

Development of some pteridophytes in India during Tertiary

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Kar, R.K. 1993. Development of some pteridophytes in India during Tertiary. *Geophytology* **23** (1): 137 — 140.

Evolution of some pteridophytes in India during the Tertiary Period has been traced on the basis of spores. It has been observed that *Lycopodiumsporites* was very common in northeast India during Palaeocene and followed by *Dandotiaspora*. Polypodiaceae was persistently present in India since Palaeocene but exhibits its maximum development during Middle Eocene-Miocene. *Ceratopteris* evolved probably in India during Middle Eocene and became dominant in Oligocene and Miocene. *Osmunda* spores were never in prominence but found in considerable numbers in Middle-Late Eocene. The pteridophytic spores during Tertiary have been divided into two associations : (1) the lower *Lycopodiumsporites*-*Dandotiaspora* association in Palaeocene and the upper Polypodiaceae - *Ceratopteris* association during Oligocene and Miocene.

Key-words—Palaeopalynology, pteridophytes, Tertiary, India.

INTRODUCTION

THE fossil history of the pteridophytic spores is very fascinating. Their oldest record is from the Late Devonian. They still form a major group of plants and are found as dominant elements in many localities. The spores are thus conveniently used to determine the age of rocks, for correlation and deciphering the palaeoecological condition of deposition of the basin. The present paper deals with development of some pteridophytes in India during the Tertiary Period.

It may be mentioned here that Indo-Malayan region harbours the maximum representation of pteridophytes of the world at present. During Palaeocene, northeast India was also populated by many families of pteridophytes as the palynological assemblage is dominated by the pteridophytic spores. The families identified are Lycopodiaceae, Polypodiaceae, Matoniaceae, Schizaeaceae and Cyatheaceae.

TERTIARY PTERIDOPHYTES IN INDIA

Lycopodiaceae

The family is generally divided into 5 genera. Of these *Diphasium*, *Palhinhaea* and *Lycopodium* are mostly confined to the subalpine forest whereas *Huperzia* and *Phlegmariurus* are restricted to the tropical and subtropical forests.

The spores of Lycopodiaceae are homosporous,

tetrahedral, triangular-subtriangular in shape, trilete, size ranging from 30-58 μm . The sculptural pattern on the exospore may be pitted, reticulate or rugulate. The terrestrial procumbent species of *Lycopodium* and *Diphasium* have reticulate spores except *D. carsurinoides* which produce scabrate spores (Wilce, 1972). All the epiphytic species of *Huperzia* and three terrestrial erect species have spores with pitted exine. Fifteen species of *Huperzia* known from India have basically pitted spores. The spores of different species of the genus *Palhinhaea* are granulate and the ornamental pattern is more pronounced on the distal surface.

Fossil spores showing affinity to *Lycopodium* are generally accommodated in *Lycopodiumsporites* Thiergart ex Delcourt & Sprumont (1955). This genus is one of the most common elements in Palaeocene of northeast India and is known to occur since Palaeozoic. Sah and Dutta (1966), Dutta and Sah (1970), Singh (1974), Mehrotra and Sah (1980) and Kar and Kumar (1986) described many species of *Lycopodiumsporites* from this region. Besides, Ramanujam (1966) recovered this genus from the Cuddalore Series (Miocene) of Tamil Nadu; Potonié and Sah (1961), Kar and Jain (1981) reported their occurrence in Kerala; Sah and Kar (1969) and Kar (1985) observed them in Kutch; Baksi and Deb (1981) noted them from the subsurface of West Bengal. Some of the species described by these authors resemble the extant spores of Lycopodiaceae. For example, *Lycopodiumsporites assamicus* described by Mehrotra and Sah

(1980) from the Mikir Formation of Assam closely resembles the spores of *Lycopodium veitchii*. This species is still growing in the eastern Himalayas.

