PALAEOENVIRONMENTAL ANALYSIS OF INDIAN TERTIARY FLORAS

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ABSTRACT

In order to decipher the environments during the Tertiary of India, an attempt has been made to analyse the generic composition of five Tertiary floras of the Indian sub-continent. The genera known from each flora have been classified into 1) native genera, now living in the geographic region of the fossil deposit, (2 exotic genera, no longer present in the geographic region of the fossil flora, and 3) genera which are botanically unidentified or extinct. The statistical representation of these in each flora is related to the geologic age. Changing ratios of the three categories indicate floral changes and the plant migrations due to climatic changes during the Cenozoic.

INTRODUCTION

The possibility of reconstructing past environments depends on the accurate identification of diverse members of fossil assemblages. Therefore, in order to infer the climate and the floral changes during the Tertiary of India, a critical analysis has been made of the generic composition of five Tertiary floras of the sub-continent viz., those of the Deccan Intertrappean series, the Siwalik beds, the Tipam series, the Cuddalore series and the Dupitila series (Tables 1-5), which are now known to a greater extent. Attempts have also been made to find out the nearest comparable modern forms of the fossils in terms of living species, wherever possible. In order to simplify the analysis of the above floras and to give it more uniformity attention is confined only to Spermatophytes including both the gymnosperms and angiosperms. Besides only the megafossil elements have been taken into consideration leaving out the microfossil forms primarily because in most cases the pollen and spores described from these Tertiary deposits have been classified artificially and their identification with modern plants is as yet not definite.

In each case the botanical components of the fossil flora have been classified into (*a*) extant genera now represented in the modern flora of the geographic region of the fossil deposit, (*b*) extant genera now exotic to the bordering geographic areas of the deposit, called exotic, and (*c*) those which are not assigned to a living genus and can be regarded as extinct or botanically unidentified. This analysis has shown that the Early Tertiary flora of India is featured by a large number of unidentified or extinct and exotic elements, which decline appreciably during the Late Tertiary when the genera native at present to the respective geographic areas increase at an almost exponential rate indicating somewhat similar pattern as that of the modern vegetation except some regional migration that has occurred in the distribution of some taxa.

It should also be noted here that out of the three categories of the generic groups the exotic genera are more significant than the other two with respect to the floral changes and the plant migrations during the geologic time. The exotic types give us a better estimate of

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past environment because they reflect a different climate than that of native group near the locality.

FLORISTIC COMPOSITION

The fossil floras so far known from the Tertiary of India can be classified into (*a*) Palaeogene flora, almost exclusively of Eocene age, and (*b*) Neogene flora, largely of Miocene age. The Palaeogene flora as revealed here (Table 1) is represented by the assemblage of petrified flowers, fruits, leaves and woods in contrast to almost only leaf impressions and fossilized fragments of woods in the Neogene (Tables 2—5).

The most striking fact about the Tertiary plant remains is the paucity of conifers throughout although they are comparatively better represented during the Palaeogene. Another interesting feature is the rich assemblage of palms in the Intertrappean flora of the Palaeogene and their scarcity during the Neogene period.

Further there is a definite evidence among the angiosperms that the following families and genera appeared during the Palaeogene in India and continued till the present time.

Palmae—*Nypa*
Smilaceae
Flacourtiaceae
Guttiferae—*Mesua*, ? *Calophyllum*
Elaeocarpaceae—*Elaeocarpus*
Simaroubaceae—*Ailanthus*
Burseraceae
Sapnidaceae
Anacardiaceae
Leguminosae
Combretaceae—*Terminalia*
Lecythidaceae—*Barringtonia*
Sonneratiaceae—*Sonneratia*
Lauraceae
Euphorbiaceae—*Mallotus*, ? *Bridelia*

Out of these, the families Leguminosae and Combretaceae which were very meagrely represented earlier, became abundant in the Neogene deposits.

It would be interesting also to note that out of a number of families that have appeared so far in the fossil record of Neogene, the family Dipterocarpaceae is represented so abundantly in all the deposits throughout the country that considering the modern distribution of the taxa known then, it has revealed some interesting data of phytogeographical importance.

In the following pages attempts are being made to draw some striking conclusions regarding the climatic and floral changes during the Tertiary of India based mostly on the exotic types which effectively measure the difference between the past and the present climate of the region.

CLIMATIC AND PHYTOGEOGRAPHICAL CONSIDERATIONS

It is evident from the known fossil plants from the Tertiary of India, as presented in the lists shown here, that several of these are yet to be recognised in terms of modern genera and species, especially those belonging to Palmae. Therefore, the present interpretations are only generalized and would be supported by further investigations.

Based on the modern distribution of the genera represented by the fossil plants, the flora of India during the Tertiary was predominantly tropical or sub-tropical in nature, the conifers and some other forms (*Sparganium*) might be growing on the uplands.

Considering the Eocene flora of the Deccan Intertrappean series one at once notices that only some of the fossils have reliably been assigned to modern genera while others are described without any proper generic affinities. However, it needs tremendous

Table 1—Plant remains from the Deccan Intertrappean series (Early Eocene)

Family	Fossil species	Modern comparable form	Locality	Reference
GYMNOSPERMAE				
CONIFERALES				
?Abitineae	1. *Indostrobus bifidolepis Sahni*			Sahni, 1931*a*
	2. *Takliostrobus alatus* Sahni		Takli	Sahni, 1931*a*
	3. *?Pityostrobus crassitesta* Sahni		Takli	Sahni, 1931*a*
Araucariaceae	4. *Mohgaostrobus sahnii* Prakash	*?Araucaria*	Mohgaon kalan	Prakash, 1956*a*, 1959a
	5. *Dadoxylon deccani* Shukla		Chhindwara district	Shukla, 1938
	6. *D. resinosum* Shukla		Chhindwara district	Shukla, 1944
	7. *D. eocenum* Chitaley		Chhindwara	Chitaley, 1949
	7a *D. shuklai* Singhai		Chhindwara district	Singhai, 1958
ANGIOSPERMAE MONOCOTYLEDONS				
Musaceae	8. *Musa cardiosperma* Jain	*Musa* spp.	Mohgaon Kalan	Jain, 1964*a*
	9. *Musocaulon indicum* Jain	*Musa* or *Ensete*	Mohgaon Kalan	Jain, 1964*b*; Rao & Menon, 1963*a*
Smilaceae	10. *Smilacites mohgaoensis* Nambudiri	*?Smilax aspera*	Mohgaon Kalan	Nambudiri, 1966*a*
Zingiberaceae	11. *Amomocarpum sulcatum* Sahni	*Ellettaria*	Unknown	Sahni, Srivastava & Rao, 1934
	12. *A. affine* Sahni	*Ellettaria cordamomum*	Unknown	Sahni, 1940, 1964
Cyclanthaceae	13. *Cyclanthodendron sahnii* (Rode) Sahni & Surange	*Cyclanthus, Carludovica*	Mohgaon Kalan	Sahni & Surange, 1944, 1953; Ramanujam, 1959
	14. Floral axis of Cyclanthaceae		Mohgaon Kalan	Mahabale, 1950
Sparganiaceae	15. *Sparganium* sp. Mahabale	*Sparganium*	Mohgaon Kalan & Sausar	Mahable, 1953
?Araceae	16. *Viracarpon hexaspermum* Sanni		Mohgaon Kalan and Takli	Carter, 1884; Sahni, 1934, 1944; Chitaley, 1954, 1958; Shukla, 1944
	17. *V. elongatum* Sahni syn. *Shuklanthus superbum* Verma		Takli & Mohgaon Kalan	Sahni, 1944; Verma 1956 ; Chitaley & Patil, 1971
	18. *V. tenue* Sahni		Unknown	Sahni, 1964
	19. *Sahnipushpam shuklai* Verma		Mohgaon Kalan & Mahurzari	Verma, 1956; Prakash 1956b; Prakash & Jain, 1964
Gramineae	20. Wood cf. Bamboo		Worli & Malabar Hills, Bombay and Mohgaon Kalan	Carter, 1852; Shukla, 1942

Cyperaceae	21. Stem and Flower cf. *Scirpus*	*Scirpus*	Worli & Malabar Hills, Bombay.	Carter, 1852.
	22. *Cyperaceoxylon intertrappeum* Chitaley & Patel		Mohgaon Kalan	Chitaley & Patel, 1970.
Palmae	23. *Palmoxylon blanfordi* Schenk		Near Jhansi on the Narbada	Schenk, 1882; Sahni 1931*b*, 1964
	24. *P. liebigianum* Schenk		Sitabaldi	Sahenk, 1882; Sahni, 1931*b* 1964
	25. *P. edwardsi* Sahni		Near Jabbalpur	Sahni, 1931*b*, 1964.
	26. *P. sagri* Sahni		Saugar	Sahni, 1964
	27. *P. kamalam* Rode		Mohgaon Kalan & Reserve Forest near Pupuldoh village	Rode, 1933; Shukla, 1939; Sahni, 1964.
	28. *P. hislopi* Rode		Mohgaon Kalan	Rode, 1933; Sahni, 1964
	29. *P. sclerodermum* Sahni		Seoni & Nawargaon	Sahni, 1943; Shukla, 1946
	30. *P. (Cocos) sundaram* Sahni	*Cocos nucifera*	Saugar	Sahni, 1946
	31. *P. sundaram* Sahni var. *vidarbhai* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1964*a*
	32. *P. surangei* Lakhanpal		Keria	Lakhanpal. 1956
	33. *Palmoxylon* cf. *Phoenix*	*Phoenix rupicola* and *Phoenix robusta*	Mohgaon Kalan	Mahabale, 1959
	34. *P. chhindwarense* Prakash		Mohgaon Kalan	Prakash, 1960*a*
	35. *P. dakshinense* Prakash		Mohgaon Kalan	Prakash, 1960*a*
	36. *P. eocenum* Prakash		Mahurzari	Prakash, 1962
	37. *P. narayanai* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1962
	38. *P. parthasarathyi* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1964*b*
	39. *P. mahabalei* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1967
	40. *P. mahesharii* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1963*b*
	41. *P. trabeculosum* Sahni		Saugar	Sahni, 1964
	42. *P. fibrosum* Menon		Mohgaon Kalan	Menon, 1965*a*
	43. *P. deccanense* Sahni		Maragour	Sahni, 1964
	44. *P. krishna* Sahni		Sitabaldi	Sahni, 1931*b*, 1964
	45. *P. scotti* (Menon) Dayal and Menon		Mohgaon Kalan	Menon, 1964*a*; Dayal and Menon, 1965.
	46. *P. pyriforme* Sahni		Mohgaon Kalan	Rao & Menon, 1968
	47. *P. intertrappeum* Sahni		Sindhi Vihira	Sahni, 1964.
	48. *P. kraeuselii* Rao & Menon		Mohgaon Kalan	Rao & Menon, 1966
	49. *P. raci* Menon		Mohgaon Kalan	Menon, 1968
	50. *P. superbum* Trivedi & Verma		Keria	Trivedi & Verma, 1971*a*
	51. *P. cordatum* Trivedi & Surange		Mohgaon Kalan	Trivedi & Surange, 1969
	52. P. *mohgaoensis* Trivedi & & Surange		Mohgaon Kalan	Trivedi & Surange, 1970

