Cenophytic Palaeobotany in India – An Overview*

R.N. Lakhanpal

B-21, Sector A, Mahanagar, Lucknow-226 006

I deem it a matter of great honour to be awarded the Palaeobotanical Society International Medal for 1995. The significance is further enhanced by the fact that this award pertains to the period during which the Palaeobotanical Society celebrated its Golden Jubilee. I accept it in all humility and offer my deep gratitude to the Society for this rare distinction.

For such award lectures as the present, it is customary to speak about one's speciality, possibly incorporating one's own contributions to the same. Consequently I have decided to speak on Cenophytic palaeobotany in India, dealing with the different stages in its development and appraising its current position.

To start with, let us consider the term "Cenophytic". In the general geological time scale which is based on the evidence of animal fossils, there is a clear distinction between the Mesozoic and Cenozoic eras. However, considering the plant evidence, the typical components of the Cenozoic are also quite frequent in the upper part of the Cretaceous period. Similarly, the boundary between the Palaeozoic and Mesozoic also differs on the evidence of plants; the common Mesozoic elements extending back into the Permian. To bring out the differences in duration of each of the five main *Zoic* and *Phytic* eras, Traverse (1988, Fig. 2.1) has shown them in two different columns in a chart illustrating the geological time scale. According to it the Cenophytic era includes most of the Cretaceous and the Tertiary and Quaternary periods. It is characterised by the dominance of angiosperms.

Cenophytic plants of India have been collected since the second quarter of the Nineteenth Century. However, they did not receive much attention of the investigators until the year 1921, when Professor Birbal Sahni reviewed the position of Indian palaeobotany at that time. Out of the large number of Tertiary woods, leaf impressions and remains of fruits and seeds, the only fossils known taxonomically were a coniferous wood, *Peuce schmidiana* and two leaf impressions, *Phyllites kamrupensis* and *Sabal major.*

During the next nearly three decades there was considerable development in Indian Cenophytic palaeobotany due primarily to the contributions of Prof. Sahni along with those of scholars inspired by his able guidance. Most of the early investigations were carried out on plant fossils of the Deccan Intertrappean flora. Prominent amongst Sahni's associates working on them were S.R.N. Rao, T.S. Mahabale, K.P. Rode, V.B. Shukla and K.R.Surange. The flora, as known then, included many palms and dicotyledonous remains, conifers and a large aquatic elements comprising algae, charophyta and water ferns. The water ferns included *Azolla, Rodeites* (a bisporangiate sporocarp resembling that of the Brazilian water fern *Regnellidium)* and massulae and megaspores like those of *Salvinia.*

The conifers were represented by the cones *Takliostrobus, Indostrobus* and *Pityostrobus* and many woods referred to *Dadoxylon* and *Cupressinoxylon.*

Amongst the angiosperms the most numerous were palm stems assigned to the artificial genus *Palmoxylon.* According to K.N. Kaul, on the basis of the characters of the ground tissue some species of *Palmoxylon* could be identified anatomically with modern palm genera like *Borassus, Bactris* and *Cocos.* Rode discovered a palm fruit from the famous Deccan Intertrappean locality Mohgaon Kalan, which Prof. Sahni found anatomically identical with the fruit of the modern *Nipa.* Hence he named it *Nipa hindi.*

---

* Lecture delivered during *The Palaeobotanical Society International Medal Award Function* held on 26th December, 1997

According to Sahni and Surange, *Palmoxylon sahnii* of Rode might not be a true palm but an extinct member of Cyclanthaceae and therefore put it under a new genus called *Cyclanthodendron.*

The dicotyledons were represented by leaves, woods, fruits and flowers, of which the genera *Enigmocarpon, Sahnianthus, Sahnipushpam* and *Indocarpa* were noteworthy.

