Neogene vegetation of peninsular India

J. S. Guleria

Guleria JS 1992. Neogene vegetation of peninsular India. *Palaeobotanist* **40** : 285-311.

The Neogene vegetation of peninsular India has been analysed on the basis of which some broad conclusions have been derived. During the Neogene Period the whole of peninsular India was covered by luxuriant tropical evergreen to deciduous forests. Occurrence of Dipterocarpaceae from East to West and North to South alongwith other common elements suggests a more or less uniform warm tropical climate throughout the peninsula. A gradual decrease in rainfall during Neogene due to northward shift of the Indian peninsula from equator and growing continentality caused by the rise of Himalayan mountains is decipherable. Further decrease in rainfall towards the end of Neogene is evidenced by the complete eradication of dipterocarps and the appearance of dry or desertic conditions towards the end of Pliocene in the western (Gujarat and Rajasthan) and south-eastern (Cuddalore) part of the peninsula is noticeable. Large scale migration and admixture of floras took place between the Indian peninsula, south-east Asia and Africa due to establishment of land connections by the Neogene. Wide spread occurrence of Dipterocarpaceae and dominance of legumes together with Sapotaceae, Ebenaceae and Rosaceae, etc. distinguishes the Neogene flora of peninsular India from the Palaeogene.

Key-words—Neogene, Megafossils, Palaeoecology, Peninsular India.

J. S. Guleria, Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.

सारॉंश

प्रायद्वीपीय भारत की पश्च-तृतीयक युगीन वनस्पति

जसवन्तसिंह गुलेरिया

प्रायद्वीपीय भारत की पश्च-तृतीयक वनस्पति का विश्लेषण किया गया है जिसके आधार पर कुछ महत्वपूर्ण निष्कर्ष निकाले गये हैं। इस कल्प में सम्पूर्ण प्रायद्वीपीय भारत उष्णकटिबन्धीय सदाहरित से पर्णपाती वनों से युक्त था। पूर्व से पश्चिम तक तथा उत्तर से दक्षिण तक डिप्टेरोकार्पेसी कुल की उपस्थिति तथा अन्य सहयुक्त अवयवों से यह प्रस्तावित होता है कि प्रायः एक जैसी जलवायु पूरे प्रायद्वीप में विद्यमान थी। इस काल में भूमध्यरेखा से भारतीय प्रायद्वीप के उत्तर की ओर खिसकने से शनैः शनैः कम वर्षा तथा हिमालय के उत्थान से महत्वपूर्ण परिवर्तन हुए। पश्चनूतन कल्प की समाप्ति पर डिप्टेरोकार्पेसी कुल का विलुप्तीकरण तथा प्रायद्वीप के पश्चिमी (गुजरात व राजस्थान) तथा दक्षिण-पूर्वी भाग में शुष्क अथवा मरुस्थली स्थिति का प्रादुर्भाव अत्यन्त महत्वपूर्ण है। इसी कल्प में भारतीय प्रायद्वीप, दक्षिण-पूर्व एशिया तथा अफ्रीका के बीच वनस्पतिजातों का बड़े पैमाने पर पारस्परिक प्रवासन हुआ। डिप्टेरोकार्पेसी कुल का दूर-दूर तक विस्तार तथा सैपोटेसी, एबीनेसी एवं रोजेसी आदि कुलों के साथ-साथ लैग्यूमों की बाहुल्यता से प्रायद्वीपीय भारत के पश्च-तृतीयक वनस्पतिजात की तृतीयक-पूर्व वनस्पतिजात से पृथकता इंगित होती है।

THERE has been a considerable work on the Neogene fossil floras during the last four decades. Investigations have been intense during the past three decades resulting into a better understanding of the flora of this period on account of newly discovered fossiliferous localities, increased availability of fossil material and knowledge of anatomy. Perhaps, the history of Neogene fossil studies in the country is about two hundred years old when a French naturalist (Sonnerat, 1782) reported the occurrence of petrified woods near Pondicherry. However, no attention was paid to these fossils for a very long time until and after the return of Prof. Birbal Sahni from Cambridge. Prof. Sahni initiated work on Tertiary plants of India in thirties (1922, 1924, 1928, 1931a, b, c) and thus provided necessary impetus to Indian Tertiary Palaeobotany.

Peninsular India lies south of Indo-Gangetic Plains and includes Rajasthan, Kutch, Saurashtra in the West to Assam Shelf in the north-east. The Assam Shelf includes the Shillong Plateau, the Garo, Khasi, Jaintia, Mikir hills and Upper Assam Valley.

Four Decades of Indian Palaeobotany
Editors : B. S. Venkatachala & H. P. Singh
Publisher : Birbal Sahni Institute of Palaeobotany, Lucknow

Geologically this is north eastern prolongation of the Indian Peninsular Shield. Compared to extensive Deccan Trap deposits of Upper Cretaceous to Palaeogene age in the peninsular India the Neogene sediments appear sporadically along the West (Kutch, Saurashtra, Cambay, Konkan and Kerala Coast) and East Coast (Cauvery, Krishna, Godavari, Mahanadi and Bengal basins). In the northeast region they are fairly well-developed. Recently fossils belonging to Neogene have been reported from Rajasthan, Madhya Pradesh and south Bihar, thereby indicating the occurrence of Upper Tertiary sediments in these areas.

For quick perusal the floras of different basins have been listed along with their affinities with the extant genera and remarks on identification of some of the taxa have been made.

COMPOSITION OF NEOGENE FLORA OF PENINSULAR INDIA

The commonest plant fossils found in the Neogene deposits are petrified woods. Most of the woods belong to dicotyledons and monocotyledons. Palms are few and gymnosperms rare. In addition, some impressions or compressions of leaves, fruits and seeds have also been reported.

The Neogene flora of peninsular India has been divided into five groups for consideration and discussion.

1. *Western India Floras*
   - (i) Gujarat flora (Kutch and Saurashtra basins)
   - (ii) Rajasthan flora (Jaisalmer and Bikaner basins)
   - (iii) Konkan flora
   - (iv) Kerala Coast flora (Kerala-Lakshadweep Basin)
2. *East Coast Floras*
   - (i) Rajahmundry flora (Krishna-Godavari Basin)
   - (ii) Neyveli lignite flora
   - (iii) Cuddalore Series flora
3. *North East Flora (Assam-Arakan Basin)*
4. *Bengal and Bihar flora*
5. *Central India flora*
6. *Andaman and Nicobar Islands flora*

DISCUSSION

1. Western Indian Neogene floras

(i) Gujarat *(Kutch and Saurashtra basins)*—A fairly large amount of data is now available on the Neogene flora of Kutch (Lakhanpal & Guleria, 1983; Lakhanpal *et al.*, 1984). The flora is represented by four genera of calcareous red algae, a gymnosperm (*Podocarpoxylon*), three monocot and over 25 dicot genera (see Table 1). The number of known algal taxa is very small, consisting of five species belonging to four genera, viz., *Aethesolithon, Archaeoporolithon, Lithophyllum* and *Mesophyllum.* Occurrence of the algae indicates definite marine habitat, transgression and regression of the sea in Kutch during Miocene. The fossil localities lie adjacent to the Tropic of Cancer and hence fall in the tropical region, indicating tropical conditions which is corroborated by *Aethesolithon, Archaeoporolithon* and *Lithophyllum* together with fossil remains of higher plants. *Mesophyllum* is the only exception which is primarily a cold water genus (Wray, 1977, p. 67). Structurally *Mesophyllum, Lithophyllum* and *Neogoniolithon* are very similar except in a few characters, but whereas *Mesophyllum* is a cold water genus the last two are warm water genera. It is thus suggested that the affinities of *Mesophyllum* need reinvestigation based on more and better preserved material because it is highly improbable that cold water genus would survive in tropical sea around Kutch.

The higher plants primarily consists of petrified woods, impression of leaves and a few fruits and seeds. A general survey of the Neogene flora shows that out of the known modern comparable genera, viz., *Afzelia-Intsia, Albizia, Bauhinia, Barringtonia, Cassia, Ceriops, Chlorophora, Cinnamomum, Cynometra, Dialium, Dipterocarpus, Euphoria, Ficus, Gluta, Isoberlinia, Lagerstroemia, Millettia, Millettia-Pongamia, Murraya, Podocarpus, Pterospermum, Schleichera, Sonneratia, Sterculia* and *Terminalia,* only *Bauhinia, Cassia, Ceriops, Ficus* and *Sterculia* are represented in the present day flora of Kutch. These five genera are found in protected and limited places in Kutch. It is clear from the above data that majority of the genera had a wider distribution and extended up to Kutch in the western part of the country during Neogene. Analysis of the flora has brought to light that Kutch had been the meeting ground of eastern (*Cinnamomum, Dipterocarpus, Euphoria, Gluta, Murraya, Pterospermum, Schleichera*) and western floral elements, particularly African (*Isoberlinia, Chlorophora*). This could be possible due to establishment of land connections between Malaysia, India, Arabia and East Africa during Neogene. The occurrence of *Ceriops, Sonneratia, Barringtonia* and *Lagerstroemia* indicates the existence of littoral and riverine or swampy conditions. Likewise the occurrence of *Afzelia-Intsia, Cinnamomum, Cynometra, Dipterocarpus,*

Table 1—Neogene megafossils of Gujarat (Kutch and Saurashtra basins)

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
ALGAE			
Corallinaceae	*Lithophyllum* aff. *L. kladosum* Johnson; Pal & Ghosh 1974	*Lithophyllum* Philippi	Khari Series (Lower Miocene)
	Mesophyllum commune Lemoine; Pal & Ghosh 1974	*Mesophyllum* Lemoine	Khari Series (Lower Miocene)
	Aethesolithon problematicum Johnson; Pal & Ghosh 1974	*Aethesolithon* Johnson	Khari Series (Lower Miocene)
	Aethesolithon cutchensis Pal & Ghosh 1974	*Aethesolithon* Johnson	Khari Series (Lower Miocene)
	Archaeoporolithon miocenicum Pal & Ghosh 1974	*Archaeoporolithon* Pal & Ghosh	Khari Series (Lower Miocene)
GYMNOSPERMS			
Podocarpaceae	*Podocarpoxylon kutchensis* Lakhanpal *et al.* 1975	*Podocarpus wallichianus* C. Presl.	Kankawati Series (Pliocene)
ANGIOSPERMS			
Poaceae	*Culmites cutchensis* Sahni 1964		?
Arecaceae	*Palmoxylon mathuri* Sahni 1964	Palm	?
	Palmoxylon seriatum Sahni 1964	Palm	?
	Palmacites khariensis Lakhanpal & Guleria 1982	Palm	Khari Series (Lower Miocene)
	Palmoxylon kachchhensis Guleria 1983	Palm	Kankawati Series (Pliocene)
Dipterocarpaceae	*Dipterocarpoxylon malavii* Ghosh & Ghosh 1959; Guleria, 1983	*Dipterocarpus dyeri* Pierre ex De Laness	Kankawati Series (Pliocene)
	D. pondicherriense Awasthi; Guleria 1983	*D. indicus* Bedd.	Kankawati Series (Pliocene)
	Hopea (MS)	*Hopea*	Miocene-Pliocene
Sterculiaceae	*Sterculinium kalagarhense* (Trivedi & Ahuja) Guleria 1983	*Sterculia coccinea* *S. oblonga* Mast. *S. rhinopetala* K. Schum.	Kankawati Series (Pliocene)
	Pterospermoxylon kutchensis Awasthi *et al.* 1980	*Pterospermum glabrescens* W & A *P. reticulatum* W & A *P. rubiginosum* Heyne	Kankawati Series (Pliocene)
Rutaceae	*Murraya khariensis* Lakhanpal & Guleria 1982	*Murraya paniculata* (Linn.) Jack	Khari Series (Lower Miocene)
Sapindaceae	*Euphorioxylon indicum* Awasthi *et al.* 1982	*Euphoria longana* Lamk.	Kankawati Series (Lower Miocene)
	Schleicheroxylon kachchhensis Awasthi *et al.* 1982	*Schleichera oleosa* (Lour) Oken	Kankawati Series (Lower Miocene)
Anacardiaceae	*Glutoxylon burmense* (Holden) Chowdhury 1952; Guleria, 1984b Syn. *G. kalagarhense* Trivedi & Ahuja 1978	*Gluta travancorica* Bedd.	Khari Series (Lower Miocene)
Fabaceae	*Millettia asymmetrica* Lakhanpal & Guleria 1982	*Millettia ovalifolia* Kurz	Kankawati Series (Lower Miocene)
	M. miocenica Lakhanpal & Guleria 1982	*M. auriculata* Baker	Kankawati Series (Lower Miocene)
	Bauhinia kachchhensis Lakhanpal & Guleria 1982	*B. phoenicea* Heyne *B. purpurea* Linn.	Kankawati Series (Lower Miocene)
	Cassia miokachchhensis Lakhanpal & Guleria 1982	*Cassia* sp.	Khari Series (Lower Miocene)
	Leguminocarpon khariensis Lakhanpal & Guleria 1982	Fruit cf. Fabaceae	Khari Series (Lower Miocene)
	Leguminophyllum khariensis Lakhanpal & Guleria 1982	Leaf cf. Fabaceae	Khari Series (Lower Miocene)
	Leguminosites khariensis Lakhanpal & Guleria 1982	Seed cf. Fabaceae	Khari Series (Lower Miocene)