Table 1 [contd.]—Plant remains from the Deccan Intertrappean series (Early Eocene)

Family	Fossil species	Modern comparable form	Locality	Reference
	53. *Palmocaulon mohgaonense* Deshpande		Mohgaon Kalan	Deshpande, 1960
	54. *P. raoi* Menon		Mohgaon Kalan	Menon, 1964*b*
	55. *P. mahabalei* Menon		Mohgaon Kalan	Menon, 1965*b*
	56. *Rhizopalmoxylon indicum* Sahni	*Nipa fruiticans*	Mohgaon Kalan	Sahni, 1938; Mahabale & Udwadia, 1960
	57. *Palmostrobus* sp. Mahabale		Mohgaon Kalan	Mahabale, 1950
	58. *Palmophyllum dakshinense* Achutan		Mohgaon Kalan	Achutan ,1968
	59. *Palmocarpon mohgaoense* Prakash		Mohgaon Kalan	Prakash, 1954
	60. *P. insigne* Mahabale		Mohgaon Kalan	Mahabale, 1950
	61. *P. sulcatum* Prakash		Mohgaon Kalan	Prakash, 1960*b*
	62. *P. indicum* Prakash		Mohgaon Kalan	Prakash, 1960*b*
	63. *P. compressum* (Rode) Sahni		Mohgaon Kalan	Sahni & Rode, 1937
	64. *P. (Iriartites) takliensis* Sahni		Takli	Sahni, Srivastava & Rao, 1934
	65. *Palmocarpon* spp. Sahni			Sahni, Srivastava & Rao, 1934
	66. *P. bracteatum* Sahni			Sahni, Srivastava & Rao, 1934
	67. *Nipa hindi* (Rode) Sahni	*Nipa fruiticans*	Mohgaon Kalan	Sahni & Rode, 1937
	68. *Nipadites* sp. Bowerbank		Takli	Carter, 1854
	69. *Nipa* sp.	*Nipa*	Mohgaon Kalan	Chitaley, 1960*a*, 1960*b*;Nambudiri, 1966*b*
	70. *Tricoccites trigonum* Rode		Mohgaon Kalan	Sahni & Rode, 1937
	71. Fruiting axis of *Tricocates trigonum* Rode		Mohgaon Kalan	Shukla,1950*a*; Chitaley,1956
DICOTYLEDONS				
Flacourtiaceae	72. *Flacourtiaites intertrappeum* Nambudiri	*Flaccurtia indica*	Mohgaon Kalan	Nambudiri, 1966*a*
?Malvaceae	73. *Hibiscoxyloni ntertrappeum* Tirvedi & Ambwani	*?Hibiscus*	Mahurzari	Trivedi & Ambwani, 1971
Tiliaceae	74. *Grewioxylon mahurzariense* Prakash & Dayal	*Grewia laevigata*	Mahurzari	Prakash & Dayal, 1963, 1965*b*
	75. *G. indicum* Prakash & Dayal	*G. tiliaefolia*	Mahurzari	Prakash & Dayal, 1965*b*
	76. *G. intertrappeum* Shallom	*Grewia* probably *G. laevigata*	Mahurzari	Shallom, 1963*b*
Elaeocarpaceae	77. *Elaeocarpoxylon antiquum* Prakash & Dayal	*Elaeocarpus ferrugineus*	Mahurzari	Prakash & Dayal, 1964

Simaroubaceae	78. *Ailanthoxylon indicum* Prakash	*Ailanthus malabarica*	Mohgaon Kalan, Mahurzari, and Near Rewa.	Prakash 1959*b*; Shallom, 1961, Saksena, 1963; Prakash, Verma & Dayal, 1967.
	79. *A. ghiarense* (Saksena) Prakash, Verma & Dayal	*Ailanthus grandis*	Ghiar, Rewa	Saksena, 1963; Prakash, Verma & Dayal, 1967
	80. *Simarouboxylon indicum* Shallom	*Simaroba* spp.	Mohgaon Kalan	Shallom, 1960*a*; Prakash, 1964.
Burseraceae	81. *Boswellioxylon indicum* Dayal	*Boswellia serrata*	Keria	Dayal, 1964 ,1966
	82. Wood cf. Burseraceae		Mahurzari	Shallom, 1958
Sapindaceae	83. *Sapindoxylon schleicheroides* Dayal	*?Schleichera trijuga*	Keria	Dayal, 1965
	84. *S. chhindwarensis* Chitaley & Shallom		Mohgaon Kalan	Chitaley & Shallom, 1969
Ampelidaceae	85. *Leeoxylon multiseriatum* Prakash & Dayal	*Leea* spp.	Mahurzari	Prakash & Dayal, 1964
Anacardiaceae	86. *Anacardioxylon semecarpoides* Prakash & Dayal	*?Semecarpus* spp.	Mahurzari	Prakash & Dayal, 1965*a*
Leguminosae	87. *Aeschynomene tertiara* Prakash	*Aeschynomene* sp.	Mahurzari	Prakash, 1962, 1963
	88. Fruit cf. Hedysareae		Takli	Carter, 1854
	89. Fruit cf. *Cassia*		Takli	Carter, 1854
	90. Fruit cf. *Faboidea* Bowerbank		Takli	Carter, 1854
	91. Fruit cf. *Xulinosprionites*		Takli	Carter, 1854
	92. Leaflets cf. *Acacia*		Worli & Malabar Hills	Carter, 1852
Combretaceae	93. *Terminalioxylon tomentosum*	*Terminalia tomentosa*	Ghala	Mahabale & Deshpande, 1965
?Myrtaceae	94. *Dryoxylon mohgaoense* Rode		Mohgaon Kalan	Rode, 1936; Prakash, 1957
Lecythidaceae	95. *Barringtonioxylon deccanense* Shallom	*Barringtonia acutangla*	Mahurzari	Shallom, 1960*b*
	96. *B. eopterocarpum* Prakash & Dayal	*Barringtonia pterocarpa*	Mahurzari	Prakash & Dayal, 1965*c*
?Lythraceae	97. Leaf cf. *?Lygerstroemia*	*?Lagerstoremia indica*	Mohgaon Kalan & Bharatwada	Shukla, 1950*b*; Trivedi, 1956
Sonneratiaceae	98. *Sonneratioxylon dudukurense* Krishna Rao & Ramanujam	*Sonneratia* sp.	Dudukur, near Rajahmundry	Krishna Rao & Ramanujam, 1966.
	99. Wood cf. *Sonneratia*	*?Sonneratia* spp.	Mohgaon Kalan	Verma, 1950
	100. Wood cf. *Sonneratia* & *Duabanga*	*?Duabanga* spp. & *?Sonneratia* spp.	Paladon	Shallom, 1963*a*
	101. *Sahnianthus parijai* Shukla	*Sonneratia acida* &	Mohgaon Kalan	Shukla, 1944; Chitaley, 1955; Mahabale & Deshpande, 1957
	102. *Enigmocarpon parijai* Sahni	*Sonneratia apetala*	Mohgaon Kalan & Bharatwada	Sahni, 1943; Dwivedi, 1956; Mahabale & Deshpande 1957
Euphorbiaceae	103. *Bridelioxylon krauselii* (Prakash) Mädel	*Bridelia* spp.	Keria	Prakash, 1959*c*; Mädel, 1962
	104. *Mallotoxylon keriense* Lakhanpal & Dayal	*Mallotus philippinensis*	Keria	Lakhanpal & Dayal, 1964

Table 1 [contd.]—Plant remains from the Deccan Intertrappean series (Early Eocene)

Family	Fossil species	Modern comparable form	Locality	Reference
	105. *Paraphyllanthoxylon sahnii* (Prakash) Mädel	Phyllanthoideae group	Mahurzari	Prakash, 1959*b*; Mädel, 1962
	106. *Paraphyllanthoxylon keriense* Dayal	*?Bischofia*	Keria	Dayal, 1968
	107. *Euphorbioxylon sagarense* Mahabale & Deshpande	*?Bridelia* sp.	Sagar	Mahabale & Deshpande, 1963
Datiscaceae	108. *Tetrameleoxylon prenudiflora* Lakhanpal and Verma	*Tetrameles nudiflora*	Mohgaon Kalan	Lakhanpal & Verma, 1966
Guttiferae	109. Wood cf. Guttiferae		Mahurzari	Shallom, 1963*c*
Rutaceae	110. Wood cf. Rutaceae		Near Nagpur	Chitaley & Shallom, 1962
Incertae sedis	111. *Aerorhizos harrisi* Chitaley		Mohgaon Kalan	Chitaley, 1962, 1963.
	112. *Dicotylirhizos sahnii* Rao		Mohgaon Kalan	Rao, 1958
	113. *Phyllites mohgaoensis* Rode		Mohgaon Kalan	Rode, 1935
	114. *Dicotylophyllum mohgaonensis* Nambudiri		Mohgaon Kalan	Nambudiri, 1966*a*
	115. *D. intertrappeum* Nambudiri		Mohgaon Kalan	Nambudiri, 1966*a*
	116. *Indocarpa interappea* Jain		Mohgaon Kalan	Jain, 1964*c*
	117. *Carpolithus striatus* Jain & Dayal		Mohgaon Kalan	Jain & Dayal, 1966

For References also see Prakash, 1960c, 1965a.