Since long there has been a controversy about the age of the Deccan Intertrappean flora. While some of the geologists regarded it as Upper Cretaceous, Prof. Sahni strongly felt that it was Early Eocene. In any case it would fall in the domain of Cenophytic palaeobotany.

Apart from the Deccan Intertrappean series, important Tertiary plant-bearing strata are those of the Siwalik system exposed along the foot-hills of the great Himalayan belt stretching from Jammu in the west to Arunachal in the east. They correspond in age to Miocene and Pliocene. They have yielded rich collections of leaf impressions, petrified woods, fruits and seeds but very few of them were worked out till about 1950.

K.A. Chowdhury described petrified woods of Assam assigned to the genera *Cynometroxylon, Kayeoxylon, Glutoxylon* and *Dipterocarpoxylon.*

Profuse deposits of petrified woods were also known from the Cuddalore sandstones of South India. As early as in 1931 Sahni described from here a coniferous wood as *Mesembrioxylon schmidianum.*

A large collection of leaf and fruit impressions from the Karewa beds of Kashmir was described by G.S. Puri. Almost all of them were identifiable with such modern terrestrial plants as *Abies, Cedrus, Picea, Pinus, Populus, Quercus, Rhododendron, Salix* as well as aquatic plants like *Trapa* and *Vallisneria.*

It is quite obvious from the foregoing account of Cenophytic plants investigated during the three decades since 1921 that this was a preliminary stage in which a data-base was being built up for reconstructing the past history of plant life.

Since the middle of 1950s studies on the Cenophytic plants of India were taken up in a planned manner. Instead of investigating stray specimens from different sources and collected by different agencies and individuals, scholars undertook intensive studies of different floras. They themselves collected material from the fossil localities and tried to gather as much geological information about them as possible. Consequently, in the two decades of 50's and 60's sufficient information was generated on the basis of which it was possible to build up a broad picture of the Cenophytic plant history of India with a bearing on the adjoining areas. This was incorporated in an invited paper which was presented by me at the Eleventh International Botanical Congress in 1969 and published in 1970. I will briefly recount the main contents of that paper to represent the position of Indian Cenophytic palaeobotany at that stage.

There are two broad units under which the Cenophytic floras of India may be dealt with - the Peninsular and the Extra-peninsular. In the Peninsula the most prominent and extensive is the Deccan Intertrappean flora. A complete list of the taxa comprised by this flora at that time included 167 species of megafossils and a number of microfossils. Especially noteworthy amongst them were the 15 species of *Chara* and some estuarine algae as *Halimeda, Dissocladella, Acetabularia, Neomeris* and *Acicularia.* The fern taxa were all aquatic representing *Azolla, Salvinia* and Marsiliaceae. The conifers were either Podocarpaceae or Araucariaceae. Amongst the monocots the dominant element comprised the palms represented by 31 species of *Palmoxylon* and 8 species of *Palmocarpon* besides those of *Palmocaulon, Palmophyllum, Palmostrobus* and *Rhixopalmoxylon.* Other noteworthy monocots were *Musa, Amomocarpum, Nypa* and *Cyclanthodendron.*

Leaving aside the doubtful and unidentifiable forms, there were 29 dicotyledonous taxa belonging to 16 families. Some of the modern genera comparable to them were *Flacourtia, Grewia, Elaeocarpus, Ailanthus, Boswellia, Schleichera, Semecarpus, Terminalia, Barringtonia, Lagerstroemia, Sonneratia, Tetrameles* and *Mallotus.*

In addition to the earlier palaeobotanists who

studied the Deccan Intertrappean flora, the later ones included Uttam Prakash, R.K. Jain, J.K. Verma, S.D. Chitaley, Ramesh Dayal and R.N. Lakhanpal.

Angiospermic pollen representing Liliaceae, Palmae, Gramineae, Nymphaeaceae, *Barringtonia, Sonneratia,* Euphorbiaceae, Umbelliferae and Araliaceae were reported from the Lower Eocene of Kutch by Venkatachala and Kar. From the same beds Sah and Kar found pollen of Meliaceae, Rhizophoraceae, Myrtaceae and Proteaceae.

