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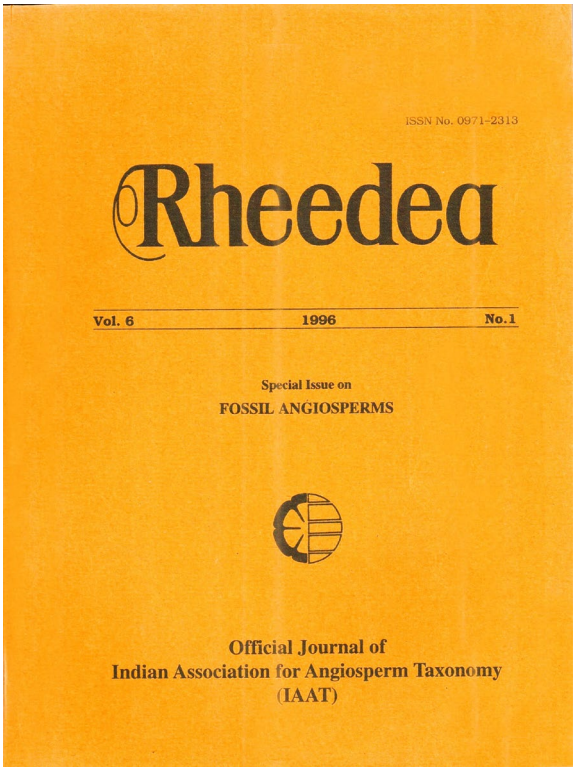

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Fossil records and antiquity of some common plants in India

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Abstract

The paper discusses the antiquity of some of the important plant genera found in India, namely *Artocarpus* J. R. & G. Forst., *Cinnamomum* Schaeffer, *Cocos* Linn., *Dipterocarpus* Gaertn., *Emblica* Gaertn., *Mangifera* Linn., *Musa* Linn., *Pandanus* L. f. ex Stickman, *Sonneratia* Linn. and *Syzygium* Gaertn., on the basis of their fossil records. It is recommended that the vast amount of fossil evidences available should be taken into account in tracing the history of Indian flora and its phytogeography.

INTRODUCTION

One of the main objectives of studying fossil plants is to trace their evolution, diversification and expansion in the geological past. This is especially important in the case of angiosperms which form the bulk of modern flora. Concerted efforts of palaeobotanists during the last four decades have led to accumulation of large data on fossil angiosperms from various Cenophytic sediments of India. Unfortunately this information is usually not made use of by taxonomists and plant geographers for tracing the antiquity of various taxa of Indian flora (Maheshwari, 1990). To draw their attention on this aspect, antiquity of a few common and commercially important Indian plants has been traced, based on the palaeobotanical evidences (Fig. 1). In the present communication the following ten taxa have been considered : *Artocarpus, Cinnamomum, Cocos, Dipterocarpus, Emblica, Mangifera, Musa, Pandanus, Sonneratia* and *Syzygium.*

It is hoped that the article will stimulate the botanists in general and plant geographers in particular to take into consideration the evidence of fossil plants while building up the history of the Indian flora and its phytogeography.

PALAEOBOTANICAL RECORDS AND DISCUSSION

Artocarpus J. R. & G. Frost.

A genus which covers the jackfruit of commerce consists of evergreen to deciduous trees found in our country in the sub-Himalayan tract from Kumaon eastwards ascending up to 1525m, in Bihar, Bengal, Assam, Khasi Hills, Orissa, Circar, Andaman islands and in the evergreen forests of Western Ghats from Konkan southwards. There are 18 species of