Table 2—Plant remains from the Tipam series, Eastern India (Upper Miocene)

Family	Fossil species	Modern comparable form	Locality	Reference
ANGIOSPERMAE				
DICOTYLEDONS				
Flacourtiaceae	1. *Homalioxylon assamicum* Prakash & Tripathi	*Homalium tomentosum*	Kuchila near Hailakandi, district Cachar, Assam	Prakash & Tripathi, 1973*b*
Guttiferae	2. *Kayeoxylon assamcium* Chowdhury & Tandon	*Kayea*	Sultanicherra near Hailakandi distt. Cachar and Thalangthu river bed on Dhansiri Manglumakh cart road.	Chowdhury & Tandon, 1949; Prakash & Tripathi, 1973*a*
Dipterocarpaceae	3. *Dipterocarpoxylon chowdhurii* Ghosh	*Dipterocarpus*	Bur-Dihing river bed between Naharkotiya and Margherita	Ghosh, 1956
	4. *Anisopteroxylon garoense* (Chowdhury) Prakash & Tripathi	*Anisoptera*	Sultanicherra near Hailakandi, distt. Cachar.	Chowdhury, 1938; Prakash & Tripathi, 1970*b*
Sterculiaceae	5. *Sterculioxylon indicum* Prakash & Tripathi	*Sterculia*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*b*
Elaeocarpaceae	6. *Elaeocarpoxylon hailakandiense* Prakash & Tripathi	*Elaeocarpus-Echinocarpus*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*c*
Burseraceae	7. *Burseroxylon serratum* Prakash & Tripathi	*Bursera serrata*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*a*
Sapindaceae	8. *Pometioxylon tomentosum* Prakash & Tripathi	*Pometia tomentosa*	Kartikicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1970*a*
Anacardiaceae	9. *Mangiferoxylon assamicum* Prakash & Tripathi	*Mangifera indica*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1970*a*
	10. *Glutoxylon burmense* (Holden) Chowdhury	*Gluta-Melanorrhoea*	Hailakandi, distt. Cachar	Chowdhury, 1952; Prakash & Tripathi, 1969*b*
	11. *Lanneoxylon grandiosum* Prakash & Tripathi	*Lannea grandis*	Dimapur-Diphu road, Mikir Hills.	Prakash & Tripathi, 1967, 1969*a*.
	12. *Swintonioxylon hailakandiense* Prakash & Tripathi	*Swintonia floribunda*	Near Hailakandi, distt. Cachar	Prakash & Tripathi, 1968, 1969*a*.
Leguminosae	13. *Adenantheroxylon pavoninium* Prakash & Tripathi	*Adenanthera pavoonina*	Near Hailakandi, distt. Cachar	Prakash & Tripathi, 1968, 1969*a*.
	14. *Ingoxylon indicum* Prakash & Tripathi	*Albizzia procera*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*c*
	15. *Cynometroxylon indicum*	*Cynometra*	Dimapur-Diphu road, Mikir Hills.	Chowdhury & Ghosh, 1946; Prakash, 1966*c*.
	16. *Leguminoxylon tertiarum* Prakash & Tripathi.	*?Ougenia*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*c*

Family	Fossil species	Modern comparable form	Locality	Reference
	17. *Peltophoroxylon borooahii* ..	*Cassia siamea*	Dimapur-Diphu road, Mikir Hills.	Prakash, 1966*c*; Prakash & Awasthi, 1970
	18. *Pahudioxylon assamicum* Prakash & Tripathi.	*Afzelia-Intsia*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*c*
Combretaceae	19. *Terminalia tomentosa*	*Terminalia tomentosa*	Near Kongan coalfield, Nagaland.	Prakash, 1966*b*.
	20. *Terminalioxylon chowdhurii* Prakash & Navale	*Terminalia*	Barail reserve, Cachar Hills.	Prakash & Navale, 1963.
Lecythidaceae	21. *Barringtonioxylon assamicum* Prakash & Tripathi.	*Barringtonia*	Kartikecherra near Bailakandi, distt. Cachar.	Prakash & Tripathi, 1972
	22. *Careyoxylon kuchilense* Prakash & Tripathi.	*Careya arborea*	Kuchila near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1972
Lythraceae	23. *Lagerstroemioxylon eoflosreginum* Prakash & Tripathi.	*Lagerstroemia flosregine*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1970*a*
Ebenaceae	24. *Ebenoxylon kartikcherriense* Prakash & Tripathi	*Diospyros ehritioides*	Kartikcherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1970*b*
Verbenaceae	25. *Vitexoxylon indicum* Prakash & Tripathi	*Vitex canescens*	Karikcherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*b*
Lauraceae	26. *Laurinoxylon indicum* Prakash & Tripathi	*Dehasia* and *Cinnamomum*	Sultanicherra near Hailakandi, distt. Cachar.	Praaksh & Tripathi, 1973*b*
Euphorbiaceae	27. *Mallotoxylon assamicum* Prakash & Tripathi	*Mallotus philippinensis*	Sultanicherra near Hailakandi, distt. Cachar.	Prakash & Tripathi, 1973*c*

For References also see Prakash, 1965*a*

Table 3—Plant remains from the Lower-Middle Siwalik Beds, Northern India (Miocene)

Family	Fossil species	Modern comparable form	Locality	Reference
MONOCOTYLEDONS				
Palmae	1. *Poacites sivalicus* Sahni		Garala-Gorah road, Poonch	Sahni, 1964
	2. *Palmoxylon jammuense* Sahni		Tawi river bed, Jammu	Sahni, 1931*b*, 1964
	3. *P. wadiai* Sahni		Tarangri, Tawi river bank, Jammu, Punjab.	Sahni, 1931*b*, 1964
Smilaceae	4. *Smilax* sp.	*Smilax*	Balugoloa near Jawalamukhi	Lakhanpal & Dayal, 1966
DICOTYLEDONS				
Dilleniaceae	5. *Dillenia* sp.	*Dillenia*	Koilabasa, Nepal	Lakhanpal, 1970
Annonaceae	6. *Fissistigma senii* Lakhanpal	*Fissistigma wallichii*	Balugoloa near Jawalamukhi	Lakhanpal, 1969
Dipterocarpaceae	7. *Dipterocarpoxylon* sp.	*Dipterocarpus*	Mohand near Dehra Dun	Rawat, 1964
	8. *Dipterocarpus* sp.	*Dipterocarpus*	Balugloloa near Jawalamukhi	Lakhanpal, 1970
	9. *Anisopteroxylon jawalamukhi* Ghosh & Ghosh	*Anisoptera*	Kundiyan, north of Jawalamukhi	Ghosh & Ghosh, 1958
Meliaceae	10. *Meliaceaephyllum mahagonites* Varma		Hardwar	Varma, 1968
Rhamnaceae	11. *Zizyphus sivalicus* Lakhanpal	*Zizyphus xylopyrus* & *Z. incurva*	Balugoloa near Jawalamukhi	Lakhanpal, 1965, 1967
	12. *Berchemia balugoloenesis* Lakhanpal	*Berchemia floribunda*	Barugoloa near Jawalamukhi	Lakhanpal, 1967
Leguminosae	13. *Bauhinioxylon indicum* Rawat	*Bauhinia*	Mohand near Dehra Dun	Rawat, 1964-65
	14. *Bauhinia* sp.	*Bauhinia*		Lakhanpal, 1970
	15. *Dalbergia sisso*	*Dalberia sisso*	Balugoloa near Jawalamukhi	Lakhanpal & Dayal, 1966
Combretaceae	16. *Terminalia* sp.	*Terminalia*	Balugoloa near Jawalamukhi	Lakhanpal, 1970
Myrtaceae	17. *Syzygium* sp.	*Syzygium*		Lakhanpal, 1970
	18. *Eucalyptophyllum raoi* Varma	*?Eucalyptus*	Hardwar	Varma, 1968
Lythraceae	19. *Lagerstroemia* sp.	*Lagerstroemia*	Balugoloa near Jawalamukhi	Lakhanpal & Dayal, 1966
Ebenaceae	20. *Diospyros embryopterisites* Varma	*Diospyros embryopteris*	Hardwar	Varma, 1968
Myristicaceae	21. *Myristica* sp.	*Myristica*		Lakhanpal, 1970
Lauraceae	22. *Litsea* sp.	*Litsea*		Lakhanpal, 1970
Euphorbiaceae	23. Leaf cf. ? *Croton tegelis*		Hardwar	Varma, 1968
Moraceae	24. *Ficus precunia* Lakhanpal	*Ficus cunia*	Balugoloa near Jawalamukhi	Lakhanpal, 1968

For References also see Prakash, 1965*a*

Table 4—Plant remains from the Cuddalore series, South India (Miocene-Pliocene)