Contd.

Table 1—Contd.

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
	Millettioxylon indicum Awasthi; Guleria 1984a	*Millettia pendula* Benth. *M. prainii* Dunn. *Pongamia pinnata* (Linn.) Pierre	Kankawati Series (Pliocene)
	Pahudioxylon sahnii Ghosh & Kazmi; Guleria 1984a	*Afzelia-Intsia*	Kankawati Series (Pliocene)
	P. assamicum Prakash & Tripathi; Guleria 1984a	*Afzelia-Intsia*	Kankawati Series (Pliocene)
	Cynometroxylon holdenii (Gupta) Prakash & Bande; Guleria 1984a	*Cynometra polyandra* Roxb. *C. ramiflora* Linn.	Kankawati Series (Pliocene)
	Isoberlinioxylon congoense Lakhanpal & Prakash; Guleria 1984a	*Isoberlinia angolensis* (Welw.) Hoyle & Brenan *I. niembaensis* Duvigan	Kankawati Series (Pliocene)
	Dialiumoxylon indicum Guleria 1984a	*Dialium* sp.	Kankawati Series (Pliocene)
	Albizinium eolebbekianum Prakash; Guleria 1984a	*Albizia lebbek* Benth.	Kankawati Series (Pliocene)
	A. pondicherriensis Awasthi; Guleria 1984a	*Albizia amara* Boivin *A. odoratissima* Benth.	Kankawati Series (Pliocene)
Rhizophoraceae	*Ceriops kachchhensis* Lakhanpal *et al.* 1984	*Ceriops decandra* (Griff.) Ding Hou *C. tagal* (Perr.) C. B. Rob.	Khari Series (Lower Miocene)
Combretaceae	*Terminalia kachchhensis* Lakhanpal *et al.* 1984	*Terminalia chebula* Retz.	Khari Series (Lower Miocene)
	Terminalioxylon burmense Mädel-Angeliewa & Müller-Stoll; Guleria 1983	*Terminalia tomentosa* W & A	Kankawati Series (Pliocene)
	T. felixii Ramanujam; Guleria 1983	*Terminalia arjuna* Bedd. *T tomentosa* W & A	Kankawati Series (Pliocene)
Barringtoniaceae (Lecythidaceae)	*Barringtonia* (Ms)	*Barringtonia* J. R. & G. Forst.	Khari Series (Lower Miocene)
Lythraceae	*Lagerstroemioxylon eoflosreginum* Prakash & Tripathi; Lakhanpal *et al.* 1984	*Lagerstroemia speciosa* L. Pers.	Khari Series (Lower Miocene)
Sonneratiaceae	*Sonneratioxylon preapetalum* Awasthi; Lakhanpal *et al.* 1984	*Sonneratia apetala* Buck-Ham. *S. caseolaris* (Linn.) Engler	Khari Series (Lower Miocene)
Lauraceae	*Cinnamomum miokachchhensis* Lakhanpal & Guleria 1982	*Cinnamomum zeylanicum* Breyn.	Khari Series (Lower Miocene)
Moraceae	*Ficus khariensis* Lakhanpal & Guleria 1982	*Ficus infectoria* Roxb.	Khari Series (Lower Miocene)
	Chlorophora (Ms)	*Chlorophora* Gaudich.	Kankawati Series (Pliocene)

Gluta, Podocarpus, Pterospermum, Sonneratia along with other deciduous elements (see Table 1) indicates luxuriant vegetation and warm conditions with plenty of rainfall during Neogene in contrast to dominant scrubby vegetation and xeric conditions of present day Kutch. The prevailing xeric conditions in Kutch can be attributed to change in the climatic conditions during post-Pliocene time.

Plant fossils have lately been collected from Miocene and Pliocene sediments of Saurashtra and are under investigation. A fossil wood of *Hopea* belonging to Dipterocarpaceae has been identified by the author from the Miocene sediments of Bhavnagar coast. It is an important component of evergreen to semi-evergreen forests. The occurrence of *Hopea* indicates that there was luxuriant forest around Bhavnagar supported by plenty of rainfall during Miocene. This kind of forest no longer exists in the area thereby indicating considerable change in the climatic conditions since Miocene. Detailed investigations of the assemblage may further substantiate the above conclusions.

(ii) *Rajasthan (Jaisalmer and Bikaner basins)*—The Late Tertiary flora of Rajasthan has a great bearing on the advent of desertic conditions. The author has under taken extensive study of Late Tertiary fossils from western part of Rajasthan. He has reported the occurrence of a number of plant fossils in a series of communications (Guleria, 1984b, 1986, 1990a, b, 1991, 1992). The flora as known today exclusively consists of petrified woods and is represented by about 25 genera (see Table 2). Except for two gymnosperms, *Araucaria-Agathis* and *Podocarpus* all other fossils are dicot genera. A fossil wood (*Araucarioxylon bikanerense*) said to be belonging to the Eocene has been described by Harsh and Sharma (1988) from Bikaner. It has already been pointed out (Guleria, 1990a) that this wood belongs to Pliocene rather than Eoçene. The dicot recorded are: *Afzelia-Intsia, Anisoptera,*

Table 2—Neogene megafossils of Rajasthan (Jaisalmer and Bikaner basins)

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
Araucariaceae	*Araucaria-Agathis* Guleria 1986	*Araucaria-Agathis*	Shumar Formation (probably Pliocene)
	Araucarioxylon bikanerense Harsh & Sharma 1988	*Araucaria-Agathis*	Mar Formation (probably Pliocene)
Podocarpaceae	*Podocarpus* Guleria 1986	*Podocarpus* L'.Herit ex. Pers.	Shumar Formation (probably Pliocene)
Dipterocarpaceae	*Dipterocarpus* Guleria 1986	*Dipterocarpus* Gaertn. f.	Shumar Formation (probably Pliocene)
	Anisoptera (Ms)	*Anisoptera* Korth.	Shumar Formation (probably Pliocene)
Sterculiaceae	*Sterculia* Guleria 1986	*Sterculia* Linn.	Shumar Formation (probably Pliocene)
Meliaceae	*Entandrophragma* Guleria 1990b	*Entandrophragma* C.DC	Shumar Formation (probably Pliocene)
	Khaya Guleria 1990b	*Khaya* A. Juss	Shumar Formation (probably Pliocene)
Rhamnaceae	*Ziziphus oxyphylla* Guleria 1992	*Ziziphus oxyphylla* Edgw.	Mar Formation (probably Pliocene)
Anacardiaceae	*Mangiferoxylon assamicum* Prakash & Tripathi; Guleria 1984b	*Mangifera sylvatica* Roxb. *M. indica* Linn.	Shumar Formation (probably Pliocene)
Fabaceae	*Afzelia-Intsia* Guleria 1986	*Afzelia-Intsia*	Shumar Formation (probably Pliocene)
	Baphia Guleria 1990b	*Baphia* Afzel.	Shumar Formation (probably Pliocene)
	Bauhinia Guleria 1986	*Bauhinia* Linn.	Shumar Formation (probably Pliocene)
	Copaifera-Detarium-Sindora Guleria 1986	*Copaifera-Detarium-Sindora*	Shumar Formation (probably Pliocene)
	Cynometra Guleria 1986	*Cynometra* Linn.	Shumar Formation (probably Pliocene)
	Erythrophleum Guleria 1990b	*Erythrophleum* Afzel-ex G. Don	Shumar Formation (probably Pliocene)
	Millettia-Pongamia Guleria 1986	*Millettia-Pongamia*	Shumar Formation (probably Pliocene)
	Ormosia Guleria 1986	*Ormosia* G. Jacks	Shumar Formation (probably Pliocene)
	Pterocarpus Guleria 1986	*Pterocarpus* Jacq.	Shumar Formation (probably Pliocene)
	Tetrapleura Guleria 1990b	*Tetrapleura* Benth.	Shumar Formation (probably Pliocene)
	Dialiumoxylon indicum Guleria 1990a	*Dialium travancoricum* Bourd.	Mar Formation (probably Pliocene)
	Ougeinioxylon tertiarum Guleria 1990a	*Ougeinia oojeinensis* (Roxb.) Hocht.	Mar Formation (probably Pliocene)
Combretaceae	*Terminalia* Guleria 1986	*Terminalia* Linn.	Shumar Formation (probably Pliocene)
Lythraceae	*Lagerstroemia* Guleria 1986	*Lagerstroemia* Linn.	Mar Formation (probably Pliocene)
	Lagerstroemioxylon eoflosreginum Prakash & Tripathi; Guleria 1990a	*Lagerstroemia speciosa* Pers.	Mar Formation (probably Pliocene)
	L. parenchymatosum Prakash; Guleria 1990a	*L. parviflora* Roxb.	Mar Formation (probably Pliocene)
Boraginaceae (Ehretiaceae)	*Cordia* Guleria 1986	*Cordia* Linn.	Shumar Formation (probably Pliocene)

Baphia, Bauhinia, Dialium, Dipterocarpus, Copaifera-Detarium-Sindora, Cordia, Cynometra, Entandrophragma, Erythrophleum, Khaya, Lagerstroemia, Mangifera, Millettia-Pongamia, Ormosia, Ougeinia, Pterocarpus, Sterculia, Terminalia, Tetrapleura and *Ziziphus*. The occurrence of member of evergreen forests such as *Araucaria-Agathis, Podocarpus, Anisoptera* and *Dipterocarpus* indicates luxuriant vegetation and tropical humid climate. However, the numerical abundance of these genera in the assemblage is meagre. The majority of the genera being deciduous, they indicate a trend towards shift in the rainfall. This is further suported by the occurrence of African elements in Rajasthan. Nevertheless, the rainfall seems adequate for fairly thick forest cover during Pliocene in contrast to the desertic conditions encountered in the area today. The occurrence of typical African genera such as *Baphia, Entandrophragma, Erythrophleum, Khaya* and *Tetrapleura* are phytogeographically significant. They are primarily confined to tropical Africa and Madagascar. They indicate migration of plants from East Africa to western part of India. These elements, however, failed to move further into eastern or southern India as none of them have so far been recorded trom other Neogene deposits of India. On the whole the above mentioned flora perished subsequently from the Jaisalmer and Bikaner region due to progressive increase in aridity. Obviously, the present desertic conditions in Rajasthan are the result of post-Pliocene climatic changes as also has been inferred in Kutch. The probable means of migration of African taxa are high velocity winds, birds and animals. The possible routes could be (i) Egypt to northern Arabia to Persia to Baluchistan and Sind to western India, (ii) Ethiopia to southern Arabia to Persia to Baluchistan and Sind to western India. The flora has a great bearing in dating the Shumar and Mar formations of Jaisalmer and Bikaner area as equivalent to Kankawati Series (Pliocene) of Kutch on account of very close floral similarity exhibited by them including the presence of tropical African elements (Guleria 1986, 1990a).