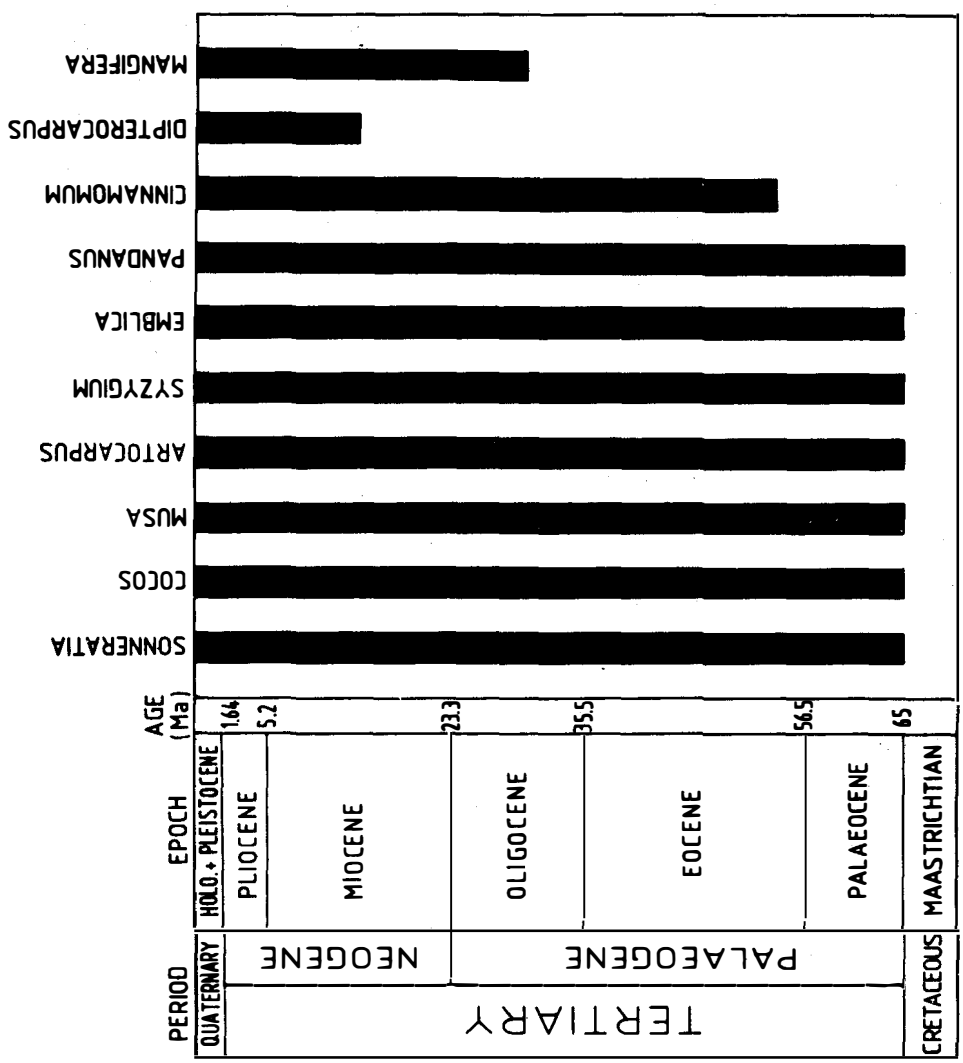

Fig. 1. Antiquity of some common plants in India.

Artocarpus in India (Santapau & Henry, 1973) of which *A. chaplasha, A. hirsuta* and *A. lakoocha* are important timber trees and *A.heterophyllus, A. communis* and *A. lakoocha* yield edible fruits.

The earliest record of *Artocarpus* in India is from the Deccan Intertrappean sediments of Late Cretaceous- Early Tertiary age from Mandla District of Madhya Pradesh in the form of a fossil wood, viz., *Artocarpoxylon deccanensis* (Mehrotra *et al.,* 1984), (Fig. 3, B, F). The wood has been compared with that of *Artocarpus heterophyllus* Lamk. (Jackfruit). It continued in the Miocene as revealed by fossil wood reported from Kalagarh in Uttar Pradesh (Prasad, 1993). The plant is indigenous to India and grows wild in the Western Ghats. It is also grown in Sri Lanka, Myanmar, Malaysia and Brazil and has been introduced to many other countries. Its fruits and seeds are eaten raw or cooked. Fossil leaves comparable to *Artocarpus chaplasha,* have been reported from the Eocene of Meghalaya (Bhattacharyya, 1983) and from the Murree shales in Rajouri District of Jammu and Kashmir (Awasthi, 1982). Fossil wood of *A.chaplasha* has also been reported from the Miocene of Cachar District in Assam (Prakash & Lalitha, 1978). Besides the megafossils, pollen grains showing affinity with those of *Artocarpus* has been also reported from the Quilon beds of Kerala (Rao & Ramanujam, 1982). Thus it can be inferred from the available data that during the past *Artocarpus* was widely distributed than at present and has continued in India since Late Cretaceous-Early Tertiary time. The above data indicate that the Indian landmass was the centre of origin of *Artocarpus.* This has also been hypothesised by Simmonds (1976, p. 202) based on considerations other than fossils.

