axils of scars of fallen leaves, 5-merous. Bracts many, tomentose, surrounding flowers. Stamens 10-12; anthers lanceolate, apiculate-acuminate due to produced connectives. Female flowers 5-merous, sessile, solitary or in clusters of 2-5 together, on old wood or in the axils of leaves. Bracts thick, rounded. Calyx thick, coriaceous, densely velvety, deeply lobed; lobes 5, triangular-auricled. Corolla tomentose; lobes 5, thick, cohering. Staminodes 5. Ovary densely brown tomentose with long hairs, 10-celled, cells 1-ovuled; style and stigmas 5, glabrous. Fruit a truncate cone, 0.8-0.9 x 2.3-2.6 cm at apex, covered with rusty tomentum when young, glabrous with age, marked with 8-10 deep longitudinal grooves. Fruiting-calyx flat, green, coriaceous, somewhat enlarged; lobes with undulating



Distrib. Sketch Map – 15

● *Diospyros ridleyi* Bakh.; ▲ *Diospyros sahyadryensis* Danniel & Vajravelu;
■ *Diospyros saldanhae* Kostern.;
□ *Diospyros stricta* Roxb.; ★ *Diospyros sulcata* Bourd.

margins. Seeds 10, flat, *ca* 2.5 x 1 cm; embryo *ca* 13 mm long; radical longer than cotyledons; albumen equable **(Plate 22/3)**.

Lectotype : India : Kerala, Travancore, Kallour river, above Mundamuri, 90 m, 27th Jan. 1903, *T. F. Bourdillon* 1323 ♀, ♂ (K-designated here).

Fl. & Fr.: Throughout the year; profuse flowering during February – March; fruits mature in December – January.

Ecol.: Rare, found in the valley of the rivers in evergreen and secondary forests at low elevation.

Distrib.: Endemic to India, confined to Kerala **(Map-15)**.

Anatomy : Wood is hard, brownish-pink, with occasional lines of black. No black heartwood. Pores numerous in radial lines. No use of the wood is under record.

Notes : Earlier, Brandis (1906) examined the specimens *Bourdillon* 1323 and 1584 (K) and concluded that they belong to a new species, but he couldn't name it because of imperfect material in hand. Later, Bourdillon (1908) named it as *D. sulcata* Bourd. based on above mentioned specimens. After Bourdillon no other worker could report this species from Travancore or elsewhere. Further, in the protologue the type locality for the specimen number 1323 ♀ (K) has been given as Rani river. However, the type specimen with same number reflects the type locality as Kallour river. Due to insufficient material in hand, complete description could not be provided by me.

Exsicc.: KERALA : Travancore, Moni, 100 m, 10th Jan. 1905, *T. F. Bourdillon* 1584 ♂ (Lectosyntype-K).

61. ***Diospyros sylvatica*** Roxb. Pl. Cor. 1 : 37. t. 47. 1795, non Wall. ex A. DC. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 161 1873; Clarke in Hook. f. Fl. Brit. India 3 : 559. 1882; Kostermans, Rev. Handb. Fl. Ceylon 3 : 35. 1981. *D. orixensis* Klein ex Willd. Sp. Pl. 4 : 110. 1805, non Wight ex Hiern 1873; A. DC. in DC. Prodr. 8 : 230. 1844.

English name : Ebony.

Vernacular names : *Beng.*: Koru, Tiril; *Bhoj.*: Sarapata; *Kon.*: Kakasirali, Akkasarali, Bilisarali; *Mal.*: Manjathuvara; *Mar.*: Bhoma; *Or.*: Khalijya, Modhurokhalijya, Kaluchia, Kalicha, Kanchia; *Tam.*: Karupputhoveri; *Tel.*: Gadha, Gata, Tellagada, Thellagata, Gadaluti, Hallagata, Nellaka-kamushti, Verrigata, Nallaghanta, Billagochh, Michhithummeda.

Tall, dioecious trees, rarely polygamous (Kostermans, 1981), upto 30 m high, with thinly pubescent young shoots becoming glabrous with age, foliage turning black when dry. Bark greyish-black, irregularly cracked. Leaves alternate, 3-14 x 1.5-7 cm, elliptic or oblong, narrowed at both ends, usually abruptly acuminate at apex, some leaves almost rounded at apex, usually cuneate at base or rarely subrounded, chartaceous, glabrous or minutely pubescent below in young leaves; midrib flat above or subcanaliculate

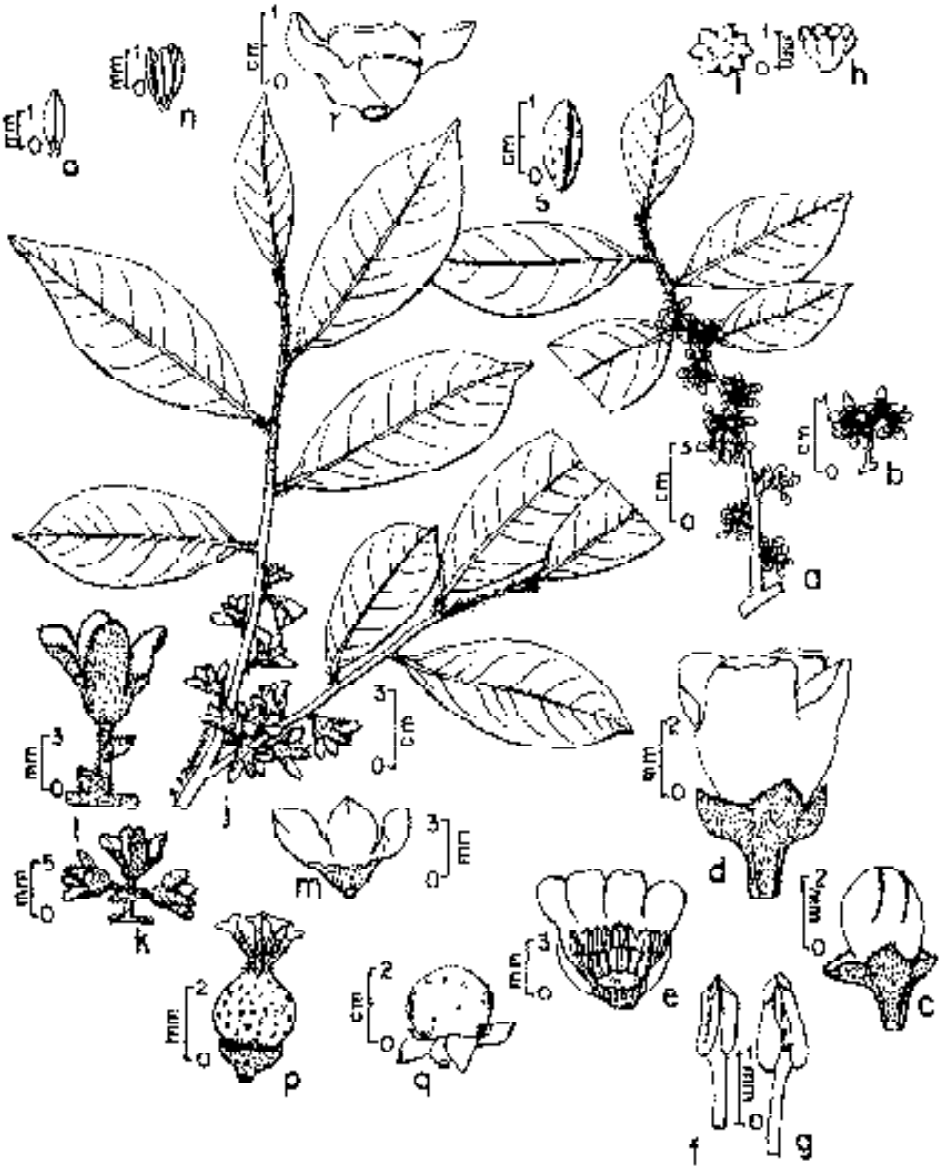


Fig. 57. ***Diospyras sylvatica*** Roxb.

Male : a. habit, b. inflorescence, c. flower-bud, d. flower, e. corolla within with stamens and pistillode, f-g. stamens, h. pistillode (lateral view), i. pistillode (top view).

Female : j. habit, k. inflorescence, l. flower-bud with bracts, m. calyx within, n. staminodes, o. staminode, p. gynoecium, q. fruit with calyx, r. fruiting-calyx, s. seed

in lower region, raised beneath, glabrous in mature leaves; lateral nerves 7-9 pairs, oblique towards apex, prominent beneath; petioles 5-10 mm long, thinly puberulous, flat above, rounded beneath. Male flowers in puberulous, much branched dichasial cymes of 7-15 flowers, subsessile or outer ones on *ca* 2 mm long pedicels. Bracts and bracteoles ovate-triangular, 1-2 mm long, pilose, caducous. Calyx cup-shaped, *ca* 2 mm long, pubescent outside, glabrous within, usually 4-lobed or rarely 3-lobed, divided about the middle; lobes triangular, ciliate, valvate. Corolla urceolate-campanulate, white, 4-6 mm long, glabrous bothsides; lobes usually 4 or rarely 3, broadly oblong, rounded at apex, rotate. Stamens usually 18-20, rarely 13-22 (Hiern, 1873; Kostermans, 1981), usually free or rarely few in pairs, hypogynous, inserted on the torus around the pistillode; filaments about as long as anthers, glabrous or with few hairs at the apex; anthers ovate, 1.5-2 mm long, apiculate, dehiscing through apico-lateral slits, glabrous or with few hairs on the back along the connectives. Pistillode a flat, 8-angular disc or obovate to obconic, flat-topped, with distinct 8 grooves and ridges resembling mericarps of *Malvaceae*. Female flowers axillary, solitary or in 3-flowered, bracteate cymes, sometimes the flowers are closely borne on small young axillary branches and appear like racemes after falling of the leaves; pedicels 2-5 mm long, pubescent, rather longer in solitary flowers than cymose ones. Bracts ovate-triangular, 2-3 mm long, pubescent bothsides, inserted at the base of pedicels in the solitary flowers and at the base of peduncles in cymose ones, soon deciduous. Bracteoles ovate-lanceolate, upto 2 mm long, pubescent, inserted at the base of pedicels in cymose flowers and about the middle on pedicels in solitary ones, semi-persistent. Calyx campanulate, 6-8 mm long, pubescent outside, glabrous within; tube 1.5-2 mm long; lobes usually 4 or rarely 3, 4-6 x 3-4 mm, broadly oblong or oblong-elliptic, obtuse at apex, valvate. Corolla urceolate, yellowish-white, 8-10 mm long, glabrous bothsides; lobes usually 4 or rarely 3, oblong-rounded, contorted. Staminodes 4, glabrous, alternating with corolla-lobes; filaments very short; sterile anthers upto 1.5 mm long, usually close to each other in bud and appearing like a cone. Ovary globose, 2-2.5 mm in diam., usually 8-celled or rarely 6-celled, glabrous or with few scattered hairs at apex, cells 1-ovuled; styles usually 4 or rarely 3, *ca* 1.5 mm long, sparsely hairy; stigmas bifid. Fruits globose, 1.25-2 cm in diam., apiculate, glabrous; fruiting-pedicels 2-3 mm long, thinly pubescent. Fruiting-calyx enlarged, 1.5-2.5 cm in diam., glabrous, tube shallow bowl-shaped and the fruit seated in the cavity of bowl; lobes usually 4 or rarely 3, ovate-triangular, reflexed or horizontally spreading. Seeds 2-8, ovoid or oblong-globose, upto 1.5 cm long; cotyledons cordate-rounded at base, tapering-obtuse at apex; albumen ruminate (**Fig.-57; Plate 22/4 & 23/1**).

Holotype : Tab. 47 of Roxburgh, Pl. Cor. (K).

Fl. & Fr.: February – November.

Ecol.: Usually found in damp evergreen forests, upto 1500 m. After epigeal germination of seeds, the cotyledons persist for many months and function as photosynthetic organ until epicotyledonary leaves are developed. The growth of epicotyledonary leaves is rather slow.

Distrib.: In India, the species chiefly concentrates in the States of Bihar, Jharkhand, W. Bengal, Orissa, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu and Kerala. It further extends southwards to Sri Lanka (**Map-16**).

Pollen: Endocolpium very faint, dumb-bell-shaped, 4 x 10 µm. Exine surface psilate. Size 34-41 x 26-30 µm (Nair & Kothari, 1985). Details of pollen morphology have been provided by Sharma & Gupta (1979) as pollen grains 3-colporate, prolate-spheroidal (30.5 x 28.5 µm), range 30-32.5 x 27.5-30 µm. Amb sub-circular. Colpi long, thin, running from pole to pole, membrane ornamented (granulate). Maximum width of colpus about 1.5 µm. Exine about 2 µm thick. Sexine thinner than nexine and sexine pattern psilate to obscure.

Anatomy : There are two vascular traces in each cotyledon and xylem splits in 8-15 groups. Each epicotyledonary leaf possesses one trace, not prolonged into root. Below the collet, the most seedlings show crude octard exarch cylinder with protoxylem groups joined by strongly lignified perimedullary zone (Wright, 1904).

The wood is diffuse-porous. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The heartwood and sapwood are indistinct, straight-grained and fine-textured. The timber is susceptible to dry wood borer (Wright, 1904; Purkayastha, 1982).

The timber is yellow or white, with small quantity of heartwood. The medullary ray cells of the sapwood possess contents some of which show signs of disintegration and acquire a distinct colour passing into the heartwood. The number of parenchymatous cells with such contents increases considerably from outside to inwards and in addition many of the vessels become partially filled with gum-resin of yellow colour. The differentiation of the elements is rather regular and the percentage of fibres is high. The length of vessels of twigs is 0.20 mm, with 0.03 mm radial and 0.028 mm tangential diameter. The length of vessels of sapwood is about 0.36 mm, with 0.13 mm radial and 0.09 mm tangential diameter. The length of wood parenchyma cells in sapwood varies from 0.07 to 0.20 mm, with 0.014 mm radial diameter. The radial diameter of wood fibre cells in sapwood is 0.011 mm and in heartwood *ca* 0.012 mm. The radial diameter of vertical medullary ray cells is 0.02 mm and tangential 0.023 mm, with 0.07 mm vertical length. The radial diameter of horizontal components is 0.07 mm and tangential 0.01 mm, with 0.02 mm vertical length (Wright, 1904).

Phytochemistry : Lupeol, betulin and betulinic acid have been reported in the bark. α-amyrin, bauerenol and a new triterpene alcohol have been isolated from the leaves (Rastogi & Mehrotra, 1993a).

Uses : The timber is very hard and of inferior quality; it is occasionally used in fancy work. The ripe fleshy sweet pulp of the fruits is occasionally eaten in South India during early winters. In Andhra Pradesh, the Koyas tribals ground root-bark of this species with dry *Zingiber officinale* Rosc. and the paste is mildly heated and applied on rib muscles for chest pain. However, Khonds and Porjas give the above mentioned paste orally to cure bone fracture (Rao & Henry, 1996).

Notes : Flowers are strongly aromatic and usually visited by the bees. Kostermans (1981) has excluded *D. arixensis* Klein ex Willd. (1805) from the synonymy of this species, but I consider it conspecific to *D. sylvatica* Roxb. The Indian material examined by me is dioecious and 4-merous.

Exsicc.: ANDHRA PRADESH : Visakhapatnam, Beyond Kottur, 325 m, 12th Oct. 1972, *G. V. Subba Rao* 42555 ♀ (MH); JHARKHAND : West Singbhum, Banki, Salai, 345 m, 2nd Jan. 1961, *G. V. Subbarao* 23102 (ASSAM); Dumka, Santhal Pargana, May 1907, *Harsukh* 478 ♀ (DD); KERALA : Malappuram, Nilambur, Thanpumala, 13th Nov. 1982, *P. Mathew* 33635 ♀ (CALI); Kottamalapallam, 1400 m, 15th May 1995, *Jony Augustine & K. P. R.* 15230 ♀ (KFRI); Iddukki, Kattappana, 1100 m, 12th June 1983, *A. G. Pandurangan* 79204 ♀ (MH); Thekkady, 200 m, 2nd May 1995, *Jony Augustine & K. P. R.* 15171 ♂ (KFRI); Travancore, Ponmudi, 13th April 1903, *T. F. Bourdillon* 859 ♂ (DD); MAHARASHTRA : Pune, Kake Pani forest, Ambavne-Lonavala, 27th May 1964, *B. Venkata Reddi* 97843 sterile (BSI); Raigarh, Khandala valley, 7th June 1950, *A. R. Bragan* 308 sterile (DD); ORISSA : Baleshwar, Baripada, Between Dongadhia & Bhanjikusum, 4th April 1964, *S. L. Kapoor & Party* 65216 ♂ (LWG); Sundergarh, Karmadihi, 21st Feb. 1988, *A. Mukherjee & D. Namhata* 3110 ♀ (CAL); Ganjam, 90 m, Feb. 1884, *J. S. Gamble* 13769 ♀ (CAL); 1230 m, 1884, *J. S. Gamble* 13758 ♀ (DD); Inukcudaji, 1500 m, March 1884, *J. S. Gamble* 13916 ♀ (DD); Mayurbhanj, Orachandabhilla, 3rd May 1940, *Without Collector* Acc. No. 88770 sterile (DD); Puri, 8th April 1916, *H. H. Haines s.n.* ♀ (DD); Khorda, Feb. 1881, *J. S. Gamble* 9303 ♀ (DD); 6th April 1917, *H. H. Haines* 48530 ♂ (DD); Angul, Antuli, 14th Dec. 1902, *J. H. Lace* 2586 ♀ (DD); TAMIL NADU : Tiruvallur, Madras, Top slip, 750 m, Oct. 1949, *R. L. Awasthi* 35 (DD); Coimbatore, Karian Shola, Anamalais, Top slip, 780 m, 2nd July 1976, *M. Chandrabose* 47250 ♀ (RHMD); Karian Shola, March 1937 *N. L. Bor* 8153 sterile (DD); Kurungumudi, Anamalais, 650 m, 19th April 1963, *J. Joseph* 16220 ♂ 16226 ♀ (MH); Nilgiri, Moyar river bank, 550 m, 16th Feb. 1972, *B. D. Sharma* 39817 ♀ (MH); WEST BENGAL : Siliguri, Junji Nadi, 16th Jan. 1907, *H. H. Haines* 2368 ♀ (DD).

62. ***Diospyros trichophylla*** Alston in Trimen, Handb. Fl. Ceylon 6 : 181 1931; Kostermans, Rev. Handb. Fl. Ceylon 3 : 29. 1981; Ramachandran & Bhargavan in Ind. J. For. 7 (3) : 247. 1984; Jayaraman in Bull. Bot. Surv. India 34 (1-4) : 230. 1992. *D. pruriens sensu* Thw. Enum. Pl. Zeyl. 423. 1860; *sensu* Trimen, Handb. Fl. Ceylon 3 : 95. 1895, non Dalz. 1852.

Dioecious trees, 5-8 m high; branchlets covered with spreading, 3-5 mm long, stiff hairs. Bark black, smooth with short longitudinal ridges. Leaves alternate, 2.5-8 (-12) x 1.5-3.5 (-5) cm, broadly elliptic-oblong or ovate-oblong, thin, chartaceous, acute or obtusely shortly subacuminate at apex, rounded at base or base slightly narrowed in elliptic-oblong leaves, hairy on the veins above and throughout beneath when young, subsequently hairy on midrib and lateral veins beneath and glabrous above except midrib, ciliate with stiff, long hairs; midrib canaliculate above, glabrous or canal filled with short hairs, hairy and raised beneath; lateral veins 8-10 pairs or more, very close, thin, inconspicuous bothsides, almost mixed with reticulation; petioles upto 5 mm long, canaliculate above, densely hairy with long, stiff hairs. Male flowers in 3 to 4-flowered axillary racemes; peduncles *ca* 1 cm long, covered with

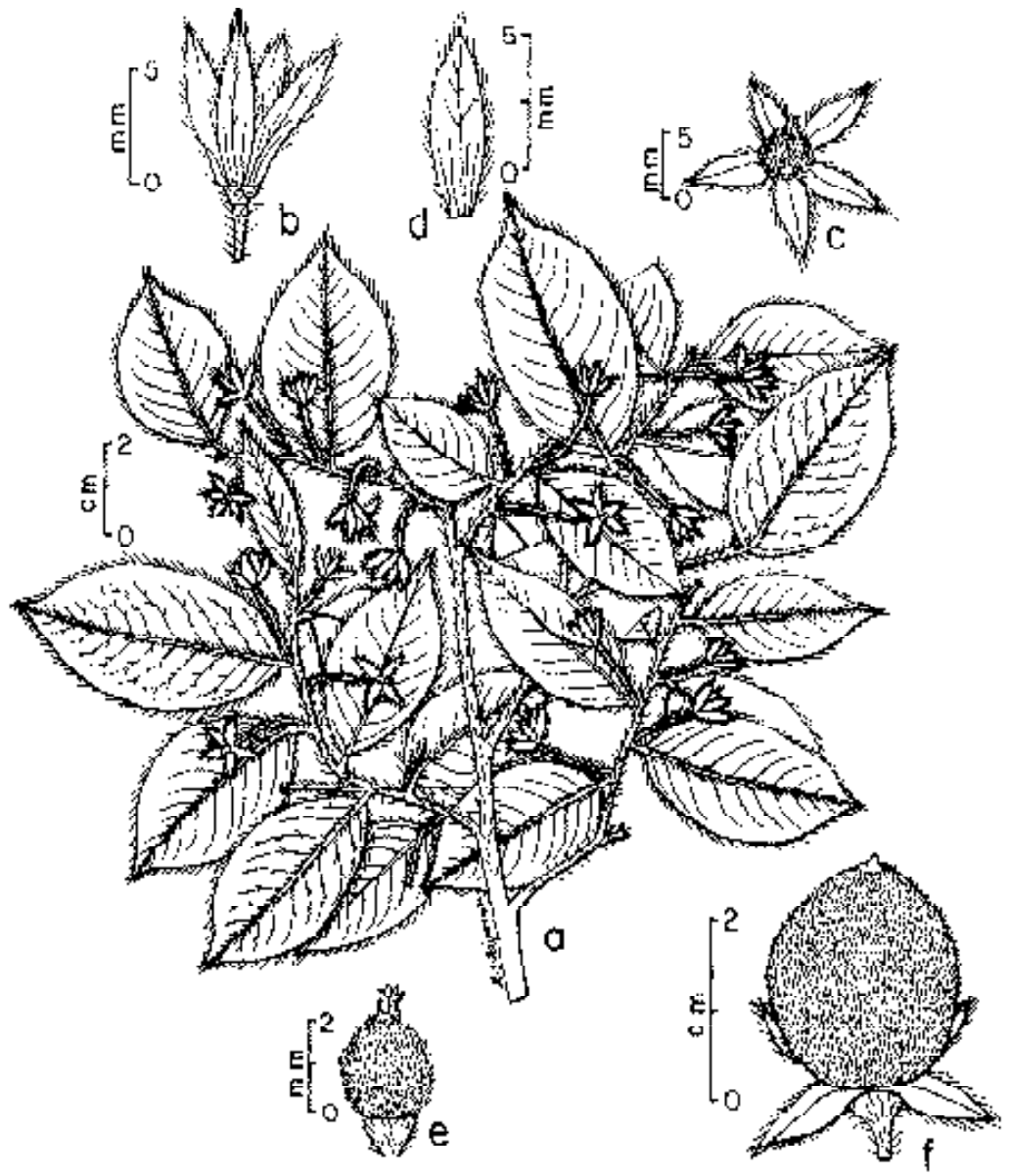


Fig.-58. ***Diospyros trichophylla*** Alston

Female : a. habit, b-c. flower, d. calyx-lobe, e. gynoecium, f. fruit with calyx.

long, stiff hairs; pedicels short, 1-2 mm long, hairy. Bracts *ca* 3 mm long, orbicular, hairy outside, caducous. Calyx-tube deeply divided, almost polysepalous; lobes 4-5, linear-oblong, 7-8 x 1-1.5 mm, narrowed at base, glabrous, finely acute to subacuminate at apex, rigid, ciliate, valvate; thalamus densely hairy. Corolla tubular, yellowish white, 1.2-2.5 cm long, tube little inflated at base due to ovary, expended lobes upto 2.5 cm across, hairy within; lobes 4-5, longer than tube, acute, contorted. Stamens 12-14, hypogynous, seated on the torus, connate into a central column; anther glabrous, narrow, acute, not apiculate. Pistillode a rudimentary disc. Female flowers solitary, in the axils of upper leaves; pedicels 1.2-2 cm long, wiry, densely hairy, widened at top. Calyx flat, no tube, deeply divided, almost polysepalous; lobes 4-5, 7-9 x 1.5-2 mm, linear-oblong, slightly narrowed at base, finely acute to subacuminate at apex, distinctly veined outside, glabrous bothsides, ciliate with stiff, long hairs, valvate. Corolla like males. Staminodes 5 or more, glabrous, inserted at the base of corolla-tube, with linear sterile anthers. Ovary ovoid-globose, 2-3 mm in diam., densely pilose-hairy, 4-celled, cells 1-ovuled; styles 2, short, thick, glabrous, concealed within the hairs of ovary; stigmas 4, glabrous. Fruits subglobose, *ca* 2.5 x 2 cm, apiculate, hairy with long white hairs. Fruiting-calyx flat, no tube, fruit seated on the disc; lobes 4-5, rigid, flattened, patent or spreading, upto 11 x 4 mm. Seeds 1-4, reddish-brown, elliptic-wedge-shaped or globose-ovoid, *ca* 1.5 x 1 cm; albumen equable **(Fig.-58; Plate 23/2)**.

Holotype : Ceylon Plants, *Thwaites* 2836 (PDA).

Fl. & Fr.: April – October.

Ecol.: In undisturbed wet evergreen forests, upto 1200 m.

Distrib.: This taxon finds distribution in Karnataka, Kerala and Andaman & Nicobar Islands in India and southwards it extends to Sri Lanka – its native home **(Map-16)**.

Anatomy : Timber is white, tinged with yellow, turns red on exposure.

Notes : Sometimes confused for *D. pruriens* Dalz. due to almost identical structure of flowers and hairy nature. However, *D. pruriens* Dalz. bears solitary or geminate, pedicelled male flowers on a common peduncle in the axils of leaves, imbricate and hairy calyx-lobes bothside with ciliate margins in both sexes, corolla glabrous within and lobes imbricate. On the other hand, in *D. trichophylla* Alston, the pedicelled male flowers are borne in 3 to 4-flowered axillary racemes, calyx-lobes valvate and glabrous bothsides with ciliate margins in both sexes, corolla hairy within and lobes contorted. Wright (1904) has recorded the presence of androgynophore in this species, a unique phenomenon.

Exsicc.: ANDAMAN & NICOBAR : South Andaman, Inanganj-Hill Jungle, 7th May 1892, *G. King's Collector s.n.*, Acc. No. 281923 ♀ (CAL); Port Blair, Corka Chund, 22nd May 1884, *G. King's Collector* 324, Acc. No. 281893 ♀ (CAL); Nemaack Ghata, 27th June 1884, *G. King's Collector* 92, Acc. No. 281892 ♀ (CAL); KERALA : Palghat, Mandambatti, Near Silent Valley, 1200 m, Jan. 1980, *H. S. Puri et al.* 3252 ♂ (MH); Idukki, Meenmutty-Kulamavu, 24th Feb. 1984, *A. G. Oandurangan* 78076 (MH); Kulamavu, 24th April 1984, *C. N. Mohanan* 81633, 81638 (MH).