From another Eocene sediment, the Fuller's Earth at Kapurdi in western Rajasthan, Kaul had reported *Cocos sahnii* and Lakhanpal and Bose described Guttiferous remains of *Mesua, Garcinia* and *Calophyllum.*

Tertiary deposits probably attain the maximum thickness in Assam region, where a complete succession of this period occurs. Leaf impressions of *Nelumbium, Trema, Neolitsea, Grewia* and Bombacaceae had been described by Lakhanpal from an Eocene deposit in Garo Hills.

The Miocene of Assam is rich in fossil plants which are mostly preserved as petrified woods. Their main investigators were K.A. Chowdhury, Uttam Prakash, G.K.B. Navale, N. Awasthi and P.P. Tripathi. In all about 35 genera of fossil woods belonging to 18 dicotyledonous families were recognized from this area. A fossil fruit of *Nypa* was described by Lakhanpal from the Miocene of Garo Hills.

A very rich flora of fossil woods is known from the Middle Tertiary of Cuddalore Series on the eastern coast of Peninsular India. They were studied mainly by C.G.K. Ramanujam, G.K.B. Navale and N. Awasthi, who identified 2 genera of gymnosperms, one palm and 34 genera of dicotyledons in this flora.

From the Pliocene of Kutch a fossil wood was described by S.S. Ghosh and A.K. Ghosh as *Dipterocarpoxylon malavii.*

From the Extra-peninsula, Tertiary plants were described from two sediments, namely, the Lower Miocene of Kasauli and the Miocene and Pliocene of Siwalik. From the Kasauli beds were reported three ill preserved dicot leaf impressions as *Dicotylophyllum* spp. and a monocot *Sabalites microphylla* by Prof. Sahni in two posthumous papers.

From the Siwalik beds not very many megafossils were described till 1969. The taxa known were *Anisopteroxylon jawalamukhi, Dipterocarpoxylon, Smilax, Lagerstroemia, Dalbergia, Ficus precunia* and *Fissistigma senii.* There were many others still awaiting investigation. Amongst them was a collection of small leaf impression resembling the leaves of modern *Zizyphus jujuba, Bauhinia hookeri* and *Cinnamomum tamala* from the Bihar - Nepal boundary, indicating drier environment.

All the floras as known till then, could be divided into two groups - Palaeogene and Neogene. The Palaeogene flora had 6 families of pteridophytes, 2 of gymnosperms, 8 of monocots and 38 of dicots. It was predominantly tropical.

The Neogene flora had 5 families of pteridophytes, 2 of gymnosperms, 5 of monocots and 33 of dicots. It was also tropical. On comparison of the two groups, it was found that the following families appeared in the Neogene time :-

Parkeriaceae, Gleicheniaceae, Abietineae, Anonaceae, Dipterocarpaceae, Sterculiaceae, Rhamnaceae, Rosaceae, Alangiaceae, Compositae, Ericaceae, Sapotaceae, Ebenaceae, Verbenaceae, Moraceae, Fagaceae and Juglandaceae, the last two being rather doubtful.

Both the groups are made up of genera now largely confined to the old world.

Continued activity and investigation during the next two decades added further information to our growing knowledge of the subject. In a special issue of the *Palaeobotanist* entitled "Four decades of Indian Palaeobotany", covering the post-Birbal Sahni era, the advances made in Cenophytic palaeobotany have been summarized by Bande (1992), Guleria (1992) and Awasthi (1992) in three separate papers. Bande deals with the Palaeogene of Peninsular India, Guleria with the Neogene of Peninsular India, and Awasthi with the Siwalik succession of the Extra-Peninsular Tertiary. These

publications give details of the different floristic assemblages as known so far and discuss the environmental, phytogeographical and palaeogeographical issues arising out of their evidences.