The genus *Artocarpus* with its 50 species is native to Southeast Asia. The jackfruit (*A.heterophyllus*) and the two other domesticates, viz., *A. integer* and *A. incisus* (Champedak) *A. communis* (breadfruit) are closely related and are basically diploid. The three species seem to be of ancient domestication in Vavilov's Indomalayan centre. The crop, domesticated in the eastern parts of the archipelago, may be assumed to have accompanied along with coconuts, bananas and aroids (Simmonds, 1976, p. 201). In view of the antiquity of *Artocarpus* in India together with coconut and banana it seems that *Artocarpus* moved from west to east (Indomalayan region) accompanied by coconut and banana during the Tertiary period when the climate of the Indian landmass became relatively hot and dry due to northward movement of Indian Plate (Smith & Briden, 1979). On the basis of palaeomagnetic studies of Deccan Traps it has been concluded that India drifted northwards over 50° latitude and rotated about 25° anticlockwise within the last 70 m.y. (Deutsch *et al.* , 1958, 1959). Today all these taxa flourish in Southeast Asia because the area lies at the equator and provides plenty of moisture and appropriate temperature as required by these plants. Thus the fossil evidence suggests that the antiquity of *Artocarpus* in India is very ancient.

Cinnamomum Schaeffer

The genus *Cinnamomum* consists of 250 species of evergreen trees and shrubs and is confined to tropical and subtropical regions of East Asia and Indomalaya. Sixteen species of *Cinnamomum* have been reported from India (Santapau & Henry, 1973, p. 39).