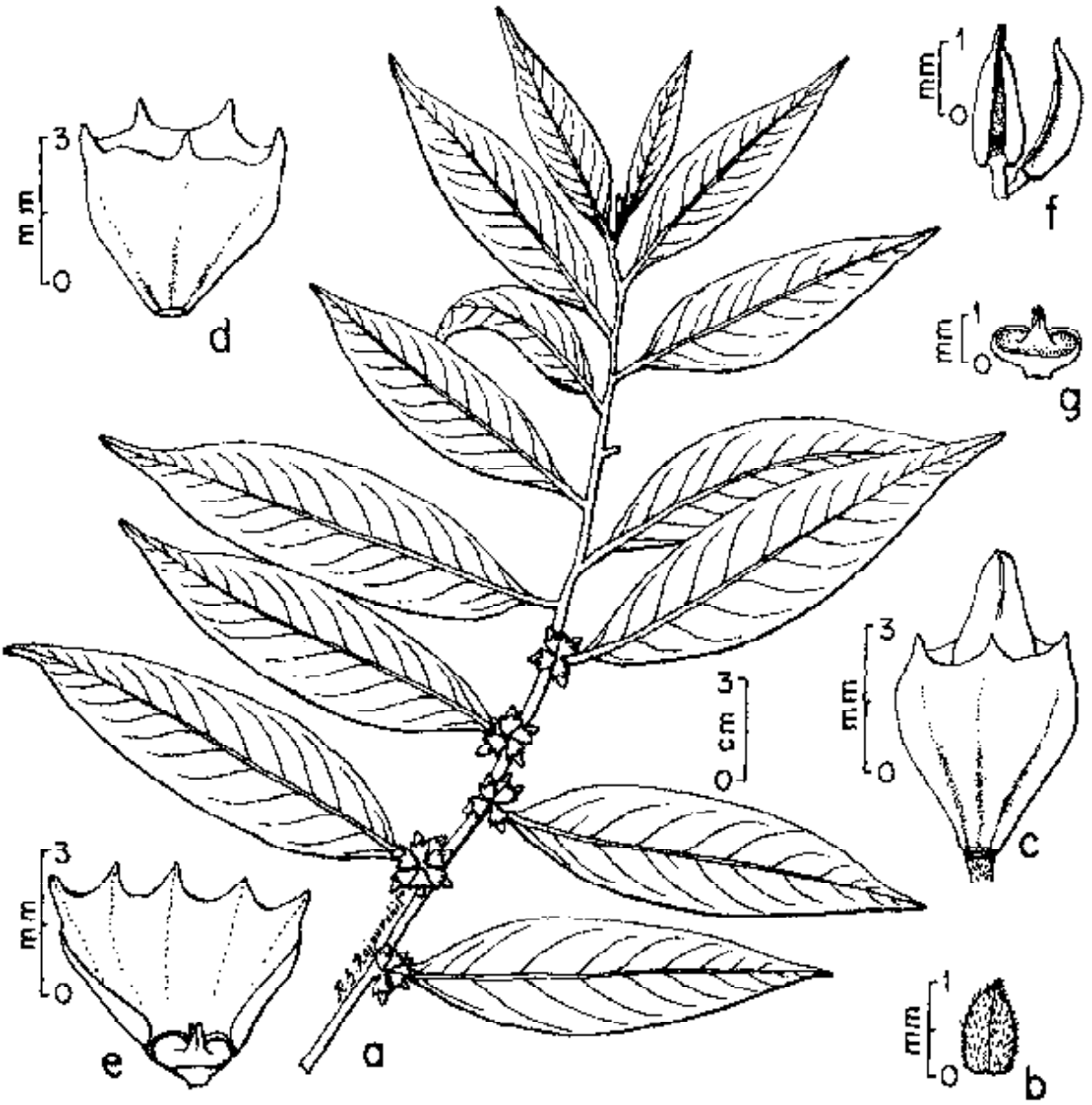


Fig.-59. ***Diospyros truncata*** Zoll. & Mor.
Male : a. habit, b. bract, c. flower-bud, d. calyx, e. calyx within with pistillode, f. stamens, g. pistillode.

63. ***Diospyros truncata*** Zoll. & Mor. in Mor. Syst. Verzeichn. Javan. Pflanzen. No. 1156 : 43. 1846; Hiern in Trans. Cambr. Philos. Soc. 12 : 172. 1873; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 228. 1938. *D. viridis* Craib. in Kew Bull. 1920 : 303. 1920. *D. truncata* Zoll. & Mor. vars. *minor* & *major* Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 230. 1938.

Dioecious trees, upto 20 m high, with glabrous, terete, widely spreading branches. Leaves alternate, subdistichous, elliptic-lanceolate, 8-13 x 1.6-3.7 cm, obtusely distinctly acuminate at apex, acumin upto 1.5 cm long, attenuately cuneate at base, glabrous bothsides, pale green, margins reflexed; midrib canaliculate above, raised beneath; lateral nerves 10-13 pairs or more, thin but conspicuous beneath, depressed and inconspicuous above, reticulate venation lax, irregular and inconspicuous; petioles 6-10 mm long, glabrous, canaliculate above, rounded beneath. Male flowers 4 to 8-together, very rarely 2 only (Hiern, 1873), in subsessile, axillary, bracteate cymes appearing like cluster of flowers; peduncles and pedicels upto 1 mm long, densely hairy. Bracts ovate-oblong or lanceolate, subpersistent, pubescent. Calyx campanulate, 3-4 mm long, narrowed at base, inflated above the middle, glabrous bothsides, mouth truncate and about as wide as length of tube; teeth 4-5, 0.5-0.75 mm long, triangular, acute, valvate. Corolla ovoid-tubular due to inflated tube in lower region; tube 5-10 mm long, glabrous bothsides; lobes 4-5, elliptic or ovate-oblong, acuminate at apex, contorted. Stamens 20 (rarely 8-11-12-14 – Hiern, 1873; Bakhuizen, 1938), inserted at the base of corolla-tube, subequal, paired, glabrous; filaments not exceeding 1 mm; anthers linear, 2-3 mm long in bud, some straight, others slightly falcate, apiculate due to produced connectives, glabrous. Pistillode glabrous, with 4 small styles united into a cone and appear emerging from the disc. Female flowers axillary, solitary, larger than males; pedicels 2.5-3 mm long, pubescent. Bracts caducous. Calyx campanulate, about as long as petioles, mouth truncate, glabrous; teeth 4-5, ovate, acute or obtuse, valvate. Corolla pale yellow, ovoid-tubular, glabrous bothsides, double the length of calyx, divided upto middle; lobes 4-5, ovate, acute, patent, contorted. Staminodes 8-10, glabrous, with terete filaments and 3-3.5 mm long, linear, sterile anthers. Ovary ovoid or globose, glabrous, 8-celled, cells 1-ovuled; styles 4, connate at base, glabrous. Fruits globose, 1.5-3 cm in diam., apiculate due to style remains, glabrous and shining on maturity. Fruiting-calyx coriaceous, 2-2.5 cm in diam., tube forming a 4-cornered shallow cup enclosing lower part of fruit; lobes 4 or 5, reflexed and undulate-plicate. Seeds ellipsoid, compressed, 1-1.8 x 0.5-0.8 cm, 3-5 mm thick; albumen equable (**Fig.-59; Plate 23/3 & 4**).

Holotype : Java : *Zollinger* 1156 (P).

Fl. & Fr.: March – July.

Ecol.: Rare, in wet evergreen forests, upto 1350 m.

Distrib.: In India, the taxon is confined to North-Eastern States, particularly Nagaland. It extends further eastwards to Sumatra, Malayan peninsula and Java – its native home (**Map-16**).

Uses : The wood is dark black, but of inferior quality. It is often used for agricultural implements, furniture and house hold articles.

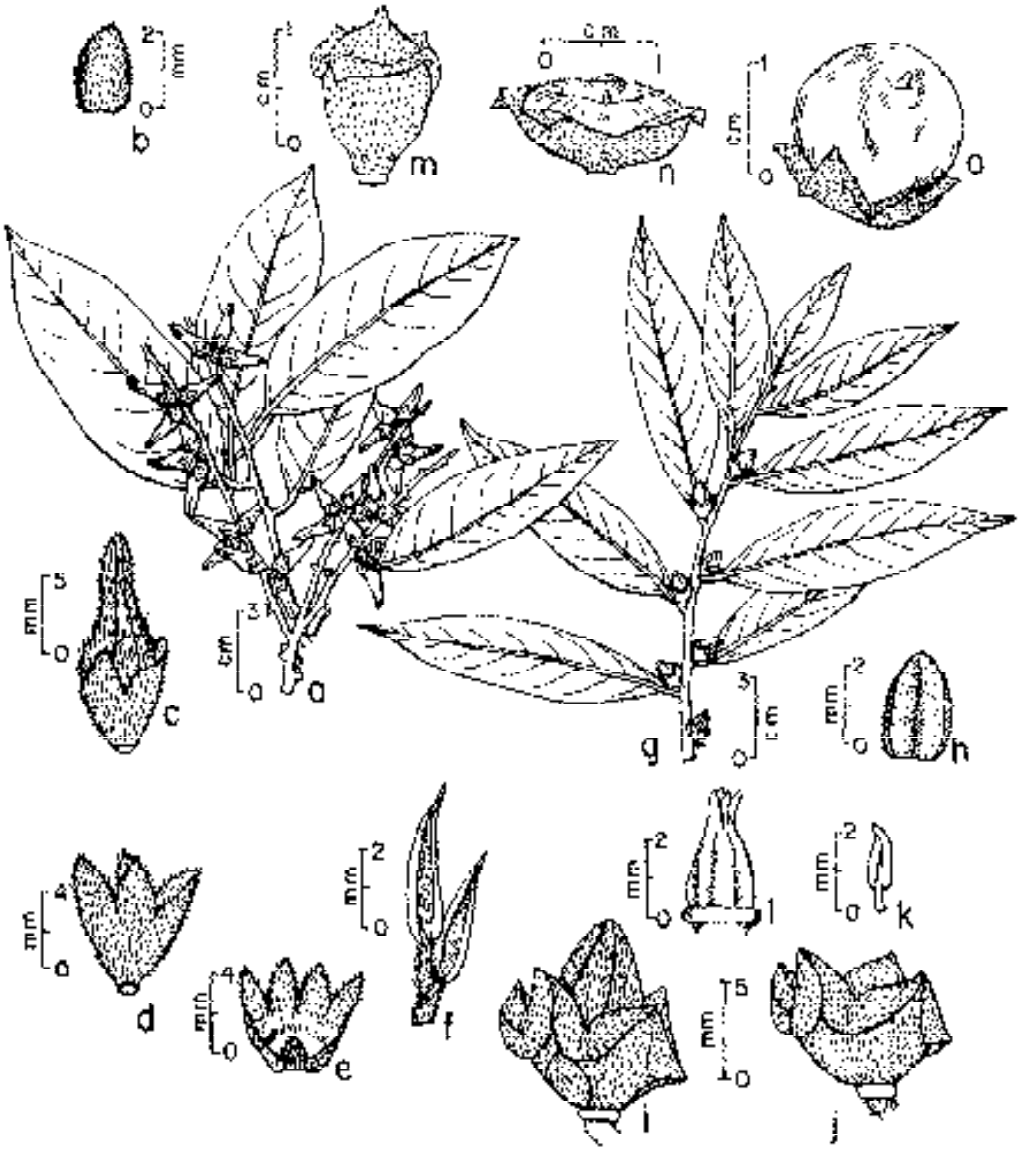


Fig.-60. ***Diospyros undulata*** Wall. ex G. Don

Male : a. habit, b. bract, c. flower-bud, d. calyx, e. calyx within with pistillode, f. stamens.

Female : g. habit, h. bract (ventral view), i. flower-bud, j. calyx, k. staminode, l. gynoecium, m. young fruit enclosed within calyx, n. semi-mature fruit within calyx, o. mature fruit with calyx.

Notes : This taxon resembles closely to *Diospyros aurea* Teysm. & Binnend., but may be distinguished by its glabrous leaves bothsides. Male flowers in 4 to 8-flowered clustered cymes, truncate calyx-mouth with 4-5 small teeth, 20 stamens and totally glabrous nature of plant. These characters keep it apart from rest species found in India. I couldn't examine female plants and the description provided here is borrowed from the literature cited.

Exsicc.: NAGALAND : Kohima, April 1896, *King's Collector* 191 ♂ (CAL); Ridima, Naga hills, 1680 m, *N. L. Bor* 2766 (K). There have been three specimens with same number (191) in CAL, and all are males.

64. ***Diospyros undulata*** Wall. ex G. Don, Gen. Hist. Dichl. Pl. 4 : 40. 1837; A. DC. in DC. Prodr. 8 : 233. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 215. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 568. 1882; Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 279. 1938. *Patonia walkeri* Wight, Illustr. Ind. Bot. 1 : 19. 1840. *Diospyros gardneri* Thw. Enum. Pl. Zey. 181 1860; Clarke in Hook. f. Fl. Brit. India 3 : 561 1882. *D. walkeri* (Wight) Gurke in Engl. & Prantl, Nat. Pflanzenfam. 4 : 162. 1890; Bhargavan in Henry *et al.* Fl. Tamil Nadu 2 : 68. 1987. *D. cratericalyx* Craib in Kew Bull. 1915 : 432. 1915. *D. undulata* Wall. ex G. Don. var. *cratericalyx* (Craib) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 281 1938. *D. undulata* Wall. ex G. Don var. *walkeri* (Wight) Bakh. in Bull. Jard. Bot. Buitz. Ser. 3. 15 (3) : 281. 1938.

English name : Ebony.

Vernacular names : *Asm.*: Dieng-thang; *Khas.*: Hingadu.

Evergreen trees, with drooping, glabrous or thinly pubescent and longitudinally striated young branches. Old bark of fissured irregular scales. Leaves alternate, 5.5-20 (-37.5) x 2-9 (-12.5) cm, oblong or oblong-elliptic to lanceolate, shortly acuminate, base narrowed or rounded and somewhat decurrent with petiole, chartaceous, membranous, glabrous and shining above, minutely pubescent and punctate beneath, margins reflexed; midrib canaliculate and glabrous above, raised and glabrous or minutely pubescent beneath, sometimes with 2-4 glands at the base; lateral veins and reticulation prominent on both surfaces; petioles 5-15 mm long, canaliculate above, rounded beneath, glabrous or thinly pubescent. Male flowers usually in 3 or sometimes upto 9-flowered, axillary, densely tomentose, short, bracteate cymes; peduncles and pedicels very short and tomentose. Bracts ovate-oblong, somewhat concave ventrally, 1.5-2 mm long, tomentose outside, glabrous ventrally. Calyx campanulate, 6-8 mm long, densely tomentose bothsides, 4-lobed, divided about half way down; lobes ovate-deltoid, acute, margins flat, valvate. Corolla-tube ovoid-tubular, not truly salver-shaped, 4-gonous in bud, 6-7 mm long, narrowed at apex at the junction with lobes, tomentose outside, glabrous within; lobes 4, ovate, about as long as tube, obtuse, spreading, contorted. Stamens 10-16, usually 14 or 16 in our plants, unequal, atleast some in pairs, inserted at the base of corolla-tube; filaments 1-2 mm long, hairy; anthers linear, 3-4 mm long, apiculate at apex due to produced connectives, with few scattered deciduous hairs or glabrous. Pistillode hairy, rudimentary. Female flowers solitary, axillary, subsessile, bracteate; pedicels

2-3 mm long, pubescent, articulated with the flowers. Bracts borne on the pedicels, ovate-oblong, 1.5-2.5 mm long, pubescent outside, glabrous ventrally, caducous. Calyx 5-6 mm long, campanulate, 4-lobed, divided about half way down, mouth rather wide, tomentose bothsides or with few scattered hairs outside; lobes broadly ovate, acute, margins prominently reflexed, valvate. Corolla shortly tubular, glabrous bothsides; lobes 4, contorted. Staminodes 16, linear-oblong, 1.5-2 mm long, glabrous, inserted at the base of corolla-tube. Ovary oblong, glabrous, 6-celled, each locule 1-ovuled; styles usually 4, united at base, glabrous; stigmas simple. Fruits 1.5-2.5 (-3.5) cm in diam., globose, truncate or rounded and apiculate at apex, brown-villous, becoming subglabrate on maturity. Fruiting-calyx upto 2.5 cm in diam., thickened, woody, deeply campanulate and embracing about lower half of the fruit, with lobes having reflexed margins in young stage; becoming rather wider and less deep with spreading lobes towards maturity and enclosing lower one-fourth to one-third part of the fruit. Seeds upto 1.6 cm long, compressed; cotyledons foliaceous, lanceolate, tapering at apex, rounded-cordate at base; albumen equable (**Fig.-60; Plate 24/1 & 2**).

Holotype : Burma, Amherst, *Wallich* Cat. No. 4136 (K).

Fl. & Fr.: February – June.

Ecol.: Found in wet evergreen tropical forests, upto 800 m. It reproduces through seeds. After epigeal germination, the cotyledons persist for many months and carry out the function of photosynthesis until epicotyledonary leaves are developed. The growth of epicotyledonary leaves is rather slow. The flowering immediately follows the new leaves every year.

Distrib.: The species finds distribution in W. Bengal, Arunachal Pradesh, Assam, Meghalaya, Nagaland, Tamil Nadu and Andaman & Nicobar Islands in India. It also extends to Bangladesh, Myanmar (native home), Malayan peninsula and Molucca (**Map-16**).

Anatomy : The wood is diffuse-porous. Pores small, scanty, in short radial lines. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly is short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The transverse bars numerous, wavy, concentric. The heartwood and sapwood are indistinct, straight-grained and fine-textured. Wood parenchyma forms distinct vasicentric sheath around the vessels. The timber is susceptible to dry wood borer (Gamble, 1881; Wright, 1904; Metcalfe & Chalk, 1950; Purkayastha, 1982).

Uses : The plant has diuretic, laxative and styptic properties (Yoganarasimhan *et al.*, 1984).

Notes : Bakhuizen (1938) has reduced *Diospyros cratericalyx* Craib to the rank of variety under this species. He mentioned its occurrence in Andaman Islands based on Kurz's collection II-1873 (K) and King's collection in fruit 15-XII-1893 (K). According to him, this variety is distinguishable from typical variety (autonym) and var. *walkeri* (Wight) Bakh. in having fruiting inflorescence subsessile, lateral nerves obscure beneath and depressed above.

Further, Bakhuizen (1938) has rightly referred *D. gardneri* Thw. to the synonymy of proper *D. undulata* Wall. ex G. Don. However, subsequently it has been considered conspecific to *D. walkeri* (Wight) Gurke which is reduced to varietal rank under *D. undulata* Wall. ex G. Don by Bakhuizen (1938) as var. *walkeri* (Wight) Bakh. According to Bakhuizen (1938) *D. undulata* Wall. ex G. Don differs from var. *walkeri* (Wight) Bakh. in having a rather shallow fruiting-calyx cup, with distinct 4 lobes and a tomentum of long adpressed hairs; in var. *walkeri* (Wight) Bakh. the fruiting-calyx cup is quite deep and lobes obscure, it has a short thick neck at base and tomentum is extremely small. During present study, it was observed that characters used to distinguish the varieties from proper *D. undulata* Wall. ex G. Don do not hold good due to wide range of variations in the morphological characters. Further, the depth of fruiting-calyx is directly related with age, as young fruits have rather deep calyx which becomes shallow due to expansion of fruit on maturity. As such, the said varieties have been merged under proper species.

Exsicc.: ANDAMAN & NICOBAR : South Andamans, North Bay, Sea level, 12^{m} Sept. 1891, *Dr. G. King s.n.* ♀ (PBL); Wright Myo, 11^{m} Sept. 1982, *D. K. Hore* 9180 ♀ (PBL); Baratang Island, South Creek, Lauruji way side, 26th Oct. 1979, *P. Basu* 7360 ♀ (PBL); Jaraoh Creek, 25th Oct. 1979, *P. Basu* 7356 ♀ (PBL); Sastrinagar, 19th Jan. 1978, *P. Basu* 7100 ♀ (PBL); Sipighat, 20 m, 25th March 1974, *R. Ansari* 1019 ♀ (PBL); Rutland, Barakhari area, 23rd Jan. 1982, *M. K. V. Rao* 8692 ♀ (PBL); Little Andaman, Dugong Creek, Sea level, 12th Jan. 1977, *N. Bhargava* 5113 ♀ (PBL); North Andamans, Saddle peak, 250 m, 27th March 1977 *N. P. Balakrishnan* 5149 ♀ (PBL); 9th May 1982, *M. K. V. Rao* 8936 ♀ (PBL); Way to Saddle peak, 175 m, 20^{m} Sept. 1982, *R. K. Premnath* 9212 ♀ (PBL); Boru, Lung-la, 16th Feb. 1916, *C. E. Parkinson* 1007 ♀ (DD); ARUNACHAL PRADESH : East Siang, Rotung valley, 350 m, 20th Jan. 1916, *U. N. Kanjilal* 6561 sterile (DD); ASSAM : Sibsagar, Dipling, 27th May 1912, *U. N. Kanjilal* 1737 ♂ (ASSAM); 116 m, 10th Dec. 1912, *U. N. Kanjilal* 2016 ♂ (DD); MEGHALAYA : Khasia & Jaintia hills, 39 miles on G. S. Road, 10th May 1935, *Shri Ram Sarma* 9266 ♂ (ASSAM); NAGALAND : Naga hills, May 1936, *N. L. Bor* 20749 ♀ (ASSAM); TAMIL NADU : Coimbatore, Udumanparai, *Fischer s.n.* (CAL); WEST BENGAL : Bhoanirigons, 8th May 1936, *V. S. Rao* 5735 ♀ (DD).

65. ***Diospyros variegata*** Kurz in J. Asiat. Soc. Bengal 40 (2) : 73. t. 11 1871; Hiern in Trans. Cambr. Philos. Soc. 12 : 203. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 557. 1882.

English name : Ebony.

Vernacular names : *Asm.*: Gab, Koilothi, Koliori, Kolonthi, Salkuli; *Khas.*: Bolgisem, Ponsokisim-bophang, Kolti-arong, Kadeng-jong-areng; *Nep.*: Kalikath.

Trees, upto 20 m high, with glabrous branches. Leaves alternate, 9.5-26 x 3.5-10 cm, broadly oblong or elliptic-oblong, acuminate at the apex, cuneate or subobtuse at base, entire, glabrous, coriaceous; midrib canaliculate above, raised beneath, glabrous bothsides; lateral nerves 8-11 pairs,

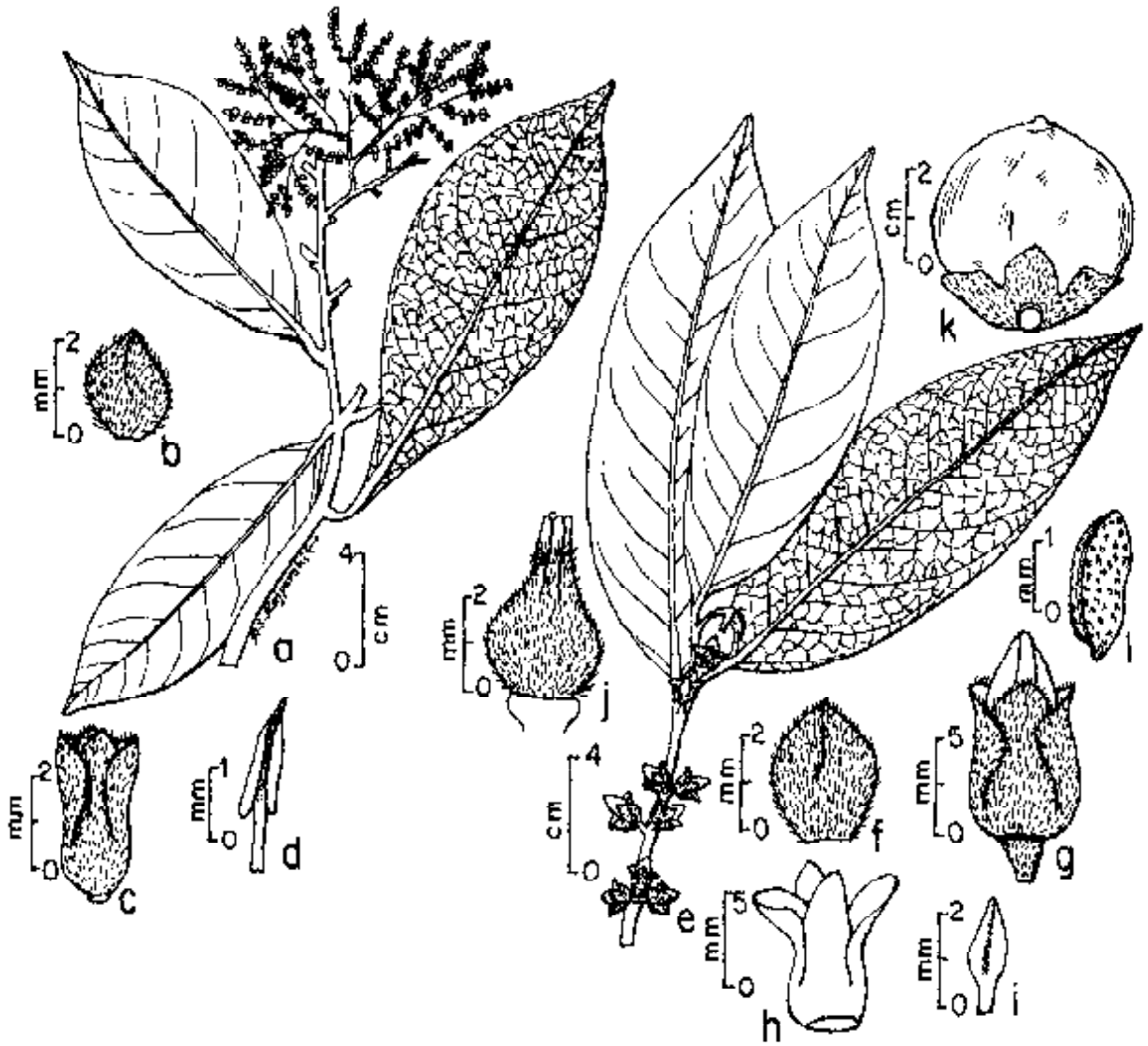


Fig.-61. ***Diospyros variegata*** Kurz

Male : a. habit, b. bract, c. calyx, d. stamen.