In the Peninsula, the oldest and the best known is of course the Deccan Intertrappean flora. Based on various evidences now available, it seems that the Deccan volcanism was initiated in the Late Maastrichtian and continued upto Early Palaeocene, extending over a period of about 4 Ma. Thus the age of the Deccan Intertrappeans would be around the Cretaceous-Tertiary Boundary.

Substantial addition to this flora has been made by working out a large collection of petrified woods from the Mandla district by Bande. The presence of *Nypa, Sonneratia, Cocos* and the marine algae *Distichoplax* and *Peyssonnelia* indicate the vicinity of sea around this flora.

Analysing the Nagpur - Chhindwara and Mandla assemblages together Bande and Prakash have envisaged that the climate of Central India during the Palaeogene time was similar to the present day climate of Western Ghats. It was humid tropical, with an annual rainfall over 2000 mm and temperature uniform throughout the year with a long rainy season.

We had already known about the occurrence in the Deccan Intertrappean flora of *Cyclanthodendron* and *Rodeites* showing affinities with types presently found in tropical South America. Another taxon lately discovered in this flora, *Simarouboxylon,* is a further addition to the tropical American element.

The occurrence of *Hyphaene,* the branched palm, indicates affinities with the tropical and sub-tropical element of Africa. Yet another palm, *Chrysalidocarpus,* a native of Madagascar, has also been found in the Deccan. Further noteworthy is the find of Australian type of taxa like *Eucalyptus* and *Tristania-Melaleuca.* All these elements in the earliest flora of the Indian Cenophytic may be the relics of the geological past when India was in contact with the other southern continents of the Gondwanaland.

An Eocene flora of Kutch had been described in detail by Lakhanpal, Guleria and Awasthi in 1984. It consists of 3 species of calcareous red algae and a variety of angiospermous leaf impressions assigned to species of *Terminalia, Syzygium, Lagerstroemia, Cinnamomum, Ficus* and *Pandanus.*

In addition to the Eocene plants from the Fuller's Earth beds of Kapurdi, Rajasthan and from Garo Hills in Meghalaya already known, Bhattacharya has described angiospermous leaf, flower and fruit impressions from three Lower to Middle Eocene localities of Garo Hills. The modern genera represented by these fossils are *Nelumbo, Nypa, Poa, Litsea, Phoebe, Artocarpus,Osmanthus* and *Ligustrum.* The fruits belong to Leguminosae.

Considered collectively the Palaeogene flora of India broadly suggests that the wet evergreen to semi-evergreen forests and humid tropical climate in Central India prevalent during the Deccan Intertrappean sedimentation, also continued in the west as well as the north-east India at least till the Middle Eocene.

For a long time there was no published record of Oligocene plants from India. In 1992 Awasthi, Mehrotra and Lakhanpal described leaf impressions of *Podocarpus oligocenicus* and *Mesua antiqua* from the Oligocene sediments of Makum Coalfield, Assam; thus making a beginning in filling up the long felt gap in the Tertiary record.

In a recent publication based on a rich collection from the same area, Awasthi and Mehrotra (1995) have further described 24 species belonging to 21 genera, namely, *Saccopetalum, Calophyllum, Garcinia, Kayea, Pterygota, Santiria, Heynea, Nephalium, Lannea, Mangifera, Parichia, Entada, Leguminocarpon, Rhizophora, Terminalia, Memecylon, Avicennia, Alstonia, Myristica, Apollonias* and *Bridelia.* From the collective evidence of all these taxa as now known, it is inferred that thick, tropical evergreen to moist deciduous forest existed in this part of north-east India during the Oligocene. Amongst them the occurrence of *Avicennia, Rhizophora* and *Terminalia catappa* is highly suggestive of deltaic, mangrove or lagoonal deposition of coal seams and associated sediments in the Makum Coalfield area at that time.