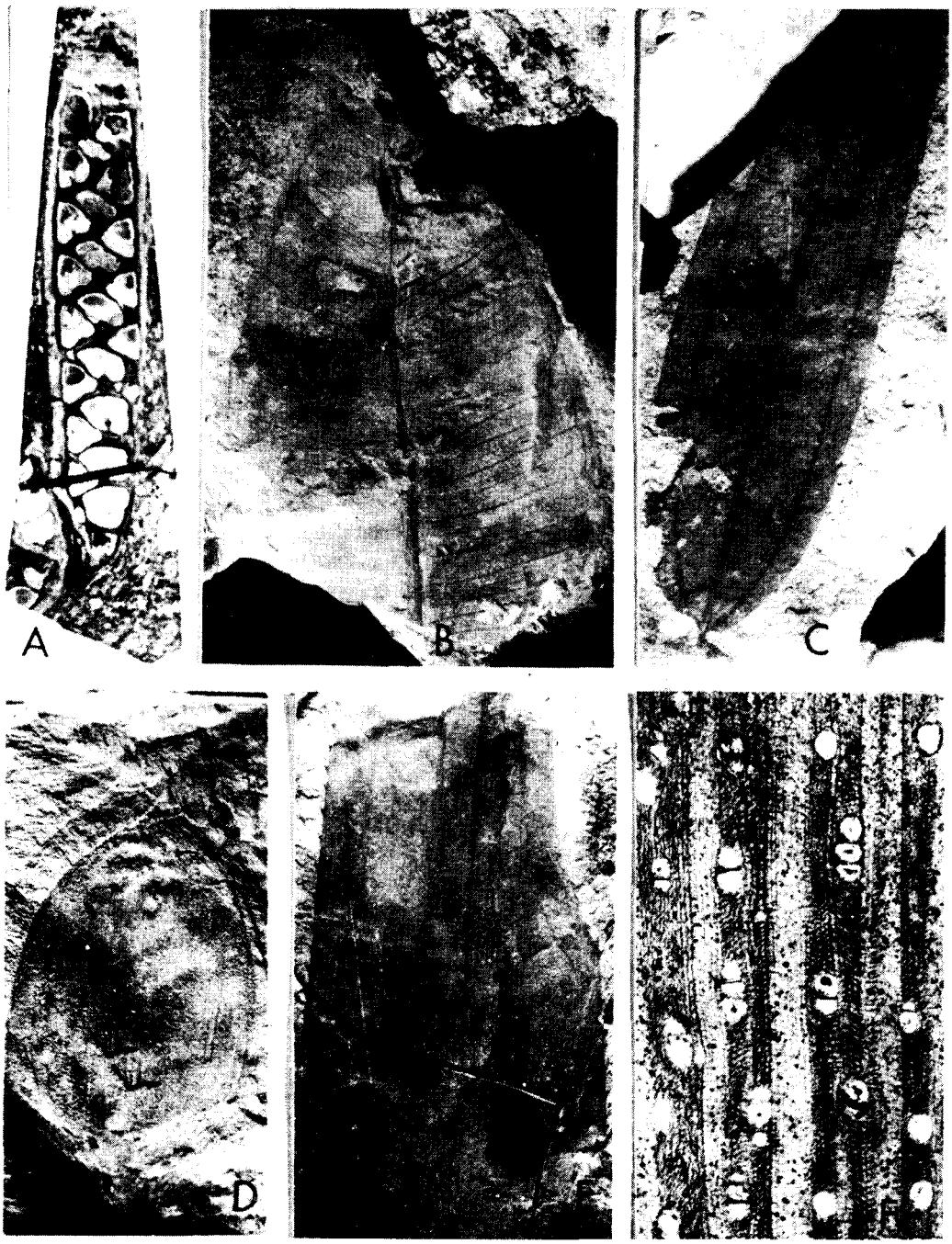

Figure 2.

Fossil records and antiquity of some common plants

The earliest fossil record of *Cinnamomum* dates back to Lower Eocene of Kutch (Fig. 1, C), western India (Lakhanpal & Guleria, 1981). *Cinnamomum zeylanicum* Bl. with which the Kutch fossils have been compared, is a large tree and is found in the Western Ghats and adjoining hill ranges from Konkan southwards and also in Tenasserim (Brandis, 1971, p. 533). The species continued during Miocene in Kutch (Lakhanpal & Guleria, 1982) but vanished thereafter from this region on the onset of arid conditions. The species is cultivated for its stem bark which provides the commerical 'Dalchini' and is extensively used as spice or condiments. Fossils of *C. tamala* have also been reported from the Upper Tertiary and Quaternary deposits of West Bengal, Bihar, Kashmir and Assam (Pathak, 1969; Lakhanpal & Awasthi, 1984; Middlemiss, 1911; Gupta, 1971). The species is source of Tejpat leaves used as spice in northermn India. Lately, fossil leaves of *Cinnamomuam* have been reported from the Siwalik sediments of Darjeeling District, West Bengal (Antal & Awasthi, 1993) and Warkalli beds of Kerala coast (Awasthi & Srivastava, 1992) . In addition, fossil woods showing resemblance with that of *Cinnamomum* type of woods have also been reported from Neogene sediments of Assam and Kerala (Prakash & Tripathi, 1974; Awasthi & Ahuja, 1982). Evidently, the genus has a long geological history in India.

Cocos Linn.

Cocos nucifera, the coconut palm is mainly concentrated in the coastal and deltaic regions of south India. It requires very warm tropical climate, abundant rainfall and well drained soil. In the coastal parts of India, there is scarcely a tree that is better known to people than the coconut tree. Economically, it is one of the most important trees and is widely cultivated in the New World and Old World tropics. Its cultivation is so ancient and widespread and its uses are so numerous that the task of assigning an original home to coconut is a formidable one. No truly wild coconuts are known. Some authors have argued in favour of South American origin, others for an origin in Polynesia or Asia or most probably southeast Asia (Simmonds, 1976,p. 222). The earliest record of *Cocos* in India is in the form of a fossil wood reported by Sahni (1946) as *Palmoxylon sundaram* from the Deccan Intertrappean sediments near Sagar (Madhya Pradesh) . The trunk shows anatomical similarity with the stem of modern *Cocos nucifera.* Subsequently, its wood and fruit have been reported from Mohgaon Kalan (Rao & Menon, 1964; Patil & Upadhye, 1984). A fruit of *Cocos* (Fig. 2, D) has also been discovered in the Eocene sediments of Rajasthan, near Barmer (Kaul, 1951) . Thus the occurrence of this genus in India dates back to Late Cretaceous-Early Tertiary and it has continued to occur in the Upper Tertiary as revealed by megafossil (Banerjee,

Explanation of Fig. 2. A. *Musa cardiosperma* Jain, longitudinal section showing spiral arrangement of seeds, x1; B. *Syzygium kachchhense* Lakhanpal & Guleria, fossil leaf showing shape, size and venation, x1; C. *Cinnamomum eokachchhensis* Lakhanpal & Guleria, fossil leaf showing shape, size and venation, x1; D. *Cocos sahnii* Kaul, showing remains of endocarp, x1; E. *Pandanus eocenicus* Guleria & Lakhanpal, fossil leaf showing venation and spinules, x1; F. *Paraphyllanthoxylon palaeoemblica* (cf. *Emblica officinalis* Gaertn.) Prakash *et al.,* cross section of the fossil wood showing distribution of vessels and broad xylem rays, X30.