Female : e. habit, f. bract, g. flower-bud, h. corolla, i. staminode, j. gynoecium, k. fruit with calyx, l. seed.

arcuating towards apex near margins, prominent bothsides, reticulate venation prominent bothsides; petioles 7-10 mm long, thick, glabrous, terete or flat above, not canaliculate. Male flowers yellowish-white, in axillary, bracteate, much branched, densely pubescent racemose panicles; branches of panicles and flowers subtended by the bracts; panicles develop on young branches of which the leaves soon fall down and the inflorescence takes the shape of a compound panicle; the flower-buds of the panicles are mostly abortive in the specimens examined by me. Bracts 2-3 x 2-3 mm, almost suborbicular, acute or apiculate at apex, pubescent bothsides but more densely outside, ciliate. Calyx 4-5 mm long, narrowly campanulate, pubescent outside, lobed more than half way down; lobes 4, elliptic, obtuse, imbricate. Corolla urceolate, glabrous bothsides, tube a little longer than the calyx; lobes 4, ovate, acute, patent, contorted. Stamens 16, unequal, inserted at the base of corolla-tube; anthers linear, cordate at base, apiculate at apex due to produced connectives, glabrous. Female flowers shortly pedicelled, axillary, solitary or in fascicles of 2-3; pedicels 2-3 mm long, pubescent, thickened upwards and articulated with the flowers. Bracts *ca* 3 x 3 mm, broadly ovate to suborbicular, pubescent bothsides, each subtending a flower, deciduous. Calyx cup-shaped, 8-9 x 7-8 mm, thinly pubescent outside, glabrous within, divided below the middle nearly to the base; lobes 4, 6-7 x 5-6 mm, almost suborbicular, obtuse, imbricate. Corolla 8-10 mm long, urceolate, glabrous bothsides, tube 2-3 mm long and included within the calyx; lobes 4, 6-7 mm long, elliptic, obtuse, slightly exserted from the calyx, contorted. Staminodes 8-10, flat, thin, glabrous, inserted at the base of corolla-tube in one row, sterile anthers *ca* 1.5 mm long and arrow-shaped, filaments *ca* 1 mm long. Ovary globose, densely hairy, usually 8-celled, rarely more-celled due to false septa, cells 1-ovuled; styles 4, *ca* 1 mm long, glabrous in upper half, hairy in lower region; stigmas 4, simple. Fruits *ca* 5 cm in diam., subglobose, ferruginous-villous when young, glabrate on maturity. Fruiting-calyx much accrescent, more than 5 times as large as flowering female calyx, flat, disciform, fruits seated on the disc; lobes 4, horizontally spreading. Seeds 3-4, oblong-elliptic, turgid, 2-2.5 x 0.7-0.8 cm, pointed at micropylar end, with two median lines from micropyle to chalazal end, testa glabrous but tuberculate; albumen equable **(Fig.-61; Plate 24/3 & 4)**.

Holotype : Burma (Myanmar) : Pegu, *Brandis s.n.* (K).

Fl. & Fr.: April – December.

Ecol.: Found in wet evergreen forests, upto 800 m or more. It reproduces through seeds. The germination of seeds is epigeal.

Distrib.: In India, this species commonly occurs in Assam, Meghalaya and Mizoram, extending further eastwards to Myanmar – its native home **(Map-16)**.

Anatomy : The wood is diffuse-porous. Growth rings indistinct. Vessels very small, evenly distributed but with a tendency to be aligned radially, mostly in short or long radial multiples of 2-5; vessel lines distinct. Parenchyma diffuse to diffuse-in-aggregates sometimes as closely spaced thin lines or forming a network with rays. Rays distinct, fine, closely spaced and uniformly distributed. The

heartwood and sapwood are indistinct, straight-grained and fine-textured. The timber is susceptible to dry wood borer (Wright, 1904; Purkayastha, 1982).

Phytochemistry : Diosindigo A, lupeol and betulin have been isolated from the wood (Rastogi & Mehrotra, 1993b).

Exsicc.: ASSAM : Nowgong, Diphu, 30th July 1935, *G. K. Deka* 13226 ♀ (ASSAM); Sonaikushi R. F., 1 mile south of Amlighat, 19th Aug. 1964, *N. P. Balakrishnan*, 39249 ♂ (ASSAM); Dehing river, 21st Jan. 1915, *U. N. Kanjilal* 571P ♂ (ASSAM); Dispur, Guwahati, University campus, 2nd May 1962, *G. J. Srivastava* 90711 ♂ (LWG); Sibsagar, Borpathar, 71 m, 23rd April 1914, *U. N. Kanjilal* 3880 sterile (ASSAM); North Cachar hills, Lumding, 150 m, 30th April 1915, *U. N. Kanjilal* 5560 ♀ (DD); MEGHALAYA : Garo hills, Tura forest, 25th March 1941, *R. N. De* 20557 ♀ (ASSAM); Rongram, 15th Dec. 1960, *G. Panigrahi* 22586 ♂ (CAL).

66. ***Diospyros virginiana*** L. Sp. Pl. 1057. 1753; A. DC. in DC. Prodr. 8 : 228. 1844; Hiern in Trans. Cambr. Philos. Soc. 12 : 224. 1873. *D. concolor* Moench, Meth. 470. 1794. *D. guaiacana* Robin, Voy. Louis 3 : 417. 1807. *D. pubescens* Pursh, Fl. N. Amer. 1 : 265. 1814, non Pers. 1807. *D. caroliniana* Muhlenb. ex Rafin. Florul. Ludov. 139. 1817. *D. persimon* Wikstr. Jahr. Schwed. 1830 : 92. 1834. *D. ciliata* Rafin. New Fl. & Bot. N. Amer. 3 : 25. 1836, non A. DC. 1844. *D. fertilis* Lodd. ex Lodd. Arb. Frut. Brit. 2 : 1197. 1838. *D. calycina* Audib. ex Spach, Hist. Veget. Phan. 9 : 405. 1840, non Wall. 1831, nec Beddome 1871, nec Hort. ex C. Koch 1873. *D. angustifolia* Audib. ex Spach, Hist. Veget. Phan. 9 : 405. 1840. *D. lucida* Hort. ex Loud. Gard. Mag. 394. 1841, non Wall. ex Steud. 1840. *D. intermedia* Hort. ex Loud. Encycl. Trees & Shrubs 627. 1842.

English names : American Persimmon, Florida Persimmon.

Polygamous or dioecious trees, upto 18 m high, with deeply cracked blackish bark and pubescent branchlets. Leaves alternate, 5-18 x 2.5-9 cm, oval, acuminate at apex, narrowed, rounded or subcordate at base, submembranous, paler pubescent beneath; petioles 0.8-2 cm long, pubescent. Male flowers 4-merous (rarely 5-merous — Hiern, 1873), in short, 1 to 3-flowered, axillary, pubescent cymes. Bracts not enveloping the calyx. Calyx 2-3 mm long, campanulate, usually 4 or rarely 5-lobed, hairy; lobes lanceolate, valvate. Corolla shortly tubular, pubescent, 7-9 mm long; lobes 4, one-third the total length of corolla, contorted. Stamens 16, in pairs; anthers hairy, dehiscing by longitudinal slits. Pistillode glabrous. Female flowers axillary, solitary, on 2-3 mm long pedicels. Calyx and corolla as in males but larger. Ovary glabrous in lower region, pilose at apex, 8-celled, cells 1-ovuled; styles 4, pilose; stigmas glabrous. Fruits subglobose, 2.5-4.5 cm in diam., glabrous, tipped at apex with remains of styles, pale-orange when ripe, marked externally with 4 depressed lines running down from apex and with a slight pruinose bloom. Fruiting-calyx spreading, 4 or 5-lobed, 1.8-4 cm across, subglabrous, tube disciform, fruit seated on the disc; lobes broadly ovate, 8-18 mm broad, somewhat concave below, not appressed to the fruit, margins recurved. Seeds 6-8, sometimes 3-5, *ca* 1.5 x 1 cm; albumen equable.

Chr. No.: 2n=90 (Zhuang *et al.*, 1990; Solovyova & Omarav, 1986).

Fl. & Fr.: March – October.

Ecol.: Sometimes cultivated in the gardens, particularly in South India. It is a slow growing tree and has capability of reproduction through root-suckers. *D. kaki* Thunb. ex L. f., *D. lotus* L. and *D. virginiana* L. cross readily in nature (Grubov, 1967). Reciprocal crosses between *D. kaki* Thunb. ex L. f. (2n=90) and plants of hexaploid race (2n=90) of *D. virginiana* L. have resulted in seed production when *D. virginiana* L. was used as carpellate parent. However, the plants of the resulting F^1 generation appear to have purely maternal inheritance (McDaniel, 1973). This evidence together with the occasional parthenocarpic development of seedless (and seeded) fruits suggest that some apomictic mechanism may be present in *Diospyros* L.

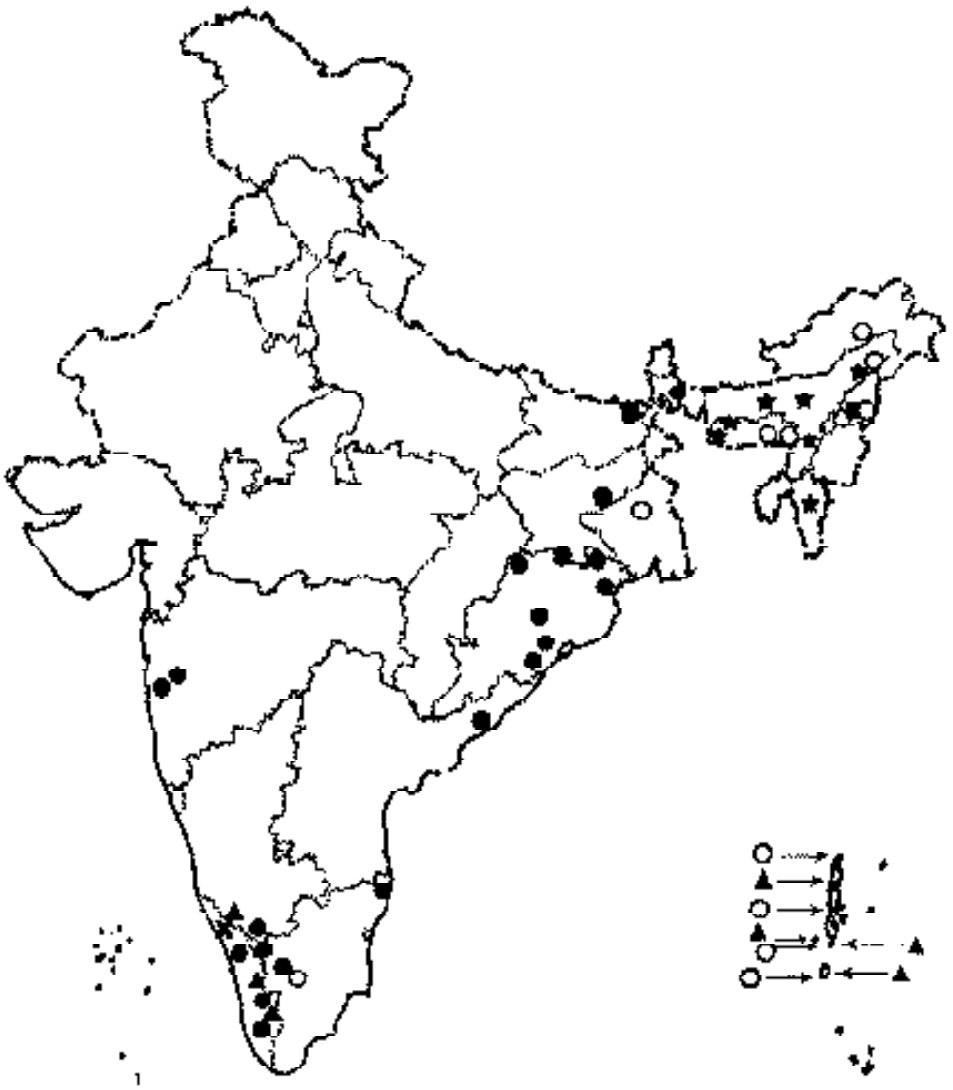
Distrib.: Native of North America; cultivated in India, Europe etc. Asolkar *et al.* (1992) reported its cultivation at Coonoor in Kerala **(Map-16)**.

Anatomy : Sapwood greenish in colour and heartwood brown, hard, compact and tough. Growth rings are distinct. The fifty per cent vessels are solitary and rest in radial multiples. Vessel perforations are exclusively simple. The tangential vessel diameter is about 115 mm. The length of fibers is about 1270 mm, with 19 mm tangential diameter. The height of medullary rays is approximately 240 mm (Graaff & Baas, 1974). Utsunomiya *et al.* (1998) have studied the tannin cells in the mesocarp of the fruit and found that they occupy 30-50 per cent area of the mesocarp.

Pollen : The pollens of this species differ in size from rest species of *Diospyros* L. as well as other genera of the family. They are rather bigger in size with mean polar diameter of 53.5 µm and mean equatorial diameter of 48.5 µm (Morton & Kincaid, 1995).

Phytochemistry : The fruits contain tannin and pectin which have cholesterol lowering properties. Besides these, they also contain sugar, lignin and colouring matter (Hiern, 1873). The bark and seeds contain isodiospyrin. The wood yields 7-methyljugulone (5-hydroxy-7-methyl-1, 4-naphthoquinone) (Asolkar *et al.*, 1992). Its 8-6' dimer, isodiospyrin, has been found toxic to termites. Carter *et al.* (1978) have also isolated shinanolone (4, 8-dihydroxy-6-methyl-1-tetralone) and scopoletin (7-hydroxy-6-methoxycoumarin) from the wood which were found non-toxic to the termites.

Uses : Fruits are sometimes eaten by man and domestic as well as wild animals. In Virginia, the fruits are made into cakes and baked. These cakes mixed with tepid water serve to make beer with the addition of hops and yeast to cause fermentation. Spirit is also distilled after further fermentation. In United States, the fruits are dried and ground to serve as meal; the seeds are roasted and used as a substitute for coffee and dried and green leaves for tea (Morton, 1963). The inner bark is used in intermittent fever, diarrhoea and with alum as a gargle in ulcerated sore throat. The fruits also yield an indelible ink. They are astringent and styptic. The fruit's tannin has strong detoxifying action against snake venoms and bacterial toxins, stronger than tannic acid. Experiments conducted with tannin on the



Distrib. Sketch Map – 16

● *Diospyros sylvatica* Roxb.; ▲ *Diospyros trichophylla* Alston; ■ *Diospyros truncata* Zoll. & Mor.; o *Diospyros undulata* Wall. ex G. Don; ★ *Diospyros variegata* Kurz; ✖ *Diospyros virginiana* L.

rats have resulted in tumour formation. The aqueous extract was injected subcutaneous once a week for 72 weeks and resulted in tumour formation in rats (Kapadia *et al.*, 1977). Fruit's pectin has cholesterol lowering properties (Asolkar *et al.*, 1992).

Notes : The archaeological plant remains of this species have been recorded from Louisiana (Coquille) which indicate probable important uses in prehistoric subsistence patterns (Dunn, 1983).

Exsicc.: This species has been included on the authority of Asolkar *et al.* (1992) from Coonoor in Kerala. However, I could not come across any specimen in Indian herbaria visited by me or specimens loaned from them. The description provided here is based on literature cited.

Species Dubiae

Diospyros quaesita Thw. Enum. Pl. Zeyl. 179. 1860; Hiern in Trans. Cambr. Philos. Soc. 12 : 174. 1873; Clarke in Hook. f. Fl. Brit. India 3 : 560. 1882; Kostermans in Rev. Handb. Fl. Ceylon 3 : 13. 1981. *D. hirsuta* Moon, Cat. 74. 1824, *nom. nud.*, non L. f. 1781

English names : Calamander Ebony, Persimmon.

Vernacular name : *Tam.*: Kalumediriya.

Dioecious trees, upto 40 m high; branchlets glabrous. Bark rough, black, peeling off in 2-3 mm thick flakes. Leaves alternate, 8-18 x 3-8 cm, elliptic-oblong or oblong-lanceolate, obtusely acuminate at apex, narrowly cuneate at base, coriaceous, glabrous; midrib deeply canaliculate above, raised beneath; lateral nerves 8-10 pairs, reticulation prominent bothsides but loose and irregular; petioles 0.8-2 cm long, canaliculate above, rounded beneath. Male flowers in 3 to 9-flowered raceme-like dichasial cymes in the axils of bracts or leaves; peduncles upto 2 cm long; pedicels *ca* 6 mm long, wider at top, nodding, pubescent, with 2, opposite, caducous bracteoles. Calyx elongate-oblong, 8-9 mm long; tube thickened; lobes 4-5, deltoid, acute, 1-2 mm long, pubescent, thickened in the center, margins dilated and coriaceous, valvate. Corolla yellow, 10-12 mm long, tubular; tube swollen at base, sericeous; lobes 4-5, broadly ovate, acute, sericeous outside, rotate. Stamens 16 or more; filaments very short, glabrous; anthers almost sessile, pilose at apex. Pistillode inconspicuous. Female flowers solitary, in the axils of leaves or caducous bracts; pedicels upto 2 cm long. Calyx broadly barrel-shaped, adpressedly brown-pilose outside; lobes 5, recurved-margined initially, later wide intersegmental pouches are formed which are first horizontal but later widen gradually and become strongly reflexed and only sharp tips remain upright, valvate. Corolla *ca* 1.5 cm long, yellowish-white or white, adpressed pilose; lobes 5, recurved in old flowers, obtuse, contorted. Staminodes 5, epipetalous, glabrous. Ovary globose, usually 5-celled or upto 10-celled, pubescent, cells 1-ovuled; styles 5, united at base; stigmas 5. Fruits subglobose or ovoid-globose, slightly compressed, 6-7 cm in diam., glabrous. Fruiting-calyx orbicular, flat, disciform, 3-4 cm in diam., woody, fruits seated on the disc; margins of lobes strongly reflexed, intersegmental pouches large. Seeds 4-10, elliptic; albumen equable; cotyledons *ca* 2.5 x 1.2 cm, oblong-ovate, rounded at apex, with strong midrib; hypocotyl glabrous.

Holotype : Ceylon Plants, *Thwaites* 5010 (PDA).

Fl. & Fr.: April – October. The plants flower after a very long interval.

Ecol.: It is believed to inhibit in wet evergreen broad-leaved forests, upto 600 m. Germination of seeds is epigeal and cotyledons get detached very early. It is a very slow growing tree. The trees grow well in rocky damp places rich in silica and iron.

Distrib.: Native of Sri Lanka, cultivated in India (Rastogi & Mehrotra, 1993b).

Anatomy : Each cotyledon has three vascular traces, median of which is abortive. Xylem is not much splitted. Epicotyledons also have one trace each, probably continued into root (Wright, 1904).

The testa of seeds is 6-7 cells thick in the ovule soon after fertilization, becoming 15-18 cells thick is half grown seeds and persists in mature seeds. The outer epidermal layer is made up of irregularly folded or rugulose palisade of radially elongated cells having elliptic-rectangular, shortly elongate or subgyrose facets and mucilaginous contents. The mesophyll (middle layers) has many crystal cells at the micropylar end. The inner integument is composed of small cells without crystals. Tegmen is 7-9 cells thick in ovule soon after fertilization. Outer epidermal cells are unspecialized but slightly lignified especially in the long endostome with narrow elongate and scarcely thick-walled cells. Nucellar tissue is very small and soon obliterated (Corner, 1976).

The heartwood is deep brown, streaked with black bands. Growth rings are inconspicuous. The length of vessels in the twigs is 0.22 mm, with radial and tangential diameter 0.04 mm. In sapwood, however, the length of vessels is 0.43 mm, with radial diameter 0.13 mm and tangential diameter 0.07 mm. The length of wood parenchyma cells varies from 0.04-0.15 mm, with radial diameter *ca* 0.009 mm. The wood fibres compose the major part (80-86 %) of secondary xylem and are responsible to a great extent for the durability of timber. Lumina of fibre cells is completely filled with dark matter. The radial diameter (transverse dimensions) of fibres in sapwood is 0.008 mm and in the heartwood is *ca* 0.0076 mm. The medullary rays form large vertical strands of tissue. The vertical length of vertical medullary ray cells is *ca* 0.09 mm, with radial diameter 0.012 mm and tangential 0.015 mm. The vertical length of horizontal components is 0.03 mm, having 0.05 mm radial and 0.010 mm tangential diameter (Wright, 1904; Metcalfe & Chalk, 1950).

Phytochemistry : The bark and timber of this species yield lupeol, betulin, betulinic acid, sitosterol, taraxerol, taraxerone, ursolic acid, oleanolic acid, scopoletin, plumbagin, elliptinone, diospyrin and diosindigo A (Herath *et al.*, 1978; Rastogi & Mehrotra, 1993b).

Uses : The seeds are used to cure asthma. However, in some places the leaves are used for this purpose. Wood is considered best for ornamental work. Ripe gummy fruits are sometimes eaten by the natives.

Notes : This taxon has been placed under doubtful taxa as no specimen was available in Indian herbaria and no mention has been made in taxonomic literature dealing with Indian flora regarding its occurrence in India. However, Rastogi & Mehrotra (1993b) have reported its cultivation in India, but without any locality. Further, Kostermans (1981) has considered it endemic to Sri Lanka, probably in correct sense.

PHYTOGEOGRAPHICAL ASPECTS

The family *Ebenaceae* are represented by two genera according to recent concepts of White (1980, 1988) and Wallnofer (2001) i.e. the genus *Euclea* Murr. and *Diospyros* L. in the World, containing *ca* 600 species. The genus *Euclea* Murr. is rather small having *ca* 20 species restricted to Africa, Arabia and Comoro Islands, and many of its components are limited to Cape flora (Wallnofer, 2001). On the other hand, the genus *Diospyros* L. is much larger, representing rest number of species of *Ebenaceae*, which find rather wide distribution in the continents of Asia, Pacific Islands, Africa (including Madagascar and Comoro Islands), Australia and North and South America (Wallnofer, 2001). Most interesting fact is that most of the species of these continents are confined to their geographical jurisdiction and do not encroach other regions except few viz. *D. discolor* Willd., *D. ebenum* Koenig, *D. fasciculosa* (F. v. Muell.) F. v. Muell., *D. ferrea* (Willd.) Bakh., *D. kaki* Thunb. ex L. f., *D. lotus* L., *D. montana* Roxb., *D. virginiana* L. etc which have crossed the continental boundaries by self or due to domestication. Thus, there appears an abrupt species-specific distributional demarcation between the components of the genus *Diospyros* L. Further, there has been no landmass of considerable common occurrence of these taxa. Under these conditions, the chances for exchange of genes between different species-specific groups of species are very poor in nature. It indicates that different continental groups of species have evolved and developed independently.

According to the number of species, *ca* 300 species occur in Asia and Pacific Islands alone, constituting about fifty per cent of total strength of the genus in the World. The other zones of concentration are Americas which constitute about seventeen per cent of the total taxa by the representation of *ca* 100 species, and African mainland and Madagascar and Comoro Islands which together support *ca* 98 species, about as much as in Americas. The representation of *Diospyros* L. in Australia is very poor as 15 species contribute only about 2.5 per cent to the World strength. The representation of the genus *Diospyros* L. in Europe is almost negligible and most of the taxa have been introduced for domestication.

Table 2 revealed that out of 66 species of *Diospyros* L. found in India, 39 species have originated in India, representing *ca* 59 per cent of total taxa found in India. Of these species of Indian origin, 17 species are still endemic to India, particularly to South India, representing *ca* 43.5 per cent of total species of Indian origin. Rest 22 species of Indian origin have migrated beyond the boundaries of the country in different directions. About 4 species viz. *D. affinis* Thw., *D. melanoxylon* Roxb. var.

Table 2. Centre of origin and distribution pattern of different species of *Diospyros* L. found in India and in some neighbouring Asian countries. (+ represents presence and – absence).

Name of species found in India	Native home	Distribution							
		Nepal & Bhutan	China	Indo-China and other neighbouring countries	Myanmar	Bangladesh	Malaysia-Indonesia	Pacific Islands incl. Japan & Korea	Sri Lanka
1	2	3	4	5	6	7	8	9	10
Diospyros affinis Thw.	India								+
andamanica (Kurz) Bakh.	India						+		
apiculata Hiern	Malaysia-Indonesia				+		+		
assimilis Beddome	India								
attata (Thw.) Alston	Sri Lanka								+
barberi Ramas.	India								
benghalensis Bakh.	Bangladesh					+			
bourdillonii Brandis	India								
buxifolia (Bl.) Hiern	Malaysia			+	+		+	+	
cacharensis (Das & Kanj. f.) Naithani	India				+				
candolleana Wight	India	+							
cauliflora Blume	Malaysia-Indonesia			+		+	+	+	
chloroxylon Roxb. var. *chloroxylon*	India				+	+			+
chloroxylon Roxb. var. *cupulosa* Singh	India								
cordifolia Roxb.	India				+		+		+
courtallumensis Bahadur & Gaur	India								
crumenata Thw.	Sri Lanka				+				+
discolor Willd.	Mayalsia-Indonesia				+		+	+	
ebenum Koenig	India				+	+	+	+	+
ehretioides Wall. ex G. Don	Myanmar			+	+				
elegans Clarke	India								
fasciculosa (F. v. Muell.) F. v. Muell.	Indonesia						+	+	
ferrea (Willd.) Bakh.	India				+		+	+	+

1	2	3	4	5	6	7	8	9	10
foliolosa Wall. ex A. DC.	India								
ghatensis Ramesh & Franceschi	India								
glandulosa Lace	Myanmar			+	+				
hirsuta L. f.	Sri Lanka								+
holeana Gupta & Kanjilal	Nepal	+							
insignis Thw.	Sri Lanka								+
kaki Thunb. ex L. f.	Japan	+	+	+	+		+	+	
kanjilali Duthie	India								
kika Debbarman & Biswas	India				+				
kurzii Hiern	India				+		+		
lanceaefolia Roxb.	Myanmar	+			+	+	+	+	+
lotus L.	China	+	+	+	+			+	
marmorata Parker	India								
martabanica Cl. var. *pellucido-punctata* (Hiern) Cl.	India								
melanoxylon Roxb. var. *melanoxylon*	India								+
melanoxylon Roxb. var. *tupru* (Buch.-Ham.) Singh	India	+							
montana Roxb.	India	+	+	+	+		+	+	+
multibracteata (Merr.) Bakh.	Philippine							+	
neilgerrensis (Wight) Kosterm.	India								
nilagirica Bedd.	India						+	+	
oocarpa Thw.	Sri Lanka								+
ovalifolia Wight	India						+		+
paniculata Dalz.	India						+		
peregrina (Gaertn.) Gurke	India	+		+	+		+		+
pilosanthera Blanco var. *helferi* (Cl.) Bakh.	Myanmar			+	+		+		
pilosiuscula G. Don var. *pilosiuscula*	Myanmar				+	+			
pilosiuscula G. Don var. *andamanensis* (Jayar. & Nayar) Singh	India								
pruriens Dalz.	India								+
pyrrhocarpa Miq.	Sumatra			+	+		+	+	
pyrrhocarpoides Ramesh & Franceschi	India								
racemosa Roxb.	India			+	+	+	+	+	+

1	2	3	4	5	6	7	8	9	10
ramiflora Roxb.	India				+	+			
ridleyi Bakh.	Malaysia						+		
sahayadryensis Danniel & Vajravelu	India								
saldanhae Kosterm.	India								
stricta Roxb.	India					+			
sulcata Bourd.	India								
sylvatica Roxb.	India								+
trichophylla Alston	Sri Lanka								+
truncata Zoll. & Mor.	Java						+		
undulata Wall. ex G. Don	Myanmar				+	+	+	+	
variegata Kurz	Myanmar				+				
virginiana L.	North America								

melanoxylon, *D. pruriens* Dalz. and *D. sylvatica* Roxb. have invaded Sri Lanka southwards; one species viz. *D. stricta* Roxb. has migrated to Bangladesh; two species viz. *D. andamanica* (Kurz) Bakh. and *D. paniculata* Dalz. have been reported from Malaysia-Indonesia, without intermediate links; *D. nilagirica* Bedd. has migrated further eastwards to Pacific Islands through Malaysian region, with no other links; eastwards movement of *D. cacharensis* (Das & Kanj. f.) Naithani and *D. kika* Debbarman & Biswas are sofar confined to Myanmar; however, *D. ramiflora* Roxb. has reached Myanmar through Bangladesh and *D. kurzii* Hiern has further crossed the borders of Myanmar to establish itself in Malaysian and Indonesian region; *D. chloroxylon* Roxb. var. *chloroxylon* has migrated eastwards to Myanmar through Bangladesh and southwards to Sri Lanka; similarly *D. ovalifolia* Wight has established eastwards in Malaysia-Indonesia region and southwards in Sri Lanka; *D. ebenum* Koenig, *D. ferrea* (Willd.) Bakh. and *D. cordifolia* Roxb. also show almost similar distribution pattern as some of them have well established southwards in Sri Lanka and eastwards in Pacific Islands through Myanmar, Malaysia and Indonesia; *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh – a native of high altitudinal zones, has invaded Himalayas from Nepal to Afghanistan and similarly *D. candolleana* Wight has migrated to Nepal. On the other hand, a few senior species of Indian origin show rather wide distribution. *D. montana* Roxb. and *D. peregrina* (Gaertn.) Gurke have been reported from Nepal, Bhutan, Bangladesh, Myanmar, Malaysia-Indonesia, Indo-China (Laos, Cambodia and Vietnam) and Sri Lanka. *D. racemosa* Roxb. has also migrated almost on the same pattern through Bangladesh, Myanmar, Malaysia-Indonesia, Indo-China (Laos, Cambodia and Vietnam) to Pacific Islands eastwards and to Sri Lanka southwards.