In addition to the fossils listed in Table 2, Trivedi (1959) reported six dicot leaf-impressions from the tufaceous limestone beds of Miocene age near Udaipur. She subsequently (1980) identified them as the leaves of *Ficus religiosa, F. carica* and *Psidium guava*. The presence of *Ficus* trees in the area are the result of protection provided to the trees owing to religious feelings of the natives. *Psidium guava* is an exotic plant belonging to Central America, cultivated and naturalised throughout India. Guava plant may have been planted around the limestone quarry office. Obviously, the reported leaves are infact, the imprints of recent leaves on tufaceous sediments, hence cannot be recorded as fossils of Miocene age. Thus these record should be totally discarded.

(iii) *Konkan flora*—The flora of this region is meagrely known (see Table 3) at present and comes from the lignitic beds of Ratnagiri District (Kulkarni & Phadtare, 1980; Dalvi & Kulkarni, 1982; Phadtare & Kulkarni, 1984; Shinde & Kulkarni, 1989). The fossils are in the form of compressions or mummified leaf remains and carbonised fruits. In terms of extant comparable genera the assemblage consists of *Alangium, Diospyros, Dracontomelum, Eugeissona, Garcinia, Nothopegia, Nypa* and *Nyssa* and ranges from deciduous to evergreen trees. The occurrence of *Nypa* indicates estuarine conditions which even now exist at Ratnagiri allowing the growth of mangroves. However, *Nypa* no longer occurs in the present day flora of Ratnagiri. *Garcinia, Diospyros, Nothopegia* are presently found in Western Ghats whereas *Nyssa* is confined to Sikkim, North Bengal and Assam extending further to Malayan region. *Eugeissona* and *Dracontomelum* are typical tropical Malaysian genera. Of the two, *Dracontomelum* is found in the Andaman and Nicobar Islands in damp places along streams and rivers. The overall assemblage indicates a warm humid palaeoclimate.

(iv) *Kerala Coast flora (Kerala-Lakshadweep Basin)*—The sedimentary rocks along the Kerala Coast, classified as Warkalli beds or Varkala beds overlying the Quilon beds contain rich deposits of carbonised woods. According to Poulose and Narayanaswamy (1968) the age of Warkalli beds is Late Miocene or Miocene-Pliocene and the beds are considered equivalent to the Cuddalore Sandstones. The flora of Neogene deposits of Kerala Coast is better known than the Konkan flora and is entirely based on carbonised woods. So far twenty genera belonging to 15 families have been reported (Table 4) by Awasthi and Ahuja (1982), Awasthi and Panjwani (1984), Awasthi and Srivastava (1989, 1990, 1992) from the Warkalli beds of Varkala, Payangadi and Padappakara. The extant comparable taxa reported are: *Anisophyllea, Anisoptera, Calophyllum, Canarium, Careya, Cassia, Cynometra, Diospyros-Maba, Dryobalanops, Fagara-Acronychia, Gluta, Gonystylus, Hopea, Hydnocarpus, Leea, Litsea-Cinnamomum, Payena-Palaquium, Shorea, Swintonia* and *Terminalia*. Most of the genera are important elements of tropical evergreen forests and are found in the present day flora of Western Ghats thus indicating the existence of nearly similar climatic conditions. The occurrence of *Anisoptera,*

Table 3—Neogene megafossils of Konkan area

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
Arecaceae	*Eugeissonocarpon indicum* Shinde & Kulkarni 1989	*Eugeissona* Griff.	Lignite beds of Ratnagiri District (age—Miocene)
Nypaceae	*Nypa fruticans* Kulkarni & Phadtare 1980	*Nypa fruticans* Wurmb	Lignite beds of Ratnagiri District (age—Miocene)
Clusiaceae	*Garcinia indica* Dalvi & Kulkarni 1982	*Garcinia indica* Choiss	Lignite beds of Ratnagiri District (age—Miocene)
Anacardiaceae	*Nothopegia* Dalvi & Kulkarni 1982	*Nothopegia colebrookiana* Blume	Lignite beds of Ratnagiri District (age—Miocene)
	Dracontomelumoxylon mangiferumoides Ghosh & Roy; Phadtare & Kulkarni 1984	*Dracontomelum mangiferum*	Lignite beds of Ratnagiri District (age—Miocene)
	Anacardioxylon ratnagiriense Phadtare & Kulkarni 1984	? *Gluta* Linn.	Lignite beds of Ratnagiri District (age—Miocene)
Alangiaceae	*Alangium* Dalvi & Kulkarni 1982	*Alangium salvifolium* Wang	Lignite beds of Ratnagiri District (age—Miocene)
Ebenaceae	*Diospyros microphylla* Dalvi & Kulkarni 1982	*Diospyros microphylla* Bedd.	Lignite beds of Ratnagiri District (age—Miocene)
Nyssaceae	*Nyssa brandoniana* Shinde & Kulkarni 1989	*Nyssa* Gronov. ex. L.	Lignite beds of Ratnagiri District (age—Miocene)

Dryobalanops, Gonystylus and *Swintonia* which are rain forest trees further suggests that high rainfall and excessive humid conditions at the time of deposition. However, their total absence in the present day flora of Western Ghats or Kerala Coast probably indicates a shift in the amount of precipitation in the Western Ghats since Neogene.

2. East Coast Neogene floras

(i) *Rajahmundry flora (Krishna-Godavari Basin)*—A few plant fossils have been reported from the Rajahmundry Sandstones of Godavari Basin in Andhra Pradesh. The Rajahmundry Sandstones overlie unconformably, the Deccan Trap sediments and have been considered to be equivalent to the Cuddalore Sandstones of South Arcot District, Tamil Nadu (King, 1880; Pascoe, 1963; Krishnan, 1960). On the basis of their deposition over the Deccan Traps, the age of Rajahmundry Sandstones has been given as Middle Eocene by King (1880), Miocene-Pliocene by Krishnan (1960) and Miocene? by Rao & Raju (1968). Most of the fossils said to be belonging to the Rajahmundry Sandstones have been reported by Mahabale and his associates (see Table 5) who consider the age of the sandstones as Oligo-Miocene. In addition, dicotyledonous leaves have been reported by Ramanujam and Rao (1967b), and Verma and Mathur (1968). However, the occurrence of typical Gondwanic taxa like *Dadoxylon* cf. *barakarense, Dadoxylon* cf. *jamudhiense, Mesembrioxylon rajmahalense, Polyloboxylon raniganjense, Ginkgo* and intertrappean species like *Mesembrioxylon* sp. cf. *M. dudukurense, Cocos nucifera* (leaf) together with dicotyledonous leaf impressions gives a very confusing picture. The composition of the flora seems to be most unlikely of Oligo-Miocene age. The possibility of reworking of fossils from the older horizons and their mixing with the Intertrappean fossils cannot be ruled out since the Gondwana and Intertrappean sediments are closely associated with the Rajahmundry Sandstones in the area. The occurrence of *Terminalia* which ranges from Eocene onwards in India (Lakhanpal & Guleria, 1981; Guleria, 1991) does not help much in fixing the age of Rajahmundry Sandstones. The generic affinity of dicotyledonous leaf-impressions recovered from the Rajahmundry Sandstones (Ramanujam & Rao, 1967b; Verma & Mathur, 1968; Mahabale & Rao, 1973) has not been ascertained. Thus in view of the available fossil records known so far and in the absence of any index fossil of Neogene the Rajahmundry flora cannot be regarded as belonging to Miocene or Neogene. A detailed exploration and critical investigation of the fossils of Rajahmundry sandstones may provide us evidence in deciphering its age. Till such time the question of exact age of the Rajahmundry sandstones may be kept open.

(ii) *Cuddalore Series flora (Cauvery Basin)*—The Cuddalore flora of South Arcot District, Tamil Nadu is one of the best investigated Neogene floras of India and consists almost exclusively of petrified woods. Occurrence of these woods are known since long (Sonnerat, 1782). The flora has been extensively reviewed by Ramanujam (1968), Lakhanpal (1970, 1973) and Awasthi (1974b). The

Table 4—Neogene megafossils of Kerala Coast (Kerala-Lakshadweep Basin)

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/BEDS
Clusiaceae	*Calophylloxylon* sp. Awasthi & Ahuja 1982	*Calophyllum* L.	Warkalli beds
Dipterocarpaceae	*Dryobalanoxylon keralaensis* Awasthi & Ahuja 1982	*Dryobalanops* Gaertn. f.	Warkalli beds
	Anisopteroxylon varkalaensis Awasthi & Srivastava 1990	*Anisoptera polyandra* Bl.	Warkalli beds
	Hopenium payangadiensis Awasthi & Srivastava 1990	*Hopea parviflora* Bedd.	Warkalli beds
	Shoreoxylon arcotense Awasthi; Awasthi & Srivastava 1992	*Shorea acuminata* Dyer	Warkalli beds
Ampelidaceae	*Leeoxylon cannanorense* Awasthi & Panjwani 1984	*Leea angulata* Korth. *L. philippinensis* Merill	Warkalli beds
Anacardiaceae	*Swintonioxylon tertiarum* Awasthi & Ahuja 1982	*Swintonia foxworthyi* Elmer	Warkalli beds
	Glutoxylon burmense (Hold) Chowdhury; Awasthi & Panjwani 1984	*Gluta* Linn.	Warkalli beds
Fabaceae	*Cynometroxylon holdenii* (Gupta) Prakash & Bande; Awasthi & Ahuja 1982	*Cynometra* Linn.	Warkalli beds
	Cassinium prefistulai Prakash; Awasthi & Srivastava 1992	*Cassia fistula* Linn.	Warkalli beds
Combretaceae	*Terminalioxylon varkalaensis* Awasthi & Ahuja 1982	*Terminalia chebula* Retz. *T. travancorensis* W & A	Warkalli beds
Ebenaceae	*Ebenoxylon obliquiporosum* Awasthi & Ahuja 1982	*Diospyros-Maba*	Warkalli beds
Lauraceae	*Laurinoxylon varkalaensis* Awasthi & Ahuja 1982	*Litsea-Cinnamomum*	Warkalli beds
Tymelaceae	*Gonystyloxylon indicum* Awasthi & Panjwani 1984	*Gonystylus* spp.	Warkalli beds
	G. tertiarum Awasthi & Panjwani 1984	*Gonystylus macrophyllus* (Miq.) Airy Shaw *Gonystylus* sp.	Warkalli beds
Burseraceae	*Canarium palaeoluzonicum* Awasthi & Srivastava 1989	*Canarium luzonicum* (Bl.) A Gray	Warkalli beds
Flacourtiaceae	*Hydnocarpoxylon keralaensis* Awasthi & Srivastava 1990	*Hydnocarpus sumatrana* Koorders	Warkalli beds
Sapotaceae	*Sapotoxylon prepayena* Awasthi & Srivastava 1990	*Payena-Palaquium*	Warkalli beds
Rutaceae	*Fagaroxylon acronychioides* Awasthi & Srivastava 1992	*Fagara-Acronychia*	Warkalli beds
Rhizophoraceae	*Carallioxylon indicum* Awasthi; Awasthi & Srivastava 1992	*Anisophyllea* R. Br.	Warkalli beds
	C. miocenicum Awasthi & Srivastava 1992	*Anisophyllea* R. Br.	Warkalli beds
Lecythidaceae	*Careyoxylon pondicherriense* Awasthi; Awasthi & Srivastava 1992	*Careya arborea* Roxb.	Warkalli beds