1986) and palynological records (Ramanujam, 1966; Ramanujam & Reddy, 1984; Rao & Ramanujam, 1978) . The available evidences thus indicate that *Cocos* may have originated on the Indian landmass. The existence of *Cocos* far in the interior (inland) during Early Tertiary indicates the vicinity of the sea close to the fossil localities. The occurrence of fossil *Cocos* throws light on the palaeogeography of our country.

Dipterocarpus Gaertn.

The genus *Dipterocarpus* grows mainly in the Indo-Malayan region and 10 species of the genus occur in India (Santapau & Henry, 1973) . *Dipterocarpus* yields commerical timber known as Gurjan and an oleo-resin known in trade as Gurjan oil or Gurjan balsam. Oleo-resin from several species of *Dipterocarpus* has medicinal properties.

In India the history of the genus *Dipterocarpus* dates back to Neogene (about 20 m.y.). So far there is no authentic record of *Dipterocarpus* from the Palaeogene deposits of our country. Much of the fossil records of the genus are in the form of woods which have been described under the generic name *Dipterocarpoxylon* (Fig. 3, A, E) from Assam, Meghalaya, West Bengal, Uttar Pradesh, Himachal Pradesh, Rajasthan, Kachchh, and south India (Awasthi, 1974, 1992; Awasthi & Mehrotra, 1993; Bande & Prakash, 1984; Guleria, 1983,1986, in press; Prakash *et al.*, 1994; Prasad, 1993; Prasad & Khare, 1994) . Well preserved leaves of *Dipterocarpus* have also been reported from Jawalamukhi in Himachal Pradesh (Lakhanpal & Guleria, 1987) . Pollen grains referable to Dipterocarpaceae or *Dipterocarpus* type have been reported from the Neyveli lignite of Tamil Nadu and Varkala beds of Kerala (Kar, 1992; Rao & Ramanujam, 1982). From these records it is evident that the genus *Dipterocarpus* was fairly widespread in India during Neogene and its distribution has dwindled since then. In view of the earliest known record of Dipterocarpaceae from the Oligocene of Southeast Asia (Muller, 1981) and the numerical abundance of the modern dipterocarpacean members in the Malayasian region it has been suggested that *Dipterocarpus* entered into India sometime in the Early Miocene when the land connections between Malaya, Myanmar and India were established (Guleria, in press).

Explanation of Fig. 3. A. *Dipterocarpoxylon pondicherriense* Awasthi, cross section of the fossil wood showing nature and distribution of vessels and gum canals arranged in tangential rows, x10; B. *Artocarpoxylon deccanensis* Mehrotra *et al.*, cross section of the fossil wood showing shape, size and distribution of vessels and parenchyma, x45; C. *Sonneratioxylon preapetala* Awasthi, cross section of the fossil wood showing type and distribution of vessels, x30; D. *Mangiferoxylon scleroticum* Awasthi, cross section of the fossil wood showing type and distribution of vessels and parenchyma, x12; E. *Dipterocarpoxylon pondicherriense* Awasthi, tangential longitudinal section of the fossil wood showing xylem rays, x60; F. *Artocarpoxylon deccanesis* Mehrotra *et al.*, tangential longitudinal section of the fossil wood showing xylem rays, x70; G. *Sonneratioxylon preapetala* Awasthi, tangential longitudinal section of the fossil wood showing uniseriate xylem rays, x40; H. *Mangiferoxylon scleroticum* Awasthi, tangential longitudinal section of the fossil wood showing xylem rays, x60.