The distribution pattern of the species of *Diospyros* L. within the country is also very interesting, as out of total 66 species, 30 per cent, i.e. 20 species are confined to South India. Further, about 50 per cent, i.e. 10 species are endemic among those found in South India, representing about 26 per cent of the total species of Indian origin and 59 per cent of total Indian endemics. The genus *Diospyros* L.

is represented by 1 endemic and 11 non-endemic species exclusively in North-East Indian States, constituting about 18 per cent of total strength. Again, 3 endemic and 6 non-endemic species find distribution exclusively in Andaman & Nicobar Islands, constituting about 16 per cent of total strength. In addition, 2 endemic and 3 non-endemic species of South Indian origin have also migrated to Andaman & Nicobar Islands during recent years. Four more non-endemic species have enriched the flora of Andaman & Nicobar Islands from North-Eastern States during last few years. About 11 species, constituting about 17 per cent of total strength of the genus in India, find rather wide distribution in the country beyond the limits of three zones discussed above. Among these species, 1 is endemic and rest non-endemic. About 3 non endemic species viz. *D. discolor* Willd., *D. ebenum* Koenig and *D. sylvatica* Roxb. are common to South India and N. E. States. Again, *D. fasciculosa* (F. v. Muell.) F. v. Muell. – a non endemic species, finds distribution only in Uttar Pradesh and Uttranchal and similarly *D. holeana* Gupta & Kanjilal is confined to Uttar Pradesh and Madhya Pradesh – the central parts of India. About 6 species are under cultivation in different parts of the country.

Thus, it may be concluded that there are three main zones of high concentration of species of *Diospyros* L. in India viz. South India – consisting Karnataka, Kerala, Tamil Nadu and Andhra Pradesh; North-East India – consisting Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura; and Andaman & Nicobar – including islands. South India is the major center of speciation and evolution and Andaman & Nicobar stand on second place. North-East India, though rich in diversity, is poor in speciation and evolution.

The next maximum components of *Diospyros* L. are of Myanmar (7 species) and Sri Lankan (6 species) origin. Kostermans (1981) has described about 20 species endemic to Sri Lanka. It is interesting to note that about 20 per cent (4 species) of them viz. *D. atrata* (Thw.) Alston, *D. crumenata* Thw., *D. hirsuta* L. f. and *D. trichophylla* Alston have established in South India during recent years. Further, out of 22 presently non-endemic species of Indian origin, growing mostly in South India, 12 species are represented in Sri Lankan flora. Thus, Sri Lankan and Indian species have fair chances of gene exchange in nature as compared to other parts of the globe and together constitute a mega center (Indian subcontinent) of speciation in Asia. The species of Myanmar origin are mostly confined to North-Eastern States of India except a few which extend to Andaman & Nicobar Islands. Similarly, about 11 non-endemic species of Indian origin, growing mostly in N. E. India, almost equally contribute to Myanmar flora, indicating non-effective or absence of geographical barriers and fair possibilities of exchange of genetic material.

There occur 8 species of *Diospyros* L. in India which have originated in Malaysia-Indonesian region viz. *D. buxifolia* (Bl.) Hiern, *D. pyrrhocarpa* Miq., *D. cauliflora* Blume, *D. discolor* Willd., *D. fasciculosa* (F. v. Muell.) F. v. Muell., *D. ridleyi* Bakh., *D. apiculata* Hiern and *D. truncata* Zoll. & Mor. These species find very restricted distribution in India. The first species has established in South India, the second, third and fourth ones in Andaman & Nicobar Islands, fifth and sixth find rather wide

distribution probably due to domestication and last two in N. E. States. The species originated in Pacific Islands have very hard path to reach Indian land due to sea as a wide barrier and sofar only *D. kaki* Thunb. ex L. f. and *D. multibracteata* (Merr.) Bakh. could land in this country. The species of high altitude origin are also very poorly represented in India. *D. holeana* Gupta & Kanjilal of Nepal and *D. lotus* L. of Chinese origin have confined themselves upto the foot of Indian Himalayas. *D. virginiana* L. is the only American species which has been domesticated in India. No element of African, Australian and European origin occurs in India. Further, the species of *Diospyros* L. growing in India are also very poorly represented in the above mentioned continents. *D. kaki* Thunb. ex L. f., *D. lotus* L. and *D. virginiana* L. are recorded in Europe and America, but under cultivation. *D. discolor* Willd. is also known in Americas under cultivation. *D. fasciculosa* (F. v. Muell.) F. v. Muell., *D. montana* Roxb. and *D. cordifolia* Roxb. grow wild in Australia. *D. ferrea* (Willd.) Bakh. has been under record from Africa and Australia and *D. ebenum* Koenig from Australia and America.

The study revealed that the species of *Diospyros* L. show species-specific widely segregated distribution in different continents due to wide separation of continents by oceans. The continents connected by landmass have barren areas as barrier where the genus *Diospyros* L. is poorly represented viz. Western Asia. Westwards to India, Pakistan, Afghanistan, Iran, Iraq, Kuwait, Saudi Arabia etc are the countries which connect India to African continent. These countries support very few species of *Diospyros* L. viz. *D. kaki* Thunb. ex L. f., *D. lotus* L., *D. montana* Roxb. and *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh, some of which are mostly domesticated for fruits and foliage. This intermediate dry, arid and sandy landmass keeps the Indian and African elements confined to their boundaries. Similarly, the climatic and edaphic conditions of Europe are not healthy for the survival of the species of *Diospyros* L. As such, inspite of land connection with Asia and Africa, there has been hardly any migration to north or vice versa. The high altitudinal long range of Himalaya between Asia and Europe is another barrier for migration and settlement of species of *Diospyros* L. on either side.

Out of 66 species found in India, 19 are common to Sri Lanka, 25 to Myanmar, 23 to Malaysia-Indonesia, 15 to Pacific Islands, 9 to Bangladesh, 11 to Indo-China (Laos, Cambodia and Vietnam) and neighbouring countries, 8 to Nepal, 3 to Pakistan and Afghanistan and 3 to China. This indicates that Indian *Ebenaceae* have more close affinity with Sri Lanka and East Asian countries than northern and western countries.

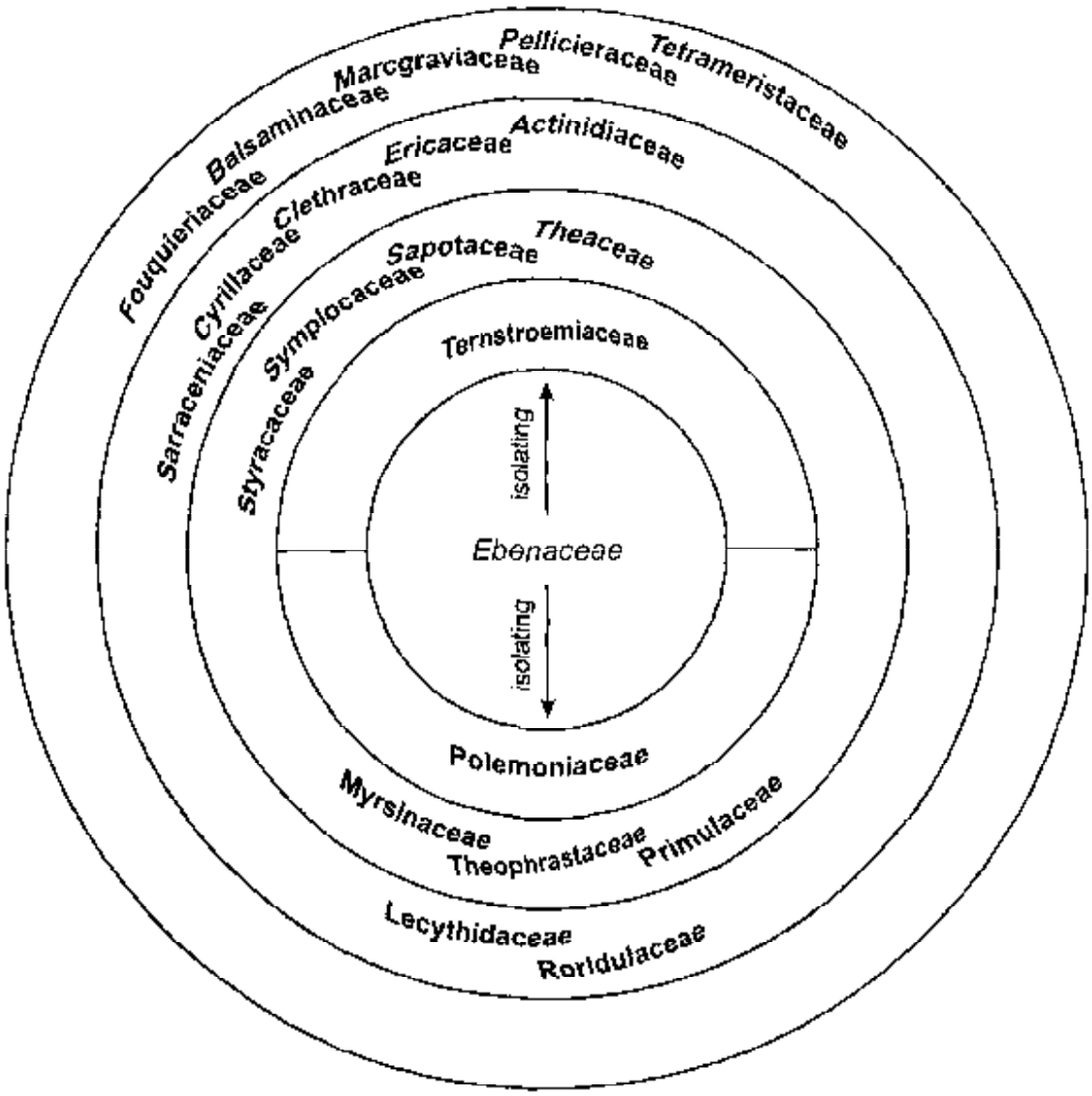
PHYLOGENETIC AFFINITES

Traditionally, the evolutionary relationship of *Ebenaceae* have been based on the importance of few key characters in combination which the other families share together with *Ebenaceae* viz. woodiness, simple leaves, radially symmetrical flowers, axile placentation, upto ten uninucleate ovules and few large seeds with endosperm. Based on above characters, Cronquist (1981, 1988) established affinities and placed the families *Lissocarpaceae, Sapotaceae, Styracaceae* and *Symplocaceae* together with *Ebenaceae*

under the order Ebenales and believed that Ebenales were derived from thealean complex. Thorne (1976, 1992) followed Cronquist's (1981, 1988) concept but placed *Symplocaceae* closer to Theales, whereas Dahlgren (1980, 1983, 1989) considered *Symplocaceae* to belong within Cornales. Takhtajan (1987) placed *Ebenaceae, Lissocarpaceae* and *Styracaceae* in Ebenales, *Sapotaceae* in Sapotales and *Symplocaceae* in Theales. Wagenitz (1964) included *Ebenaceae, Hoplestigmataceae, Lissocarpaceae, Sapotaceae, Sarcospermataceae, Styracaceae* and *Symplocaceae* in Ebenales. Hutchinson (1967 1969, 1973) recognized two orders viz. Ebenales and Styracales. The former include *Ebenaceae, Sapotaceae* and *Sarcospermataceae* (usually included in *Sapotaceae*) and latter include *Lissocarpaceae, Styracaceae* and *Symplocaceae*. He believed that *Ebenaceae* provide a link between *Myrsinaceae* (Myrsinales) and *Sapotaceae* (Ebenales), suggesting that both orders probably were derived from thealean stock. Nooteboom (1975) also believed that *Symplocaceae* may be better placed within *Cornaceae* or possibly *Theaceae*, due to identical pollen morphology, leaf and wood anatomy, gynoecium and leaf-margins. Goldberg (1986) included only *Ebenaceae* and *Sapotaceae* in Ebenales. He placed *Lissocarpaceae* and *Styracaceae* in Styracales and placed *Symplocaceae* in Theales.

Earlier to these workers, Hiern (1873) also made an attempt to establish phylogenetic affinities of the family *Ebenaceae* with *Olacaceae, Styracaceae, Annonaceae, Theaceae, Ternstroemiaceae, Sapotaceae* and *Illiciaceae*. His hypothesis regarding affinities was almost an improved concept of Choisy (1855) and Miers (1862) as he considered *Ericaceae, Humiriaceae, Tiliaceae, Bixaceae, Magnoliaceae, Dichapetalaceae, Chailletiaceae, Euphorbiaceae, Lauraceae, Myrsinaceae, Convolvulaceae, Celastraceae* and *Oleaceae* quite far from *Ebenaceae*, indicating low level affinities. Such disagreements suggest that probably Ebenales in broad sense do not represent a natural group. To have a more comprehensive understanding of the phylogenetic relationship, molecular studies based on rbcL sequence data have been carried out during recent years. According to Morton *et al.* (1997), the most closest groups to *Ebenaceae* are *Sapotaceae, Styracaceae, Sarcospermataceae, Symplocaceae* and monogeneric *Lissocarpaceae*. Molecular studies based upon rbcL sequences (Morton *et al.*, 1997) and other molecular data support monophyletic origin of *Ebenaceae*. They placed these families under the order Ebenales and considered latter a polyphyletic group. Their studies indicate that *Ebenaceae* may be a sister-group of Primulales (including the families *Myrsinaceae, Primulaceae* and *Theophrastaceae*) within the large Ericalean clade, which, on the other hand, is a part of the Asteridae clade among Eudicots. Soltis *et al.* (1997 2000), who analysed 18 S ribosomal DNA, proposed the position of *Ebenaceae* under the order Ericales within the Ericalean clade at a very different level. They placed it between *Polemoniaceae* and *Ternstroemiaceae* – the most closely allied to *Ebenaceae*. Some of the other closely related families which gradually stand little far are *Styracaceae, Symplocaceae, Sapotaceae, Theaceae, Ericaceae, Tetrameristaceae* etc in ascending sequence, and *Myrsinaceae, Theophrastaceae, Primulaceae, Lecythidaceae, Roridulaceae* show reducing affinities in gradual descending order as illustrated in Illustration 1

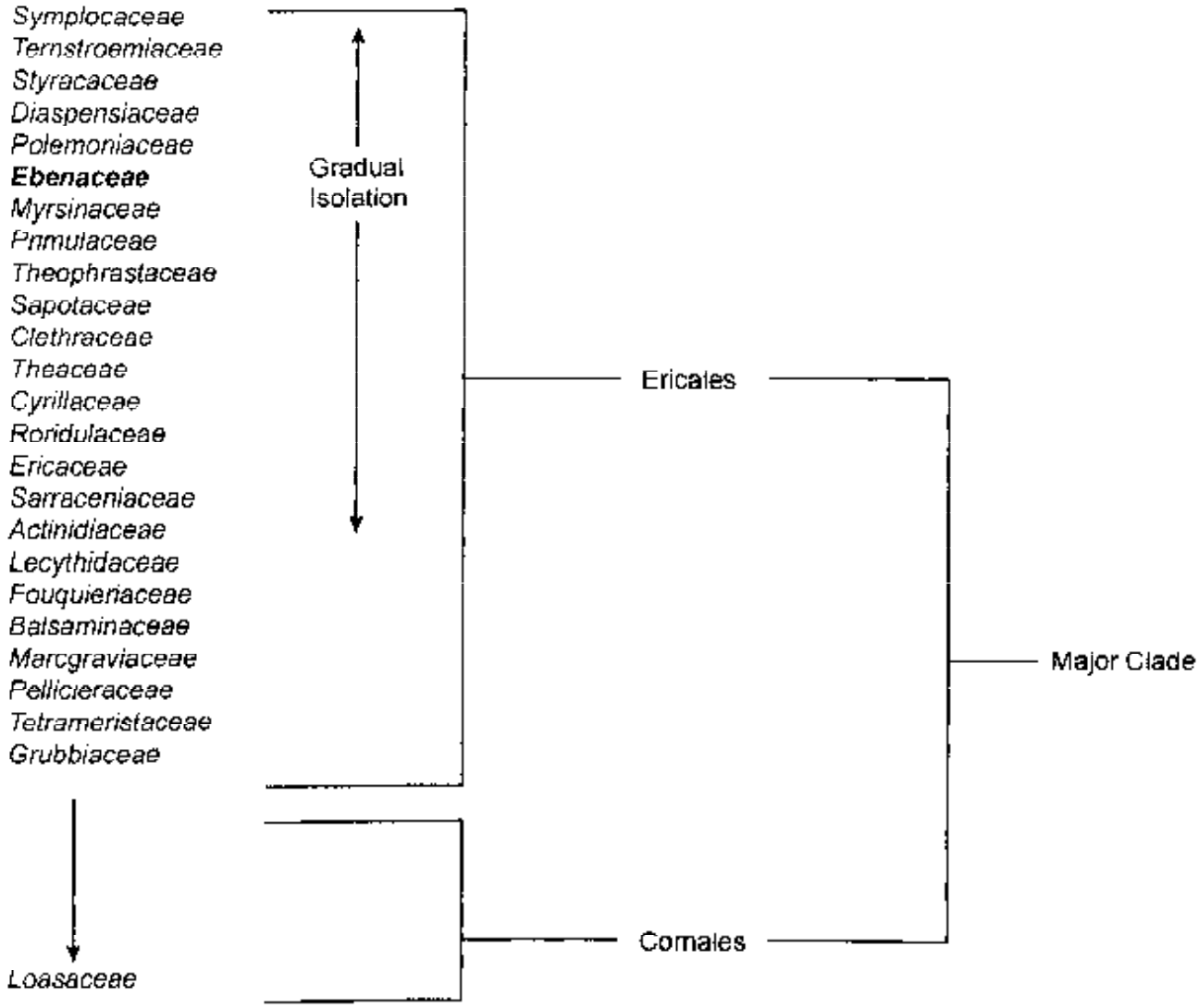
Nandi *et al.* (1998) based on rbcL and non molecular data presented three cladograms wherein *Ebenaceae* were located at three different positions within the clade "asterid III" which is a part of major clade "asterids". Studies carried out by Savolainen *et al.* (2000) based on rbcL gene sequences support



Illust. - 1. Plan exhibiting phylogenetic affinities of *Ebenaceae* within Ericales based on Soltis *et al.* (1997, 2000) concept.

the findings of Soltis *et al.* (2000) to some extent. They also placed the family *Ebenaceae* under the order Ericales and considered Ericales and Cornales to form a major clade in evolutionary seccession. Within Ericales, the family *Ebenaceae* was considered to stand between *Polemoniaceae* and *Myrsinaceae* as a link. The other important groups which show rather low affinities in gradual ascending

sequence are *Diaspensiaceae, Styracaceae, Ternstroemiaceae* and *Symplocaceae*. The families like *Primulaceae, Theophrastaceae, Sapotaceae, Theaceae, Ericaceae, Actinidiaceae, Lecythidaceae, Marcgraviaceae, Tetrameristaceae* etc also show reducing affinities in gradual descending order as illustrated in Illustration – 2.



Illust. – 2. Evolutionary trend and phylogenetic affinities of *Ebenaceae* within Ericales based on Savolainen *et al.* (2000) concept.

Though conflicting, the recent molecular analysis combined with morphology, chemistry, palynology, embryology and other non DNA characters have greatly improved our understanding on phylogenetic relationship of *Ebenaceae* with other flowering plants. Baas (2000) has made an attempt to supplement the recently proposed evolutionary cladograms based on wood anatomical characters. The order Ericales,

under which the monophyletic family *Ebenaceae* is placed by most molecular biologists, is characterized mainly by solitary vessels, scalariform or mixed scalariform simple and scalariform perforation plates, distinctly bordered fibre pits, apotracheal parenchyma and heterocellular rays, usually of two distinct sizes. Most of the families placed under the order Ericales by molecular biologists may be easily accommodated on wood anatomical characters except *Sapotaceae* and *Lecythidaceae* which have large vessel-ray pits, fibres with simple pits and vessels frequently in long radial multiples. These two families are less coherent to rest families in Ericales. The embryological studies further provide supporting evidences to establish close affinity of *Ebenaceae* with *Styracaceae* as both have bitegmic, upto ten uninucleate ovules. However, the *Sapotaceae* and *Symplocaceae* stand little isolated from *Ebenaceae* as they have unitegmentary, ten uninucleate ovules. The clues provided through palynological studies also support evolutionary trends proposed through molecular data to some extent (Nair & Kothari, 1985). Palynological studies carried out by Morton & Kincaid (1995) throw light on evolutionary trends within the family *Ebenaceae* at generic level. The genus *Euclea* Murr. constitutes one group as regard pollen morphology, especially in respect of polar and equatorial diameters and *Diospyros* L., together with other genera viz. *Cargillea* R. Br., *Gunisanthus* A. DC., *Maba* J. R. & G. Forst., *Macreightia* A. DC., *Rospidios* A. DC., *Royena* L. and *Tetraclis* Hiern which have been merged under *Diospyros* L. presently, constitutes another group except *Diospyros virginiana* L. which forms third independent group and stands far removed and isolated from both groups. These observations provide another taxonomic support to the concept of White (1980, 1983), who recognized only two genera in *Ebenaceae* viz. *Euclea* Murr. and *Diospyros* L. and merged rest genera under latter.

A perusal of literature revealed that our present knowledge is quite inadequate to resolve contradictory preliminary results on evolution and phylogeny of *Ebenaceae* due to the lack of adequate fossil evidences. Additional features from various disciplines also need to be vigorously examined and analyzed to test generic limits, phylogenetic trends within the family and phylogenetic and evolutionary affinities with other families and higher groups at various taxonomic levels. Further, the affinities within the species of the genus *Diospyros* L. will be discussed in the chapter dealing with phenetic affinities in present monograph.

PHENETIC AFFINITIES

The present study revealed that the genus *Diospyros* L. in the family *Ebenaceae* is rather more polymorphic than the genus *Euclea* Murr. The dioecious, monoecious and polygamous nature of species and remarkably high degree of variations in morphological features within the individuals of a species have greatly enhanced the difficulties in delimiting infra-generic and infra-specific taxa through a limited suits of morphological characters. In the revisionary studied where a taxonomist has to depend on preserved herbarium specimens, the range of certain characters cannot be assessed due to non availability of adequate material in perfect state. Difficulties in classifying and establishing phylogenetic relationship between the species of the genus *Diospyros* L. have also been realized due to non availability of plants of opposite sex in certain species. Further, lack of adequate supporting clues

of taxonomic interest from other disciplines in the genus *Diospyros* L. has also resulted in misidentification and misinterpretation of the infra-generic taxa. Under such circumstances, establishment of phenetic affinities between the species to determine phylogenetic relationship and evolution is rather a difficult task.

In the present work, the author has, however, made an attempt to understand phenetic affinities based on gross morphological characters. Thirty morphological characters forming fifteen pairs of almost constant contrasting characters of taxonomic value have been selected and each character has been given equal weightage. The selected characters are mainly reproductive, as vegetative characters are highly variable within a species or even within a plant. These characters, though overlap at certain points, may be easily assessed and expressed in dry preserved herbarium specimens. The selected contrast characters have been grouped into two groups viz. Group A – with odd number of characters and Group B – with even number of characters. The numbers of species representing such characters have been given in parentheses as under :

Group A	Group B
1. Midrib of leaf canaliculate above (60 spp.)	2. Midrib of leaf flat above (15 spp.)
3. Calyx and corolla 3-lobed (11 spp.)	4. Calyx and corolla 4 to 5 or more-lobed (58 spp.)
5. Calyx-lobes valvate (50 spp.)	6. Calyx-lobes contorted or imbricate (16 spp.)
7. Calyx glabrous bothsides (15 spp.)	8. Calyx pubescent or hairy on one or bothsides (63 spp.)
9. Corolla urceolate or bell-shaped (22 spp.)	10. Corolla tubular or hypocrateriform (45 spp.)
11. Corolla glabrous bothsides (14 spp.)	12. Corolla hairy or pubescent on one or bothsides, fully or partly (51 spp.)
13. Stamens hypogynous, inserted on the torus (28 spp.)	14. Stamens epipetalous, inserted on the corolla-tube (38 spp.)
15. Anthers apiculate due to produced connectives (46 spp.)	16. Anthers obtuse or acute, connectives not produces (15 spp.)
17. Anthers glabrous (45 spp.)	18. Anthers hairy (23 spp.)
19. Staminodes present (50 spp.)	20. Staminodes absent (11 spp.)
21. Ovary glabrous (23 spp.)	22. Ovary hairy or pubescent, partly or fully (43 spp.)

Group A	Group B
23. Ovary 3 or 4-celled (27 spp.)	24. Ovary more than 4-celled, partly or fully (45 spp.)
25. Cells of ovary 1-ovuled (62 spp.)	26. Cells of ovary 2-ovuled (3 spp.)
27. Fruiting-calyx cupuliform or bowl-shaped, enclosing full or lower part of the fruit (23 spp.)	28. Fruiting-calyx flat, disciform, with spreading or reflexed-lobes; fruit seated on the disc formed by calyx-tube and torus, not enclosed within the calyx (41 spp.)
29. Albumen of seeds equable (48 spp.)	30. Albumen of seeds ruminate (13 spp.)