flora consists of about 78 species belonging to 48 genera (see Table 7). The flora is predominently angiospermous and dominated by dicots. Monocots are represented by only 3 species of palms. Although gymnosperms are particularly abundant at a few localities yet they are only represented by 6 species, five of them belong to a single genus of Podocarpaceae and one to Taxodiaceae. However, the affinities of *Taxodioxylon cuddalorense* with Taxodiaceae have been doubted by Ramanujam (1976, p. 105). The occurrence of evergreen moisture loving elements such as *Anisoptera, Dipterocarpus, Dryobalanops, Hopea, Calophyllum, Mesua, Gluta, Cynometra, Afzelia-Intsia, Alangium, Duabanga, Sonneratia*, and *Podocarpus* along with other deciduous trees suggest the existence of

Table 5—?Oligo-Miocene megaflora of Rajahmundry area (Krishna-Godavari Basin)

	FOSSIL TAXA	LOCALITY
Gymnosperms	*Dadoxylon* sp. cf. *D. barakarense* Surange & Saxena; Mahabale & Satyanaryana 1978a	Pangidi, West Godavari District
	Dadoxylon sp. cf. *D. jamudhiense* Maheshwari; Mahabale & Satyanaryana 1978a	Rajahmundry, East Godavari District
	Mesembrioxylon rajmahalense Jain; Mahabale & Satyanaryana 1978a	Pangidi, West Godavari District
	Mesembrioxylon sp. cf. *M. dudukurense* Mahabale & Rao; Mahabale & Satyanaryana 1978a	Rajahmundry, East Godavari District
	Ginkgo dixitii Mahabale & Satyanaryana 1978b	Pangidi, West Godavari District
	Polyloboxylon raniganjense Kräusel *et al.*; Mahabale & Rao 1973	Rajahmundry, East Godavari District
Angiosperms	*Phyllites* spp. 1-4; a seed-like organ Ramanujam & Rao 1967b	1.5 miles east of Tyajampudi, West Godavari District
	Dicotylophyllum sp. 1-4 Verma & Mathur 1968	About 1.5 km south of Pangidi, West Godavari District
	Dicot and monocot leaf-impressions Mahabale & Rao 1973	Bommuru, East Godavari District
	Terminalioxylon ghoshii Satyanaryana & Mahabale 1984	Pangidi, West Godavari District
	Palm leaves Leaf-impression cf. *Cocos nucifera*	Pangidi, West Godavari District
	Palm fruit cf. *Cocos plumosa* *C. coronata* Mahabale & Rao 1968	Pangidi, West Godavari District

Table 6—Neogene megafossils of Neyveli lignite (Cauvery Basin)

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
Arecaceae	Wood Navale, 1973, 1974a Compressed bark/leaf sheath	Palm	Neyveli lignite (Miocene)
	Shoot with crown of leafy bracts/leaves Chatterjee & Bhattacharya 1965	Palm	Neyveli lignite (Miocene)
	Phoenix Upadhyay & Verma 1986	*Phoenix* L.	Neyveli lignite (Miocene)
Agavaceae	*Dracaena* Ambwani 1982	*Dracaena* Wand. ex. L.	Neyveli lignite (Miocene)
Poaceae	Cuticle Navale 1973, 1974a	—	Neyveli lignite (Miocene)
Clusiaceae	*Calophyllum/Mesua* Navale 1973, 1974a	*Calophyllum/Mesua*	Neyveli lignite (Miocene)
Dipterocarpaceae	*Dipterocarpus* Navale 1973, 1974a	*Dipterocarpus* Gaertn. f.	Neyveli lignite (Miocene)
	Hopenium neyveliensis Awasthi 1984	*Hopea plagata* Vidal	Neyveli lignite (Miocene)
	Shorea Verma *et al.* 1989	*Shorea robusta* Gaertn. f.	Neyveli lignite (Miocene)
Sterculiaceae	**Sterculioxylon* sp. Reddy 1989	*Sterculia* Linn.	Neyveli lignite (Miocene)
Tiliaceae	*Grewioxylon microcoides* Agarwal 1991a	*Grewia microcos* Linn.	Neyveli lignite (Miocene)
Anacardiaceae	*Glutoxylon burmense* (Holden) Chowdhury; Awasthi 1984	*Gluta* Linn.	Neyveli lignite (Miocene)
	Bouea neyveliensis Agarwal 1989	*Bouea burmanica* Griff.	Neyveli lignite (Miocene)
Fabaceae	*Cassia/Acacia* Navale 1973, 1974a	*Cassia/Acacia*	Neyveli lignite (Miocene)
	Bauhinia deomalica Awasthi & Prakash; Agarwal 1991b	*Bauhinia foveolata* Dalz. *B. malabarica* Roxb. *B. racemosa* Lam. *B. retusa* Ham.	Neyveli lignite (Miocene)
Rosaceae	*Parinarioxylon neyveliensis* Awasthi & Agarwal 1986	*Parinari indicum* Bedd. *P. travancoricum* Bedd.	Neyveli lignite (Miocene)
Hamamelidaceae	+*Altingia rhodoleioides* Kramer; Agarwal 1991b	*Altingia excelsa* Noronha	Neyveli lignite (Miocene)
Rhizophoraceae	*Caraltioxylon indicum* Awasthi 1984	*Carallia lucida* (= *C. brachiata*)	Neyveli lignite (Miocene)

Contd.

Table 6—Contd.

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
Combretaceae	*Terminalia* Navale 1973, 1974a	*Terminalia* Linn.	Neyveli lignite (Miocene)
Lythraceae	*Lagerstroemia* Verma *et al.* 1989	*Lagerstroemia indicum* Linn.	Neyveli lignite (Miocene)
Lecythidaceae (Barringtoniaceae)	*Careyoxylon pondicherriense* Awasthi; Agarwal 1990	*Careya* Roxb.	Neyveli lignite (Miocene)
Rubiaceae	*Randia neyveliensis* Agarwal 1990	*Randia uliginosa* Retz.	Neyveli lignite (Miocene)
Sapotaceae	Wood cf. Sapotaceae Lakshmanan & Levy 1956	Probably Sapotaceae	Neyveli lignite (Miocene)
	Bassia/Mimusops Navale 1973	*Bassia-Mimusops*	Neyveli lignite (Miocene)
Ebenaceae	*Diospyros-Maba* Navale 1968a	*Diospyros-Maba*	Neyveli lignite (Miocene)
	Ebenoxylon arcotense Awasthi 1984	*Diospyros-Maba* *D. assimilis* Bedd.	Neyveli lignite (Miocene)
Apocynaceae	+*Malodinus japonicus* Tanai; Agarwal 1990	*Melodinus monogynus* Roxb.	Neyveli lignite (Miocene)
Asclepiadaceae	*Cryptostegia* Verma *et al.* 1989	*Cryptostegia grandiflora* R. Br.	Neyveli lignite (Miocene)
Boraginaceae	*Cordioxylon multiseriatum* Awasthi 1984	*Cordia myxa* Linn.	Neyveli lignite (Miocene)
Lauraceae	*Litsea* Srivastava 1984	*Litsea* Lam.	Neyveli lignite (Miocene)
Euphorbiaceae	Wood cf. Phyllanthoidae group Navale 1973, 1974a	—	Neyveli lignite (Miocene)
	Excoecaria preagallocha Agarwal 1990	*Excoecaria agallocha* Linn.	

+Need confirmation.
*It should be treated as *Sterculinium* sp. (see Guleria, 1983).

Table 7—Neogene megafossils of Cuddalore Series near Pondicherry (Cauvery Basin)

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA
Gymnosperms		
Podocarpaceae	*Podocarpoxylon schmidianum* (Sahni) Krausel 1949 Syn. *Mesembrioxylon schmidianum* Sahni 1931	*Podocarpus* L'Herit ex. Pers.
	P. tiruvakkarainum (Ramanujam) Trivedi & Srivastava 1990	*Podocarpus* L'Herit ex. Pers.
	Syn. *Mesembrioxylon tiruvakkarainum* Ramanujam 1953b	*Podocarpus* L'Herit ex. Pers.
	P. sahnii (Ramanujam) Trivedi & Srivastava 1990 Syn. *Mesembrioxylon sahnii* Ramanujam 1953b	*Podocarpus* L'Herit ex. Pers.
	P. speciosum (Ramanujam) Trivedi & Srivastava 1990 Syn. *Mesembrioxylon speciosum* Ramanujam 1954	*Podocarpus* L'Herit ex. Pers.
	P. mahabalei (Agashe) Trivedi & Srivastava 1990 Syn. *Mesembrioxylon mahabalaei* Agashe 1969	*Podocarpus* L'Herit ex. Pers.
?Taxodiaceae	*Taxodioxylon cuddalorense* Ramanujam 1960	?
Angiosperms		
Arecaceae/Palmae	*Palmoxylon pondicherriense* Sahni 1931, 1964	Palms
	P. arcotense Ramanujam 1953a	*Livistona* R. Br.
	P. puratanum Ramanujam 1958	Palms
Polygalaceae	*Xanthophyllum cuddalorense* Awasthi 1986	*Xanthophyllum flavescens* Roxb.
Guttiferae/Clusiaceae	*Calophylloxylon indicum* Lakhanpal & Awasthi 1965	*Calophyllum wightianum* Wall.
	C. cuddalorense Lakhanpal & Awasthi 1965	*C. inophyllum* L. *C. tomentosa* Wight
	Mesuoxylon arcotense Lakhanpal & Awasthi 1964	*Mesua ferrea* L.
Dipterocarpaceae	*Dipterocarpoxylon pondicherriense* Awasthi 1974a	*Dipterocarpus indicus* Bedd.
	Dipterocarpoxylon arcotense Awasthi 1980	*Dipterocarpus tuberculatus* Roxb.
	Dryobalanoxylon indicum (Ramanujam) Awasthi 1971 Syn. *Dipterocarpoxylon indicum* Ramanujam 1956a	*Dryobalanops oblongifolia* Dyer
	Dryobalanoxylon holdeni (Ramanujam) Awasthi 1971 Syn. *Shoreoxylon holdeni* Ramanujam 1956a	*Dryobalanops* Gaertn. f.
	S. mortandranse Ramanujam 1956a	
	S. megaporosum Ramanujam 1960	

Contd.