Family	Fossil species	Modern comparable form	Locality	Reference
GYMNOSPERMAE				
Podocarpaceae	1. *Mesembrioxylon schmidianum* Sahni		Tiruvakkarai	Sahni, 1931*a*
	2. *M. sahnii* Ramanujam		,,	Ramanujam, 1953*a*
	3. *M. tiruvakkarainum* Ramanujam		,,	Ramanujam, 1953*a*
	4. *M. speciosum* Ramanujam		Mortandra	Ramanujam, 1955
Taxodiaceae	5. *Taxodioxylon cuddalorense* Ramanujam.		Tiruvakkarai	Ramanujam, 1960
ANGIOSPERMAE				
MONOCOTYLEDONS				
Palmae	6. *Palmoxylon pondicherriense* Sahni		Near Pondicherry	Sahni, 1931*b*, 1964.
	7. *P. arcotense* Ramanujam	*Livistona*	Tiruchhitambalam	Ramanujam, 1953*b*.
	8. *P. puratanum* Ramanujam		Mortandra-Murattandichavdi	Ramanujam, 1958
DICOTYLEDONS				
Guttiferae	9. *Calophylloxylon indicum* Lakhanpal & Awasthi.	*Calophyllum wightianum*	,,	Lakhanpal & Awasthi, 1965
	10. *C. cuddalorense* Lakhanpal & Awasthi	*C. inophyllum* & *C. tomentosum*	,,	Lakhanpal & Awasthi, 1965
	11. *Mesuoxylon arcotense* Lakhanpal & Awasthi	*Mesua ferrea*	,,	Lakhanpal & Awasthi, 1964
Dipterocarpaceae	12. *Dipterocarpoxylon pondicherriense* Awasthi	*Dipterocarpus*	,,	Awasthi, 1972*a*
	13. *Dryobalanoxylon indicum* (Ramanujam) Awasthi	*Dryobalanops*	,,	Ramanujam, 1956*a*; Awasthi, 1971.
	14. *D. holdeni* (Ramanujam) Awasthi.	*Dryobalanops*	,,	Ramanujam, 1956*a*, 1960; Awasthi, 1971.
	15. *Anisopteroxylon coromondalense* Navale	*Anisoptera*	Usteri	Navale, 1963*b*
	16. *Shoeroxylon krauseli* Ramanujam & Rao	*Shorea*	Murttandichavdi	Ramanujam, & Rao 1967, 1969
	17. *S. speciosujm* Navale	*Shorea*	Bangalamod	Navale, 1963*b*
	18. *S. pondicherriense* Awasthi	*Shorea, Parashorea*	Murttandichavdi	Awasthi, 1972*a*
	19. *S. arcotense* Awasthi	*Shorea*	,,	Awasthi, 1972*a*
Simaroubaceae	20. *Ailanthoxylon indicum* Prakash	*Ailanthus*	Murttandichavdi and Tiruchhitambalam.	Ramanujam, 1960; Navale, 1964*c*; Awasthi, 1965; Prakash, Dayal & Verma, 1967

Sapindaceae	21. *Sapindoxylon indicum* Navale		Tiruchhitambalam	Navale, 1957
Anacardiaceae	22. *Mangiferoxylon scleroticum* Awasthi	*Mangfiera altissima*	Near Pondicherry	Awasthi, 1966
	23. *Glutoxylon burmense* (Holden) Chowdhury.	*Gluta-Melanorrhoea*	Murttandichavdi	Awasthi, 1966
	24. *G. cuddalorense* Awasthi	,,	,,	Awasthi, 1966
	25. *Anacardioxylon mangiferides*		,,	Ramanujam, 1960
Leguminosae	26. *Cynometroxylon dakshinense* Navale	*Cynometra*	Kashikoppam	Navale, 1959
	27. *C. indicum* Chowdhury & Ghosh.	*Cynometra*	Near Pondicherry	Ramanujam & Rao, 1966*a*
	28. *Erythrophloeoxylon feistmantali* (Ramanujam) Muller-Stoll & Madel, 1967	*Erythrophloem* and anatomically allied genera.	Murttandichavdi	Ramanujam, 1960; Muller-Stoll & Madel, 1967
	29. *E. sitholeyi* (Ramanujam) Muller Stoll & Madel, 1967.	*Erythrophloem* and anatomically allied genera.	,,	Ramanujam, 1965; Muller-Stoll & Madel, 1967
	30. *Millettioxylon indicum* Awasthi	*Millettia*	,,	Awasthi, 1967
	31. *Pterocarpoxylon arcotense* Ramanujam	*Pterocarpus*	,,	Ramanujam, 1960
	32. *Pterogynoxylon felexii* (Navale) Muller-Stoll & Madel, 1967.	*Pterogyne* and allied genera	Usteri	Navale, 1963*a*; Muller-Stoll & Madel, 1967
	33. *Peltophoroxylon indicum* (Ramanujam) Muller-Stoll & Madel	*Peltophorum* and allied genera	Murttandichavdi	Ramanujam, 1955; Muller-Stoll & Madel, 1967
	34. *P. variegatum* (Ramanujam) Muller-Stoll & Madel	*Peltophosum* and allied genera	,,	Ramanujam, 1960; Muller-Stoll & Madel, 1967
	35. *Pahudioxylon sahnii* Ghosh & Kazmi	*Afzelia-Intsia*	,,	Ramanujam, 1960; Muller-Stoll & Madel, 1967; Awasthi, 1972*b*
	36. *P. arcotense* Navale	*?Afzelia-Intsia*	Kashikoppam	Navale, 1963*a*
	37. *Tamarindoxylon antiquum* Ramanujam	*Tamarindus*	Murttandichavdi	Ramanujam, 1961
	38. *Euacacioxylon bharadwajii* (Navale) Muller-Stoll & Madel	*Acacia*	Murttandichavdi and Bangalamod	Navale, 1963*a*; Ramanujam, 1960; Muller-Stoll & Madel 1967; Awasthi, 1972*b*
	39. Wood cf. *Bauhinia*	*Bauhinia*	Murttandichavdi	Ramanujam & Rao, 1966*b*
Rosaceae	40. *Parinarioxylon cuddalorense* Awasthi.	*Parinarium*	Murttandichavdi-Kashipplaiyam.	Awasthi, 1969*b*
Combretaceae	41. *Terminalioxylon speciosum* Ramanujam	*Termanialia*	Tiruchhitambalam	Ramanujam, 1956*b*
	42. *T. felixii* Ramanujam	*Terminalia*	Murtandichavdi	Ramanujam, 1956*b*
	43. *T. mortandrense* Navale	*Terminalia*	Murtandichavdi	Navale, 1956
	44. *T. sahnii* Navale	*Terminalia*	,,	Navale, 1956

Family	Fossil species	Modern comparable form	Locality	Reference
	45. *T. grandiporosum* Ramanujam	*Terminalia*	,,	Ramanujam, 1966; Navale, 1963*b*; Awasthi, 1972*b*
	46. *T. coromandelinum* Ramanujam	*Terminalia*	Murtandichavdi	Ramanujam, 1966
	47. *T. traumaticum* Ramanujam	*Terminalia*	,,	Ramanujam, 1966
	48. *Anogeissusoxylon indicum* Navale	*Anogeissus*	,,	Navale, 1964*b*
Lecythidaceae	49. *Barringtonioxylon arcotense* Awasthi	*Barringtonia angusta*	Murttandichavdi-Pattanur	Awasthi, 1970*a*
	50. *Careyoxylon pondicherriense* Awasthi	*Careya arborea*	Muranttandichavdi	Awasthi, 1970*a*
Sonneratiaceae	51. *Sonneratioxylon preapetala* Awasthi	*Sonneratia apetala*	Chinnokottaikoppam	Awasthi, 1969*a*
	52. *S. dakshinense* Ramanujam	*?Sonneratia*	Murttandichavdi	Ramanujam, 1957
Alangiaceae	53. *Alangium sclariforme* Awasthi	*Alangium*	,,	Awasthi, 1969*c*
Sapotaceae	54. Wood cf. Sapotaceae	,,	Neyveli	Lakshmanan & Levy, 1956
Ebenaceae	55. *Ebenoxylon arcotense* Awasthi	*Diospyros assimilis*	Murttandichavdi	Awasthi, 1970*b*
	56. Wood cf. Ebenaceae	*Diospyros-Maba*	Neyveli	Navale, 1968
Euphorbiaceae	57. *Putranjivoxylon puratanum* Ramanujam	*Putranjiya*	Murttandichavdi	Ramanujam, 1956*c*
	58. *Bridelioxylon cuddalorensee* Ramanujam	*?Bridelia*	,,	Ramanujam, 1956*c*
	59. *B. mioccenicum* (Ramanujam) Madel.	*?Bridelia*	,,	Ramanujam, 1960; Madel, 1962
	60. *Paraphyllanthoxylon tertiarum* (Ramanujam) Madel	Phyllanthioideae	,,	Ramanujam, 1956*c*; Madel, 1962
	61. *P. bangalamodense* (Navale) Lakhanpal & Dayal	Phyllanthioideae	Bangalamod	Navale, 1962; Lakhanpal and Dayal, 1964
Fagaceae	62. *Castanoxylon indicum* Navale	*?Castanopsis*	Usteri	Navale, 1964*a*
	63. *C. tertiarum* Navale	*?Castanopsis*	Near Pondicherry	Navale, 1964*a*

For References also see Prakash, 1965a.

Table 5—Plant remains from the Dupitila series, Eastern India (Mio-Pliocene)

Family	Fossil species	Modern comparable form	Locality	Reference
ANGIOSPERMAE				
DICOTYLEDONS				
Guttiferae	1. *Calophylloxylon eoinophyllum* Prakash	*Calophyllum inophyllum*	Namsang river bed near Deomali, NEFA	Prakash, 1966*a*
Dipterocarpaceae	2. *Shoreoxylon deomaliense* Prakash & Awasthi	*Shorea*	,,	Prakash & Awasthi, 1971
Leguminosae	3. *Cynometroxylon indicum* Chowdhury & Ghosh	*Cynometra*	,,	Prakash & Awasthi, 1971
	4. *Pahudioxylon deomaliense*	*Afzelia-Intsia*	,,	Prakash, 1965*b*
	5. *P. sahnii* Ghosh & Kazmi	*Afzelia-Intsia*	,,	Prakash, 1966*a*
Combretaceae	6. *Terminalioxylon coriaceum* Prakash & Awasthi.	*Terminalia coriacea*	,,	Prakash & Awasthi, 1971
	7. *T. tertiarum* Prakash	*Terminalia*	,,	Prakash, 1966*a*
Sapotaceae	8. *Siderinium deomaliense* Awasthi.	*Sidroxylon*	,,	Prakash & Awasthi, 1970
Ebenaceae	9. *Ebenoxylon indicum* Ghosh & Kazmi.	*?Diospyros-Maba*	,,	Ghosh & Kazmi, 1958

For References also see Prakash, 1965*a*.

amount of work on modern plants in order to make comparison before a true picture of this flora could be evolved. It may not be out of place to mention here that quite a few forms may be in the evolutionary flux and hence evade proper generic assignment. Even, then, if you take into account the modern distribution of the living comparable forms of the Intertrappean fossil plants in terms of species, wherever possible, it would indicate a different picture of the environment than what we see today in the Nagpur-Chhindwara region of the trap from where most of the petrified flowering plants are known.