The representation of above mentioned characters by sixty six infra-generic taxa of *Diospyros* L. have been assessed in tabular form. It is evident from the table 3 that most of the species represent either the characters of Group A or of Group B, except in (i) *D. atrata* (Thw.) Alston and *D. pyrrhocarpa* Miq. – anthers are apiculate as well as obtuse or acute; (ii) *D. kanjilali* Duthie, *D. lanceaefolia* Roxb., *D. melanoxylon* Roxb. var. *melanoxylon*, *D. nilagirica* Bedd., *D. oocarpa* Thw., *D. sylvatica* Roxb. and *D. undulata* Wall. ex G. Don – the anthers glabrous as well as hairy; (iii) *D. discolor* Willd., *D. oocarpa* Thw., *D. paniculata* Dalz. and *D. stricta* Roxb. – the stamens epipetalous as well as inserted on the torus; (iv) *D. cauliflora* Blume, *D. insignis* Thw., *D. melanoxylon* Roxb. var. *melanoxylon*, *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh, *D. multibracteata* (Merr.) Bakh., *D. ovalifolia* Wight and *D. racemosa* Roxb. – ovary 4 to 8-celled; (v) *D. lotus* L. – ovary glabrous to hairy; (vi) *D. sylvatica* Roxb., *D. fasciculosa* (F. v. Muell.) F. v. Muell. and *D. oocarpa* Thw. – calyx 3 to 4-lobed; (vii) *D. courtallumensis* Bahadur & Gaur and *D. lotus* L. – calyx glabrous to hairy; (viii) *D. lotus* L. – calyx-lobes valvate in male and imbricate in female; *D. sahayadryensis* Danniel & Vajravelu and *D. virginiana* L. – corolla urceolate to tubular; (ix) *D. candolleana* Wight and *D. ferrea* (Willd.) Bakh. – the fruiting-calyx cupuliform to flat; (x) *D. fasciculosa* (F. v. Muell.) F. v. Muell. and *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh – staminodes present to absent; (xi) *D. elegans* Clarke, *D. ferrea* (Willd.) Bakh., *D. glandulosa* Lace, *D. insignis* Thw., *D. melanoxylon* Roxb. var. *melanoxylon*, *D. montana* Roxb. and *D. cordifolia* Roxb., *D. paniculata* Dalz., *D. stricta* Roxb. and *D. sylvatica* Roxb. – the midrib of leaves canaliculate to flat on the upper surface. Such taxa which have contrasting characters of both groups together provide links in evolutionary process through which the genus is still passing.

Table 3. Representation of thirty characters by Indian species of *Diospyros* L. (Number 1 to 30 represent respective characters of Group A and B, + indicates presence and – represents absence).

Name of species	Characters																											No. of characters		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Gr A	Gr B	Common to type species
Diospyros affinis Thw.	+			+	+	–		+		+		+	+		+			+	+			+		+	+			+		+	6	9	11
andamanica (Kurz) Bakh.	+		+		+	–		+		+		+	+		+		+			+	+			+	+		+				10	5	8
apiculata Hiern	+			+	+	–		+		+		+		+		+	+		+			+	+		+			+	+		7	8	10
assimilis Beddome	+			+		+		+		+	+			+	–		+			+	+			+	+			+	+		7	8	12
ahara (Thw.) Alston	+			+	+			+		+		+		+	+	–		+	+			+		+	+			+	+		6	10	13
barberi Ramos	+			+	+	–		+		+	+		+		–		+		+			+	+		+		+				10	4	9
benghalensis Bakh	+			+	+	–		+		+	+		+			+	+		+			+	+		+			+	+		9	6	10
boundillonii Brandis	+			+	+	–		+		+		+	+			+	+		+			+		+	+		+		+		8	7	6
burkilla (Bl.) Hiern	+			+		+		+	+			+		+	+		+			+		+	+		+			+	+		7	8	11
cacharensis (Das & Kanj. f.) Naithani	+		+		+			+		+		+							+			+		+	+						5	5	7
candolleana Wight	+			+	+	–		+		+		+		+	+		+		+			+	+		+		+	+		+	8	8	10
capitiflora Blume	+			+		+		+	+			+		+	+		+		+			+	+	+	+			+	+		7	9	14
chloroxylon Roxb. var. *chloroxylon*		+		+		+		+	+			+		+	+		+		+		+			+	+			+	+		7	9	12
chloroxylon Roxb. var. *cupulosa* Singh		+		+		+		+	–			+		+	+		+		+		+			+	+		+		+		8	7	11
candifolia Roxb.	+	+		+		+		+	+		+			+		+	+		+		+			+	+			+	+		8	8	13

Name of species	Characters																												No. of characters		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Gr. A	Gr. B	Common to type species
courtallumensis Bahadur & Gour	+			+	+		+	+	+		+			+		+	+		+		+		+		+			+	+		11	5	13
crumenata Thw.	+			+	+			+		+		+	+		+		+		+			+		+	+			+		+	7	8	10
discolor Willd.	+			+		+		+		+		+	+	+	+		+		+			+		+	+			+	+		7	9	12
ebenum Koenig	+			+		+		+		+	+			+	+		+		+		+			+	+	+		+			9	6	12
ehretioides Wall. ex G. Don	+			+	+			+	+			+		+	+		+		+		+			+	+			+		+	8	7	12
elegans Clarke	+	+	+		+			+		+		+		+	+			+														4	6	6
fasciculosa (F. v. Muell.) F. v. Muell.	+		+	+	+			+	+		+		+				+		+	+	+		+	+	+	+	+		+		13	5	11
ferrea (Willd.) Bakh.	+	+	+		+			+		+		+	+		+		+			+		+	+			+	+	+	+			9	8	7
foliolosa Wall. ex A. DC.	+			+	+		+		+		+		+		+		+			+		+	+		+			+		+	10	5	10
glotensis Ram. & Franc.		+		+	+			+		+		+		+		+	+				+		+		+			+	+		6	8	8
glandulosa Lace	+	+		+	+			+	+			+	+		+			+	+			+		+	+		+		+			9	7	12
hirsuta L. f.	+			+	+			+		+		+		+	+			+	+			+		+	+			*		+	5	10	12
holosna Gupta & Konjilal	+			+		+		+		+		+		+	+			+	+			+		+	+		+		+		6	9	12
insignis Thw.	+	+		+	+			+		+		+			+		+		+			+	+	+	+		+			+	8	9	10
kaki Thunb. ex L. f.	+			+	+			+	+			+		+	+			+	+		+			+	+				+	+		8	7	14
konjilali Dutkie	+			+	+				+			+		+	+		+	+	+					+	+		+		+		10	6	13
kika Debb. & Biswas	+			+	+			+	+			+		+	+			+														4	5	7
kurzii Hiern	+			+	+			+		+		+		+	+		+		+		+	+	+		+			+	+		9	7	12
lanceaefolia Roxb.	+			+	+			+		+		+		+	+		+	+	+			+		+	+		+		+		8	8	12

Name of species	Characters																												No. of characters		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Gr. A	Gr. B	Common to type species
latus L.	+			+	+	+	+	+	+		+			+	+			+	+		+	+		+				+	+		10	8	
marmorata Parker	+		+		+			+		+		+		+	+			+			+			+	+			+		+	6	8	10
mortabanica Cl. var. *pellucido-punctata* (Hiern) Cl.	+			+	+			+		+		+		+		+	+		+			+		+	+						5	8	9
melanoxylon Roxb. var. *melanoxylon*	+	+		+	+			+		+		+	+		+		+	+	+			+	+	+	+			+		+		8	10	11
melanoxylon Roxb. var. *lupra* (Buch.-Ham.) Singh	+	+		+	+			+		+		+	+		+			+	+	+		+	+	+	+			+		+		7	11	11
moniana Roxb.	+	+		+	+			+	+		+			+	+		+		+		+			+	+			+	+			10	6	14
multibracteata (Merr.) Bakh.	+		+		+			+		+		+		+	+		+		+		+		+	+	+			+	+			10	6	11
neilgherrensis (Wight) Kosterm.	+		+		+			+		+		+	+			+	+			+		+	+			+	+		+				8	7	5
nilagirica Bedd.	+			+	+			+		+		+		+	+		+	+	+			+		+			+						8	8	12
oocarpa Thw.	+		+	+	+			+		+		+	+	+	+		+	+	+			+		+	+		+		+				10	8	12
ovalifolia Wight	+			+		+		+	+			+		+		+	+		+			+	+	+	+			+	+			7	9	12
paniculata Dalz.	+	+		+		+		+		+		+	+	+	+		+			+		+	+		+		+		+			6	9	9
peregrina (Gaertn.) Guike	+			+	+			+	+		+	+		+	+			+	+		+			+	+		+		+			10	6	14
pilosanthera Blanco var *helferi* (C.) Bakh.	+			+	+			+		+		+	+		+			+	+			+		+			+		+			8	7	11
pilosiuscula G. Don var. *pilosiuscula*	+			+	+			+		+		+	+				+			+		+	+		+			+		+		7	7	8

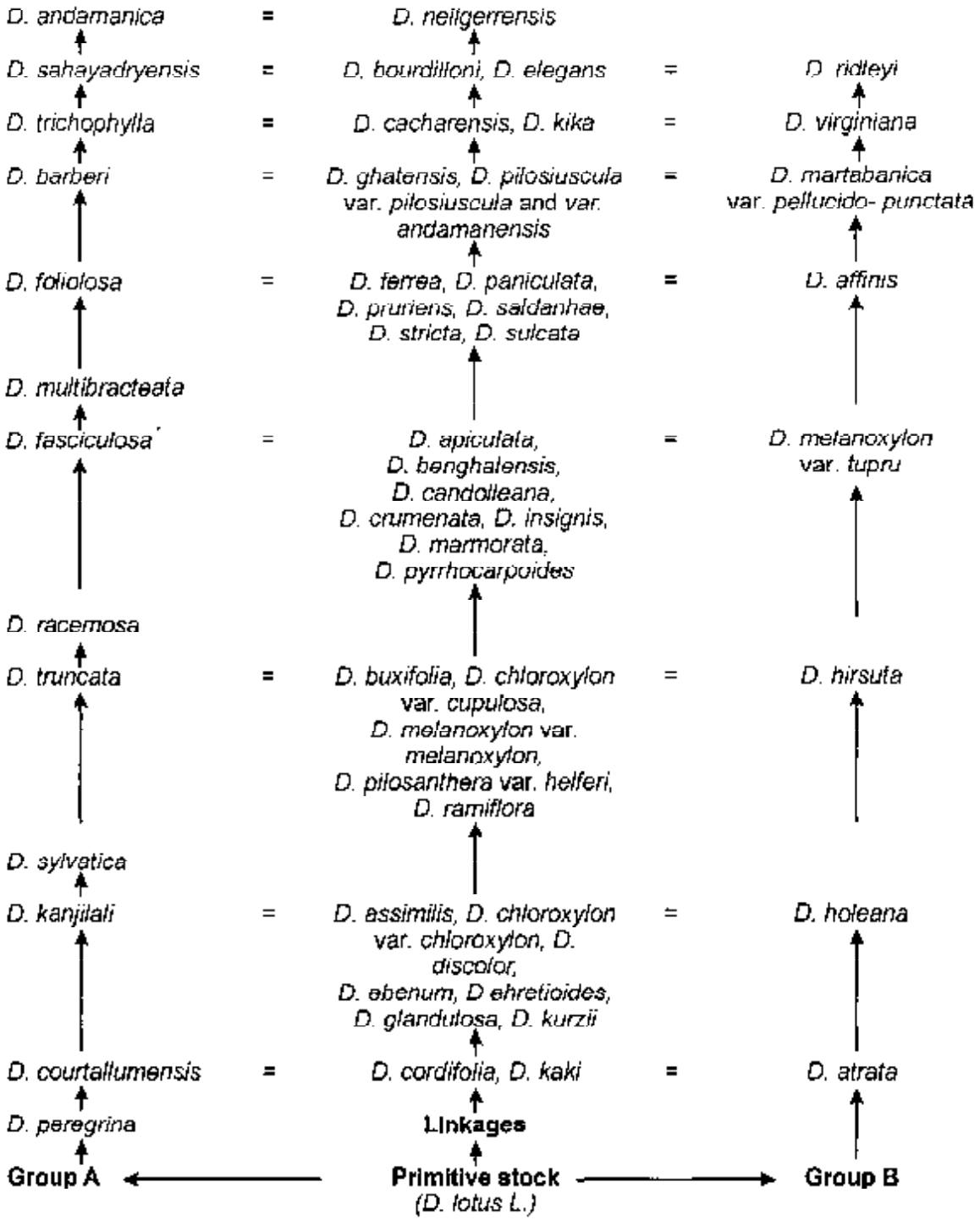
Name of species	Characters																											No. of characters		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	Gr A	Gr B	Common to type species
pilosiuscula G. Don var. *andamanensis* (Jayar & Nayar) Singh	+			+	+			-		+		-	+				+			+		+			+			+	+		7	7	9
proviens Dalz.	+			+		+		+		+		+	+			+	+		+			+	+		+			+	+		7	8	9
pyrrhocarpa Miq.	+			+	+			+		+		+	+		+	+		+	+			+		+	+			+	+		7	9	12
pyrrhocarpoides Ram. & Franc.	+			+	+			+		+		+	+		-		+		+			+	+		-			+	+		9	6	10
racemosa Roxb.	+			+	+			+	+			+	+		+		+		+			+	+	+	+			+	+		10	6	12
ramiflora Roxb	+			+	+			+		+		+	+		+			+	+			+		+	+			+		+	6	9	11
ridleyi Bakh.	+			+	+			+		+		+	+			+	+					+		+	+			+		+	5	9	8
sahyadriyensis Danniel & Vajravelu		+	+		+			+	+	+				+					+		+			+	+		+		+	8	5	9
saldanhae Kosterm	+			+		+		+		+		+							+			+	+		+			+	+		5	7	9
stricta Roxb.	+	+		+		+		+		+		+	-	+		+	+				+		+		+			+	+		7	9	9
sulcata Bourd.				+				+				+			+				+			+		+	+			+	+		4	6	9
sylvatica Roxb.	+	+	+	+	+			+	+		+		+		+		-	+	+		+			+	+		+			+	10	6	12
trichophylla Alston	+			+	+		+			+		+	+			+	+		+			+	+		+			+	+		9	6	9
truncata Zoll. & Mor.	+			+	+		+			+	+			+	+		+		+		+			+	+		+		+		11	4	12
undulata Wall. ex G. Don	+			+	+			+		+		+		+	+		+	+	+		+			+	+		+		+		9	7	12
variegata Kurz	+			+		+		+	+		+			+	+		+		+			+		+	+			+	+		8	7	14
virginiana L.		+	+			+	+	+		+									+			+		+	+			+	+		4	7	9

To determine phenetic affinities between the species and phylogenetic evolution in the genus *Diospyros* L., the type species *D. lotus* L. which presents typical characters of the genus may serve as primitive or basic stock. *D. lotus* L. bears 10 characters from Group A and 8 characters from Group B, almost equal. A perusal of table 3 revealed that *D. cauliflora* Blume, *D. kaki* Thunb. ex L. f., *D. montana* Roxb., *D. peregrina* (Gaertn.) Gurke and *D. variegata* Kurz are most closely related species to primitive stock as they share 14 characters in common with type species. Further, it is interesting to record that like type species all these species bear almost equal characters (7 to 9) from Group A and Group B, except *D. peregrina* (Gaertn.) Gurke which shows more tendency towards Group A (10 : 6) characters, indicating a line of evolution towards dominance of Group A characters.

A step divergent stand *D. atrata* (Thw.) Alston, *D. courtallumensis* Bahadur & Gaur, *D. kanjilali* Duthie and *D. cordifolia* Roxb. which share 13 characters in common with primitive stock. The second and third species of this group show evolution towards Group A characters as they represent 11 : 5 and 10 : 6 characters respectively from Group A and B. *D. cordifolia* Roxb., however, bears 8 : 8 characters from both groups indicating linkages with both groups of species. *D. atrata* (Thw.) Alston bears 6 : 10 characters from Group A and B respectively, opening a second line of evolution towards dominance of Group B characters.

The third group of species includes *D. assimilis* Bedd., *D. chloroxylon* Roxb. var. *chloroxylon*, *D. discolor* Willd., *D. ebenum* Koenig, *D. ehretioides* Wall. ex G. Don, *D. glandulosa* Lace, *D. kurzii* Hiern, *D. lanceaefolia* Roxb., *D. nilagirica* Bedd., *D. oocarpa* Thw., *D. ovalifolia* Wight, *D. pyrrhocarpa* Miq. and *D. undulata* Wall. ex G. Don which bear characters from Group A and B in almost equal proportion (7 to 9 or 10 to 8) and share 12 characters in common with basic stock. Evolutionary divergence in the characters towards Group A was noticed in *D. racemosa* Roxb. (10 : 6), *D. truncata* Zoll. & Mor. (11 : 4) and *D. sylvatica* Roxb. (12 : 6) and towards Group B characters in *D. hirsuta* L. f. (5 : 10) and *D. holeana* Gupta & Kanjilal (6 : 9), which, otherwise, have 12 characters common with primitive stock.

The taxa like *D. buxifolia* (Bl.) Hiern, *D. chloroxylon* Roxb. var. *cupulosa* Singh, *D. melanoxylon* Roxb. var. *melanoxylon*, *D. pilosanthera* Blanco var. *helferi* (Cl.) Bakh. and *D. ramiflora* Roxb. constitute fourth group of species with almost equal proportion of characters from Group A and B (6 to 9) and 11 characters common with basic stock. However, *D. affinis* Thw. (6 : 9) and *D. melanoxylon* Roxb. var. *tupru* (Buch.-Ham.) Singh (7 : 11) of this group show divergence towards Group B and *D. fasciculosa* (F. v. Muell.) F. v. Muell. (13 : 5) and *D. multibracteata* (Merr.) Bakh. (10 : 6) towards Group A.



Illust. 3. Diagrammatic presentation of infra-generic probable evolution in *Diospyros* L.

Further more divergent from basic stock stand *D. apiculata* Hiern, *D. benghalensis* Bakh., *D. candolleana* Wight, *D. crumenata* Thw., *D. insignis* Thw., *D. marmorata* Parker and *D. pyrrhocarpoides* Ram. & Franc. with almost equal proportion (9 to 6) of characters from Group A and B, indicating

uniform status of evolution. They share 10 characters in common with type species. However, *D. foliolosa* Wall. ex A. DC. of this group shows evolution towards Group A by having 10 characters from Group A and 5 from Group B.

Rather more evolved species which constitute 6th group of species bear only 50 per cent characters (9) common to primitive stock. Among these species *D. ferrea* (Willd.) Bakh., *D. paniculata* Dalz., *D. pruriens* Dalz., *D. saldanhae* Kosterm., *D. stricta* Roxb. and *D. sulcata* Bourd. stand on the same platform of evolution as they represent characters of Group A & B in almost equal proportion. However, the species like *D. virginiana* L. (4 : 7) and *D. martabanica* Cl. var. *pellucido-punctata* (Hiern) Clarke (5 : 8) show tendency towards Group B characters. Towards Group A line of evolution *D. sahayadryensis* Danniel & Vajravelu (8 : 5) and *D. trichophylla* Alston (9 : 6) have marched rather slowly than *D. barberi* Ramas. (10 : 4).

At this point of junction it is interesting to record that the number of species decreases gradually with the increase in distance with basic stock. It gives an indication of slow rate of evolution in this genus. *D. andamanica* (Kurz) Bakh. (10 : 5) has followed Group A path of evolution, while *D. ridleyi* Bakh. (5 : 9) path of Group B. Rest species, viz. *D. ghatensis* Ram. & Franc., *D. pilosiuscula* G. Don var. *pilosiuscula* and var. *andamanensis* (Jayar. & Nayar) Singh have characters of Group A and B in almost equal proportion (6 to 8). These taxa of 7th group of species share only 8 characters with basic stock. Further distant position is occupied by *D. cacharensis* (Das & Kanj. f.) Naithani (5 : 5) and *D. kika* Debb. & Biswas (4 : 5) which have only 7 characters common with primitive stock, but have Group A and B characters in almost equal proportion. *D. bourdillonii* Brandis and *D. elegans* Clarke share 6 characters, while *D. neilgerrensis* (Wight) Kosterm. stands farthest from type species sharing only 5 characters in common with basic stock, but interestingly bearing characters of Group A and B in equal proportion.

It is evident from the discussion that evolutionary process is rather slow in *Diospyros* L. The evolutionary divergence has taken place through limited suits of characters in two directions, one leading to Group A and other to Group B characters. The species which bear both contrasting characters together provide linkages within the groups and species. The different characters, however, behave independently in different species and different groups in evolutionary succession. As such, a definite line of progressive or retrogressive evolution as regard to a particular character cannot be drawn based on morphological characters alone in this genus. The evolution within the genus *Diospyros* L., therefore, seems to be multidirectional. A perusal of cytological data revealed that most of the species of *Diospyros* L. are deploids, as such the polyploidy has played very limited role in infra-generic evolution. The palynological, anatomical and embryological characters also show close resemblances in different species and are not worth to trace the evolutionary sequences. The micro characters of wood anatomy may, however, be used as phylogenetic tool for evolutionary studies, but very little information is available for

limited number of species. Free hybridization in nature seems to be mainly responsible for multidirectional evolution through contaminated diversity in the characters.

CONSERVATION

India is a megabiodiversity country with high level of endemism. The endemic plants by virtue of being restricted to a particular ecological niche, habitat, biogeographic region or a country are more vulnerable in comparison to those which find rather wide distribution. The Convention on Biological Diversity, ratified by India on 18th February, 1994, has focused attention on urgent need of conservation of depleting plant resources for fulfilment of human needs and ecologically sustainable development. The global biodiversity crisis has given rise to a growing concern at the prospects of a rapidly accelerating loss of species, populations, domesticated varieties and natural habitats of rates higher than ever witnessed before in the history of human evolution. It is estimated that about 10 per cent of the flowering plants of the country are under different degrees of threat.

The genus *Diospyros* L. is not only largest genus (*ca* 600 spp.) in the Ebony family, but consists geographically isolated groups of species with maximum endemism. In India, the genus *Diospyros* L. is represented by 66 taxa; of these 39 species have originated in India and 17 species are still endemic. Most of the species provide beautiful timber of global repute and high demand and edible fruits to local inhabitats. Conservation assessment of such an important genus is of prime importance. During the course of present study it was noticed that some taxa of *Diospyros* L. need immediate intensive surveys in the localities of their possible occurrence, their multiplication and conservation in *in-situ* and *ex-situ* conditions. Recently, Nayar (1996) has, however, thrown some light on the endemic taxa of Indian *Ebenaceae* which are insufficiently known and are in critical position. The present study revealed that among endemic taxa the most critically threatened are : (i) *D. andamanica* (Kurz) Bakh. – poorly represented in Andaman & Nicobar Islands; (ii) *D. elegans* Clarke – confined to Assam and Meghalaya, no report after collections of Clarke made in 1872; (iii) *D. kanjilali* Duthie only few collections from wild after the collections of Gamble made during 1921-22; (iv) *D. marmorata* Parker – insufficiently known in Andaman & Nicobar Islands; (v) *D. martabanica* Clarke var. *pellucido-punctata* (Hiern) Clarke – no collections after holotype and Kurz collections from Andamans; (vi) *D. ramiflora* Roxb. – insufficiently known in N. E. India and Andaman & Nicobar Islands; (vii) *D. sahayadryensis* Danniel & Vajravelu – very insufficiently known on Sahayadri hills in Maharashtra and Karnataka and (viii) *D. sulcata* Bourd. – no collections after Bourdillon's collections from Travancore made in 1905. These taxa may be considered super sensitive from conservation point of view and need intensive surveys in the respective areas of occurrence. Possibilities are that some of these taxa would have disappeared from the biosphere due to large scale destruction of habitats for socio-economic developments after independence or due to over-exploitation for valued timber. However, perfect comments on the extinction of taxa may be made after thorough surveys.

The second category of plants which need immediate attention includes those taxa which are endemic, find restricted distribution and have thin density and frequency in nature, viz. *D. assimilis*

Bedd., *D. barberi* Ramas., *D. bourdillioni* Brandis, *D. cacharensis* (Das & Kanj. f.) Naithani, *D. courtallumensis* Bahadur & Gaur and *D. saldanhae* Kosterm. Conservation of these depleting plant resources is necessary for the fulfilment of human needs and ecologically sustainable development.

The third category of plants which have drawn attention for their protection includes those species which have migrated from neighbouring countries and are under threat in their native homes, viz. *D. apiculata* Hiern - migrated from Malayan peninsula and established in North-Eastern States of India, *D. atrata* (Thw.) Alston – migrated from Sri Lanka and established in South India, *D. ehretioides* Wall. ex G. Don – migrated from Myanmar and known under cultivation in West Bengal, *D. hirsuta* L. f. - migrated from Sri Lanka and established in Kerala in South India, *D. multibracteata* (Merr.) Bakh. – migrated from Philippines and settled in Andaman & Nicobar forests, *D. pilosanthera* Blanco var. *helferi* (Clarke) Bakh. – migrated from Malayan peninsula and settled in Andaman & Nicobar Islands in the end of 18th century. *D. pyrrhocarpa* Miq. – migrated from Sumatra and settled in N. E. India and Andamans and *D. truncata* Zoll. & Mor. – migrated from Java and settled in North-Eastern States of India during the end of 18th century. A perusal of literature revealed that the populations of these taxa have been shrinking throughout their range of distribution. As such, conservation of such taxa is of international interest.

Moreover, if we compare the ratio of relative degree of threat with general 10 per cent of flowering plants, it becomes obvious that about 33.33 per cent taxa are under high degree of threat and need immediate conservation measures. The main causes of threat to the Indian species of *Diospyros* L. are destruction of habitats for socio-economic development, over exploitation of plants for timber, fire-wood and charcoal and seed germination problems. Most species of *Diospyros* L. have long seed-dormancy due to hard testa and copious endosperm. As such, the germination of seeds is delayed from 12 to 250 days (Ng, 1991). Sometimes, the seedlings die because the plumule remains trapped within the partially splitted seed-coat. In nature, the germination problems in *Diospyros* L. are sorted out by wild animals through ingestion of seeds by animals which causes structural modifications in seed-coat and facilitates quick and perfect germination of seeds. The rapid decline of populations of the involved animals, could also be responsible for the notorious rarity of several species of *Diospyros* L.

No serious efforts have so far been made to protect the depleting species of *Diospyros* L. in India. Inspite of high degree of threat, none of the species could find space in Indian Red Data Books published sofar. As such, due to insufficient taxonomic knowledge, the conservation of valuable taxa has been neglected. Distribution pattern of threatened taxa indicates that their populations are localized at specific places, but frequency and density is very poor. As such, *in-situ* conservation may be a useful tool for the protection of such taxa. Further, most of the species have capacity to multiply through seeds as well as root-suckers. *In-situ* conservation may hasten the multiplication and the taxa may come out of danger under natural conditions. Experiments have shown that some species may be multiplied through biotechnological methods. As such, they have potential for *ex-situ* conservation also. Necessity is to develop technologies for rapid multiplication and rehabilitation of depleting Ebony resources.