Fossil records and antiquity of some common plants

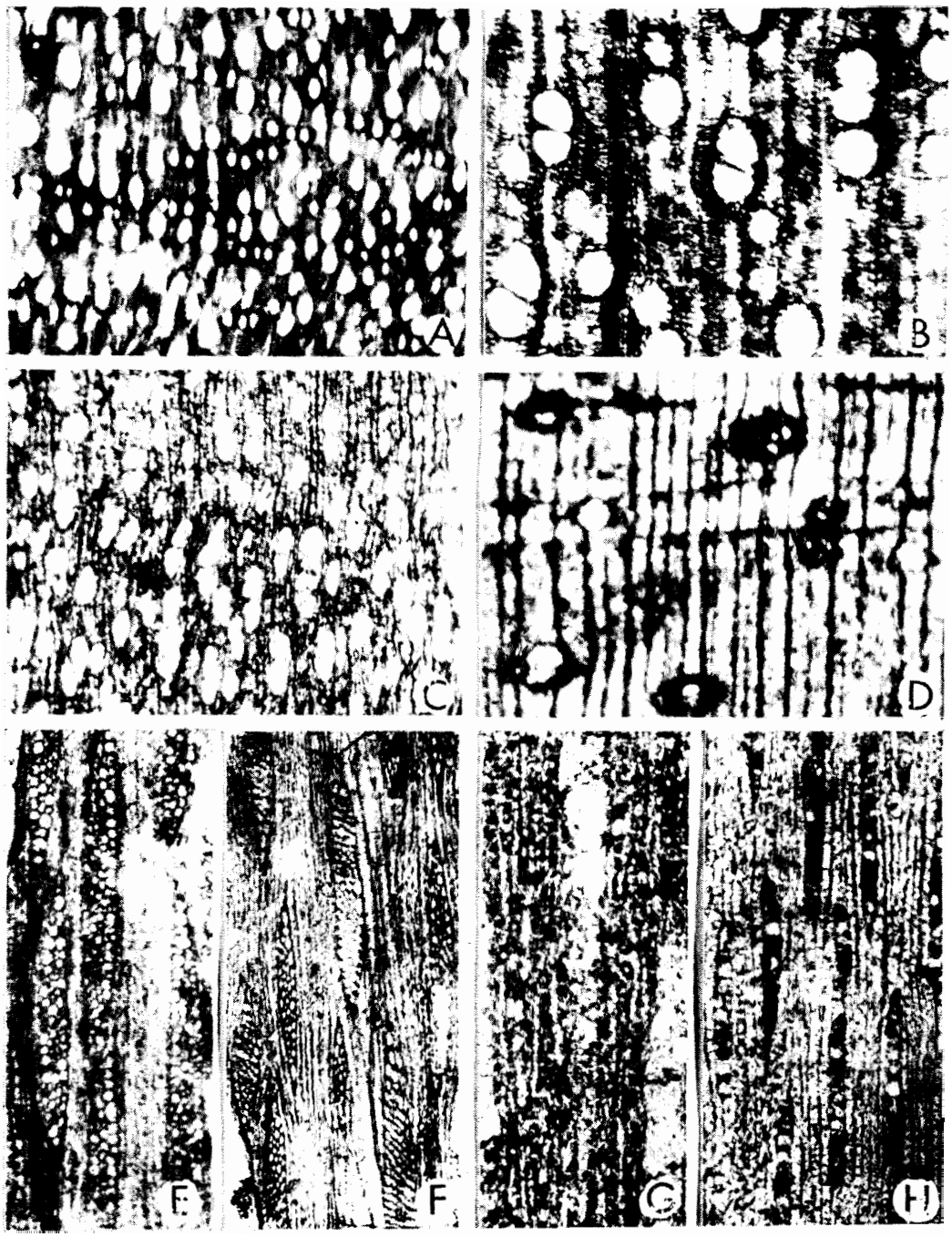

Figure 3.

Emblica Gaertn.

A genus of small to medium-sized trees, consisting of 4 species of which only two, viz., *Emblica fischeri* Gamble and *E. officinalis* Gaertn. are found in India (Santapau & Henry, 1973). *E. officinalis* (vern. Amla) is a widespread species and is common in the mixed deciduous forests of India ascending up to 1372 m. The history of amla can be traced to the Late Cretaceous - Early Tertiary time. Similar to its present distribution, amla was fairly widespread even in the geologic past. In the Late Tertiary the wood of *E.officinalis* has been reported from Assam and its earlier record comes from the Deccan Intertrappean sediments of Wardha District in Maharashtra (Fig. 2, F) (Prakash *et al.*, 1986).

Mangifera Linn.