The presence of *Elaeocarpoxylon antiquum*, *Ailanthoxylon ghiarense*, *Barringtonioxylon deccanense*, *B. eopterocarpum*, *Tetrameleoxylon prenudiflora*, *Aeschynomene tertiara*, *Grewioxylon mahurzariense*, *Palmoxylon* cf. *Phoenix*, *Musa cardiosperma*, *Heliconiaites mohgaoensis* (TRIVEDI & VERMA, 1971*b*, 1972) and *Cannaites intertrappea* (TRIVEDI & VERMA, 1971*c*) comparable to modern *Elaeocarpus ferrugineus*, *Ailanthus grandis*, *Barringtonia acutangula*, *B. pterocarpa*, *Tetrameles nudiflora*, *Aeschynomene* sp., *Grewia laevigata*, *Phoenix robusta*, *P. rupicola*, *Musa* sp., *Heliconia* sp. and *Canna indica* respectively indicate a somewhat more humid climate in the Deccan Trap country during the Eocene times than that of the present day as most of these plants are presently growing in moist places like Western Ghats, Ceylon, Assam, Meghalaya, Mizoram Nagaland, Burma and Thailand (see Table 6). Some of these comparable forms like *Barringtonia acutangula* and *Grewia laevigata* are generally found in damp places along streams or sea shores. Even *Musa superba* which grows in the present day flora of the Deccan grows near rapidly flowing rivulets. The presnece of a sea shore in Nagpur-Chhindwara region has already been indicated by the discovery of coastal forms like *Nypa*, *Sonneratia* and *Cocos* from Mohgaon and Saugar indicating the presence of estuarine conditions there during the Eocene either due to presence of Tethys sea or an arm of sea from the Gulf of Cambay and probably this might explain the presence of moist loving forms in some evergreen to semi-evergreen or monsoon forests close to the sea. The dry deciduous comparable forms of the fossils like *Mallotus philippinensis*, *Boswellia serrata*, *Grewia tiliaefolia*, *Terminalia tomentosa*, and *Leea indica* would appear to occupy low dry hills of the Deccan Trap farther away from the watershed. With the rise of the Himalayas and the disappearance of the Tethys sea, desiccation followed in the Deccan Trap country due to which moist loving members of the evergreen to semi-evergreen forests were pushed into more favourable climatic regions like nearby Western Ghats where similar moist conditions still exist, while the dry deciduous types like *Mallotus philippinensis*, *Boswellia serrata*, *Terminalia tomentosa* and *Grewia tiliaefolia* remained onthe plateau. Even comparable species of *Grewia laevigata* also remained there along the streams. Also one might think of this as a cummulative effect with the shifting of the Indian sub-continent to the present position from that of the one south of the equator during the Eocene period where obviously there is more atmospheric precipitation.

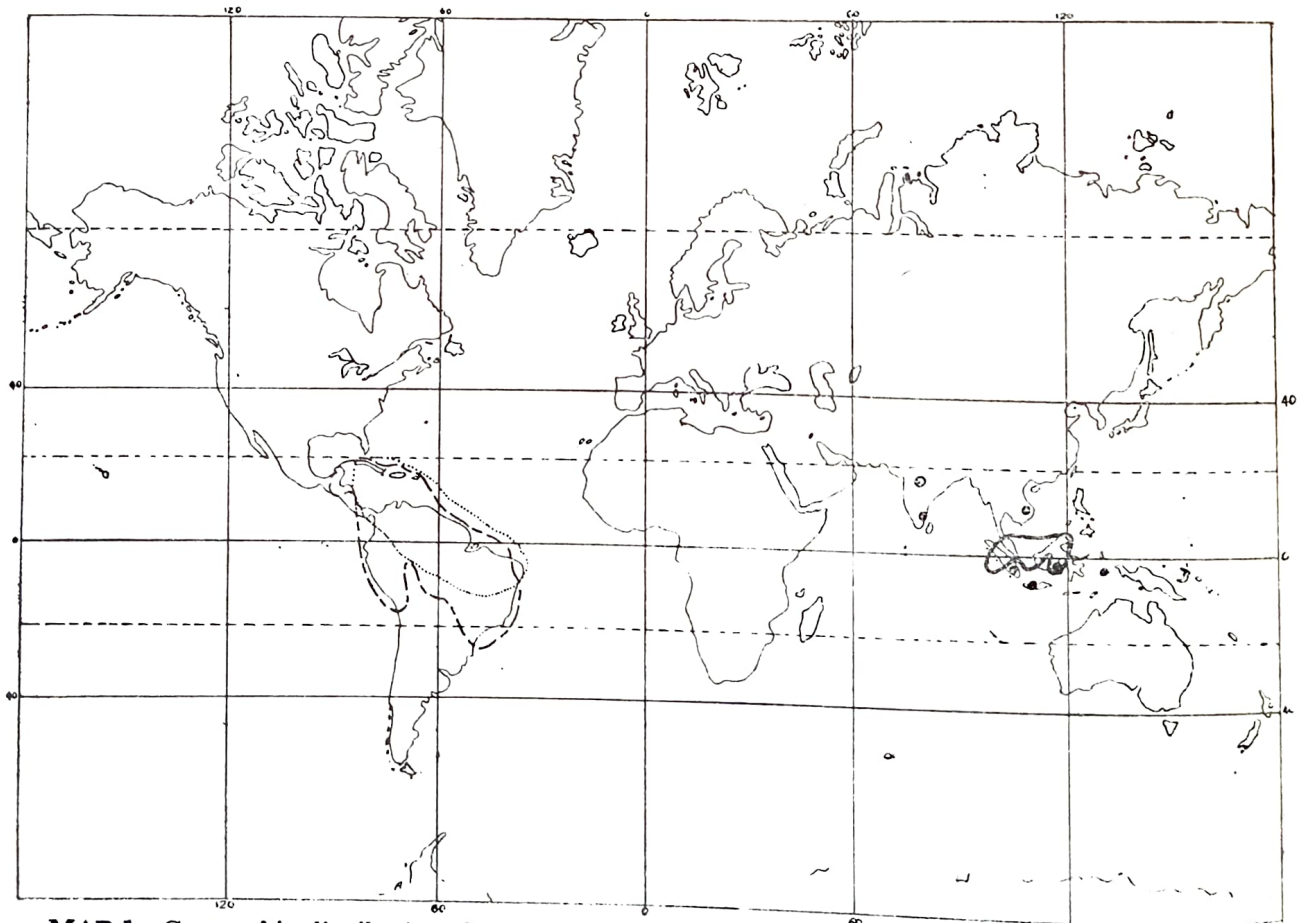
The more humid and warm condition of the Eocene period of the Deccan Trap country which became drier later on is further strengthened by the fact that abundance of Palmoxyla are known here during the Intertrappean period in the areas now relatively poor in palms. Even the presence of fossil leaves comparable to *Mesua ferrea* and *Garcinia lanceaefolia*, both evergreen taxa (LAKHANPAL, 1964), a little north west at Kapurdi in Rajasthan during the Eocene also indicate a much higher rain fall and a moist climate in that region during the Eocene times in contrast to desert conditions with a poor type of scrub forest found today. Since the area comprising of eastern Bengal (Bangla Desh) and Upper Burma is most suitable for a natural growth of *Mesua ferrea*, *Garcinia*, and some other Guttiferae at the present time, it may seem probable that conditions similar to these existed in Rajasthan during the Eocene times when *Mesua ferrea* and other Guttiferae flourished in that area.

Table 6—Distribution of the modern comparable species of fossil taxa from the Deccan Intertrappean series

Fossil species	Modern comparable species	Modern distribution
MONOCOTYLEDONS		
1. *Musa cardiosperma*	*Musa* sp.	Western Ghats, Bihar, Assam, Meghalaya, Mizoram, Arunachal, Nagaland, Eastern Himalayas, Nepal, Ceylon, Burma, Malaysia.
2. *Sparganium* sp.	*Sparganium* sp.	Kashmir, Sikkim Himalaya, Meghalaya, Burma.
3. *Nipa hindi* 4. *Rhizopalmoxylon indicum*	*Nipa fruiticans*	Sunderbuns, southwards Malaya Peninsula & Ceylon
5. *Palmoxylon (Cocos) sundaram*	*Cocos nucifera*	Coasts of India and Ceylon.
6. *Palmoxylon* sp. cf. *Phoenix.*	*Phoenix rubusta* & *Phoenix rupicola*	Bhorkas in Poona district, Nandgaon in Western Ghats, and Parasnath Hills in Bihar. Assam and other places in Eastern Himalayas.
DICOTYLEDONS		
7. *Aeschynomene tertiara*	*Aeschynomene* sp.	Thailand.
8. *Sahnianthus parijai* 9. *Enigmocaropon parijai*	*Sonneratia acida* & *Sonneratia apetala*	Tidal creeks and littoral forests of India, Burma, Ceylon and the Andamans, extending to Indus delta. Tidal creeks and littoral forests of West Bengal, Bangla Desh, Konkan, the Coromandel coast and Burma; rare in Ceylon.
10. *Grewioxylon mahurzariense*	*Grewia laevigata*	Assam, Meghalaya, Mizoram, Nagaland, Arunachal, Central and Southern India, outer Himalayas from Jumna eastwards to Bangla Desh in Chittagong, Andamans, Burma; common in the vicinity of streams and along sea shores.
11. *Grewioxylon indicum*	*Grewia tiliaefolia*	Sub-Himalayan tracts from Jumna to Nepal, throughout Central and Southern India; rather common in Madhya Pradesh and Western Ghats particularly Coorg and Wynaad.
12. *Elaeocarpoxylon antiquum.*	*Elaeocarpus ferrugineus*	Western Ghats, Nilgiris, Anamalais, Pulney hills and hills of Kerala.
13. *Ailanthoxylon indicum*	*Ailanthus malabarica*	Wester Ghats and Burma.
14. *Ailanthoxylon ghiarense*	*Ailanthus grandis*	Assam, Meghalaya, Mizoram, Nagaland, Arunachal, and Darjeeling.
15. *Boswellioxylon indicum*	*Boswellia serrata*	Common in dry forests throughout India; not found in West Bengal, Bangla Desh, Assam, Meghalaya, Mizoram, Nagaland, Arunachal and Burma. Common in most parts of the Madhya Pradesh, Bihar and Maharastra, Orissa, Tamilnadu, the Carnatic Districts; equally common in Rajasthan and North Gujarat.
16. *Terminalioxylon tomentosum.*	*Terminalia tomentosa*	Very common all over India except arid zones of Punjab, Sind (Pakistan) and Rajasthan. Occurs in West Bengal, Bangla Desh, Assam, Meghalaya, Mizoram, Arunachal, Nagaland, West Coast, Bihar, Madhya Pradesh, Orissa and the South.