REFERENCES

Achiwa, Y., Hibasami, H., Katzuzaki, H., Imai, K. & Komia, Y. (1997). Inhibitory effects of persimmon (*Diospyros kaki*) extract and related polyphenol compounds on growth of human lymphoid leukemia cells. *Biosci. Biotech. Biochem.* **61** : 1099-1101

Agharkar, S. P. (1991). *Medicinal Plants of Bombay Presidency*, pp 91-92. Scientific Publishers, Jodhpur.

Agrawal, V. S. (1970). *Wood yielding plants of India*, pp. 22-23. Indian Museum, Calcutta.

Ahmed, R. U. (1993). Medicinal plants used in ISM-their precurement, cultivation, regeneration and import/ export aspects — a report. In Govil, J. N. *et al.* (Edits.) *Medicinal Plants : New vistas of Research* **1** : 221-258. Today and Tomorrow Printers & Publishers, New Delhi.

Aitchison, J. E. T. (1880). *Flora of the Kuram valley and Central Afghanistan.* Taylor & Francis, London.

Alston, A. H. G. (1931). In H. Trimen *A Handbook to the Flora of Ceylon*, Vol. 6. Dulau & Co., London.

Ambasht, R. S. (1968). Ecology of a river bank. *Proc. Symp. Recent. Adv. Trop. Ecol.* **2** : 469.

Anjaneyulu, C. & Lakshminarayan, K. (1989). Microsporogenesis and the development of male gametophyte in two species of *Diospyros* L. *Taiwania* **34** : 187-191.

Anonymous (1952). *The Wealth of India — A dictionary of Indian raw materials* **3** : 76-87. CSIR Publication, New Delhi.

Ash, J. (1983) Note on paper Growth rings and rainfall correlations in a Mangrove tree of the genus *Diospyros* (*Ebenaceae*) by N. C. Duke *et al. Aust. J. Bot.* **31** : 19-22.

Asolkar, L. V., Kakkar, K. K. & Chakre, O. J. (1992). *Second Supplement to Glossary of Indian Medicinal Plants with Active Principles.* PID, CSIR, New Delhi.

Astanova, S. B. (1984). Chromosome numbers in some species of the families *Alliaceae, Asteraceae, Caryophyllaceae, Ebenaceae, Linaceae, Oleaceae, Lamiaceae* from Tadjikistan. *Bot. Zurn. SSSR.* **6a** (11) : 1563-1564 (In Russian).

Athaya, C. D. (1985). Ecological studies of some forest tree seeds II. Seed storage and viability. *Ind. J. For.* **8** (2) : 137-140.

---------- & Mishra, G. P. (1979). On occurrence of monoecious trees of *Diospyros melanoxylon* Roxb. *Curr. Sci.* **48** (17) : 791-792.

----------, Yadav, A. S. & Mishra, G. P. (1982). Architectonic of the root system of *Diospyros melanoxylon* Roxb. *Ind. J. For.* **5** (4) : 331-332.

Awasthi, A. K. (1986). Sucker regeneration and sprouting in *Diospyros melanoxylon* Roxb. *J. Trop. For.* **2** (1) : 66.

---------- (1990). Spatial distribution pattern of *Diospyros melanoxylon*. *Trop. Eco.* **31** (1) : 69-74.

Awasthi, N. (1974). Neogene angiospermous woods. In Surange, K. R. *et al.* (Edits.) *Aspects and Appraisal of Indian Paleobotany.* Birbal Sahni Institute of Paleobotany, Lucknow.

Ayala-Nieto, M. L. & Ludlow-Wiechers, B. (1983). Catalogo Palinologico para la Flora de Veracruz, No. 13, Familia *Ebenaceae*. *Biotica* **8** : 215-216.

Baas, P. (2000). Dicotyledonous wood anatomy and the APG system of angiosperm classification. *Bot. J. Linn. Soc.* **134** : 3-17.

Bailey, F. M. (1900). *The Queensland Flora* **3** : 962-966. H. J. Diddams & Co., Brisbane.

Bailey, I. W. (1957). Potentialities and limitations of wood anatomy in the study of phylogeny and classification of angiosperms. *J. Arn. Arb.* **38** : 243-254.

Bakhuizen van den Brink, R. C. (1933). Enumeration of Malayan *Ebenaceae*. *Gard. Bull. Straits Settlements* **7** : 161-189.

---------- (1936-1955). Revisio Ebenacearum Malayensium. *Bull. Jard. Bot. Buitz. Ser.* 3. **15** (1-5) : 1-515.

Balakrishnan, N. P. (1981). *Flora of Jowai*, Vol. 1. Botanical Survey of India, Howrah.

Barclay, A. S. & Earle, F. R. (1974). Chemical analysis of seeds-III. Oil and protein content of 1253 species. *Econ. Bot.* **28** (2) : 178-236.

Baldwin, J. T. & Culp, R. (1942). Polyploidy in *Diospyros* L. *Amer. J. Bot.* **28** : 942-944.

Basinger, J. F. & Christophel, D. C. (1985). Fossil flowers and leaves of the *Ebenaceae* from the Eocene of southern Australia. *Canad. J. Bot.* **63** : 1825-1843.

Beddome, R. H. (1871). *The Flora Sylvatica for Southern India*. Gantz Brothers, Madras.

Bedi, Y. S., Bir, S. S. & Gill, B. S. (1980). In IOPB Chromosome numbers reports – LXVII. *Taxon* **29** : 347-367.

Benthall, A. P. (1946). *The trees of Calcutta and its neighbourhood*. Thacker, Sprink & Co., Calcutta.

Bentham, G. & Hooker, J. D. (1876). *Genera Plantarum* **2** : 662-666. Lovell Reeve & Co., Williams & Norgate, London.

Berhaut, J. (1975). *Flore illustree du Senegal*, Vol. 3. Dakar, Gouvernement du Senegal.

Berry, E. W. (1923). *Tree ancestors*. Williams & Wilkins Co., Baltimore.

Berry, P. E., Savolainen, V., Sytsma, K. J., Hall, J. C. & Chase, M. W. (2001). *Lissocarpa* is sister to *Diospyros* (*Ebenaceae*). *Kew Bull.* **56** : 725-729.

Bhakuni, D. S., Dhar, M. L., Dhar, M. M., Dhawan, B. N., Gupta, B. & Srimal, R. C. (1971). Screening of Indian plants for biological activity : Part III. *Ind. J. Exp. Biol.* **9** : 91-102.

Bhandari, R. S. & Upadhyay, A. K. (1986). *Cossus cadambae* Moore (Lepidoptera : Cossiae) A new pest for tendu (*Diospyros melanoxylon*). *Ind. For.* **112** : 169-173.

Bhargavan, P. (1987). *Ebenaceae* In Henry, A. N., Kumari, G. V. & Chithra, V. (Edits.) *Flora of Tamil Nadu*, Vol. 2. Botanical Survey of India, Coimbatore.

Bhaumik, T., Dey, A. K., Das, P. C., Mukhopadhyaya, A. K. & Chatterjee, A. (1981). Triterpenes of *Diospyros peregrina* (Gaertn.) Gurke : Partial synthesis of olean-9 (11), 12-dien-3-one & ursan-9 (11), 12-dien-3-one (marsformosanone). *Ind. J. Chem.* **20B** (8) : 664-668.

Billore, S. K., Mehta S. C. & Mall, L. P. (1976). Changes in chlorophyll a, b and carotenoids in summer leaves of tree species in a dry deciduous forest. *J. Ind. Bot. Soc.* **55** : 56-59.

Bir, S. S. & Chatha, G. S. (1983). SOCGI plant chromosome number reports – I. *J. Cytol. Genet.* **18** : 56-58.

---------- & ---- ----- (1985). SOCGI plant chromosome number reports – III. *J. Cytol. Genet.* 20 : 204 205.

----------, Gill, B. S. & Bedi, Y. S. (1979). In IOPB Chromosome numbers reports – LXIV. *Taxon* 28 : 391-408.

----------, ---------- & ---------- (1984). Cytological studies in some Western Himalayan woody species. I. Gamopetalae and Monochlamydae. In G. S. Paliwal (Edit.) *The Vegetational Wealth of Himalayas*, pp. 483-496. Puja Publishers, Delhi.

---- -, ---- ---, -- -- & Singhal, V. K. (1980). Evolutionary status of the woody taxa of Garhwal Himalaya. In P. K. Khosla (Edit.) *Improvement of Forest Biomass*, pp. 81-96. Indian Society of Tree Scientists, Solan, India.

Biswas, K. (1936). Two new flowering plants. *J. Ind. Bot. Soc.* 16 : 57-59.

---------- (1944). Pectin in fruits of the Indian Persimmon (*D. embryopteris* Pers.) *Science & Culture* 9 (11) : 501.

Boissier, P. E. (1867). *Flora Orientalis*, Vol. 2. Brasileae.

Bourdillon, T. F. (1908). *The forest trees of Travancore*. Govt. of Travancore.

Brandis, D. (1874). *The Forest Flora of North-West and Central India*. W. H. Allen & Co., London.

---------- (1906). *Indian Trees*. Archibald Constable & Co., London.

Brown, R. (1810). *Prodromus Florae Novae Hollandiae et Insulae van – Diemen*. J. Johnson & Co., London.

Burkart, A. (1979). *Flora ilustrada de Entre Rios (Argentina)*, Vol. 6 (5). Buenos Aires, Instituto Nacional de Technologia Agropecuaria.

Burkill, I. H. (1935). *A Dictionary of Economic Products of the Malay Peninsula*, 2 Vols. Crown Agents for the Colonies, London.

Busch, P. (1913). *Anatomisch-systematische Untersuchung der Gattung Diospyros*. Wilhelm Greven, Crefeld.

Candolle, A. de (1844). *Prodromus Systematis Naturalis Regni Vegetabilis*, Vol. 8. Treutl & Wurtz, Paris.

Carter, F. L., Garlo, A. M. & Stanley, B. (1978). Termiticidal components of wood extracts : 7-Methyljugulone from *Diospyros virginiana*. *J. Agric. Food Chem.* 26 (4) : 869-873.

Cavalcante, P. B. (1963a). Contribuicao ao conhecimento do genero *Diospyros* Dalech. (*Ebenaceae*) na Amazonia. *Bol. Mus. Paraense Emilio Goeldi, N. S., Bot.* 20 : 1-53.

---------- (1963b). Nova contribuicao ao conhecimento do genero *Diospyros* Dalech. (*Ebenaceae*) na Brasil. *Bol. Mus. Paraense Emilio Goeldi, N. S., Bot.* 21 : 1-15.

Ceschmedjiev, I. V. (1983). In IOPB Chromosome numbers reports – LXXX. *Taxon* 32 : 506.

Chatha, G. S. & Bir, S. S. (1987). Population analysis of some woody species from Palni Hills, South India. *J. Cytol. Genet.* 22 : 83-94.

Chatterji, A. K. (1964). Cytological studies on some species of *Diospyros*. *Sci. & Cult.* 30 (8) : 390-391.

Chauhan, J. S. & Kumari, G. (1978). New leucoanthocyanin from the stem of *Diospyros peregrina*. *J. Ind. Chem. Soc.* 55 (10) : 1068-1070.

---------- & ---------- (1980). Nonadecan-7-0L-2-2-one, an aliphatic Ketol from *Diospyros peregrina*. *Phytochemistry* **19** : 2637-2638.

----------, Saraswat, M. & Kumari, G. (1979). Structure of a new dihydroflavonol glycoside from *Diospyros peregrina* roots. *Planta Med.* **35** (4) : 373-375.

Chen, L. (1935). *Diospyros* in south-east China. *Lignan Sci. J.* **14** : 665-685.

Chen, R. Y. (1993). Chromosome atlas of Chinese fruit trees and their close wild relatives. *Chromosome Atlas Chin. Princ. Econ. Pl.* Vol. I.

----------, Li, X. L., Song, W. Q. & Lin, S. H. (1985). Studies on chromosomes of some tropical fruit trees in China. *J. Wuhan Bot. Res.* (Wuhan Zhiwuxue Yanjou) **3** (4) : 423-428 (In Chinese).

Choi, J. Y., Kim, H. J., Lee, C. H., Bae, J. M., Chung, Y. S., Shin, J. S. & Hyung, N. I. (2001). Efficient and simple plant regeneration via organogenesis from leaf-segments of persimmon (*Diospyros kaki* Thunb.). *In Vitro Cell Dev. Biol. Plant* **37** (2) : 274-279.

Choisy, J. D. (1855). *Memoires sur les familles des Ternstroemiacees et Camelliacees*, pp. 9. Geneve.

Chopra, R. N. (1933). *Indigenous Drugs of India*. The Art Press, Calcutta.

----------, Badhwar, R. L. & Ghosh, S. (1984). *Poisonous Plants of India*, Vol. **1**. Academic Publishers, Jaipur (reprinted edition).

----------, Chopra, I. C., Handa, K. L. & Kapur, L. D. (1958). *Indigenous Drugs of India*, pp. 505-604. U. N. Dhur and Sons Pvt. Ltd., Calcutta.

----------, ---------- & Varma, B. S. (1969). *Supplement to Glossary of Indian Medicinal plants*, pp. 26. CSIR (Publication and Information Directorate), New Delhi.

----------, Nayar, S. L. & Chopra I. C. (1956). *Glossary of Indian Medicinal plants*, pp. 98-99. CSIR (Publication and Information Directorate), New Delhi.

Chowdhery, H. J. (1984). *Ebenaceae* In Chowdhery, H. J. & Wadhwa, B. M. (Edits.) *Flora of Himachal Pradesh*, Vol. **2**. Botanical Survey of India, Calcutta.

Clarke, C. B. (1882). *Ebenaceae* In J. D. Hooker (Edit.) *Flora British India* **3** : 549-572. L. Reeve & Co., London.

Collinson, M. E., Boulter, M. C. & Holmes, P. L. (1993). Magnoliophyta (Angiospermae). In Benton, M. J. (Edit.) *The Fossil Record* **2** : 809-841. Chapman & Hall, London.

Compton, R. H. (1976). The Flora of Swaziland. *J. South Afr. Bot. Suppl.* **11** : 684.

Cooke, R. G. & Dowd, H. (1952). *Aust. J. Sci. Res. Ser. A.* **5** : 760.

Cooke, T. (1904). *Flora of the Presidency of Bombay*, Vol. **2**. Taylor & Francis, London.

Corner, E. J. H. (1976). *The Seeds of Dicotyledons* **1** : 123. Cambridge University Press, Cambridge.

Cronquist, A. (1981). *An integrated system of classification of flowering plants*. Columbia Univ. Press, New York.

---------- (1988). *The evolution and classification of flowering plants*, New York Bot. Garden, New York (2nd edit).

Cutillas-Iturralde, A., Fulton, D. C., Fry, S. C. & Lorences, E. P. (1998). Xyloglucan-derived oligosaccharides induce ethylene synthesis in persimmon (*Diospyros kaki* L.) fruit. *J. Exp. Bot.* **49** (321) : 701-706.

----------, Zarra, I. & Lorences, E. P. (1993). Metabolism of cell wall polysaccharides from persimmon fruit. Pectin solubilization during fruit ripening occurs in apparent absence of polygalacturonase activity. *Physiol. Plant.* **89** (2) : 369-75.

Dagar, J. C. & Singh, N. T. (1999). *Plant resources of the Andaman and Nicobar Islands*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Dahlgren, R. M. T. (1980). A revised system of classification of the angiosperms. *Bot. J. Linn. Soc.* **80** : 91-124.

---------- (1983). General aspects of angiosperm evolution and macrosystematics. *Nordic J. Bot.* **3** : 119-149.

---------- (1989). The last Dahlgrenogram system of classification of the dicotyledons – In *Davis & Hedge Festschrift : plant taxonomy, phytogeography and related subjects*, ed. K. Tan. Edinburgh Univ. Press.

Dalzell, N. A. (1852). In *Hook. Kew J. Bot.* **4** : 110.

Daniel, M., Sabnis, S. D. & Prathapasenan, G. (1980). A phytochemical survey of the plants of the forests in Gujarat for alkaloids, saponins and tannins. *Ind. J. For.* **3** (3) : 238-248.

Daulatabad, C. D. & Ankalagi, R. F. (1982). Minor seed oils 1. Component fatty acids of some seed oils. *J. Food Sci. Tech.* **19** (3) : 112 123.

Davis, G. L. (1966). *Systematic embryology of angiosperms*. John Wiley & Sons, New York, London & Sydney.

Deb, D. B. (1981). *Flora of Tripura State*, Vol. 1. Today and Tomorrow Printers and Publishers, New Delhi.

Delay, C. (1947). Recherches sur la structure des noyaux quiescent chez les Phanerogames. *Rev. Cytol. & Cytophysiol. Veg.* **9** (1-4) : 169-222 & **10** (1-4) : 103-229.

Desarkar, B. K. (1963). A note on Bidi leaf (*Diospyros melanoxylon*). *Ind. For.* **89** : 39-45.

Deshpande, S., Sharma, B. D. & Nayar, M. P. (1993). *Flora of Mahabaleshwar*, Vol. 1. Botanical Survey of India, Calcutta.

Dhar, M. L., Dhar, M. M., Dhawan, B. N., Mehrotra, B. N. & Ray, C. (1968). Screening of Indian plants for biological activity Part I. *Indian J. Exp. Biol.* **6** : 232.

Dhar, S., Mahendra, A. K. & Ansari, M. Y. (1989). Tendu leaves – their collection and trade for the benefit of rural people. *Ind. For.* **115** : 296-302.

Dhawan, B. N., Patnaik, G. K., Rastogi, R. P., Singh, K. K. & Tandon, J. S. (1977). Screening of Indian plants for biological activity Part VI. *Indian J. Exp. Biol.* **15** : 208-219.

Ditsch, E. & Barthlott, W. (1997). Mikromorphologie der Epicuticularwachse und das System der Dilleniidae and Rosidae – Trop. Subtrop. *Pflanzenwelt* **97** : 1-248.

Don, G. (1837). *A general history of the dichlamydeous plants* (A general system of Gardening and Botany), Vols. **4**. J. G. & F. Rivington, London.

Duke, N. C., Birch, W. R. & Williams, W. T. (1981). Growth rings and rainfall correlations in a mangrove tree of the genus *Diospyros* (*Ebenaceae*). *Aust. J. Bot.* **29** : 135-142.

Dunn, M. E. (1983). Coquille flora (Louisiana) : An ethnobotanical reconstruction. *Econ. Bot.* **37** : 349-359.

Duthie, J. F. (1905). A new species of *Diospyros*, *D. kanjilali* Duthie. *Ind. For.* **31** : 307-308.

---------- (1911). *Flora of the Upper Gangetic plain and of the adjacent Siwalik and sub-Himalayan tracts*, Vol. 2. Calcutta.

Dymock, W., Warden, C. J. & Hooper, D. (1890-99). *Pharmacographia Indica*. Trubner & Co., London.

Edwards, W. N (1931). Dicotyledons (Ligna). In Jongmans, W. (Edit.) *Fossilium Catalogus-II. Plantae Pars 17* W. Junk, Berlin.

Elsler, E. (1907). Das extraflorale Nektarium unde die Papillen der Blattunterseite bei *Diospyros discolor* Willd. – Sitzungsber. *Kaiserl. Akad. Wiss. Math. – Naturewiss. Cl., Abt. 1*, **116** : 1563-1590.

Erdtman, G. (1952). *Pollen morphology and Plant taxonomy – Angiosperm*. Almquist & Wiksell, Stockholm.

Fallas, A. L. & Thomson, R. H. (1968). *Ebenaceae* extractives. Part. III – Binaphthaquinones from *Diospyros* species. *J. Chem. Soc.* C : 2279 – 2282.

Fedorov, A. A. (1974). *Chromosome numbers of flowering plants*. Otto Koeltz Science Publishers, Koenigstein, Germany (reprinted edition).

Fischer, C. E. C. (1938). Plants new to Assam. *Kew Bull.* **1938** : 210.

Franceschi De, D. (1993). Phylogenie des Ebenales : analyse de l'ordre et origine biogeographique des especes indiennes. *Publications du Departement d'ecologie, Institut Francais de Pondichery* **33** : 1-153.

Gamble, J. S. (1881). *A Manual of Indian Timbers*, pp. 453-463. Calcutta.

---------- (1922). *Flora of the Presidency of Madras*, Vol. 2, Part IV. West Newman & Co., Adlard & Son, London.

Ganguly, A. K. & Govindachari, T. R. (1966). Structure of *Diospyros*. *Tetrahedron Letters* No. 29 : 3373-3376.

Gautam, M. P. & Purohit, R. M. (1973). Antibacterial activity of leaves and seeds of *Diospyros montana* Roxb. *Ind. J. Pharm.* **35** : 93-94.

George, A. P., Nissen, R. J., Collins, R. J. & Rasmussen, T. S. (1996). Effect of shoot variables and canopy position on fruit set, fruit quality and starch reserves of persimmon (*Diospyros kaki*) in subtropical Australia. *J. Hort. Sci.* **71** (2) : 217-226.

Ghazanfar, S. A. (1978). *Ebenaceae* In Nasir, E. & Ali, S. I. (Edits.) *Fl. West Pakistan* **116** : 1-3. National Herbarium, A. R. C., Islamabad.

Ghosh, R. C., Mathur, N. K. & Singh, R. P. (1976). *Diospyros melanoxylon* – its problems of cultivation. *Ind. For.* **102** : 326-336.

Gill, B. S., Singhal, V. K., Bedi, Y. S. & Bir, S. S. (1990). Cytological evolution in the woody taxa of Pachmarhi hills. *J. Cytol. Genet.* **25** : 308-320.

Goldberg, A. (1986). Classification, evolution and phylogeny of the families of dicotyledons. *Smiths. Contrib. Bot.* **58** : 122-124.

Goldblatt, P. (1981). Index to plant chromosome numbers – 1975-78. *Monogr. Syst. Bot. Missouri Bot. Gard.* **5** : 207.

---------- (1984). Index to plant chromosome numbers – 1979-81. *Monogr. Syst. Bot. Missouri Bot. Gard.* **8** : 165.

---------- (1985). Index to plant chromosome numbers - 1982-83. *Monogr. Syst. Bot. Missouri Bot. Gard.* 13 : 86.

---------- (1988). Index to plant chromosome numbers – 1984-85. *Monogr. Syst. Bot. Missouri Bot. Gard.* 23 : 97.

---------- & Johnson, D. E. (1990). Index to plant chromosome numbers – 1986-87. *Monogr. Syst. Bot. Missouri Bot. Gard.* 30 : 79.

---------- & ---------- (1991). Index to plant chromosome numbers 1988-89. *Monogr. Syst. Bot. Missouri Bot. Gard.* 40 : 93.

---------- & ---------- (1994). Index to plant chromosome numbers – 1990-91. *Monogr. Syst. Bot. Missouri Bot. Gard.* 51 : 88.

---------- & ---------- (1996). Index to plant chromosome numbers – 1992-93. *Monogr. Syst. Bot. Missouri Bot. Gard.* 58 : 107.

---------- & ---------- (1998). Index to plant chromosome numbers – 1994-95. *Monogr. Syst. Bot. Missouri Bot. Gard.* 69 : 75.

Gondo, M., Tanaka, N., Tanaka, T., Shimomura, K., Nakanishi, F. & Ishimaru, K. (1999). A naphthalene glycoside from callus cultures of *Diospyros kaki*. *Phytochemistry* 51 (7) : 879-881.

Gordon, T. (1974). Indigenous trees of Rhodesia. *Trees South Afr.* 26 (1) : 20-22.

Graaff, van der N. A. & Baas, P. (1974). Wood anatomical variations to latitude and altitude. *Blumea* 22 : 101-121.

Grubov, V. I. (1967). *Ebenaceae* – In Shishkin, B. K. & Bobrov, E. G. (Edits.) *Flora U. S. S. R.* 18 : 349-355. Israel Program for Scientific Translations, Jerusalem (English edition).

Guinet, Ph. (1962). Pollens d' Asie tropicale Inst. Fr. Pondichery. *Trav. Sec. Sci. Tech.* 5 (1) : 1-8.

Gupta, B. L. & Kanjilal, P. C. (1924). A new species of *Diospyros*. *Ind. For.* 1 : 254-257.

Gupta, R. K. & Dhar, M. M. (1969). Naphthoic acid derivatives from *Diospyros ebenum*. *Phytochemistry* 8 : 789.

---------- & Mahadevan, V. (1967). Chemical examination of the heartwood of *Diospyros ebenum*. *Indian J. Pharm.* 29 : 289.

---------- & ---------- (1968). Triterpenoids from the leaves of *Diospyros ebenum*. *Indian J. Pharm.* 30 : 93.

---------- & Tiwari, R. D. (1964). Chemical examination of the bark of *Diospyros peregrina* Gurke. *Proc. Nat. Acad. Sci.* 34 (A) : 180-181.

Gurke, M. (1891). In Engler, A. & Prantl, K. (Edits.) *Die Naturlichen Pflanzenfamilien* 4 : 153-165. Leipzig.

Hague, S. M. (1911). A morphological study of *Diospyros virginiana*. *Bot. Gaz.* 52 : 33-34.

Haines, H. H. (1922). *The Botany of Bihar & Orissa*, Part IV. Adlard & Son & West Newman Ltd., London.

Hanfi, M. I. (1997). *Ebenaceae* In Mudgal, V., Khanna, K. K. & Hajra, P. K. (Edits.) *Flora of Madhya Pradesh*, Vol. 2. Botanical Survey of India, Calcutta.

Harden, G. J. (1990). *Ebenaceae*. In Harden, G. J. (Edit.) *Flora of New South Wales* 1 : 496-498. New South Wales Univ. Press, Kensington.

Haridasan, K. & Rao, R. R. (1987). *Forest Flora of Meghalaya*, Vol. 2. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Hazra, B., Sur, P., Roy, D. K., Sur, B. & Banerjee, A. (1984). Biological activity of *Diospyros* towards Ehrlich Ascites Carcinoma in a Swiss mice. *Planta Med.* 51 (4) : 295-297.

----------, ----------, Sur, B., Banerjee, A. & Roy, D. K. (1981). A preliminary note on the activity of *Diospyros montana* bark extract on Ehrlich Ascites Carcinoma in mice. *J. Ind. Chem. Soc.* 58 (6) : 627-628.

Hegnauer, R. (1966). *Chemotaxonomy der Pflanzen*, Vol. 4. Birkhauser Verlag, Basel.

---------- (1989). *Chemotaxonomy der Pflanzen*, Vol. 8. Birkhauser Verlag, Basel.

Hemadri, K. & Rao, S. S. (1984). Jaundice : Tribal medicine. *Ancient Sci. Life* 3 (4) : 209-219.

Hemsley, W. B. (1911). Persimmons – *Diospyros kaki* L. f. and *D. roxburghii* Carriere. *Kew Bull.* 1911 : 234-245.

Herath, W. H. M. W., Rajasekera, N. D. S., Sultanbawa, M. U. S., Wannigama, G. P. & Balasubramaniam, S. (1978). Triterpenoid, Coumarin and Quinone constituents of eleven *Diospyros* species (*Ebenaceae*). *Phytochemistry* 17 (5) : 1007-1009.