There has been remarkable increase in our

knowledge of the Neogene flora. Whereas in 1970 we knew partly only two Neogene floras, *viz.* Assam and Cuddalore, and the report of a petrified wood from the Pliocene of Kutch. Guleria (1992) has now listed 11 Neogene floras from different parts of the country. This illustrates the noteworthy augmentation in the composition of the earlier known floras. In addition, contributions have been made to floras from Rajasthan, Konkan, Kerala coast, Rajahmundry, Neyveli lignite, Bengal, Bihar, Central India and Andaman & Nicobar islands.

Some significant conclusions can be drawn from the observations on all these floras considered collectively:-

(i) The Neogene vegetation of Peninsular India is mainly represented by dicot woods which are widely distributed throughout the Peninsula. Palms are infrequent and gymnosperms rare.

(ii) During Neogene the entire peninsula was covered by rich vegetation as the climate must have been more or less uniform because of the warm sea surrounding and intruding into the land mass.

(iii) All the floras from different basins show close similarity in their composition as most of the genera are common to them. The wide distribution of the tropical rain forest family Dipterocarpaceae along with other associated genera, indicates more or less uniform tropical moist climate throughout the Peninsular India.

(iv) Aridity could have increased gradually towards the close of the Neogene due to the growing continentality caused by the rise of the Himalayas and disappearance of the Tethys sea in the north. This resulted in complete eradication of dipterocarps from Kutch, Rajasthan and Cuddalore and their recession from the western Himalayan foothills to north-eastern India.

(v) There were large scale migrations and admixture of floras over Malaysia, India, Arabia, and Africa during the Neogene times due to establishment of land connections by Early Miocene.

(vi) The presence of families such as Dipterocarpaceae, Ebenaceae, Rhamnaceae and Sapotaceae alongwith the dominance of legumes distinguishes the Neogene flora with the Palaeogene flora of India.

There has also been considerable addition to our knowledge of the Cenophytic floras of the extra-Peninsular India, which are found in the Himalayan region. There are three longitudinal sedimentary zones in the Himalayas. Chronologically, the first is the Tethys Himalayan; the second Lesser or Lower Himalayan; and the third is the outer or sub-Himalayan.

In the Tethys Himalaya, from Dras Volcanics of Ladakh a Palaeocene assemblage of palynofossils exhibits the occurrence of a rich coastal vegetation, predominantly tropical. From the same zone, a Late Eocene – Miocene palynoassemblage from the Tarumsa Formation shows that the coastal semi-evergreen type of vegetation was transformed into moist deciduous type by the Middle Tertiary time, suggesting the onset of sub-temperate climate.

From the Late Eocene - Oligocene Hemis Conglomerate horizon of Ladakh was described the leaf impression of a tropical palm as *Livistona wadiai* (Lakhanpal *et al.* 1983). It provided further evidence that the climate in the Himalaya was tropical till the Oligocene epoch.

The advent of temperate element in the Ladakh flora was indicated by the recovery of two Miocene megafossils, a petrified wood of *Prunus* (Guleria *et al.* 1983) and a leaf impression of *Trachycarpus,* a warm temperate palm (Lakhanpal *et al.* 1984).

In Lesser Himalaya of the west, the Subathu Formation of Upper Palaeocene - Eocene age, the palynofossil assemblage suggests shallow marine to coastal transitional environment with semi – evergreen vegetation, more or less similar to that of Early Tertiary of Ladakh.

Recently Mathur, Mishra and Mehra (1996) described fragmentary leaf impressions of grasses and dicot genera *Millettia, Bauhinia, Persea, ? Mallotus* and *Ficus* and a seed assigned to *Carpolithus* from the Upper Oligocene - Lower Miocene Dagshai Fomation of Western Himalaya. The small collection indicates a moist tropical environment. This

supplements information on the meagrely known vegetation of the Oligocene epoch.