Fossil species	Modern comparable species	Modern distribution
17. *Barringtonioxylon deccanense.*	*Barringtonia acutangula*	West Bengal, Bangla Desh, Assam, Meghalaya, Mizoram, Nagaland, Arunachal, Burma and on the West Coast, Madhya Pradesh, Maharastra, Deccan, Carnatic, and in parts of Bihar, Orissa and Chota Nagpur; generally found along streams and damp places.
18. *Barringtonioxylon eopterocarpum.*	*Barringtonia pterocarpa*	Pegu and Martaban in Burma.
19. *Mallotoxylon keriense*	*Mallotus philippinensis*	Generally found every where in India, widely distributed from Sind (Pakistan) to Arunachal, Central, Western and Southern India, Burma in drier forests and Andamans.
20. *Tetrameleoxylon prenudiflora.*	*Tetrameles nudiflora*	Assam, Meghalaya, Mizoram, Nagaland, Arunachal, Andaman Islands, West Bengal, Western Ghats, from Konkan to Kerala, specially Malabar coast and low country of Ceylon.

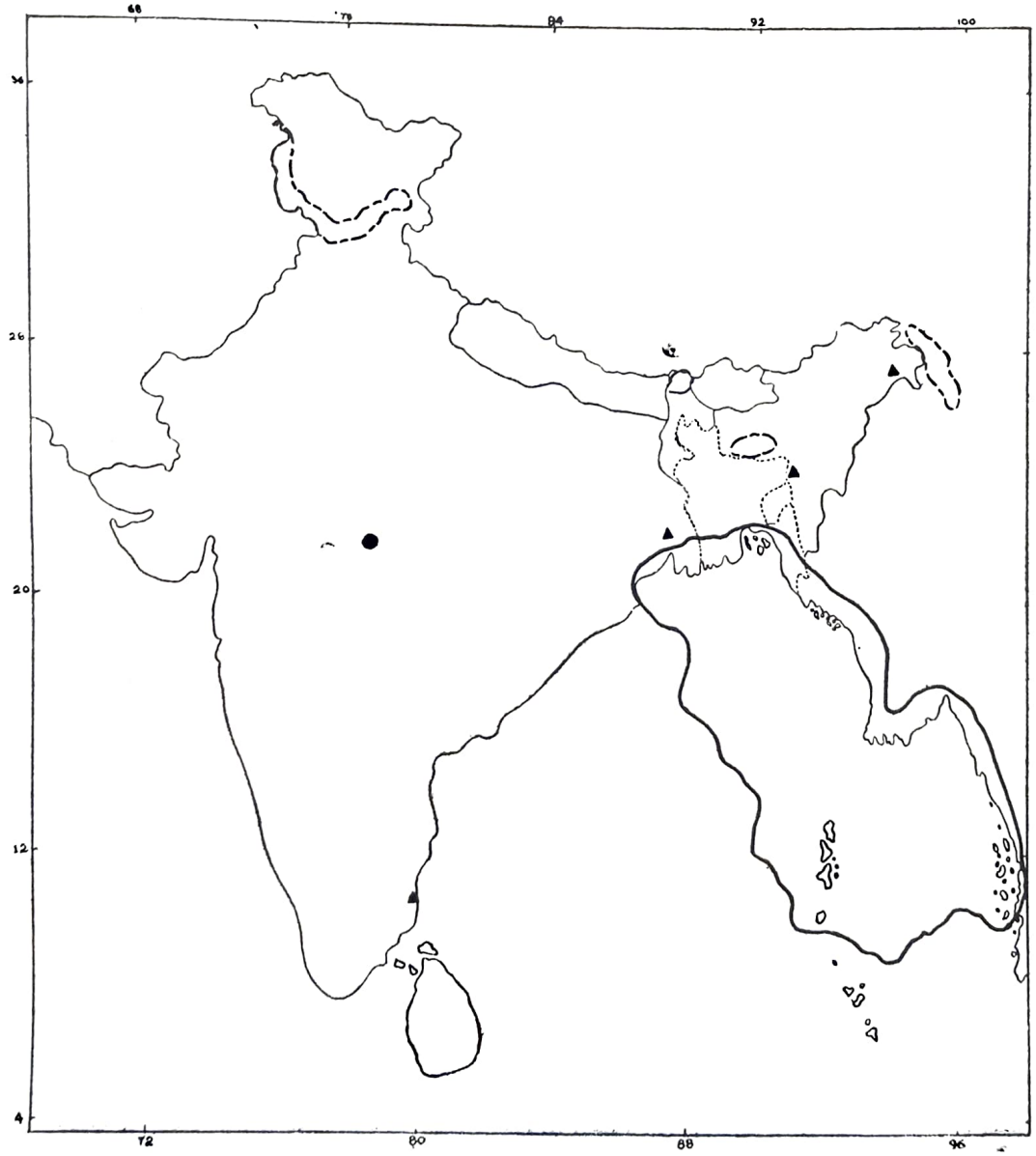
A notable feature of phytogeographical importance during the Palaeogene is the presence of some elements in the Intertrappean flora, whose modern relatives are found now in the Tropical America. These are *Cyclanthodendron* compared to the tropical American genera *Cyclanthus* and *Carludovica*, and *Simarouboxylon* identified with the genus *Simarouba* of Brazil, Venezuela, British Guiana and Cuba (Map 1). *Rodeites*, a hydropteridean sporo-



MAP 1—Geographic distribution of the fossil (encircled dot) and living (broken line) *Cyclanthus-Carludovica*, fossil (encircled dot) and living (encircled dotted area) *Simarouba*, and (fossil black dot) and living (solid line) *Dryobalanops*.

carp, has further been compared with *Regnellidium*, a water fern of Brazil. All these forms provide a link between the Eocene flora of the Deccan and the modern flora of Tropical America. Although their origin in the Indian flora is quite obscure it seems quite likely that these groups, once enjoying a wider and greater distribution in the tropics, seem to have been strongly reduced at the present time.

Another phytogeographically important genus is *Sparganium* (Map 2) which is also known from the Deccan Intertrappean series of Chhindwara. *Sparganium* is a temperate genus and in the modern flora of the Indian region only two species are known to grow. These are *Sparganium ramosum* distributed in North West India from the plains to 5,200 ft. in Kashmir and Burma and *S. simplex* found in Sikkim Himalaya, at an altitude of 7—9000 ft., in Khasi Hills at 5—6000 ft. and also in Burma. This indicates a trend of migration towards north west and eastern India since the Palaeogene. What could be the height of the then Trap hills on which *Sparganium* and the conifers are supposed to grow is a matter of conjecture? Their disappearance from the Trap country might be due to some tectonic



MAP 2—Geographic distribution of the fossil (black dot) and living (broken line) *Sparganium*, and fossil (black triangle) and living (solid line) *Afzelia-Intsia* in the Indian region.

movements which changed the topography of the plateau and the climatic environments due to which these plants could not survive there and moved northwards to suitable places. However, the occurrence of this temperate genus as well as the South American tropical elements in the Deccan flora during the Early Tertiary of India is quite enigmatic and needs a further check up with the modern plants before a true picture of their systematic position is known.

A critical analysis of another well known flora of South India recorded from the Cuddalore series near Pondicherry also unravels some striking data of ecological and phytogeographical importance by the comparison of its fossil plants with those of the modern taxa in terms of species. The majority of modern comparable species of this fossil flora (Table 7), namely *Mesua ferrea*, *Calophyllum wightianum*, *C. tomentosum*, *Dipterocarpus sp.*, *Gluta travancorica*, *Diospyros assimilis*, *Cynometra travancorica*, *Tamarindus indica*, *Putranjiva roxburghii*, *Shorea talura* and *Careya arborea* are presently growing in the evergreen forests of the Western Ghats in south Malabar and even down south near Tinnevelly. This indicates that similar vegetation was also present near Pondicherry during the Mio-Pliocene times which died out from there due to further desiccation indicating thereby that the eastern coast of South India has become drier since the Cuddalore times as also suggested by LAKHANPAL (1970). In an attempt to survive, these plants shifted to south-west into ghats where atmospheric precipitation could have been much more and somewhat favourable climatic conditions might be present. This has been amply supported by the extinction of three dipterocarpaceous genera, the *Dipterocarpus*, *Dryobalanops* and *Anisoptera* from near Pondicherry. Although *Anisoptera* and *Dryobalanops* are altogether absent from peninsular India, two species of *Dipterocarpus*, *D. indicus* and *D. bourdillonii* are presently growing in the evergreen forests of Malabar and Kerala. In addition to this the discovery of some fossil species comparable only to Malayan modern species like *Mangifera altissima*, *Parinarium corymbosum*, *Alangium javanicum*, *A. meyeri* and *Dryobalanops oblongifolia* also support a further desiccation of this region and suggest the presence of Malayan elements in this flora. Even there is an indication of Burmese modern species now present along the coast of Tenasserim, that has been found to compare closely with the Cuddalore fossil taxa, *Barringtonioxylon arcotense* (Table 7). All these indicate a more humid climate around Pondicherry during the Mio-Pliocene times.