Table 7—Contd.

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA
	Anisopteroxylon cuddalorense Ramanujam 1960	
	**Anisopteroxylon coromandalense* Navale 1963b	*Anisoptera* ?
	Shoreoxylon kraeuseli Ramanujam & Rao 1967a, 1969	*Shorea* Roxb. ex Gaertn.
	**S. speciosum* ~~Navale 1963b~~	*Shorea* ?
	S. indicum Awasthi 1974a	*Shorea, Parashorea* and *Pentacme*
	S. arcotense Awasthi 1974a	*Shorea* spp.
	**Hopeoxylon indicum* Navale 1963b	*Hopea* ?
	Hopenium pondicherriense Awasthi 1980	*Hopea* spp.
Sterculiaceae	*Sterculinium pondicherriense* (Awasthi) Guleria 1983	
	Syn.	
	Sterculioxylon pondicherriense Awasthi 1981	*Sterculia-Firmiana*
Simaroubaceae	*Ailanthoxylon indicum* Prakash; Awasthi 1975b	*Ailanthus* Desf.
	Syn.	
	+*A. scantiporosum* Ramanujam 1960	
	+*A. pondicherriense* Navale 1964c	
	+*Guttiferoxylon indicum* Ramanujam 1960	
	+*Celastrinoxylon dakshinense* Ramanujam 1960	
Sapindaceae	**Sapindoxylon indicum* Navale 1957	Sapindaceae ?
	Euphorioxylon indicum Awasthi *et al.* 1982	*Euphoria longana* Lamk.
Anacardiaceae	*Mangiferoxylon scleroticum* Awasthi 1966	*Mangifera altissima* Blanco
	Glutoxylon cuddalorense Awasthi 1966	*Gluta* Linn.
	G. burmense (Hold) Chowdhury; Awasthi 1966	*Gluta* Linn.
	**Anacardioxylon mangiferoides* Ramanujam, 1960	Anacardiaceae ?
Leguminosae	*Millettioxylon indicum* Awasthi 1967, 1975a	*Millettia pendula-Pongamia glabra*
	Erythrophloeoxylon feistmanteli (Ramanujam) Muller-Stoll & Mädel, 1967	?*Erythrophloem* and allied genera
	syn.	
	Caesalpinioxylon feistmanteli Ramanujam 1960	
	**Pterogynoxylon felexii* (Navale) Müller-Stoll Madel 1967	?*Pterogyne* and allied genera
	Syn.	
	Caesalpinioxylon felexii Navale 1963a	
	**Pterocarpoxylon arcotense* Ramanujam 1960; Awasthi 1992	*Pterocarpus*
	Peltophoroxylon indicum (Ramanujam) Müller-Stoll & Mädel 1967	*Peltophorum* and allied genera
	Syn.	
	Acacioxylon indicum Ramanujam 1954	
	P. variegatum (Ramanujam) Müller-Stoll & Mädel 1967	?*Peltophorum* and allied genera
	Syn.	
	Cassioxylon variegatum Ramanujam 1960	
	Cynometroxylon dakshinense Navale 1959	?*Cynometra* Linn.
	C. indicum Chowdhury & Ghosh; Ramanujam & Rao 1966a	*Cynometra* Linn.
	Tamarindoxylon antiquum Ramanujam 1961	?*Tamarindus* Linn.
	**Pahudioxylon arcotense* Navale 1963a	*Afzelia* and *Intsia*?
	P. sahnii Ghosh & Kazmi; Awasthi 1975b	*Afzelia-Intsia*
	Syn.	
	Albizzioxylon sahnii Ramanujam 1960	
	Ingoxylon sahnii (Ramanujam) Müller-Stoll & Mädel 1967	
	Cf. *Bauhinia* Ramanujam & Rao 1966b	*Bauhinia* Linn.
	Euacacioxylon bharadwajii (Navale) Müller Stoll & Mädel 1967; Awasthi 1975b	*Acacia* Mill.
	Syn.	
	Acacioxylon bharadwajii Navale 1963a	
	Dalbergioxylon antiquum Ramanujam 1960	

Contd.

Table 7—Contd.

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA
	Hopeoxylon indicum (Navale) Awasthi 1977b	*Sindora* Miq. *Sindora supa* Merr. *S. siamensis* Teysm. ex Miq. *S. velutina* Baker
	H. speciosum (Navale) Awasthi 1977b; Prakash, Mishra & Srivastava 1988 Syn. *Hopeoxylon arcotense* Awasthi 1977b *Shoreoxylon speciosum* Navale 1963b	*S. siamensis* Teysm ex Miq.
	Albizinium pondicherriensis Awasthi 1979	*Albizia amara* Boivin
	Cassinium arcotense Awasthi 1979	*Cassia javanica* Linn.
	Pericopsoxylon indicum Awasthi 1979	*Pericopsis mooniana* Thw.
Rosaceae	*Parinarioxylon cuddalorense* Awasthi 1969b	*Parinarium corymbosum* (Blume) Mignel
Combretaceae	*Terminalioxylon speciosum* Ramanujam 1956b	*Terminalia* Linn.
	T felixii Ramanujam 1956b	*Terminalia* Linn.
	T mortanderense Navale 1956	*Terminalia* Linn.
	T sahnii Navale 1956	*Terminalia* Linn.
	T grandiporosum Ramanujam 1966; Awasthi 1975b Syn.	*Terminalia* Linn.
	Dipterocarpoxylon cuddalorense Navale 1963b	*Terminalia* Linn.
	T coromandelinum Ramanujam 1966	*Terminalia* Linn.
	T traumaticum Ramanujam 1966	*Terminalia* Linn.
	Anogeissusoxylon indicum Navale 1964b	*Anogeissus* Wall ex Guillem & Perr.
Barringtoniaceae (Lecythidaceae)	*Barringtonioxylon arcotense* Awasthi 1970a	*Barringtonia angusta* Kurz.
	Careyoxylon pondicherriense Awasthi 1970a	*Careya arborea* Roxb.
Lythraceae	*Lagerstroemioxylon arcotense* Awasthi 1981b	*Lagerstroemia flos-reginae* Retz. *L. lanceolata* Wall.
Sonneratiaceae	**Sonneratioxylon dakshinense* Ramanujam 1957	*Sonneratia* ?
	Sonneratioxylon preapetala Awasthi 1969a	*Sonneratia apetala* Ham.
	Duabangoxylon indicum (Navale) Awasthi 1981a Syn.	*Duabanga grandiflora* (Roxb. ex DC) Walp.
	Sapindoxylon indicum Navale 1957	*D. moluccana* Bl.
Sapotaceae	*Chrysophylloxylon pondicherriense* Awasthi 1977a	*Chrysophyllum roxburghii* Linn.
Ebenaceae	*Ebenoxylon arcotense* Awasthi 1970b	*Diospyros—Maba* *Diospyros assimilis* Bedd.
Alangiaceae	*Alangioxylon sclariforme* Awasthi 1969c	*Alangium javanicum* *A. meyeri*
Euphorbiaceae	*Putranjivoxylon puratanum* Ramanujam 1956c	*Putranjiva* wall.
	†**Bridelioxylon cuddalorense* Ramanujam 1956c	*Bridelia* ?
	†**B. miocenicum* (Ramanujam) Madel 1962 Syn. *Bischofioxylon miocenicum* Ramanujam 1960	*Bridelia* ?
	Paraphyllanthoxylon tertiarum (Ramanujam) Mädel 1962 Syn. *Glochidioxylon tertiarum* Ramanujam 1956c	Phyllanthoideae
	P. bangalamodense (Navale) Lakhanpal & Dayal 1964 Syn. *Phyllanthinium bangalamodense* Navale 1962	Phyllanthoideae
Ulmaceae	*Holopteleoxylon indicum* Awasthi 1977a	*Holoptelea integrifolia* Planch.
	Erythrophloexoxylon sitholeyi (Ramanujam) Müller-Stoll & Mädel 1967; Awasthi 1992 Syn. *Caesalpinioxylon sitholeyi* Ramanujam 1954	*Holoptelea*
Fagaceae	**Castanoxylon indicum* Navale 1964a	*Castanopsis* ?
	**C. tertiarum* Navale 1964a	*Castanopsis* ?

*Species marked (*) need re-investigation (see Awasthi, 1974b, 1992).
+Occurrence doubtful in the Cuddalore Series (see Awasthi, 1974b, 1975b).

Table 8—Neogene megafossils of peninsular North-east (Assam-Arakan Basin)

FAMILY	FOSSIL TAXA	MODERN TAXA	COMPARABLE LOCALITY	HORIZON-FORMATION/ SERIES/BED
Flacourtiaceae	*Homalioxylon assamicum* Prakash & Tripathi 1974	*Homalium tomentosum* Benth.	Kuchila near Hailakandi, Cachar District, Assam	Tipam Sandstone (Miocene)
Clusiaceae	*Kayeoxylon assamicum* Chowdhury & Tandon 1949	*Kayea assamica* Prain	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	Calophylloxylon eoinophyllum Prakash 1966a; Prakash & Awasthi 1970; Prakash & Awasthi 1971	*Calophyllum inophyllum* Linn.	Namsang River Bed Deomali, Arunachal Pradesh, Buri-Dehing River Bed near Jaipur, Assam	Probably Tipam Sandstone Dupitila Series (Miocene-Pliocene)
Dipterocarpaceae	*Dipterocarpoxylon chowdhurii* Ghosh 1956	*Dipterocarpus* Gaertn. f.	Buri-Dehing River between Nahorkatiya and Margherita.	Probably Tipam Series
	D. kalaicharparense Eyde 1963	*Dipterocarpus* Gaertn. f.	Kalaicharpara Hills in Garo Hills, Assam	Mid-Tertiary
	Anisopteroxylon garoense (Chowdhury) Prakash & Tripathi 1970b	*Anisoptera scaphula* Pierre *A. oblonga* Dyer	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	Shoreoxylon tipamense Prakash & Awasthi 1970	*Shorea assamica* Dyer	Buri-Dehing River Bed, Jaipur, Assam	Tipam Series
	S. deomaliense Prakash & Awasthi 1971	*Shorea* Roxb. ex. Gaertn.	Namsang River Bed near Deomali, NEFA	Namsang beds Dupitila Series
	S. evidens Eyde 1963	*Shorea* Roxb. ex. Gaertn.	Sonamati near Garo badha, Garo Hills, Assam	Mid-Tertiary
Celastraceae	*Gymnosporioxylon palaeomarginatum* Lalitha & Prakash, 1984	*Gymnosporia emarginata*	Sultanicherra, cachar District, Assam	Tipam Sandstone (Upper Miocene)
Sterculiaceae	*Sterculinium dattai* (Prakash & Tripathi) Guleria 1983 Syn. *Sterculioxylon dattai* Prakash & Tripathi 1974	*Sterculia villosa* Roxb.	Sultanicherra, Hailakandi, Cachar District, Assam	Tipam Sandstone
	S. varmahii (Lakhanpal, Prakash & Awasthi) Gurleria 1983 Syn. *Sterculioxylon varmahii* Lakhanpal *et al.* 1981	*S. alata* Roxb.	Namsang River Bed near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
	Heritieroxylon arunachalensis Lakhanpal *et al.* 1981	*Heritiera fomes* Buch	Namsang River Bed near Deomali Arunachal Pradesh	Namsang beds, Duptilia Series
Elaeocarpaceae	*Elaeocarpoxylon hailakandiense* Prakash & Tripathi 1975	*Elaeocarpus-Echinocarpus*	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
Burseraceae	*Burseroxylon preserratum* Prakash & Tripathi 1975	*Bursera serrata* Wall. ex. Coleb.	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	B. garugoides Lakhanpal *et al.* 1981	*Garuga pinnata* Roxb.	Namsang River Bed near Deomali Arunachal Pradesh	Namsang beds, Dupitila Series
Sapindaceae	*Pometioxylon tomentosum* Prakash & Tripathi 1970a	*Pometia tomentosa* Teysm et Binn.	Kartikcherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
Anacardiaceae	*Mangiferoxylon assamicum* Prakash & Tripathi 1970a; Lakhanpal *et al.*, 1981	*Mangifera indica* Linn.	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone

Contd.