Heywood, V. H. (1978). *Flowering plants of the World*. Mayflower Books Inc., New York.

Hiern, W. P. (1873). A monograph of *Ebenaceae*. *Trans. Cambr. Philos. Soc.* 12 : 1-300.

---------- (1874). Notes on *Ebenaceae* – with description of a new species. *J. Bot.* 12 : i-iii.

---------- (1875). Further notes on *Ebenaceae* – with description of a new species. *J. Bot.* 13 : 353-357.

---------- (1887). Third notes on *Ebenaceae* – with description of a new species. *J. Bot.* 15 : 97-101.

Hillis, W. E. & Soenardi, P. (1994). Formation of ebony and streak woods. *IAWA Journal* 15 : 425-437.

Howard, R. A. (1961). The correct name for *Diospyros ebenaster*. *J. Arn. Arb.* 42 : 430-436.

---------- (1971). The correct name of the Mabola or Velvet persimmon. *Baileya* 18 : 26.

---------- & Norlindh, T. C. (1962). The typification of *Diospyros ebenum* and *D. ebenaster*. *J. Arn. Arb.* 43 : 94-108.

Huang, T. C. (1968). Pollen grains of Formosan plants. *Taiwania* 14 : 164-190.

---------- (1972). *Pollen flora of Taiwan*. Nat. Taiwan Univ., Bot. Deptt. Press.

Hunter, J. R. (1981). Tendu (*Diospyros melanoxylon*) leaves, Bidi Cigarettes and resources management. *Econ. Bot.* 35 : 450-459.

Hutchinson, J. (1967). *The genera of flowering plants – Dicotyledons*, Vol. II. Clarendon Press, Oxford.

---------- (1969). *Evolution and phylogeny of flowering plants – Dicotyledons : facts and theory*. Academic Press, New York.

---------- (1973). *The families of flowering plants* Vol. 1. Clarendon Press, Oxford (3rd edit.).

Ikuse, M. (1956). *Pollen grains of Japan*. Hirokawa Publishing Co., Tokyo.

Jain, A. & Srivastava, S. K. (1984). 3, 3'-Di-O-Methylellagic acid 4-O-β-D-Xylopyranosyl-(1 4)-β-D-Glucopyranoside I from the stem bark of *Diospyros discolor*. *Curr. Sci.* 53 (23) : 1233-1235.

Jain, N. & Yadava, R. (1996). A novel chromenoflavone from fruits of *Diospyros peregrina*. *Fitoterapia* 67 : 348.

Jain, S. K. (1965). Medicinal plant lore of the tribals of Baster. *Econ. Bot.* 19 : 243.

---------- (1991a). *Dictionary of Indian folk medicine and ethnobotany*. Deep Publications, New York.

---------- (1991b). *Contribution to Indian ethnobotany*. Scientific Publishers, Jodhpur.

---------- & Filipps De R. A. (1991). *Medicinal Plants of India*, pp. 284-286. Reference Publications, Michigan.

---------- & Tarafdar, C. R. (1970). Medicinal plant lore of the Santales. *Econ. Bot.* 24 : 241-278.

----------, Sinha, B. K. & Gupta, R. C. (1991). *Notable plants in ethnomedicine of India*. Deep Publications, New Delhi.

Jayaraman, U. (1992). A note on the distribution of some species of *Diospyros*. *Bull. Bot. Surv. India* 34 (1-4) : 230-232.

---------- (1996). Economic importance of the genus *Diospyros* L. (*Ebenaceae*) in India. *Ind. For.* 122 : 1040-1044.

---------- & Nayar, M. P. (1992). *Diospyros pilosula* Wall. ex Hiern var. *andamanensis* Jayaraman & Nayar var. nov. (*Ebenaceae*) from the Andamans. *Bull. Bot. Surv. India* 34 (1-4) : 180.

---------- & Singh, V. (1987). A census of edible species of *Diospyros* L. in India. *J. Econ. Taxon. Bot.* 10 (2) : 416-419.

---------- & ---------- (1988). Medicinal importance of the genus *Diospyros* Dalech ex L. *J. Curr. Biol. Sci.* 5 (4) : 137-139.

Jayaweera, D. M. A. (1980). *Medicinal plants (Indigenous and Exotic) used in Ceylon* 2 : 180-181. The National Science Council of Sri Lanka, Colombo.

Johri, B. M., Ambegaokar, K. B. & Srivastava, P. S. (1992). *Comparative embryology of angiosperms* 2 : 643-644. Springer-Verlag, Berlin.

Jones, G. D., Bryant, V. M., Lieux, M. H., Jones, S. D. & Lingren, P. D. (1995). Pollen of the Southeastern United States : with emphasis on melissopalynology and entomopalynology. *Contr. Ser. Amer. Assoc. Stratigr. Palynologists* 30 : 1-76.

Joshi, P. (1993). Ethnomedicine of the Kathodias – A monkey eating tribe in Rajasthan. In Govil, J. N. *et al.* (Edits.) *Medicinal Plants : New Vistas of Research* 1 : 79-95. Today and Tomorrow Printers & Publishers, New Delhi.

Jussieu, A. L. de (1804). Premier (-treizieme) memoire les ..... de familles tiresdes graines. *Annales Mus. Hist. Nat.* 5 : 417.

Kang, I.-K., Suh, S. G., Gross, K. C. & Byun, J. K. (1994). N-terminal amino acid sequence of persimmon fruit β-galactosidase. *Pl. Physiol.* 105 (3) : 975-979.

Kang, S. K., Motosugi, H., Yonemori, K. & Sugiura, A. (1998). Cold-hardiness of persimmon (*Diospyros kaki* Thunb.) buds in relation to dormancy release and temperature conditioning. *J. Jap. Soc. Hort. Sci* **67** (2) : 153-160.

Kanjilal, P. C. (1939). *Ebenaceae* In Kanjilal, U. N., Das, A., Kanjilal, P. C. & De, R. N. (Edits.) *Flora of Assam*, Vol. 3. Avon Book Co., Delhi.

Kapadia, G. J., Shukla, Y. N., Basak, S. P., Young, E. B., Ghosh, B., Pradhan, S. N. & Morton, J. F. (1977). Potential Carcinogens-XI. Carcinogenicity in rats of some folk medicinal herbs. *Lloydia* **40** (6) : 619-620.

Kapil, R. P. (1970). Role of honey bees in agriculture. *Indian Bee J.* **32** : 53-57.

Kapil, R. S. & Dhar, M. M. (1961). Chemical constituents of *Diospyros montana* Roxb : Part I : Isolation of Diospyrin, a new Binaphthyl derivative. *J. Sci. Industr. Res.* **20B** : 498-500

Kapp, R. O. (1969). *How to know pollen and spores. Pictured key* **10** : 249. Nature series, Wm. C. Brown Co. Publisher, Dubuque, Iowa.

King, G. & Gamble, J. S. (1905). *Flora of the Malayan Peninsula. J. Asiat. Soc. Bengal* **74** (2) : 202-230.

Kirtikar, K. R. & Basu, B. D. (1935). *Indian Medicinal plants* **2** : 1498-1509. M/s Bishen Singh Mahendra Pal Singh, Dehradun & Periodical Experts, Delhi (Jayyed Press, Delhi).

Knapp, S. & Gilbert, M. G. (2002). Proposal to conserve the name *Diospyros discolor* against *Cavanillea philippensis* (*Ebenaceae*). *Taxon* **51** : 579-580.

Kohli, R. P., Singh, N., Srinivas, R. K. & Palit, T. K. (1972). Studies on the anti-inflammatory, anti-pyretic and analgesic activities of *Diospyros cordifolia*. *Indian J. Pharm.* **4** : 109.

Kolbe, K. P. & John, J. (1980). Serology and systematics of the Ebenales and the Theales *Biochem. Syst. & Ecol.* **8** : 249-256.

Kostermans, A. J. G. H. (1977a). Notes on Ceylonese Ebony trees (*Ebenaceae*). *Ceylon J. Sci. (Biol. Sci.)* **12** (2) : 90-108.

---------- (1977b). Notes on Asiatic, Pacific and Australian *Diospyros*. *Blumea* **23** : 449-474.

---------- (1977c). A new species of *Diospyros* (*Ebenaceae*) from Western India. *J. Bombay Nat. Hist. Soc.* **74** : 326.

---------- (1981). *Ebenaceae* In Dassanajake, M. D. & Fosberg, F. R. (Edits.) *A Revised Handbook of Flora of Ceylon* **3** : 1-54. Oxford & IBH Publishing Co., New Delhi, Bombay, Calcutta.

Kotani, M., Fujita, A. & Tanaka, T. (1999). Inhibitory effects of persimmon leaf extract on allergic reaction in human basophilic leaukemia cells and mice. *J. Jap. Soc. Nutrit. Food Sci.* **52** : 147-151.

----------, Matsumoto, M., Fujita, A., Higa, S., Wang, W., Suemura, M., Kishimoto, T. & Tanaka, T. (2000). Persimmon leaf extract and astragalin inhibit development of dermatitis and 9gE evaluation in NC/Nga mice. *J. Allergy Clinical Immun.* **106** : 159-166.

Kress, W. J., De Filipps, W. J., Farr, E., & Kgi, D. Y. Y. (2003). A checklist of the trees, shrubs, herbs and climbers of Myanmar. *Smiths. Inst. Contrib. United States Nat. Herb.* **45** : 209-211

Kumar, S., Prasad, L. & Khan, H. R. (1989). Bionomics and control of tendu defoliator *Hypocala rostrata* L (Lepidoptera : Noctuidae). *Ind. For.* **115** : 258-263.

Kumar, V & Subramaniam, B. (1986). *Chromosome atlas of flowering plants of Indian subcontinent,* Vol. 2. Botanical Survey of India, Calcutta.

Kurz, S. (1877). *Forest Flora of British Burma,* Vol. 2. Superintendent of Govt. Printing, Calcutta.

Labouriau, M. L. S. (1973). *Contribucao a palinogia des Cerrados,* pp. 291. Editado pela Academia Brasileira de Ciencias, Rio de Janeiro.

----------, Freire De Carvalho, L. D. A. & Cavalcante, P. B. (1969). Pollen grains of the plants of the Cerrado – XXI. *Ebenaceae, Nyctaginaceae, Rhamnaceae* and *Solanaceae. Bot. Mus. Para. Emilio Geoldi N. S. Bot.* 32 : 1-12.

Lal, B. & Ambasht, R. S. (1981). Impairment of chlorophyll contents in leaves of *Diospyros melanoxylon* by fluoride pollution. *Wat. Air Soil Pollut.* 16 (3) : 361-65.

---------- & ---------- (1982). Fluoride accumulation in a deciduous forest tree species in the neighbourhood of an Aluminium factory. *Ind. J. For.* 4 (4) : 261-264.

Lal, J. B. & Dave, R. K. (1991). Tendu leaves trade in Madhya Pradesh : A big co-operative venture. *Ind. For.* 117 : 728-732.

Laurie, M. V. (1945). *Fodder trees in India.* FRI, Dehra Dun.

Lecomte, H. (1930). *Flore Generale de'l Indochine* 3 : 915-978. Paris.

Lester, P. J., Dentener, P. R., Petry, R. J. & Alexander, S. M. (1995). Hot water immersion for disinfestations of light-brown apple moth (*Epiphyas postvittana*) and long-tailed mealy bug (*Pseudococcus longispinus*) on persimmons. *Postharvest Biol. Technol.* 6 (3-4) : 349-356.

Letouzey, R. & White, F. (1970a). *Ebenaceae – Flora of Cameroun* 11 : 3-184. Museum Nat. Hist., Paris.

---------- & ---------- (1970b). *Ebenaceae - Flora of Gabon* 18 : 1-187. Museum Nat. Hist., Paris.

Lewis, F. (1934). *The vegetable products of Ceylon.* The Associated New-papers of Ceylon Ltd., Colombo.

Linnaeus, Carl (1753). *Species Plantarum,* Vol. 2. Impensis Laurentii Salvii, Holmiae, Stockholm.

Loder, J. W., Mongolsuk, S., Alexander, R. & Whalley, W. B. (1957). Diospyrol – a constituent of *D. mollis. J. Chem. Soc.* 1957 : 2233.

Lopes, R. C. (1998). *Ebenaceae* Vent. do Estado do Rio Janeiro. *Rodriguesia* 50 (76-77) : 85-106.

Macbride, J. F. (1959). *Ebenaceae* – Flora of Peru. *Publ. Field. Mus. Nat. Hist. Bot.* Ser. 13 (5/1) : 206-214.

Maheshwari, J. K. (1963). *Flora of Delhi.* CSIR, New Delhi.

---------- (1995). Ethnobotanical resources of hot, arid zones of India. In Schults, R. E. & Reis Von S. (Edits.) *Ethnobotany-Evolution of a Discipline,* pp. 235-249. Chapman & Hall, London.

Maheshwari, P. & Singh, U. (1965). *Dictionary of economic plants of India.* ICAR Publication, New Delhi.

Mai, D. H. (1995). *Tertiar vegetationsgeschichte Europas.* Gustav Fischer, Jena.

Mallavadhani, U. V., Panda, A. K. & Rao, Y. R. (1998). Pharmacology and chemotaxonomy of *Diospyros. Phytochemistry* 49 : 901-951.

----------, ---------- & ---------- (2001). *Diospyros melanoxylon* leaves : A rich source of pentacyclic triterepenes. *Pharm. Biol.* 39 (1) : 20-24.

Mani, M. S. (1973). *Plant Galls of India.* The Macmillan Co. India Ltd., New Delhi.

Manilal, K. S. & Sivarajan, V. V. (1982). *Flora of Calicut.* Bishen Singh Mahendra Pal Singh, Dehra Dun.

Matsumoto, T., Mochida, K., Itamura, H. & Sakai, A. (2001). Caryopreservation of persimmon (*Diospyros kaki* Thunb.) by vitrification of dormant shoot-tips. *Plant Cell Rep.* **20** (5) : 398-402.

Matsuura, S. & Iinuma, M. (1978). Studies on the constituents of useful plants-VI. Constituents of the calyx of *Diospyros kaki* and carbon –13 nuclear magnetic resonance spectra of flavonol glycosides. *Chem. Pharm. Bull. (Tokyo)* **26** (6) : 1936-1941.

---------- & ---------- (1985). Lignan from the calyx of *Diospyros kaki*. *Phytochemistry* **24** (3) : 626-628

Matthew, K. M. & Rani, N. (1981). *Ebenaceae* In Matthew, K. M. (Edit.) *Flora of the Tamil Nadu Carnatic* Rapinat Herbarium, Tiruchirapalli.

McDaniel, J. C. (1973). American persimmon, an emerging horticultural crop. *Fruit Var. J.* **27** . 16-18

Mehra, P N. (1976). *Cytology of Himalayan hardwoods.* Shree Saraswaty Press, Calcutta.

---------- & Bawa, K. S. (1969). Chromosomal evolution in tropical hardwoods. *Evolution* **23** : 466-481.

Merrill, E. D. (1923). *An Enumeration of Philippine Flowering Plants* **3** : 289-296. Bureau of Printing, Manila.

Metcalfe, C. R. & Chalk, L. (1950). *Anatomy of Dicotyledons,* Vol. 2. Clarendon Press, Oxford.

Meyrick, E. (1907). Description of Indian Micro-Lepidoptera. *J. Bombay Nat. Hist. Soc.* **17** : 730-754.

Miers, J. (1862). *Contributions to Botany* **1** : 24. Williams & Norgate, London.

Miquel, F. A. W. (1859). *Flora Indiae Batavae* **2** : 1043-1053. Amsterdam.

Mishra, K., Mishra, A. & Padhi, G. S. (1986). Studies on quality gradation and Mycobial contamination in processed Kendu (*Diospyros melanoxylon* Roxb.) leaves. *Ind. For.* **112** : 687-697.

Misra, P. S., Misra, C., Nigam, S. K. & Mitra, C. R. (1971). Constituents of *Diopyros peregrina* fruit and seed. *Phytochemistry* **10** : 904.

Modi, S., Siddiqui, N., Rai, S. & Rai, P. K. (1992). Foliar injuries in *Diospyros melanoxylon* Roxb. exposed to auto-exhaust pollution. *Indian J. Appl. Pure Biol.* **7** (1) : 29-32.

Mohl, H. (1834). Uber den Bau und die Formen der Pollenkorner. Beitrage zur Anatomie und Physiologie der Gewachse. *Erstes Helf Bern.* 4 : 130.

---------- (1835). Sur la structure et les formes des graines de pollen. *Ann. Sci. Nat.* 3 (ser. 2) : 148-180.

Morton, C. M. (1994). *The use of pollen morphology and wood anatomy in the study of phylogeny of Ebenaceae and Rutaceae subtribe Cuspariinae.* Ph. D. Dissertation, The City Univ. of New York.

---------- & Kincaid, D. T. (1995). A model for coding pollen size in reference to phylogeny using examples from the *Ebenaceae. Amer. J. Bot.* **82** (9) : 1173-1178.

----------, Chase, M. W., Kron, K. A. & Swensen, S. M. (1997). A molecular evaluation of the monophyly of the order Ebenales based upon rbcL sequence data. *Syst. Bot.* **21** (4) : 567-586

Morton, J. F. (1963). Principal wild food plants of the United States. *Econ. Bot.* **17** (1) : 319-330

Mukherjee, B. B. (1969). *Vegetational history of southern parts of West Bengal with an introduction to the pollen flora of Sundarbans.* Ph. D. Thesis, Univ. Calcutta

Musgrave, O. C. & Skoyles, D. (1970). A2, 2' - binaphthyl-1, 1'-quinone from *Diospyros buxifolia Chem Communications* **1970** : 1461.

Nadkarni, A. K. (1976). *Indian Materia Medica,* Vol. 1. Popular Prakashan, Bombay (revised and enlarged reprinted edition).

Nair, M. N. B. (1987) Occurrence of helical thickenings on vessel element walls of dicotyledonous woods. *Ann. Bot. (London)* **60** : 23-32.

---------- & Mohan Ram, H. Y. (1989). Vestured pits and vestured vessel member walls in some Indian dicotyledonous woods. *Bot. J. Linn. Soc.* **100** : 323-336.

Nair, N. G. (1976). *Diospyros multibracteata* (Merr.) Bakh. (*Ebenaceae*) in Car Nicobar island, India. *Philipp. J. Biol.* **5** (3) : 325-328.

Nair, P. K. K. & Kothari, S. (1985). Studies in the pollen morphology of Indian heteromerae. In Nair, P. K. K. (Edit.) *Advances in Pollen Spore Research* **13** : 40-42.

Nakamura, Y. & Kobayashi, S. (1994). DNA restriction fragment length variability in *Diospyros kaki* and related *Diospyros* species. *Hort. Sci.* **29** (7) : 809-811.

---------- , ---------- & Nakajima, I. (1998). Agrobacterium-mediated transformation and plant regeneration from hypocotyl segments of Japanese persimmon (*Diospyros kaki* Thunb.). *Plant Cell Rep.* **17** (6-7) : 435-440.

Namikawa, J. & Higashi, M. (1928). On the number of chromosomes in *Diospyros kaki* L. f. and *D. lotus* L. *Bot. Mag. (Tokyo)* **42** (501) : 436-438.

----------, Sisa, M. & Asai, K. (1932). On the flower types of *Diospyros kaki* L. f. *Jap. J. Bot.* **6** (2) : 139-172.

Nanda, P. C. (1962). Chromosome number of some trees and shrubs. *J. Ind. Bot. Soc.* **41** (2) : 271-277.

Nandi, O. I., Chase, M. W. & Endress, P. K. (1998). A combined cladistic analysis of angiosperms using rbcL and non-molecular data sets. *Ann. Missouri Bot. Gard.* **85** : 137-212.

Naphade, S. R. (1970). A new *Discosia* leaf spot of *Diospyros peregrina* from India. *Maharashtra Vigyan Mandir Patrika* **5** (1-2) : 50-52.

Narayan, G. K. A. S. S., Row, L. R. & Satyonarayana, P. (1978). Chemical examination of *Diospyros* species. *Curr. Sci.* **47** (10) : 345.

Nayar, M. P. (1984). *Key to the Flowering Plants* **2** : 75-79. Botanical Survey of India Publication, Calcutta.

---------- (1996). *Hot Spots of Endemic Plants of India, Nepal and Bhutan.* TBGRI, Palode, Thiruvananthapuram.

----------, Ramamurthy, K. & Agrawal, V. S. (1989). *Economic Plants of India* **1** : 103-104. Botanical Survey of India, Calcutta.

Neuwinger, H. D. (1998). *Afrikanische Arzneipflanzen und Jagdgift, 2. Auflage.* Wissenschaftlich Verlagsgesellschaft, Stuttgart.

Ng, F. S. P. (1971). A taxonomic study of the *Ebenaceae* with special reference to Malaysia. Thesis of the Univ. of Oxford (microfilmed by British Lending Library Division, no. D. 183904).

---------- (1977). Notes on the systematy of Malayan phenerogams, XXVI *Ebenaceae. Malays. For.* **40** (4) : 210-248.

---------- (1978a). *Diospyros roxburghii* and the origin of *Diospyros kaki. Malays. For.* **41** : 436-438.

---------- (1978b). *Ebenaceae-Tree Flora of Malaya* 3 : 56-94. Longman, London & Kualalumpur.

---------- (1979). The origin of *Diospyros lotus* and other notes on the genus *Diospyros* (*Ebenaceae*). *Malays For.* 42 (2) : 165-170.

---------- (1991). Manual of forest fruits, seeds and seedlings. *Malaysian Forst. Records No. 34.* 1 . 61-62 and 319-327. FRI Malaysia, Kualalumpur.

---------- (2001). New species, varieties and reductions in *Diospyros* (*Ebenaceae*) in Borneo and Peninsular Malaysia including peninsular Thailand. *Gard. Bull. Sing.* 53 : 291-313.

Nooteboom, H. P. (1975). Revision of the *Symplocaceae* of the Old World, New Caledonia. *Leiden Botanical Series* 1 : 1-335.

Pacheco, L. (1981). *Ebenaceae — Flora Veracruz* 16 : 1-21. Institute Nacional de Invest. Sobre Recursos Bioticos, Xalapa.

Paknikar, S. K., Pai Fondekar, K. P., Kirtany, J. K. & Natori, S. (1996). 4-Hydroxy-5-methylcoumarin from *Diospyros kaki* Thunb. and *D. kaki* var. *sylvestris* Makino. *Phytochemistry* 41 (3) : 931-933.

Pandey, G. (1988). Contribution to the botanical identity of Ayurvedic drug Tinduka with special reference to Visatinduka. *Bull. Medico-Ethno-Bot. Res.* 9 (1-2) : 40-57.

Paphassarang, S., Becchi, M. & Rayanaud, J. (1984). A new Diospyrol gyycoside from *Diospyros mollis* Griff. *Tetrahedron Letters* 25 (5) : 523-526.

Pardhasaradhi, M. & Krishnakumari, L. (1979). Tetra hydrodiospyrin, a reduced binaphthoquinone from the bark of *Diospyros montana*. *Phytochemistry* 18 (4) : 684-685.

Parker, R. N. (1931). The Andaman Marble wood. *Ind. For.* 57 : 209-210.

Parkinson, C. E. (1923). *The forest flora of the Andaman Islands*. Bishen Singh Mahendra Pal Singh, Dehra Dun (reprinted edit.).

Pathak, G. N., Singh, B., Tiwari, K. M., Srivastava, A. A. & Pande, K. K. (1949). Chromosome numbers in some angiospermous plants. *Curr. Sci.* 18 (9) : 347.

Pearson, R. S. & Brown, H. P. (1981). *Commercial Timber of India* 2 : 689-708. A. J. Reprint Agency, New Delhi.

Periasamy, K. (1966). Rumination in the *Araliaceae, Aristolochiaceae, Caprifoliaceae* and *Ebenaceae*. *Proc. Indian Acad. Sci.* 64B : 127-134.

Perrier de la Bathie, H. (1952a). *Ebenacees — Flora of Madagascar* 165 : 137. Publiee sous les auspices du Gouvernement general de Madagascar et souis la Direction de H. Humbert, Paris.

---------- (1952b). Revision des *Ebenacees* Madagascar et des Comores. *Mem. Inst. Sci. Madagascar Ser. B. Biol. Veg.* 4 : 93-154.

Phengklai, C. (1972). The genus *Diospyros* L. (*Ebenaceae*) in Thailand. *Thai. For. Bull. Bot.* 6 : 1-27

---------- (1978). *Ebenaceae* of Thailand. *Thai. For. Bull. Bot.* 11 : 1-103.

---------- (1981). *Ebenaceae* — In Smitinand, T. & Larsen, K. (Edits.) *Flora of Thailand* 2 (4) 281-392 Applied Scientific Research Corporation of Thailand, Bangkok.

Polak, E. (1933). Uber Torf und Moor in Niederlandischen Indien. *Verhandel. Koninkl. Ned. Akad. Wetenschap* **30** (3) : 1-85.

Pool, A. (2001). *Ebenaceae* Gurke In Stevens, W. D. *et al.* (Edits.) Flora de Nicaragua. *Monogr. Syst. Bot. Missouri Bot. Gard.* **85** (1) : 815-816.

Pradhan, S. G. (2001). *Ebenaceae* In Singh, N. P., Lakshminarasimhan, P., Karthikeyan, S. & Prasanna, P. V. (Edits.) *Flora of Maharashtra State*, Vol. 2. Botanical Survey of India, Calcutta.

Prajapati, N. D., Purohit, S. S., Sharma, A. K. & Kumar T. (2003). *A Handbook of Medicinal Plants – A complete source book*, pp. 200-202. Agrobios (India), Jodhpur.

Prasad, B. & Simlot, M. M. (1982). Antifungal activity of fruit of Temru (*Diospyros cordifolia*) *Sci. & Cult.* **48** : 290-291.

Prasad, R. & Mishra, G. P. (1984). Studies on root system of important tree species in dry deciduous teak forests of Sagar (M. P.) *Ind. J. For.* **7** (3) : 171-177.

Pullaiah, T. & Moulali, D. A. (1997). *Flora of Andhra Pradesh*, Vol. 2. Scientific Publishers, Jodhpur.

Purkayastha, S. K. (1982). *Indian Woods – their identification, properties and uses*. Controller of Publication, Delhi.

Ramaswami, M. S. (1914). A new species of *Diospyros* from the Tinnevelly Hills. *J. Asiat. Soc. Bengal N. S.* **10** (2) : 47-49.

Ramesh, B. R. & Franceschi De, D. (1993). Two new species of *Diospyros* (*Ebenaceae*) from India. *Blumea* **38** (1) : 131-136.

Rao, J. V. S., Raja Reddy, K. & Das, V. S. R. (1981). Physiological studies on some semiarid scrub species. *Ind. J. Exp. Biol.* **19** (3) : 256-260.

Rao, M. Rama (1914). *Flowering plants of Travancore*. Govt. Press, Trivandrum.

---------- & Henry, A. N. (1996). *The Ethnobotany of Eastern Ghats*, pp. 78-80. Botanical Survey of India, Calcutta.

Rao, R. J. (1986). *Flora of Goa, Diu, Daman, Dadra & Nagar Haveli*, Vol. 2. Botanical Survey of India, Calcutta.