The mango is the king of Indian fruits and is undoubtedly the most important fruit crop of India (Singh, 1960). Geologically, history of mango in India is not very old. All the fossil records of *Mangifera* in India are known from the Neogene sediments except one from the Oligocene deposits of Assam. Most of them are in the form of fossil woods *(Mangiferoxylon)* (Fig. 3, D, H) and have been reported from Rajasthan, West Bengal, Assam and South India (Awasthi, 1966; Bande & Prakash, 1984; Guleria, 1984). Fossil leaf of *Mangifera* is known from the Late Tertiary of West Champaran District of Bihar (Lakhanpal & Awasthi, 1984). All these forms show resemblance with the modern wood and leaves of *Mangifera indica* except for the wood described from South India which shows resemblance with *M.altissima* Blanco, a Malayan species. The evidences provided by fossils substantiate the conclusion of Mukherjee (1972) that India was the place of origin of mango. Simmonds (1976, p. 8) in his map has also shown the centre of its origin in India and nearby areas particularly in the eastern India. It is interesting to note that the oldest record of the mango comes from the Oligocene sediments of Makum Coalfield, Tinsukia District, Assam (Awasthi & Mehrotra, 1995). Some species like *M. altissima* probably dispersed to Malayan region on joining the Indian Plate with the Asian Plate. The fossil evidence also refutes the contention of Maheswari (1990, pp. 101-102) that many fruits like mango and banana were introduced in India.

Mangifera indica , which yields the mango fruit is found throughout India upto 900 m excepting the northwestern part. Like its present distribution, it was fairly widespread in the past extending up to Ramgarh-Jaisalmer area in western India.

Musa Linn.

A genus consisting of 35 species (Willis, 1973) of wild and edible bananas is widely distributed in moist tropics of Africa in the West to the Polynesian Islands in the East. It is a characteristic genus of the rain forest. In addition to four exotic species which are cultivated for ornamental and fibre purposes, fourteen species of the genus have been reported in India (Santapau & Henry, 1973). The wild bananas are diploid and are distributed in Southeast Asia and Pacific, the primary centre of origin (Simmonds, 1976, pp. 211-212; Edlin, 1973, p.123, map 6). Their fruits are trilocular berries in which seeds are surrounded by a mass of starchy parenchymatous pulp. The wild progenitors of edible bananas have been traced to two

variable species, viz., *M. acuminata* Colla. and *M.balbisiana* Colla., both of which are represented in India. The fossil history of the genus in India goes back to the Late Cretaceous - Early Tertiary time. The fossils are in the form of fruits, *Musa cardiosperma* (seeded banana) (Fig. 2, A) (Jain, 1964 a) and leaf (*Musophyllum*) (Prakash *et al.*, 1979). In addition, pseudostems most probably belonging to *Musa* have also been reported (Jain, 1964b; Rao & Menon, 1963). The finding of banana fossils led Jain (1965) to suggest that India was a part of the native home of banana. Lately, Bande *et al.,* (1994) have reported a fruit cast of *Musa* with well preserved seeds from the Deccan Intertrappean sediments of Mandla District of Madhya Pradesh. This provides further evidence of wide distribution of banana in Central India. Thus the available evidences prove that *Musa* is quite ancient in India and has persisted since Late Cretaceous. In view of the above fossil records of banana in India as early as Late Cretaceous there is every possibility that *Musa* might have dispersed to Africa from India around that time when Indian landmass was close to Madagascar and Africa, rather than Malaysia as conjuctured by Simmonds (1976, p.213). The fossil records demolish the myth (Maheshwari, 1990, pp. 101-102) that fruits like mango and banana were introduced in India during the medieval period.

Pandanus L. f. ex Stickman.

A large genus of palm like evergreen trees or shrubs (screw pines), widely distributed in the moist tropics of the Old World; from Africa on the West to Pacific islands in the East. About 36 species have been recorded from India (Santapau & Henry, 1973) . Occurrence of *Pandanus* in the fossil form was reported by Guleria and Lakhanpal (1984) from the Lower Eocene of Kutch (Fig.2, E). The comparable extant species grow in Assam and on the sea coasts of the Indian Peninsula on both sides and the Andamans. In the peninsular region *Pandanus* occurs as a low gregarious tree forming dense, almost impenetrable thickets in marshy places, near water courses. *Pandanus* is a very useful plant. Its leaves are used for paper making, its fibres are used for making nets, mats, sacks and cordages. It is sometimes cultivated for ornamental purposes for its fragrant inflorescences. 'Kewda', one of the most popular perfumes, is extracted from the ripe spadices of this plants and is extensively used in India since ancient times. Its fruits are also eaten by local inhabitants of the Andamans. Lately a single seeded drupe showing affinities with *Pandanus* fruit has been reported from the Deccan Intertrappean sediments of Madhya Pradesh (Bonde, 1990). Pollen showing affinities with *Pandanus* have also been reported from the Oligocene of West Bengal and Miocene of Ratnagiri, Maharashtra (Saxena, 1991).