The sub-Himalayan zone contains rich assemblage of leaf impressions and petrified woods from the widely extending Siwalik beds. Some of the commonest genera described from them are: *Albizia, Anisoptera, Bauhinia, Calophyllum, Cassia, Cinnamomum, Cynometra, Dalbergia, Diospyros, Dipterocarpus, Duabanga, Ficus, Fissistigma, Gluta, Hopea, Litsea, Mallotus, Mangifera, Polyalthea, Shorea, Sindora, Smilax, Sterculia, Swintonia, Syzygium, Terminalia* and *Ziziphus.*

The Lower and Middle Siwalik Sub-groups are rich in plant fossils but the megafossils in the Upper Siwalik are very scarce. However, from the Lower Karewa beds of Kashmir, which are equivalent to the Upper Siwalik of the Western Himalaya in being of Upper Pliocene age, a rich flora is known, comprising a large number of angiosperms, six species of gymnosperms and three of pteridophytes. Most of the Lower Karewa plants are specifically identifiable with the modern plants of the surrounding area.

In the ensuing Quaternary period, the gradual changes in the physical conditions ultimately resulted in the vegetation acquiring its modern complexion.

This in short is a very brief account of the development of Cenophytic palaeobotany in India. We have really come a long way from the year 1921 when all that was taxonomically known about the subject were just three species of Tertiary plant fossils.

REFERENCES

Awasthi N. 1992. Changing patterns of vegetation through Siwalik succession. *Palaeobotanist,* **40**: 312-327.

Awasthi N. & Mehrotra R.C. 1995. Oligocene flora from Makum Coalfield, Assam, India. *Palaeobotanist,* **44**: 157-188.

Awasthi N., Mehrotra R.C. & Lakhanpal R.N. 1992. Occurrence of *Podocarpus* and *Mesua* in the Oligocene sediments of Makum Coalfield, Assam, India. *Geophytology,* **22**: 193-198.

Bande M.B. 1992. The Palaeogene vegetation of Peninsular India (megafossil evidences). *Palaeobotanist* **40**: 275-284.

Guleria J.S. 1992. Neogene vegetaton of peninsular India. *Palaeobotanist,* **40** : 285-311.

Guleria J.S., Thakur V.C. , Virdi N.S. & Lakhanpal R.N. 1983. A fossil wood of *Prunus* from the Kargil (=Liyan) Formation of Ladakh. *In* : V.C. Thakur & K.K. Sharma (eds) - *Geology of Indus Suture Zone of Ladakh* : 187-193. Wadia Institute of Himalayan Geology, Dehradun.

Lakhanpal R.N. 1970. Tertiary floras of India and their bearing on the historical geology of the region. *Taxon,* **19** (5): 675-694.

Lakhanpal R.N., Gyan-Prakash, Thussu J.L. & Guleria J.S. 1984. A fossil fan palm from the Liyan Formation of Ladakh (Jammu & Kashmir). *Palaeobotanist,* **31** (3): 201-207.

Lakhanpal R.N., Sah S.C.D. , Sharma K.K. & Guleria J.S. 1983. Occurrence of *Livistona* in the Hemis Conglomerate horizon of Ladakh. *In* : V.C. Thakur & K.K. Sharma (eds) - *Geology of Indus Suture Zone of Ladakh* : 179-185. Wadia Institute of Himalayan Geology, Dehradun.

Mathur A.K., Mishra V.P. & Mehra S. 1996. Systematic study of plant fossils from Dagshai, Kasauli and Dharamsala formations of Himachal Pradesh. *Palaeontologia indica* (*N.S.*), **40** : 1-121.

Sahni B. 1921. The present position of Indian Palaeobotany. *Proc. Asiat. Soc. Beng.* (*N.S.*), **17** (4) : cliii-clxxv.

Traverse, A. 1988. *Palaeopalynology.* Unwin Hyman, Boston.

(Received 15.09.1998; Accepted 08.12.1998)