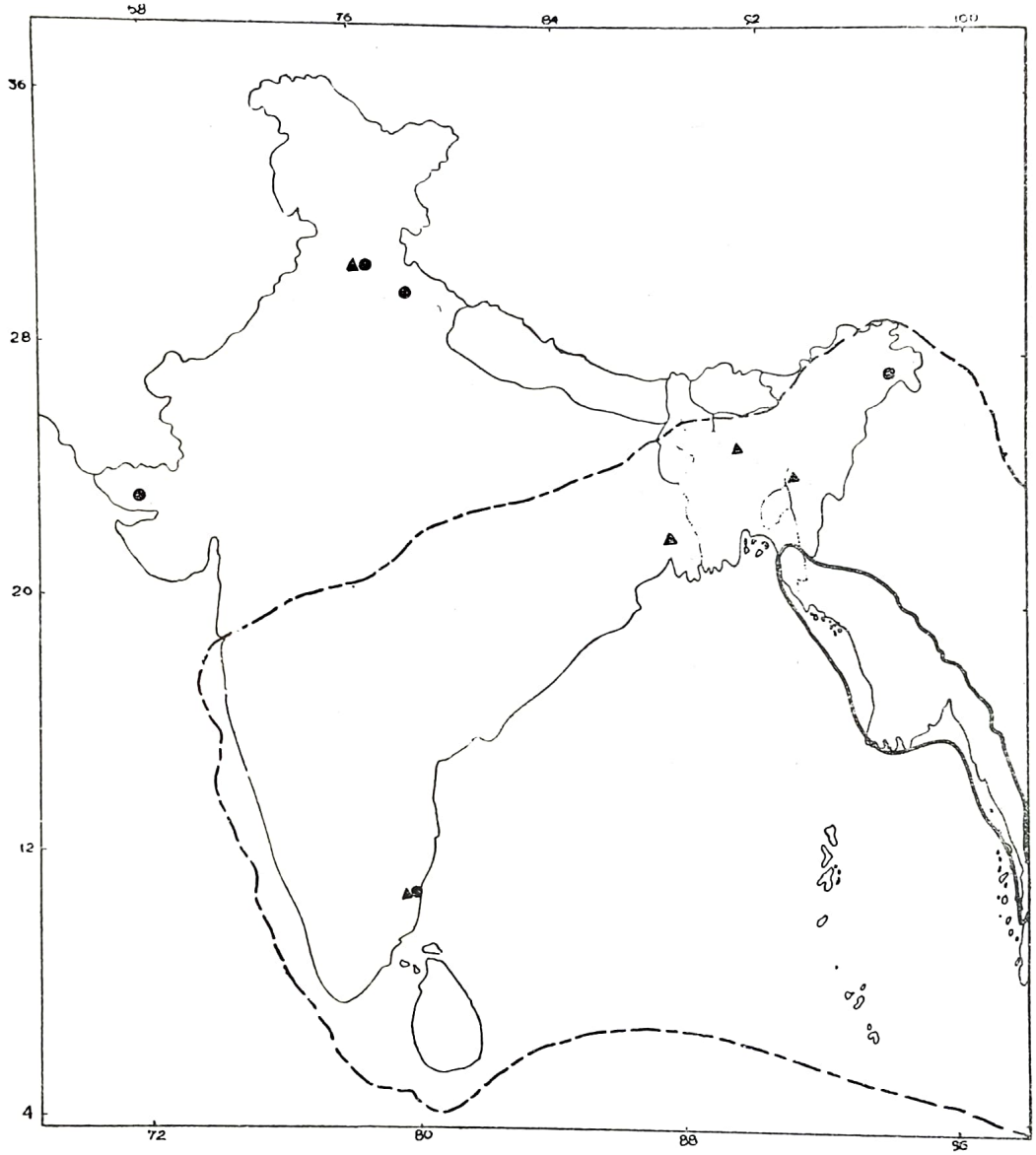
As regards *Dryobalanops* about 13 species of this genus are known from the Tertiary of South India (AWASTHI, 1971), Indonesia and Cambodia (Map 1). However, in the present flora, this genus is distributed in Sumatra, Borneo and Malaya Peninsula, being altogether absent from India and other adjacent countries. This strongly suggests that *Dryobalanops* was distributed more widely during the Neogene than it is today.

Further the genus *Anisoptera* is known in the past from the Miocene of Tipam sandstones near Hailakandi (Map 3) in Mizoram, and in Garo Hills, Meghalaya (CHOWDHURY, 1938; PRAKASH & TRIPATHI, 1970*b*), in West Bengal (GHOSH & KAZMI, 1958), from near Jwalamukhi in Himachal Pradesh (GHOSH & GHOSH, 1958), and in the Mio-Pliocene of Cuddalore series of South India (NAVALE, 1963*b*). However, at present this genus is comprised of 13 species distributed from Chittagong to New Guinea in the Far East. Of these, only two species namely *Anisoptera scaphula* and *A. oblonga* occur in Chittagong and southern Burma. The fossil history of *Anisoptera* indicates that during the Late Tertiary it was present in widely scattered southern and northern boundaries of India, where there are no *Anisopteras* at present and it now appears that the genus has migrated about 2000 kilometres towards the east during the last 25 million years.

Table 7—Distribution of the modern comparable species of fossil taxa from the Cuddalore series

Fossil species	Modern comparable species	Modern distribution
1. *Mesuoxylon arcotense* ..	*Mesua ferrea*	Evergreen forests of Western Duars, Assam, Meghalaya, Mizoram, Nagaland, Arunachal, Chittagong, Upper Burma, Tenasserim, Andaman Islands, Western Ghats from North Kanara southwards to Tinnevelly.
2. *Calophylloxylon indicum.*	*Calophyllum wightianum*	Evergreen forests of Western Ghats, North Kanara to Kerala.
3. *C. cuddalorense*	*Calophyllum tomentosum* & *C. inophyllum.*	Evergreen forests of Western Ghats from North Kanara to Kerala. West coast, Orissa, Andamans, Burma. Found along coasts above high water mark and in the mangrove.
4. *Glutoxylon burmense*	*Gluta travancorica* & *Melanorrhoea*	Evergreen forests of south Kerala. South-east Asia.
5. *Mangiferoxylon scleroticum.*	*Mangifera altissima*	Malaya with evergreen leaves.
6. *Ebenoxylon arcotense*..	*Diospyros assimilis*	Evergreen forests of north Tamil Nadu, Western Ghats, south Kanara to Kerala from 300—900 m
7. *Cynometroxylon dakshinense.*	*Cynometra travancorica*	Evergreen forests of south Kerala and in Carnati near Tinnevelly.
8. *Tamarindoxylon antiquum.*	*Tamarindus indica*	Evergreen tree diffused throughout India and the tropics generally.
9. *Peltophoroxylon variegatum.*	*Cassia fistula*	Indus to Arunachal in the east, down south in Gujrat, Madhya Pradesh, Maharastra, Deccan Carnatic, east and west coasts and southwards to Ceylon. Usually a deciduous tree ascending to 4,000 ft. in Himalayas.
10. *Putranjivoxylon puratanum.*	*Putranjiva roxburghii*	Evergreen tree found along river banks throughout tropical India.
11. *Ailanthoxylon indicum*	*Ailanthus malabarica*	Western Ghats and south Kanara.
12. *Shoreoxylon krauseli*	*Shorea talura* & *Shorea tumbuggaia.*	Evergreen or moist deciduous forests of West coast, Coorg, Tamil Nadu, Malabar, Mysore. North Arcot and Cuddalore in Andhra Pradesh.
13. *Dryobalanoxylon indicum.*	*Dryobalanops ?oblongifolia*	Sumatra, Borneo and Malayan Peninsula.
14. *Barringtonioxylon arcotense.*	*Barringtonia angusta*	Coast of Tenasserim with evergreen leaves.
15. *Careyoxylon pondicherriense.*	*Careya arborea*	Throughout India in moist forests also in Tamil Nadu and Kerala.
16. *Sonneratioxylon preapetala.*	*Sonneratia apetala*	Litteral species of evergreen trees or shrubs of the Coromandal coast.
17. *Parinarioxylon cuddalorense.*	*Parinarium corymbosum*	Malaysia.
18. *Alangioxylon scalariforme.*	*Alangium javanicum* & *A. meyeri.*	Malaysia.
19. *Anogeissusoxylon indicum.*	*Anogeissus latifolia*	Throughout the dry forests in India from north to south, in Tamil Nadu, Eastern Coorg and Shimoga districts in Mysore and south Kerala.

Yet another phytogeographically striking genus is *Dipterocarpus* (Map 3) which is known from the Miocene of Tipam sandstones in Arunachal (GHOSH, 1956), the Siwalik beds near Mohand in Uttar Pradesh (RAWAT, 1964) and near Jwalamukhi (LAKHANPAL, 1970), the Mio-Pliocene of the Cuddalore series in South India (AWASTHI, 1972a), and the Pliocene of Kutch (GHOSH & GHOSH, 1959). At present this genus grows in South India, Assam and other parts of Eastern India, Bangla Desh and south-east Asia. The fossil history of *Dipterocarpus* indicates that during the geological past it was present in widely scattered western and northern regions of India, where there are no *Dipterocarpus* at present. This means the genus has migrated towards the south and east since the Mio-Pliocene times, which may be due to some changes in the climatic conditions of these regions.



MAP 3—Geographic distribution of the fossil (black dot) and living (crossed areas) *Gluta-Melanorrhoea* and fossil (black triangle) and living (encircled area) *Pometia* in the Indian region.

As *Dipterocarpus* grows in moist, humid conditions, its extinction from near Dehra Dun, Jwalamukhi, Kutch and Pondicherry may indicate a somewhat drier climate in these regions since the Mio-Pliocene times. The Late Tertiary desiccation in northern India is further supported by the extinction of *Anispotera* from Jwalamukhi and by a closer com-

N.B. The legend printed for Map 3 is really for Map 4 and *vice versa*. Read accordingly.—*Ed.*

parison of the Siwalik fossil species *Fissistigma senii* and *Zizyphus sivalicus* with the living *Fissistigma wallichii* and *Zizyphus incurva* respectively, which are presently growing in areas where there is more atmospheric precipitation. *F. wallichii* is a large woody climber of eastern Bengal (Bangla Desh), Assam and Sylhet, whereas *Z. incurva* is found in the evergreen or semi-evergreen, moist forests of Nepal, Bhutan, Assam and Burma.