Sonneratia Linn.

A genus of evergreen mangrove trees, distributed along the tropical coasts of East Africa, Asia and adjacent Islands, North Australia and Pacific Islands. It consists of five species of which three occur in India. The history of this genus is well documented in the Late Cretaceous to Neogene sediments of India, contrary to the view of Muller (1981) that the earliest definite pollen record of Sonneratiaceae or *Sonneratia* comes from the Lower Miocene. Almost all parts of the genus such as pollen, flowers, fruits, leaf, roots and woods (Fig. 3- C,

E), have been reported in fossil form. The roots and woods of *Sonneratia* have been reported from Madhya Pradesh, Maharashtra, Andhra Pradesh, Kachchh and Pondicherry (Lakhanpal *et al* . ,1984; Guleria, 1991). Well preserved flowers (*Sahnianthus*) and fruits (*Enigmocarpon*) referable to *Sonneratia* have been reported from Deccan Intertrappean deposits of Chhindwara District (Prakash, 1972). Leaf impression of *Sonneratia* has been reported from the Palaeocene sediments of Meghalaya (Ambwani, 1991). The pollen grains referable to family Sonneratiaceae have been reported from the Palaeogene and Neogene sediments of Kachchh, Cauvery, Cambay, Ratnagiri, Neyveli, Varkala and Quilon (Kar, 1985; Kar & Jain, 1981; Phadtare & Kulkarni, 1980; Ramanujam & Rao, 1977; Ramanujam, 1987; Rawat *et al.*, 1977; Venkatachala & Rawat, 1973). From the above account it is evident that the genus *Sonneratia* has continued to exist in India since Late Cretaceous till today. Its occurrence in Central India during Tertiary further provides evidence of the vicinity of sea near Chhindwara and Wardha districts.

Syzygium Gaertn.

The genus *Syzygium* is palaeotropical in distribution and about 75 species of this genus occur in India (Chadha, 1976). The majority of these species are moisture loving and thrive in moist localities. Some species bear edible fruits (jamun), a few yield timber and one species, *Syzygium aromaticum* Merr. et Parry (syn. *Eugenia caryophyllata* Thunb.), a native of Malayan archipelago, cultivated in Kerala and Tamil Nadu in India and other countries, is the source of commercial cloves. The earliest record of the genus in India is from the Late Cretaceous - Early Tertiary. The fossils have been found in the form of woods and leaves. The woods have been reported from the Deccan Intertrappean sediments of Mandla and Chhindwara districts of Madhya Pradesh (Bande & Prakash, 1984; Nambudiri & Tidwell, 1977; Patil & Singh, 1974); whereas the leaves are known from the Lower Eocene of Kachchh (Fig. 2, B) (Lakhanpal & Guleria, 1981) and from the foothills of the Himalayas (Lakhanpal, 1970; Awasthi, 1992, pp. 317, 318). Its pollen grains are known from the Varkala beds of Kerala (Ramanujam, 1987). These reports show that *Syzygium* has existed in India since the Late Cretaceous and has spread as far west as Kachchh although it no longer occurs in Kachchh and western Rajasthan.

GENERAL REMARKS

India presents a wide range in topography and climate. Accordingly, its vegetation also shows equal diversity ranging from wet evergreen forests of Northeast India and the Western Ghats to the alpine vegetation of the Himalayas and almost xeric vegetation of Rajasthan. The flora of India is one of the richest and diverse floras of the world. The roots of modern flora of India can be traced back to two important events in geological history (i) the past land connections of the Indian Plate with other Gondwanaland countries till Upper Cretaceous and (ii) joining of the Indian Plate with the Asian Plate. The latter event established land connections between India and Southeast Asia and opened the way for migration of plants between these two landmasses. For an understanding of the history and evolution of the modern flora of India and its phytogeography, therefore, it is important to take into account the vast amount

of Palaeobotanical information, especially from the Tertiary Period onwards. During last few decades palaeobotanists have accumulated extensive data in this regard from various Cenophytic exposures of India. Unfortunately, this rich information is not usually made use of in tracing the history of various Indian taxa. In view of the above facts and examples cited it is strongly recommended that the valuable evidence of fossil records should be given due consideration in building up the history of Indian flora and its phytogeography.

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