Rao, R. R. & Jamir, N. S. (1982). Ethnobotanical studies in Nagaland-I. Medicinal plants. *Econ. Bot.* **36** : 176-181.

Rao, T. A. (1951). Studies on foliar sclerids in dicotyledons. I. Structure and ontogeny of sclerids in the leaf of *Diospyros discolor* Willd. *Proc. Indian Acad. Sci.* **34B** : 92-98 (+ plate IV).

Rao, V. G. & Subramoniam, V. (1976). Pink-rot of *Diospyros tomentosa* Roxb. *Sci. & Cult.* **42** (7) : 373-374.

Rastogi, R. P. & Mehrotra, B. N. (1993a). *Compendium of Indian Medicinal Plants* 1 : 165-166. CDRI, Lucknow & PID, New Delhi (reprinted edition).

---------- & ---------- (1993b). *Compendium of Indian Medicinal Plants* 2 : 274-280. CDRI, Lucknow & PID, New Delhi (reprinted edition).

---------- & ---------- (1993c). *Compendium of Indian Medicinal Plants* 3 : 253-254. CDRI, Lucknow & PID, New Delhi.

Rathore, J. S. (1969). Distribution pattern of male and female plants of *Diospyros melanoxylon* Roxb. in the forests of Sagar, M. P. *Ind. For.* 95 (10) : 701.

---------- (1970). Phenological observations on *Diospyros melanoxylon* Roxb. *Ind. For.* 96 : 711-712.

---------- (1971). Studies in the root system and regeneration of *Diospyros melanoxylon* Roxb. *Ind. For.* 97 : 379-386.

---------- (1972). *Diospyros melanoxylon*, A bread winner tree in India. *Econ. Bot.* 26 (4) : 333-339.

---------- (1976). *Diospyros melanoxylon* Roxb. Quantitative morphology of leaf forms. *Ind. For.* 102 : 876-884.

Reinders, G. C. A. & Stahel (1948). Wood anatomy and systematic position of *Ropourea guianensis* Airbl. *Meded. Landbouwho geschool Wageningen* 49 : 17-24.

Ribeiro, J. E. L. da S. *et al.* (1999). *Flora da Reserva Ducke.* INPA, Manaus.

Richardson, I. B. K. (1981). *Ebenaceae — Flora Mascareignes* 47 : 1-19. Mautitius, M. S. I. R. I., Paris, O. R. S. T. O. M., RBG, Kew.

Roubik, D. W. & Moreno, P. J. E. (1991). Pollen and spores of Barro Colorado Island. *Monogr. Syst. Bot. Missouri Bot. Gard.* No. 36.

Row, L., Ramachandra & Rao Sankara, C. (1969). Chemical examination of *Diospyros* species. VII. Triterpenes of leaves of *D. melanoxylon*. *Indian J. Chem.* 7 : 204.

Roy, A. K., Choubey, N. & Saha, R. P. (1983). Hitherto some unrecorded diseases of indigenous medicinal plants. *Biol. Bull. India* 5 (2) : 161-164.

Roy, B., Halder, A. C. & Pal, D. C. (1998). *Plants for human consumption in India.* Botanical Survey of India, Calcutta.

Royal, J. F. (1839). *Illustrations of the Botany of the Himalayan Mountains.* London.

Sahni, K. C. (1998). *The book of Indian Trees.* Oxford University Press, Delhi.

Saldanha, C. J. & Ramesh, B. R. (1984). *Ebenaceae* In Saldanha, C. J. (Edit.) *Flora of Karnataka*, Vol. 1. Oxford & IBH Publishing Co., New Delhi, Bombay, Calcutta.

Sankaram, A. V. B., & Reddy, V. V. N. (1984). Structure of Ebenone, a possible biogenetic precursor of elliptinone, from *Diospyros ebenum*. *Phytochemistry* 23 (9) : 2039-2042.

----------, ---------- & Sindhu, G. S. (1981). A pentacyclic quinone and diosindigo B from the heartwood of *D. melanoxylon*. *Phytochemistry* 20 (5) : 1093-1096.

Santos, C. Fo. (1961). *Morfologia e valor taxonomico do polem dos principais plantas apicolas.* These Universite de Sao Paulo, Bresil.

---------- (1963). Characteristicas morfologicas dos Graos de polem dos principais Plantas Apicolas. *Anais Escola Super. Agr. Luiz de Queiroz, Univ. Sao Paulo* 20 : 176-228.

Satyavati, G. V., Raina, M. K. & Sharma, M. (1976). *Medicinal plants of India* 1 : 359-362. ICMR, New Delhi.

Sauget, J. S. & Liogier, E. E. (1957-1963). *Ebenaceae - Flora of Cuba (Leon)* 4 (3-4) : 138-141. LA Hubana, Cuba.

Savolainen, V., Fay, M. F., Albach, D. C., Backlund, A., van der Bank, M., Cameron, K. M., Johnson, S. A., Lledo, M. D., Pintaud, J. C., Powell, M., Sheahan, M. C., Soltis, D. E., Soltis, P. S., Weston, P., Whitten, W. M., Wurdack, K. J. & Chase, M. W. (2000). Phylogeny of the eudicots : a nearly complete familial analysis based on rbcL gene sequences. *Kew Bull.* 55 : 257-309.

Saxena, H. O. & Brahmam, M. (1995). *The Flora of Orissa*, Vol. 2. Orissa Forest Development Corporation Ltd., Bhubaneswar.

Secoy, D. M. & Smith, A. E. (1983). Use of plants in control of agricultural and domestic pests. *Econ. Bot.* 37 : 28-57.

Selling, O. H. (1947). Studies in Hawaiian pollen statistics – part II. The pollens of Hawaiian phanerogams. *B. P. Bishop Museum Special Publication* 38 : 1-430.

Sen, K. C. & Ray, S. N. (1971). *Nutritive values of Indian cattle feeds and the feeding of animals*. ICAR, New Delhi.

Sharma, B. D., Singh, N. P., Raghavan, R. S. & Deshpande, U. R. (1984). *Flora of Karnataka*. Botanical Survey of India, Howrah.

Sharma, B. M. & Kachroo, P. (1981). *Flora of Jammu and Plants of neighbourhood*. Bishen Singh Mahendra Pal Singh, Dehra Dun.

Sharma, C. & Gupta, H. P. (1979). Pollen morphology and phylogeny of Indian *Ebenaceae*. *Geophytology* 8 (2) : 209-214.

Sharma, S. K. (1977). A further contribution to the study of nursery behaviour of *Diospyros marmorata* Parker (Marble wood). *Ind. For.* 103 : 542-549.

Shu-Gang, L., Gilbert, M. G. & White, F. (1996). *Ebenaceae – Flora of China* 15 : 215-234. Science Press, Beijing.

Sidhu, G. S. & Pardhasaradhi, M. (1967a). The structure of so called red Methyl Ether of Diospyrin. *Tetrahedron Letters* 43 : 4263-4267.

---------- & ---------- (1967b). Structure of Diospyrin. *Tetrahedron Letters* 14 : 1313-1316.

---------- & Prasad, K. K. (1967). (-) Isodiospyrin – A novel binaphthaquinone showing atropisomerism and other extractives from *Diospyros chloroxylon*. *Tetrahedron Letters* 30 : 2905-2910.

---------- & ---------- (1970). Xylospyrin – a novel trinaphthylenequinone from *Diospyros chloroxylon* and comments on PMR spectrum of (-) isodiospyrin leucohexaacetate. *Tetrahedron Letters* 20 : 1739-1742.

Singh, H. B. & Arora, R. K. (1978). *Wild edible plants of India*. ICAR, New Delhi.

Singh, N. P. (1988). *Flora of Eastern Karnataka*, Vol. 1. Mittal Publications, Delhi.

----------, Mudgal, V., Khanna, K. K., Srivastava, S. C., Sahoo, A. K., Bandopadhyay, S., Aziz, N., Das, M., Bhattacharya, R. P. & Hajra, P. K. (2001). *Flora of Bihar*. Botanical Survey of India, Calcutta.

Singh, N., Rastogi, S. K., Gupta, M. B., Palit, T. K. & Kohli, R. P. (1971). A study of pharmacological activity of *Diospyros cordifolia*. *J. Res. Indian Med.* 6 : 229.

Singh, U. N., Srivastava, V. K. & Sengar, R. B. S. (1982). A comparative study of the rate of dry matter production in forest tree seedlings of *Diospyros montana* Roxb. & *Buchanania latifolia* Roxb. *Ind. J. For.* 5 (1) : 8-14.

Singh, V. (1991). *Ebenaceae* In Shetty, B. V. & Singh, V. (Edits.) *Flora of Rajasthan*, Vol. 2. Botanical Survey of India, Calcutta.

---------- & Pandey, R. P. (1998). *Ethnobotany of Rajasthan*. Scientific Publishers, Jodhpur.

Singh, V. K. (1993). Selected Indian folk medicinal claims and their relevance in primary health care programme. In Govil, J. N. *et al.* (Edits.) *Medicinal Plants : New Vistas of Research* 1 : 147-153. Today and Tomorrow Printers & Publishers, New Delhi.

---------- & Dhar, U. (1993). Folk medicines of Orissa : Keonjhar forests. In Govil, J. N. *et al.* (Edits.) *Medicinal Plants : New Vistas of Research* 1 : 104-107. Today and Tomorrow Printers & Publishers, New Delhi.

Sinha, B. K. (1999). *Ebenaceae* In Hajra, P. K. & Rao, P. S. N. (Edits.) *Flora of Great Nicobar Island*. Botanical Survey of India, Calcutta.

Sladkov, A. N. & Samoilovich, S. R. (1954). The morphology of pollen in some tropical and arid subtropical plants (in Russian). *Pustyni SSSR i Osveonie Akad. Nauk. SSSR.* 2 : 634-718.

Smith, A. C. (1971). Studies on Pacific Island plants, XXIII. The genus *Diospyros* (*Ebenaceae*) in Fizi, Samoa and Tonga. *J. Arn. Arb.* 52 (3) : 369-403.

Sobti, S. N. & Singh, S. D. (1961). A chromosome survey in Indian medicinal plants. *Proc. Indian Acad. Sci. Sect. B.* 54 (3) : 138-144.

Solovyova, L. V. & Omarov, M. D. (1986). Cytological studies of some species and varieties of *Diospyros* L. *Vestn. Moskovsk. Univ. Ser.* 16 (4, *Biol.*) : 19-21.

Soltis, D. E., Hibsch-Jetter, C., Soltis, P. S., Chase, M. W. & Farris, J. S. (1997). Molecular phylogenetic relationship among angiosperms : an overview based on rbcL and 18S rDNA sequences. In Iwatsuki, K. & Raven, P. H. (Edits.) *Evolution and diverification of land plants*. Springer, Tokyo.

----------, Soltis, P. S., Chase, M. W., Mort, M. E., Albach, D. C., Zanis, M., Savolainen, V., Hahn, W. H., Hoot, S. B., Fay, M. F., Axtell, Swensen, S. M., Prince, L. M., Kress, W. J., Nixon, K. C. & Farris, J. S. (2000). Angiosperm phylogeny inferred from 18S rDNA, rbcL and atpB sequences. *Bot. J. Linn. Soc.* 133 : 381-461.

Sothers, C. & Berry, P. E. (1998). *Ebenaceae* — In Berry, P. E., Holst, B. K. & Yatskievychy K. (Edits.) *Flora of Venezuela Guayana* 4 : 704-712. Missouri Botanical Garden, Missouri.

Sowunmi, M. A. (1974). Pollen grains of Nigerian plants. I. Woody species. *Grana* 13 : 145-186.

Srivastava, G. S. (1979). Plant introduction at the National Botanical Research Institute. In Khoshoo, T. N. & Nair, P. K. K. (Edits.) *Progress in Plant Research* 2 : 117-126.

Srivastava, R. & Kharya, M. D. (1980). Pharmacological studies and antibacterial activity of unsaponifiable matter of seeds of *Diospyros tomentosa* Roxb. *Ind. J. Hosp. Pharm.* 117 (3) : 73-74.

---------- & Omray, A. (1979). Antibacterial activity of unsaponified matter of fixed oil from *Diospyros melanoxylon*. *Indian Drugs* 16 (11) : 261-262.

Srivastava, S. C. & Rout, N. (1994). Some plants of ethnopaediatric importance in district Koraput, Orissa. *Bull. Bot. Surv. India* 36 (1-4) : 166-168.

Srivastava, S. K. & Pitre, S. (1985). A new anthraquinone glycoside from the bark of *Diospyros discolor*. *Planta Med* 6 : 537-538.

Stace, C. A. (1965). Cuticular studies as an aid to plant taxonomy. *Bull. Brit. Mus. Nat. Hist. Bot.* 4 : 1-78.

Standley, P. C. (1920-1926). Trees and shrubs of Mexico. *Contr. U. S. Natl. Herb.* 23 : 1721.

---------- & Williams, L. O. (1966). *Ebenaceae* — Flora of Guatemala. *Fieldiana Bot.* 24 (8/1-2) : 244-251.

St. John, H. (1986). Revision of the Hawaiian *Diospyros* (*Ebenaceae*) — Hawaiian Plant studies. *Phytologia* 59 (6) : 389-405.

Straka, H. (1967). Die pollen morphologie einiger madagassischer pflanzenfamilien und ihre Darstellung in pollenfromeln und auf Lochkarten. *Rev. Palaeobotan. Palynol.* 3 (1-4) : 93-103.

Sugiura, A., Ohkuma, T., Choi, Y. A., Tao, R. & Tamura, M. (2000). Production of nonaploid (2n=9x) Japanese persimmon (*Diospyros kaki*) by pollination with unreduced (2n=6x) pollen and embryo rescue culture. *J. Am. Soc. Hort. Sci.* 125 (5) : 609-614.

Sundararamaiah, T. & Row, L. R. (1963). Isolation of Betulin and Lupeol from *Diospyros melanoxylon* Roxb. *Indian J. Appl. Chem.* 26 (1-2) : 29-30.

Sunderarajan, D. D. & Balasubramanyam, G. (1959). *Guide to the economic plants of South India*. Amudha Nilayam Pvt. Ltd., Madras.

Taira, S., Oba, S. & Watanabe, S. (1992). Removal of astringency from "Hiratamenashi" persimmon fruit with a mixture of ethanol and carbon dioxide. *J. Jap. Soc. Hort. Sci.* 61 (2) : 437-443.

Takeoka, M. (1965). Electron microscopic investigations on the surface structure of pollen grains of trees. *Sci. Repl. Kyoto. Univ. Agr.* 17 : 43-69.

Takhtajan, A. (1987). *Systema Magnoliophytorum*. Officina Editoria Nauka, Leningrad.

Tamura, M., Tao, R. & Sugiura, A. (1996). Production of dodecaploid plants of Japanese persimmon (*Diospyros kaki* L. f.) by colchicines treatment of protoplasts. *Plant Cell Rep.* 15 (7) : 470-473.

Tandon, R. N. & Lal, Bihari (1964). Pathological studies of *Pestalotia bicolor* Ell. & Ev. causing leaf spot disease of *Diospyros peregrina* (Gaertn.) Gurke. *Proc. Nat. Acad. Sci. India* 34 (1) : 343-349.

Tao, R., Ito, W. & Sugiura, A. (1992). Adventitious bud formation on callus derived from anthers of persimmon "Meotogaki" and isozyme variations observed in the regenerated plantlets. *J. Jap. Soc. Hort. Sci.* 61 : 527 – 533.

---------- & Sugiura, A. (1992). Adventitious bud formation from callus cultures of Japanese persimmon. *Hort. Sci.* 27 (3) : 259-261.

---------- & ---------- (1994). Comparison of growth and rooting characteristics of micropropagated adult plants and juvenile seedlings of persimmon (*Diospyros kaki*). *J. Jap. Soc. Hort. Sci.* 63 (3) : 259-261.

Tezuka, M., Takahashi, C., Kurayanagi, M., Satake, M., Yoshihira, K. & Natori, S. (1973). New nephthoquinones from *Diospyros*. *Phytochemistry* 12 : 175-183.

Thorne, R. F. (1976). Phylogenetic classification of the Angiospermae. *Evolutionary Biol.* 9 : 35-106.

---------- (1992). An updated phylogenetic classification of flowering plants. *Aliso* 13 : 365-389.

Tomer, E., Cohen, M. & Gottreich, M. (1996). Light and Scanning Electron Microscope (SEM) observations of trichomes in persimmon (*D. kaki* L. f.) and mango (*Mangifera indica* L.) leaves. *Isr. J. Pl. Sci.* 44 (1) : 57-67.

Troup, R. S. (1921). *The silviculture of Indian trees*, Vol. 1. Clarendo Press, Oxford.

---------- (1986). *Indian woods and their uses*, pp. 127-130. Soni Reprints Agency, Delhi (reprinted edition)

Troupin, G. (1985). *Ebenaceae* — *Flora of Rwanda* 3 : 31-34. Agence de cooperation cultere et Technique Musee Royal de L' Afrique antrale Tervuren, Belgique.

Turner, I. M. (1995). A catalogue of the vascular plants of Malaya. *Gard. Bull. Singapore* 47 (2) : 196-200

Tutin, T. G. (1972). *Ebenaceae* In Tutin *et al.* (Edits.) *Flora Europaea* 3 : 52. Cambridge University Press, London.

Udgate, H. B. (1997). Effect of fertilizers on leaf production and leaf quality of Kendu bushes (*Diospyros melanoxylon*) with its commercial aspects. *Ind. For.* 123 : 366-370.

Umekawa, H., Takada, Y., Furuichi, Y., Takahashi, T., Achiwa, Y., Komia, T. & Yoshida, S. (1999). Inhibition of eukaryotic DNA polymerase by a persimmon (*Diospyros kaki*) extract and related polyphenols. *Biochem. Molec. Biol. Intern.* 47 : 795-801.

Utsunomiya, N., Subhadrabandhu, S., Yonemori, K., Oshida, M., Kanzaki, S., Nakatsubo, F. & Sugiura, A. (1998). *Diospyros* species in Thailand : Their distribution, fruit morphology and uses. *Econ. Bot.* 52 (4) : 343-351.

Varier, P. S. (1994). *Indian Medicinal Plants — a compendium to 500 species* 2 : 339. Orient Longman Ltd., 160-Anna Salai, Chennai.

Vasques, R. (1993). Una Nueva *Lissocarpa* (*Ebenaceae*) de la Amozonia Peruana. *Novon* 3 : 211-212.

Ventenat, E. P. (1799). *Tableau du Regne Vegetal.* Paris.

Wagenitz, G. (1964). Ebenales In Engler, A. (Edit.) *Syllabus der Pflanzenfamilien.* Gebruder Borntrager, Berlin (12th edit.).

Wallich, N. (1828-1832). *Wallich's Catalogue.* London.

Wallnofer, B. (2001). The biology and systematics of *Ebenaceae* : a review. *Ann. Naturhist. Mus. Wien* 103B : 485-512.

---------- & Mori, S. A. (2002). *Ebenaceae* In Mori, S. A. *et al.* (Edits.) Guide to the vascular plants of Central French Guiana : Part 2. Dicotyledons. *Mem. New York Bot. Gard.* 76 (2) : in press.

Wang, F. H. (1960). *Pollen grains of China.* China (in Chinese).

Watson, L. & Dallwitz, M. J. (2000). *Ebenaceae* Gurke – *http://biodiversity.uno. edu/delta/.*

Watt, G. (1890). *A dictionary of economic products of India* 3 : 136-156. Cosmo Publications, Delhi.

White, F. (1955). Distribution of the African species of *Diospyros. Webbia* 11 : 525-540.

---------- (1956). Notes on *Ebenaceae. Bull. Jard. Bot. Brux* 26 : 237-246, 277-307.

---------- (1978a). The taxonomy, ecology and chorology of African *Ebenaceae.* I. The Guineo-Congolian species. *Bull. Jard. Bot. Belg.* 48 : 245-358.

---------- (1978b). *Ebenaceae* – Flora of Panama. *Ann. Missouri Bot. Gard.* **65** : 145-154.

---------- (1980). Notes on the *Ebenaceae*. VIII. The African sections of *Diospyros*. *Bull. Jard. Bot. Belg.* **50** : 445-460.

---------- (1981). *Ebenaceae* In Maguire, B (Edit.) The botany of Guayana Highland, Part XI. *Mem. New York Bot. Gard.* **32** : 323-329.

---------- (1983). *Ebenaceae* – In Launert, E., Brenan, J. P. M., Mendes, E. J. & Wild, H. (Edits.) *Flora Zambesiaca* **7** (1) : 248-300. Managing Committee, London.

---------- (1987) *Ebenaceae* – *Flora Afrique Centr.*, pp. 103.

---------- (1988). The taxonomy, ecology and chorology of African *Ebenaceae*. II. The non-Guineo-Congolian species of *Diospyros* (excl. sect. Royena). *Bull. Jard. Bot. Belg.* **58** : 325-448.

---------- (1993a). Twenty two new and little known species of *Diospyros* (*Ebenaceae*) from New Caledonia, with comments on section *Maba*. *Bull. Mus. Nation. Hist. Nat. B. Adansonia* **14** (2) : 179-222.

---------- (1993b). *Ebenaceae* – *Flora of Nouv. Caledonie* **19** : 3-89.

---------- & Verdcourt, B. (1993). *Flora East Tropical Africa*. A. A. Balkema, Rotterdam & Brookfield.

---------- & ---------- (1996). *Ebenaceae* – In Polhill, R. (Edit.) *Flora Tropical East Africa*, pp. 51. A. M. Balkema, Rotterdam & Brookfield.

Williams, A. J., Gupta, B. N. & Banerjee, S. K. (1996). Effect of thermal power plant emissions on vegetation. *Ind. J. For.* **19** (4) : 330-334.

Williams, Clute N. (1943). *Useful plants of the World*. Indiana.

Willis, J. C. (1985). *A dictionary of the flowering plants and ferns*. Cambridge Univ. Press, Cambridge.

Winter, B. de (1963). *Ebenaceae* – In Dyer, R. A., Codd, L. E. & Rycroft, H. B. (Edits.) *Flora South Africa* **26** : 54-99. Govt. Printer, Republic of South Africa, Pretoria.

Wood, C. E. (Jr.) & Channell, R. B. (1960). The genera of Ebenales in South-Eastern United States. *J. Arn. Arb.* **41** (1) : 17-22.

Wright, H. (1904). The genus *Diospyros* in Ceylon : its morphology, anatomy and taxonomy. *Ann. Royal Bot. Gard. Paradeniya* **2** (1) : 1-106; **2** (2) : 133-210.

Yakovlev, M. S. & Zhukova, G. Ya (1980). Chlorophyll in embryos of angiosperm seeds – a review. *Bot. Not.* **133** : 323-336.

Yamazaki, T. (1972). Embryological studies in Ebenales (4). *J. Jap. Bot.* **47** (1) : 20-28.

---------- (1974). Gamopetalous plants in far eastern regions of Micronesia : 2. *Ebenaceae J. Jap. Bot.* **49** (8) : 241-249.

Yang, R. Z. & Tang, C. S. (1988). Plants used for pest control in China : A literature review. *Econ. Bot.* **42** (2) : 376-406.

Yasui, K. (1915). Studies on *Diospyros kaki* I. *Bot. Gaz.* **60** (5) : 362-373.

Yoganarasimhan, S. N., Shantha, T. R., Murthy, K. R. K. & Nair, K. V. (1984). Medico-botany of Andaman & Nicobar Islands II – Elucidation of medicinal plants. *J. Econ. Taxon. Bot.* **5** (2) : 297-333.

Yokoyama, T. & Takeuchi, M. (1976). Organ and plantlet formation from callus in Japanese persimmon (*Diospyros kaki*). *Phytochemistry* **26** : 273-275.

Yonemori, K., Sugiura, A. & Yamada, M. (2000). Persimmon genetics and breeding. In Janick, J. (Edit.) *Plant Breeding Reviews* **19** : 191-225. John Wiley & Sons.

Yoshihira, K., Natori, S. & Kanchanapee, P. (1967). The structure of Diospyrol, the principle from the fruits of *Diospyros mollis*. *Tetrahedron Letters* **48** : 4857-4860.

----------, Tezuka, M. & Natori, S. (1970). Nephthoquinone derivatives from *Diospyros* species : bisisodiospyrin a tetrameric nephthoquinone. *Tetrahedron Letters* **1** : 7-10.

----------, ---------- & ---------- (1971). *Chem. Pharm. Bull.* **19** (11) : 2308.

Zhuang, D. H. (2000). *Plant Breading Reviews*. John Wiley & Sons.

----------, Kitajima, A., & Ishida, M. (1992). Seed development and chromosome in seedless cultivars of Japanese persimmon. *J. Jap. Soc. Hort. Sci.* **60** : 747-754.

----------, ----------, ---------- & Sobajima, Y. (1990). Chromosome numbers of *Diospyros kaki* cultivars. *J. Jap. Soc. Hort. Sci.* **59** : 289-297.

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About the Author

Dr. V. Singh, born on August 15th 1947 obtained his M. Sc. and Ph. D. degrees in Botany from the University of Meerut (U. P.) during the year 1967 and 1974 respectively, with specialization in Taxonomy. He is devoted to the study of Indian biodiversity right from the date of completion of post graduation and in thirty seven years of his research career he has published books like : 3-volumed Flora of Rajasthan, Flora of Banswara district, Ethnobotany of Rajasthan, Asteraceae of Sikkim and Ethnobotany and Medicinal Plants of India and Nepal (edited) which have got worldwide recognition. He is also recognized for the monographs on Indian *Zygophyllaceae*, *Lamiaceae* (the genus *Leucas* R. Br.) and *Caesalpiniaceae* (subtribe *Cassiinae*). He has worked on different aspects of Indian flora viz. taxonomy, ecology, phytosociology, ethnobotany, medicinal botany, conservation etc and has more than 100 research papers in his credit.

About the Book

The present monograph on Indian *Diospyros* L. (*Ebenaceae*) deals with 66 taxa. Besides adopting correct valid names for the Indian plants and providing complete synonymy, the description provided is based on personal observations of the author. Phenological data along with ecological notes have been provided to almost all taxa. Distribution pattern of the taxa in the World and India have been discussed and marked on the maps. Important findings of other workers on anatomy, embryology, cytology, palynology, phytochemistry etc have been used to supplement the description based on morphological characters and as an additional tool to solve certain taxonomic problems in this genus. A new classification has been proposed based on persistent suits of characters for the family *Ebenaceae* and for the genus *Diospyros* L. in particular to accommodate Indian taxa. The phylogenetic affinities of the family *Ebenaceae* and phenetic affinities between the species of *Diospyros* L. have been discussed to trace the evolutionary sequences.

Moreover, one new taxon (variety) has been added to the science and two new combinations have been made, besides selection of eight lectotypes for the species and several changes in taxonomic status and systematic position of infra-generic taxa. Detailed figures of about 61 taxa and 96 photographs have been appended for easy determination of the components. Vernacular names in different Indian languages and dialects have been provided along with economic uses to make the monograph usable at grass root level. It is hoped that the work will prove a milestone in the advancement of Ebony systematics, conservation of biodiversity and sustainable utilization of plant resources.

Front Cover : ***Diospyros peregrina*** (Gaertn.) Gurke

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