Table 8—Contd.

FAMILY	FOSSIL TAXA	MODERN TAXA	COMPARABLE LOCALITY	HORIZON-FORMATION/ SERIES/BED
			Namsang River beds near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
	Glutoxylon burmense (Holden) Chowdhury 1952; Ghosh & Taneja 1961; Prakash & Tripathi 1969b; Prakash & Awasthi 1971	*Gluta-Melanorrhoea*	Near Nailabung Rly. St., Cachar Hills; Rath Tila about 25 km from Hailakandi, Assam	Tipam Series
			Buri Dehing River Bed near Jaipur, Assam	Tipam Sandstone
	Swintonia hailakandiense Prakash & Tripathi 1968, 1969a	*Swintonia floribunda* Griff.	Hailakandi, Cachar District, Assam	Tipam Series
	Lanneoxylon grandiosum Prakash & Tripathi 1967, 1969a	*Lannea grandis* Engler Syn. *Odina wodier* Roxb.	Road cutting at mile stone 9 on Dimapura-Diphu road in Mikir Hills, Assam	Tipam Series
	Holigarnoxylon assamicum Prakash & Awasthi 1970	*Holigarna beddomei* Hook. f.	Buri-Dehing River Bed Jaipur, Assam	Tipam Series
	Glutoxylon cacharense (Prakash & Tripathi) Guleria 1984b Syn. *Melanorrhoeoxylon cacharense* Prakash & Tripathi 1976	*Gluta*	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Series
	Anacardioxylon shardai Prakash & Tripathi 1976	—	Karitkcherra near Hailakandi, Cachar District, Assam	Tipam Series
Fabaceae (Leguminosae)	*Adenantheroxylon pavoninium* Prakash & Tripathi 1968, 1969a	*Adenanthera pavonina* Linn.	Hailakandi Cachar District, Assam	Tipam Series
	Cassinium prefistulai Prakash, Awasthi 1992 Syn. *C. cassioides* Prakash 1975 *Peltophoroxylon cassioides* Prakash & Awasthi 1970	*Cassia fistula* Linn.	Buri-Dehing River Bed near Jaipur, Assam	Tipam Series
	C. borooahi (Prakash 1966c; Prakash 1975		Mikir Hills, Assam	Tipam Sandstone
	C. tripuranum Acharya & Roy 1986	*Cassia* Linn.	Near Khowi bridge Teliamura, Tripura	Probably Tipam Sandstone
	Cynometroxylon holdeni (Gupta) Prakash & Bande 1980; Chowdhury & Ghosh 1946; Prakash 1966a; Prakash & Awasthi 1971; Prakash & Tripathi 1976	*Cynometra polyandra* Roxb. *C. ramiflora* Linn.	Sultanicherra near Hailakandi, Cachar District, Assam; Nailalung Rly. St. Assam	Tipam Sandstone
			Namsang River Bed near Deomali, NEFA	Namsang beds, Dupitila Series.
	Pahudioxylon assamicum Prakash & Tripathi 1975	*Afzelia-Intsia*	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	P. sahnii Ghosh & Kazmi 1961; Prakash 1966a; Prakash & Awasthi 1971	*Afzelia-Intsia*	Khowai bridge at Teliamura, Tripura;	Tipam Sandstone
			Namsang River Bed Deomali, Arunachal Pradesh	Dupitila Series

Contd.

Table 8—Contd.

FAMILY	FOSSIL TAXA	MODERN TAXA	COMPARABLE LOCALITY	HORIZON-FORMATION/ SERIES/BED
	P. deomaliense Prakash 1965	*Afzelia-Intsia*	Namsang River Bed Deomali, Arunachal Pradesh.	Dupitila Series
	Ougeinioxylon tertiarum Prakash & Tripathi 1977	*Ougeinia dalbergioides* Benth.	Sultanicherra near Hailakandi Cachar District, Assam	Tipam Sandstone
	Hopeoxylon assamicum Lalitha & Prakash 1980	*Sindora-Copaifera-Detarium*	Sultanicherra near Hailakandi Cachar District, Assam	Tipam Sandstone
	Albizinium eolebbekianum Prakash; Lakhanpal *et al.* 1981	*Albizia lebbek* Benth.	Namsang River Bed Near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
	Millettioxylon palaeopulchera Lakhanpal *et al.* 1981	*Millettia pulchra* Kurz.	Namsang River Bed near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
	M. bengalensis Ghosh & Roy; Acharya & Roy 1986	*M. pulchra* Kurz.	Near Khowai bridge Teliamura, Tripura	Probably Tipam Sandstone
	Kingiodendron prepinnatum Awasthi & Prakash 1987	*Kingiodendron pinnatum* Harms	Namsang beds along Namsang River at Deomali	Namsang beds (Mio-Pliocene)
	Bauhinia deomalica Awasthi & Prakash 1987	*Bauhinia foveolata* Dalz *B. racemosa* Lam.	Namsang beds along Namsang River at Deomali	Namsang beds (Mio-Pliocene)
	Bauhinia tertiara Awasthi & Mehrotra 1990	*B. racemosa* Lam.	Nagnimara Village Mon District, Nagaland	Tipam Series
	Koompassioxylon elegans Kramer; Awasthi & Mehrotra 1990	*Koompassia malaccensis* Benth.	Bimlapur, Dibrugarh District, Assam	Tipam Series
Combretaceae	*Terminalioxylon tertiarum* Prakash 1966a; Prakash & Awasthi 1970	*Terminalia tomentosa* Wight & Arn.	Namsang beds along Namsang River at Deomali, near Jaipur, Assam	Namsang beds (Mio-Pliocene) Tipam Series
	T. burmense (Prakash) Mädel-Angeliewa & Müller-Stoll, 1973 Syn. *Terminalia tomentosa* Prakash 1966b		Nagaland	
	T. coriaceum Prakash & Awasthi 1971	*T. coriacea* (Roxb.) W & A	Kartikcherra near Hailakandi; Namsang River Bed near Deomali, Assam	Dupitila Series Namsang beds
	Terminalioxylon chowdhurii Prakash & Navale 1963; Eyde 1963	*Terminalia* Linn.	Barail reserve, Cachar; Sanamati near Garobadha, Garo Hills, Assam	Mid-Tertiary
Barringtoniaceae (Lecythidaceae)	*Barringtonioxylon assamiam* Prakash & Tripathi 1972	*Barringtonia acutangula* (Linn.) Gaertn.	Kartikcherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	Careyoxylon pondicherriense Awasthi & Srivastava 1992 Syn. *C. kuchilense* Prakash & Tripathi 1972	*Careya arborea* Roxb.	Kuchila near Hailakandi, Cachar District, Assam	Tipam Sandstone
Lythraceae	*Lagerstroemioxylon eoflosreginium* Prakash & Tripathi 1970a	*Lagerstroemia flosreginae*	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone

Contd.

Table 8—Contd.

FAMILY	FOSSIL TAXA	MODERN TAXA	COMPARABLE LOCALITY	HORIZON-FORMATION/ SERIES/BED
	L. deomaliense Lakhanpal *et al.* 1981	*L. villosa* Wall.	Namsang River Bed near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
Sonneratiaceae	*Duabangoxylon tertiarum* Prakash & Awasthi 1970	*Duabanga grandiflora* Walp.	Buri-Dehing River Bed near Jaipur, Assam	Tipam Series
Sapotaceae	**Madhucoxylon cacharense* Prakash & Tripathi 1977	*Madhuca butyracea* Roxb.	Sultanicherra near Hailakandi, Cachar District, Assam	Tipam Sandstone
	Siderinium deomaliense Prakash & Awasthi 1970	?*Sideroxylon grandifolium* Wall.	Namsang River Bed near Deomali, NEFA	Namsang beds, Duplitila Series
Ebenaceae	*Ebenoxylon kartikcherraense* Prakash & Tripathi 1970b	*Diospyros-Maba* *Diospyros ebritioides* Wall.	Kartikcherra near Hailakandi, Cachar District, Assam.	Tipam Sandstone
	**E. indicum* Ghosh & Kazmi 1958	*Diospyros-Maba*	Namsang River Bed, NEFA	Probably Dupitila Series
Verbenaceae	*Vitexoxylon miocenicum* Prakash & Tripathi 1974	*Vitex canescens* Kurz	Kartikcherra near Hailakandi, Cachar District, Assam.	Tipam Series
Lauraceae	*Laurinoxylon tertiarum* Prakash & Tripathi 1974	*Dehassia-Cinnamomum*	Sultanicherra near Hailakandi, Cachar District, Assam.	Tipam Series
	L. namsangensis Lakhanpal *et al.* 1981	*Phoebe* Nees.	Namsang River Bed near Deomali, Arunachal Pradesh	Namsang beds, Duplitila Series
	L. deomaliensis Lakhanpal *et al.* 1981	*Alseodaphne-Actinodaphne*	Namsang River Bed near Deomali, Arunachal Pradesh	Namsang beds, Dupitila Series
	L. naginimariense Awasthi & Mehrotra 1990	—	Nagnimara Village Mon District, Nagaland	Tipam Sandstone
Euphorbiaceae	*Mallotoxylon assamicum* Prakash & Tripathi 1975	*Mallotus philippinensis* Muell-Arg.	Sultanicherra near Hailakandi, Cachar District, Assam.	Tipam Sandstone
	Paraphyllanthoxylon palaeoemblica Prakash *et al.* 1986	*Phyllanthus emblica* Linn.	Near Nailalung Railway Station, about 33 km from Lumding, Assam	Tipam Sandstone
Bischofiaceae	*Bischofia palaeojavanica* Awasthi 1989; Awasthi & Mehrotra, 1990	*Bischofia javanica* Bl.	Namsang River Bed Arunachal Pradesh; Nagnimara Village Mon District, Nagaland	Namsang beds; Tipam Series
Moraceae	*Artocarpoxylon kartikcherraensis* Prakash & Lalitha 1978	*Artocarpus chaplasha* Roxb. *A. incisa* Linn.	Kartikcherra near Hailakandi, Cachar District, Assam	Tipam Series
	Antiaris deomaliensis Awasthi 1989	*Antiaris toxicaria* Lesch.	Namsang River Bed, Deomali, Arunachal Pradesh	Namsang beds
	Dryoxylon sp. Chowdhury 1938	—	Garobadha, West of Tura, Garo Hills	Tipam Series
	Nipa salinii Lakhanpal 1952	*Nipa fruiticans*	Western extremity of Garo Hills	Upper Tertiary (Miocene)

*Species marked (*) need re-investigation.

luxuriant forest supported by high amount of precipitation during Mio-Pliocene. Most of these elements are presently confined to Western Ghats and Assam region. The absence of these elements in the present day flora of Cuddalore indicates distinct and drastic change in climate. Obviously the area has become drier since the Mio-Pliocene time. The flora is also phytogeographically significant as indicated by the occurrence of a number of Indo-Malayan taxa. The comparison of the flora with other known Neogene flora of India tends to suggest the age of Cuddalore Sandstone as Upper Miocene to Pliocene.