Another interesting record from the Neogene is of the fossil genus *Pahudioxylon* Chowdhury, Ghosh & Kazmi, resembling the modern woods of *Afzelia* and *Intsia* of Leguminosae, which also needs some reference with regard to its past and present distribution (Map 2). This has been recorded from the Miocene of West Begnal (Chowdhury, Ghosh & Kazmi, 1960), Mizoram and Arunachal (Prakash, 1965*b*, 1966*a*) and the Mio-Pliocene of the Cuddalore series in South India (Awasthi, 1972*b*). The genus *Afzelia* is presently distributed in tropical Africa and Asia, while *Intsia* is mainly found in East Africa, Madagaskar and tropical Asia. In India only *Intsia* (*Afzelia*) *bijuga* and *Afzelia retusa* are found *Intsia bijuga* occurs in the tidal coast forests of West Bengal, Bangla Desh, the Andaman Islands and Burma, while *Afzelia retusa* is found in the forests of Sunderbans and the Andamans (Gamble, 1902). This shows a very limited distribution of these genera at present in India as compared to the Neogene when they were scattered as far off in the south as Pondicherry. Its regression to tidal coast forests of Eastern India also indicates some changes in the physical conditions near Pondicherry.

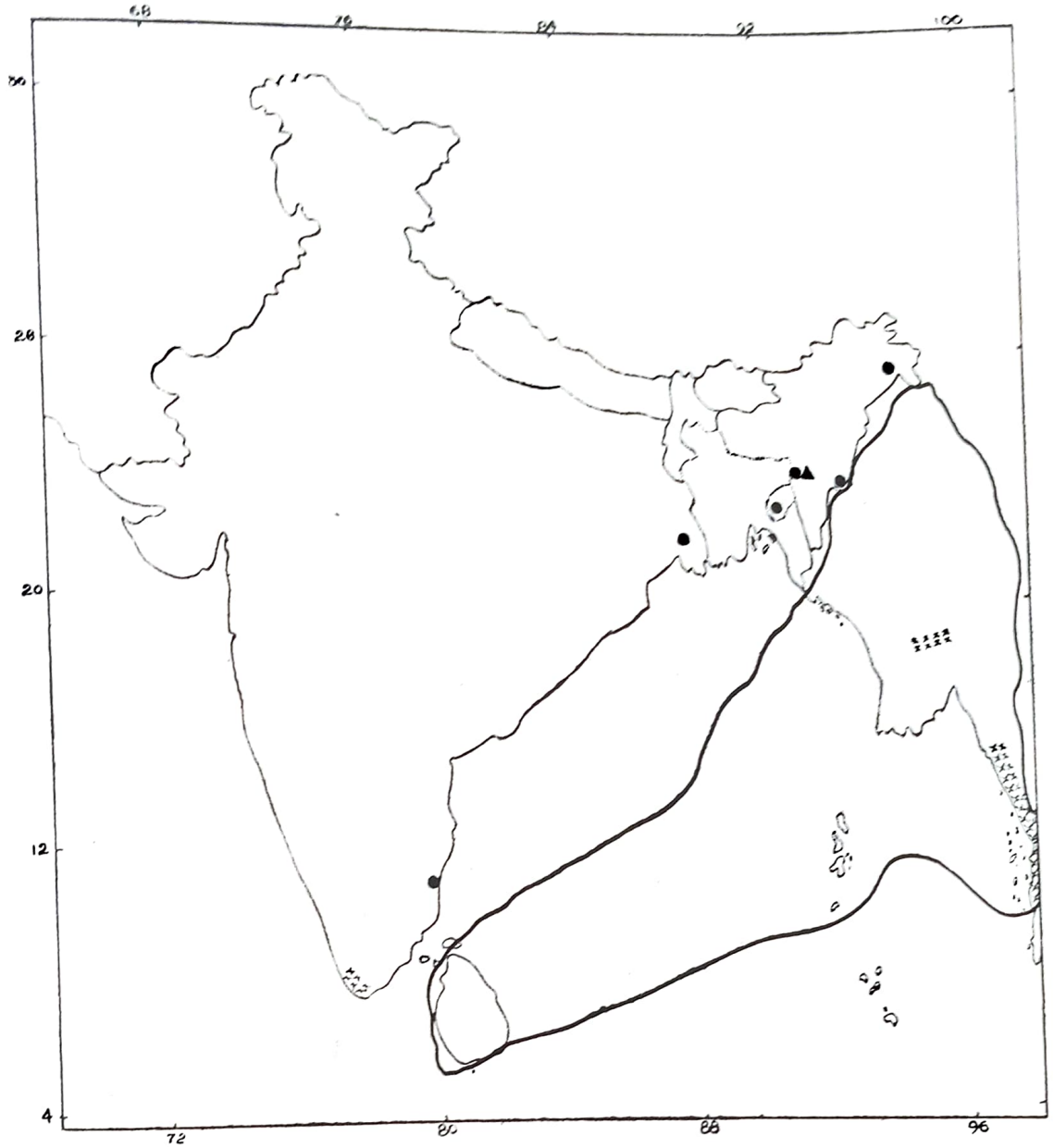
Coming to Eastern India, from where well identified megafossil floral assemblages are also known from the Tipams and Dupitila series in Mizoram and Arunachal (Tables 2, 5), a study of modern distribution of the living counterparts of the fossil species (Table 8) reveals that although some signs of migration within this region are not altogether absent (Map 4), no major change in the vegetational pattern of Eastern India could be visualized since the Mio-Pliocene times. The modern comparable species of the fossils, from Tipam series near Hailakandi in Mizoram (Table 8), such as *Kayea assamica*, *Sterculia villosa*, *Bursera serrata*, *Adenanthera pavonina*, *Albizzia procera*, *Terminalia tomentosa*, *Careya arborea*, *Lagerstroemia flosreginae*, *Vitex canescens*, *Mallotus philippinensis*, *Mangifera indica* and *Homalium tomentosum* either grow at the fossil locality or nearby indicating somewhat similar vegetational pattern in that region since the Miocene. However, there are some other forms (Table 8) which do indicate that some migration has occurred in this region. The occurrence of *Nypa* in Garo Hills (Lakhanpal, 1952) and *Barringtonia*, *Afzelia-Intsia*, and a fossil species comparable to *Cynometra ramiflora* near Hailakandi in Mizoram indicate coastal conditions there during the Miocene. This suggests that the sea was situated much more inland then than where it is to-day and this might have some influence on the Miocene vegetation of that region. The genus *Pometia* which has been recorded from the Tipams near Hailakandi has got a very restricted distribution at present in India. It is a small genus of 4-5 species of trees, predominantly Indo-Malayan but also occurring in Philippines and Java. The only species found in the Indian region is *Pometia tomentosa* occurring in the Andaman islands, Ceylon, Burma, Thailand, and the Netherlands.

Thus summarising the climatic conditions during the Tertiary of India, it can safely be said that an equable warm and moist climate prevailed over the sub-continent during the Eocene. This became drier and warmer after the Miocene in the northern and western India and on the Deccan plateau due to which the evergreen plant taxa of the Fuller's earth bed in Rajasthan and those of the Intertrappean series and the Cudadlore sandstones near Pondicherry were pushed into the pockets of the Ghats on the west coast where the rainfall could have been more than on the plateau. At the same time the Malayan elements of the Cuddalore flora became extinct, while the moist loving forms of the Siwaliks and Kutch

Table 8—Distribution of the Tipam Flora by Elements

(In the present list only those plants are included whose modern relationships are reasonably certain. Doubtful forms and those identified upto generic level are omitted).

Fossil species	Modern equivalent	Modern distribution							
		India					Bangla Desh	Burma	South-East Asia
		Northern India	Western India	Southern India	Assam Meghalaya Mizoram	Other parts of Eastern India			
1. *Kayeoxylon assamicum*	*Kayea assamica*	—	—	—	×	—	—	—	—
2. *Sterculioxylon indicum*	*Sterculia villosa*	×	—	×	×	×	×	×	—
3. *Burseroxylon serratum*	*Bursera serrata*	—	—	×	×	×	×	×	—
4. *Adenantheroxylon pavoninium*	*Adenanthera pavonina*	—	—	—	×	—	×	—	×
5. *Peltophoroxylon borooahii*	*Cassia siamea*	—	—	×	—	—	×	×	×
6. *Ingoxylon indicum*	*Albizzia procera*	×	—	×	×	×	×	×	×
7. *Cynometroxylon assamicum*	*Cynometra ramiflora*	—	—	×	—	×	×	×	×
8. *Terminalioxylon tertiarum*	*Terminalia tomentosa*	×	×	×	×	×	—	×	×
9. *Careyoxylon kuchilense*	*Careya arborea*	×	×	×	×	×	×	×	—
10. *Lagerstroemioxylon eoflosreginum*	*Largerstroemia flosreginae*	—	—	×	×	×	×	×	×
11. *Vitexoxylon miocenicum*	*Vitex canescens*	—	—	—	×	×	×	×	—
12. *Mallotoxylon assamicum*	*Mallotus philippinensis*	×	×	×	×	×	×	×	×
13. *Lanneoxylon grandiosum*	*Lannea grandis*	×	×	×	×	×	×	×	—
14. *Mangiferoxylon assamicum*	*Mangifera indica*	×	×	×	×	×	×	×	×
15. *Swintonioxylon hailakandiense*	*Swintonia floribunda*	—	—	—	—	—	×	×	×
16. *Pometioxylon tomentosum*	*Pometia tomentosa*	—	—	—	—	×	—	×	×
17. *Homalioxylon assamicum*	*Homalium tomentosum*	—	—	×	—	—	×	×	×



MAP 4—Geographic distribution of the fossil (black triangle) and living (solid line) *Anisoptera* and fossil (black dot) and living (broken line) *Dipterocarpus*.

migrated to suitable areas in Eastern India where there has not been appreciable change in the climatic conditions and the vegetational pattern since the Mio-Pliocene times.

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