Table 9—Neogene megafossils of West Bengal (Bengal Basin) and Bihar

	FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/ SERIES AND LOCALITY
A) West Bengal				
GYMNOSPERMS	Araucariaceae	*Araucarioxylon* sp. Srivastava & Prakash 1984	*Araucaria-Agathis*	Tipam Series (=Miocene) Bolpur, Birbhum District
ANGIOSPERMS	Clusiaceae	*Calophylloxylon bengalense* Ghosh & Roy 1979e	*Calophyllum tomentosa* Wight *C. inophyllum* Linn.	Santiniketan near Bolpur, Birbhum District
		Kayea assamica Bande & Srivastava 1989	*Kayea assamica* King & Prain	Muhammad Bazar, Birbhum District
	Dipterocarpaceae	*Dipterocarpoxylon bolpurense* Ghosh & Roy 1979c	*Dipterocarpus* Gaertn. f.	Santiniketan, Birbhum District
		Shoreoxylon tipamense Prakash & Awasthi; Bande & Prakash 1980	*Shorea assamica* Dyer	Santiniketan, near Bolpur
		S. robustoides Roy & Ghosh 1981a	*S. robusta* Roxb.	Near Santiniketan, Birbhum District
		Anisopteroxylon santiniketanense Ghosh & Roy 1980b	*Anisoptera* Korth.	Santiniketan, near Birbhum District
		A. aduriensis Acharya & Roy 1989	*Anisoptera* Korth.	Aduria forest, Burdwan District
	Burseraceae	*Canarioxylon indicum* Ghosh & Roy 1978	*Canarium* Linn.	Santiniketan near Bolpur, Birbhum District
	Meliaceae	*Chisochetonoxylon bengalensis* Ghosh & Roy 1979d	*Chisocheton paniculatus* Hiern	Labpur, Birbhum District
	Anacardiaceae	*Dracontomelumoxylon mangiferumoides* Ghosh & Roy, 1979b; Roy & Ghosh 1981b	*Dracontomelum mangiferum* Blume	Labpur, Birbhum District
		Glutoxylon burmense (Holden) Chowdhury; Chowdhury & Tandon, 1952; Roy & Ghosh, 1979b	*Gluta-Melanorrhoea*	Garbeta, Midnapur District; Santiniketan, Birbhum District
		Glutoxylon garbetaense (Ghosh & Roy) Guleria 1984b Syn. *Melanorrhoeoxylon garbetaense* Ghosh & Roy 1980c; Roy & Ghosh, 1981b	*Gluta-Melanorrhoea*	Garbeta, Midnapur
		Mangiferoxylon assamicum Prakash & Tripathi; Ghosh & Roy 1980e; Roy & Ghosh 1981b.	*Mangifera indica* Linn.	Santiniketan—Labpur, Birbhum District
		Lanneoxylon grandiosum Prakash & Tripathi; Roy & Ghosh 1981b.	*Lannea coromandelica* (Houtt.) Merr.	Labpur, Birbhum District
		Buchananioxylon indicum Ghosh & Roy, 1980d; Roy & Ghosh 1981b	*Buchnania latifolia* Roxb.	Labpur, Birbhum District
	Fabaceae (Leguminosae)	*Pahudioxylon bankurensis* Chowdhury *et al.* 1960; Awasthi 1992	*Pahudia* Miq.	Bankura District
		Syn. *P. bengalensis* Ghosh & Roy 1982		Labpur, Birbhum District

Contd.

Table 9—Contd.

	FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/ SERIES AND LOCALITY
		Millettioxylon bengalensis Ghosh & Roy 1979a *M. indicum* Awasthi 1967; Awasthi 1992 Syn.	*Millettia pulchra* Kurz.	Garbeta, Midnapur District
		M. pongamiensis Prakash; Bande & Prakash 1980; Ghosh & Roy 1981a	*Millettia prainii* Dunn	Bolpur, Birbhum District; Labpur, Birbhum District
		Cassinium barooahii Prakash, Bande & Prakash 1980; Ghosh & Roy 1982 *C. prefistulai* Prakash; Awasthi 1992 Syn.	*Cassia siamea* Lam.	Santiniketan near Bolpur; Labpur, Birbhum District
		C. ballavapurense Ghosh & Roy 1981b	*Cassia fistula* Linn. *C. nodosa* Linn.	Bolpur, Birbhum District
		Cynometroxylon holdenii (Gupta) Prakash & Bande; Prakash & Bande 1980	*Cynometra ramiflora* Linn. *C. polyandra* Roxb.	Bolpur, Birbhum District
		C. indicum Chowdhury & Ghosh; Ghosh & Roy 1982	*Cynometra ramiflora* Linn *C. polyandra* Roxb.	Labpur, Birbhum District
		Koompassioxylon elegans Kramer; Bande & Prakash 1980	*Koompassia malaccensis* Benth.	Santiniketan near Bolpur
		Ormosioxylon bengalensis Bande & Prakash 1980	*Ormosia robusta* Wight *O. watsonii* Fischer	Shantiniketan near Bolpur
		Albizinum eolebbekianum Prakash; Ghosh & Roy 1981a	*Albizia lebbek* Benth.	Labpur, Birbhum District
		Peltophoroxylon ferruginoides Bande & Prakash 1980	*Peltophorum ferrugineum* Benth.	Bolpur, Birbhum District
	Combretaceae	*Anogeissusoxylon bengalensis* Roy & Ghosh 1979b	*Anogeissus acuminata* Wall.	Santiniketan, Birbhum District
		Terminalioxylon Deb & Ghosh 1974	*Terminalia* Linn.	Santiniketan near Bolpur, Birbhum District
		Terminalioxylon tertiarum Prakash; Ghosh & Roy 1980a	*Terminalia* Linn	Garbeta, Midnapur District
	Datiscaceae	*Tetrameleoxylon prenudiflora* Lakahanpal & Verma; Acharya & Roy 1989	*Tetrameles nudiflora* R. Br.	Aduria forest, Burdwan District
	Lauraceae	*Laurinoxylon* sp. cf. *namsangensis* Lakhanpal *et al.*, Bande & Srivastava 1989	*Phoebe attenuata* Nees. *P. goalparense*	Muhammad Bazar, Birbhum District
	Euphorbiaceae	*Mallotoxylon cleidionoides* Roy & Ghosh 1982	*Mallotus-Blumeodendron* *Trewia-Cleidion*	Bolpur, Birbhum District
	Arecaceae	*Palmoxylon coronatum* Sahni; Roy & Ghosh 1980	*Borassus* Linn.	Labpur, Birbhum District and Bishnupur, Bankura District
B) Bihar	Dipterocarpaceae	*Shorea robusta* Gaertn. f.		Leaves
	Sterculiaceae	*Sterculia villosa* Roxb.		Leaf

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Table 9—Contd.

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/ SERIES AND LOCALITY
	Pterygota alata (Roxb.) R. Br. Syn. *Sterculia alata* Roxb.		Leaf
Tiliaceae	*Grewia tiliaefolia* Vahl. Srivastava *et al.* (in press)		Leaf
Rutaceae	*Evodia meliaefolia* Benth.		Leaf
	Murraya paniculata (Linn.) Jack. Srivastava *et al.* (in press)		
Burseraceae	*Garuga pinnata* Roxb.		Leaf
Anacardiaceae	*Spondias pinnata* (Lf.) Kurz. Syn. *S. mangifera* Willd.		Leaf
	Mangifera indica Linn. Srivastava *et al.* (in press)		Leaf
Fabaceae	*Erythrina suberosa* Roxb.		Leaf
	Millettia auriculata Baker ex. Brandis		Leaf
	Ougenia oojeinensis (Roxb.) Hochr. Syn. *O. dalbergioides* Roxb.		Leaf
	Bauhinia sp. cf. *B. purpurea* Linn.		Leaf
	Hopeoxylon speciosum (Navale) Awasthi 1977 Syn. *H. arcotense* Awasthi 1977b Prakash, Mishra & Srivastava 1988		cf. *Sindora siamensis* Tesym ex Miq. Wood, Age—Mio-Pliocene
Combretaceae	*Combretum decandrum* Roxb.		Leaf
	Terminalia tomentosa Wight & Arn.		Leaf
	Terminalia tomentosa Wight & Arn. Srivastava & Bande 1992		Wood, Age—Mio-Pliocene
Rubiaceae	*Mitragyna parviflora* (Roxb.) Korth.		Leaf
Sapindaceae	*Schleichera oleosa* (Lour.) Oken Srivastava *et al.* (in Press)		Leaf
Sapotaceae	*Madhuca indica* J. F. Gmel		Leaf
Lythraceae	*Lagerstroemia* sp. cf. *L. parviflora* Roxb. Srivastava & Bande 1992		Wood, Age—Mio-Pliocene
Ebenaceae	*Diospyros montana* Roxb.		Leaf
Verbenaceae	*Vitex negundo* Var. *incisa* Clarke Srivastava *et al.* (in Press)		Leaf
Apocynaceae	*Alstonia scholaris* Brown		Leaf
Asclepidaceae	*Cryptolepis buchanani* Roem & Schult.		Leaf
Euphorbiaceae	*Mallotus philippensis* Muell-Arg.		Leaves
Utricaceae (Moraceae)	*Ficus foveolata* Wall. ex. Miq.		Leaf
	F. glaberrima Bl. Syn. *F. infectoria* Roxb.		Leaf
	F. tomentosa Roxb.		Leaf
	A dicot flower		Flower
	Dicot flowers Type I-IV Srivastava *et al.* (in Press)		Flowers
	Dicot fruit Type-1 cf. *Dillenia* sp.		Fruit
	Dicot fruit Type-2 cf. *Ziziphus xylopyrus* Willd.		Fruit
	Dicot fruit Type-3 cf. *Z. mauritiana* Lamk.		Fruit
	Dicot fruit Type-4 cf. *Dalbergia sissoo* Roxb.		Fruit

All the taxa against which no reference has been given, have been described by Bande and Srivastava, 1990. The age of the fossils other than the woods have been assigned as Upper Tertiary or Quaternary. All the above fossils have been reported from near Mahuadanr in Palamu District, Bihar.

Table 10—Neogene megaflora of central India

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES
Fabaceae	*Millettia* sp. *miocenica* Lakhanpal & Guleria; Yadekar & Pitchai Muthu 1988	*Millettia* spp.	Katni Formation (Mio-Pliocene)
Lythraceae	*Lagerstroemia* sp. ? Yadekar & Pitchai Muthu 1988	*Lagerstroemia indica* Linn.	Katni Formation (Mio-Pliocene)
Moraceae	*Ficus* sp. *khariensis* Lakhanpal & Guleria; Yadekar & Pitchai Muthu 1988	*Ficus infectoria* Roxb.	Katni Formation (Mio-Pliocene)
Polygonaceae	*Rumex* sp. *acetosella* Yadekar & Pitchai Muthu 1988	*Rumex Acetosella* Linn.	Katni Formation (Mio-Pliocene)

Table 11—Neogene megaflora of Andaman and Nicobar Islands

FAMILY	FOSSIL TAXA	MODERN COMPARABLE TAXA	HORIZON/FORMATION/SERIES/AGE
Corallinaceae	*Lithothamnion nummuliticum* Gee 1926 = (*Archaeolithothamnium nummuliticum*)	—	? Middle or Late Tertiary
	Lithothamnion suganum Gee 1926	—	? Middle or Late Tertiary
	Lithothamnium wilsonensis Chatterji & Gururaja 1972	—	Lower Limestone of the Archipelago Series of Lower Miocene (Aquitanian)
	Lithophyllum cf. *fosliei* (Hydr.) Hydr.; Chatterji & Gururaja 1972	—	Lower Limestone of the Archipelago Series of Lower Miocene (Aquitanian)
	Lithophyllum aff. *prelichenoides* Lemoine; Chatterji & Gururaja 1972	—	Lower Limestone of the Archipelago Series of Lower Miocene (Aquitanian)
	Lithophyllum sp. Chatterji & Gururaja 1972	—	Lower Limestone of the Archipelago Series of Lower Miocene (Aquitanian)
	Amphiroa oceanica Narayana Rao 1941-42	—	Oligo-Early Miocene
	Amphiroa cf. *prefragilissima* Lemoine; Chatterji & Gururaja 1972	—	Upper Limestone of the Archipelago Series of Lower Miocene
	Amphiroa sp. Chatterji & Gururaja 1972	—	Upper Limestone of the Archipelago Series of Lower Miocene
	Corallina andamanensis Narayana Rao 1941-1942	—	Oligo-Early Miocene
	Corallina roai Chatterji & Gururaja 1972	*Corallina*	Lower Limestone of Archipelago Series (Lower Miocene)
	Jania sp. Chatterji & Gururaja 1972	—	Lower Limestone of Archipelago Series (Lower Miocene)
Solenoporaceae	*Neosolenopora ramaraoi* Gururaja 1977	—	Limestone Hut Bay Formation (Middle Miocene).
	Aethesolithon sp. 1 Venkatachalapathy & Gururaja 1984	—	Miocene
	Aethesolithon sp. 2 Venkatachalapathy & Gururaja 1984	—	Miocene

(iii) *Neyveli lignite flora*—The Neyveli lignite deposits are situated in South Arcot district of Tamil Nadu and considered to be one of the biggest brown coal deposits of India. The lignite is associated with Cuddalore Sandstone and clays. The known megafossils of the lignite are based on carbonised woods and dispersed xylinoid and nonxylinoid tissues. However, woody tissues are not as common as nonoxylinoid tissues (Navale, 1974b). It was Jacob and Jacob (1950) who first reported the occurrence of leaf cuticles belonging to Oleaceae from the Neyveli lignite. The flora at present is represented by 22 families (see Table.6) and the important genera are: *Bouea, Cassia* or *Mimusops, Calophyllum* or *Mesua. Cassia* or *Acacia, Carallia, Careya, Cordia, Cryptostegia, Diospyros-Maba, Dipterocarpus, Dracaena, Excoecaria, Gluta, Grewia, Hopea, Lagerstroemia, Litsea, Parinari,* *Randia, Shorea, Sterculia* and *Terminalia*. In addition, leaf cuticles belonging to Arecaceae, Poaceae and wood fragments of Euphorbiaceae have also been reported. The evidence provided by the fossils and by the petrologic nature (Navale, 1968b; Misra, 1992) of the lignite suggests the existence of humid tropical conditions during the formation of the lignite. The occurrence of Dipterocarpaceae, Ebenaceae, Sapotaceae, *Gluta* and the general similarity exhibited by the Neyveli flora with other Neogene floras of India suggests an Upper Tertiary age of the lignite. On the contrary, microfossil workers have inferred various ages for the Neyveli lignite ranging from Palaeocene-Eocene (Saxena, 1992), Eocene (Deb *et al.*, 1973; Venkatachala, 1973) and Miocene (Ramanujam, 1982; Singh *et al.*, 1992; Misra, 1992).

3. North-east Flora (Assam-Arakan Basin)

The flora comprises mostly of dicotyledonous woods. In addition, a fruit of *Nypa* and a few dicot leaves have also been reported (Lakhanpal, 1952; Seward, 1912). The earliest record of the fossil woods from this region goes back to 1882 when Schenk reported the occurrence of *Cedroxylon hermanii* from Dischaipur (Jaipur), Assam. This wood was subsequently discarded by Sahni (1931b) on account of incomplete preservation and lack of diagnostic features of the family Abietineae. At present about 45 genera belonging 20 families have been described by various workers (see Table 8). The important components of the flora are *Adenanthera, Afzelia-Intsia, Albizia, Anisoptera, Antiaris, Artocarpus, Bauhinia, Barringtonia, Bursera-Garuga, Calophyllum, Careya, Cassia, Cinnamomum-Dehasia, Cynometra, Diospyros, Dipterocarpus, Duabanga, Elaeocarpus-Echinocarpus, Gluta, Heritiera, Holigarnia, Homalium, Kayea, Kingiodendron, Koompassia, Lagerstroemia, Lannea* or *Odina, Madhuca, Mangifera, Mallotus, Millettia, Ougeinia, Phyllanthus, Pometia, Sindora-Capaifera-Detarium, Shorea, Sterculia, Swintonia, Terminalia* and *Vitex*. All these elements indicate the existence of warm tropical rain forest conditions in the area during Neogene. Most of these components are still growing in the area. From this evidence it can be inferred that the vegetation and climate had not changed much since the Neogene. The occurrence of *Nypa* in Garo Hills, *Afzelia-Intsia* and *Cynometra ramiflora* near Hailakandi in Mezoram indicates the existence of coastal conditions in the area during the Neogene. Obviously, sea had receeded to its present position since Neogene. The occurrence of certain genera like *Anisoptera, Dipterocarpus, Koompassia, Pometia* indicates the migration of Indo-Malayan elements in the flora.

4. Bengal and Bihar Neogene Flora

(A) *West Bengal (Bengal Basin)*—A rich flora, comprising mainly the fossil woods has been worked out from the Neogene exposures of Midnapur, Bankura, Birbhum and Bardhaman District of peninsular part of West Bengal. The flora consists of 26 genera belonging to 10 dicotyledonous families (see Table 9A). In addition, a palm and an araucarian wood have also been reported. The important components of the flora are: *Afzelia-Intsia, Anisoptera, Agathis-Araucaria, Calophyllum, Canarium, Cassia, Cynometra, Dipterocarpus, Mangifera, Dracontomelum, Gluta, Kayea, Koompassia, Laurinoxylon, Shorea*. The vegetation indicates the occurrence of warm tropical climate. The flora shows general similarity with other Neogene floras of India particularly with that of the North-east and the Cuddalore. The flora of West Bengal, like Cuddalore flora, indicates change in climatic conditions although the change has not been as drastic as in the case of flora of Cuddalore.

(B) *Bihar*—A Late Tertiary flora consisting of a large number of taxa mostly based on impression of leaves, fruits, flowers and a few petrified woods has recently been reported from the Palamu District in South Bihar (see Table 9B). The assemblage comes from two different horizons considered to be of Upper Tertiary age (Puri & Misra, 1982) exposed around village Mahudanr. The woods have been derived from the sandstone bed whereas a large number of impressions come from the overlying shaly bed. *Sindora, Terminalia* and *Lagerstroemia* which are represented by fossil woods in the Palamu flora have been reported from the Pliocene deposits of Kutch and Rajasthan. On this basis it is surmised that the woods may belong to Pliocene. Gymnosperms are totally lacking and the assemblage is represented by a large number of taxa belonging to Fabaceae. Thus the available evidence suggests that drier conditions had set in by the time the shaly material was preserved. *Dipterocarpus* and *Anisoptera* which were wide spread up to Pliocene in India as seen in Kutch and Rajasthan are lacking and the family Dipterocarpaceae is represented in Palamu flora only by *Shorea robusta*, which relatively grows in dry habitats. This probably indicates that the assemblage of shaly bed represented by impressions may belong to post-Pliocene time which continued till today. This is also supported by the very close similarity of the present day flora with that of the fossil one. However, more work in this area will help in deciphering the precise age of the flora.

5. Central Indian Neogene Flora

Yadekar and Pitchai Muthu (1988) reported the occurrence of angiospermic plant remains belonging to both dicots and monocots from the sediments of Katni Formation in Madhya Pradesh (see Table 10). The formation has been assigned Mio-Pliocene age. The assemblage consists of impressions of leaves representing Leguminosae (*Millettia*), Lythraceae (*Lagerstroemia*), Moraceae (*Ficus*) and a seed cast of (*Rumex*) Polygonaceae. This is probably the first record of Neogene plant fossils from the central India. More work is required in this area to have a better picture of the flora of this region.

6. Andaman and Nicobar Islands Neogene Flora

The area has practically remained uninvestigated as far as the megafossils are concerned except for a few records of Red algae (Table 11). Gee (1926) was the first to report the occurrence of *Lithothamnion* which is now recognised as *Archaeolithothamnium*. The other known members of the assemblage are *Aethesolithon, Amphira, Corallina, Jania, Lithophyllum, Lithothamnium* and *Neosolenopora*. Obviously the area needs detailed exploration for the study of megafossils of higher plants in order to know the past flora of the islands.

SIGNIFICANT CONCLUSIONS

The Neogene vegetation of peninsular India is mainly represented by dicotyledonous woods which are widely distributed throughout the peninsula. Palms are infrequent and gymnosperms rare.

During Neogene entire peninsula was covered by rich vegetation since the climate must have been more or less uniform on account of situation of the Indian peninsula in the tropical zone.

All the floras from different basins show very close similarity in their composition as most of the genera are common. The wide distribution of tropical rain forest family Dipterocarpaceae from East to West and North to South along with other genera clearly indicates a more or less uniform tropical moist climate throughout the peninsular India during the Neogene.

Aridity could have gradually increased towards the close of Neogene due to the growing continentality caused by the rise of the Himalayan mountains and disappearance of the Tethys Sea in the North. This resulted in complete eradication of dipterocarps from Kutch, Rajasthan, Cuddalore and their recession from the western Himalayan foot-hills to north eastern India.

There were large scale migrations and admixture of floras over Malaysia, India, Arabia and Africa during Neogene due to establishment of land connections by Early Miocene. This was most probably the time when dipterocarps migrated into India, colonised the peninsula and spread westward to Africa via Rajasthan, Kutch and Arabia. Likewise some genera did migrate into India from Africa as seen particularly in the flora of Kutch and Rajasthan.

The presence of some families and genera such as Dipterocarpaceae, Ebenaceae, Rhamnaceae, Sapotaceae, *Afzelia-Intsia, Gluta, Swintonia* along with the dominance of legumes distinguishes the Neogene flora from the Palaeogene flora of India.

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