The presence of reticulate type of *Lycopodium* spores in large numbers in Palaeocene of northeast India indicates that these plants are living in this area since the beginning of the Tertiary. The pitted foveolate-fossulate type of spore producing plants generally represented by *Huperzia* appeared later in this part of India. However, in western and southern India the pteridophytes are represented by one or two species only. The paucity of *Lycopodium* spores is a convincing proof to this statement. The dominance of *Lycopodium* during Tertiary Period was rather short-lived even in northeast India. After Palaeocene, it started disappearing and never came into prominence. Perhaps, the environment of India changed with the progress of continental drift and it was not congenial for *Lycopodium* to flourish.

***Dandotiaspora* Sah et al.**

The genus *Dandotiaspora* was instituted by Sah, Kar & Singh (1971). Out of five species proposed by them, four species are generally confined to Palaeocene. *Dandotiaspora dilata*, the type species of the genus, is commonly met with in Palaeocene sediments of Assam and Kutch basins. It is also found in the Sind basin in Pakistan, Senegal basin in western Africa and Columbian basin of South America. Unlike *Lycopodiumsporites*, it was equally distributed in eastern and western India. This species is however, not recorded after Palaeocene.

Dandotiaspora could not be tagged with any of the living species of pteridophytes. Mahabale (1978) opined that thickening on the distal side of *Dandotiaspora* are oil globules accumulated together as is found in the extant spores of *Schizoloma encifolia* (Mahabale, 1978, pl. 2, figs 9,10). The spores of *Gymnospora glabra* figured by Kremp and Kawasaki (1972, p. 66, fig. 62) come closest to *Dandotiaspora* by its presence of exinal thickening at the ray ends. However, in the opinion of Kawasaki (1972), the exine in *G. glabra* is more thickened at the apices to form a trilobed appearance. The size range of spores in *G. glabra* is 31-34 x 24-31 μm whereas in *Dandotiaspora* it varies from 40-102 x 30-95 μm .

The development and distributional pattern of *Lycopodiumsporites* and *Dandotiaspora* in India is more or less same. Both the genera show their maximum development in Palaeocene and except one or two species they have no representative in the rest of the Tertiary Period. It may be postulated that climatic condition suited them most during Palaeocene. According to Olivet et al. (1987), India was around 20°-10° south of equator during Palaeocene. Kemp & Harris (1975, 1977) investigated

the palynology of site 214 of the leg 22 drilled by DSDP. This site is situated near 10°S latitude on the Ninety east ridge. They recovered a cold loving flora during Palaeocene from this site. The presence of reticulate type of *Lycopodium* spores in Palaeocene also reflects a cold climate. But, as India was moving gradually towards the equator, the climate became warmer. This perhaps led to the large scale disappearance of these two genera.

Ceratopteris

The genus *Ceratopteris* is mostly placed under the family Parkeriaceae. Tryon and Tryon (1982) regarded *Ceratopteris* as a specialized type rather than a relict one and placed it under the tribe *Ceratopterideae*.

Ceratopteris is pantropical in distribution. Hooker & Baker (1968) observed its presence throughout the tropics in quiet water. In India, this genus occurs upto Dehra Dun and Haldwani in Uttar Pradesh, the whole of Gujarat except Kutch, Maharashtra, Goa, Kerala, Tamil Nadu, Orissa, Bihar, West Bengal and Assam (Chowdhury, 1973).

The spores of *Ceratopteris* can easily be distinguished in the dispersed condition. They are mostly triangular-subcircular in polar view with rounded apices and straight to slightly convex interapical margin. Exine is costate, costae appear as bands running more or less parallel in one inter radial area and its corresponding distal side.

The spores of *Ceratopteris* are found in abundance in fossil condition and are known as *Striatriletes* van der Hammen emend. Kar (1979). These spores have been reported from the Tertiary sediments of Assam, Meghalaya and Bengal (Meyer, 1958; Baksi, 1962, 1965; Biswas, 1962; Banerjee, 1964; Sah & Dutta, 1968; Salujha, Kindra & Rehman, 1972, 1974); Himachal Pradesh (Nandi, 1975); Kutch (Kar, 1979, 1985; Kar & Saxena, 1981); Kerala (Kar & Jain, 1981). The oldest record of *Striatriletes* in India is from Prang Limestone (Middle-Late Eocene) of Meghalaya by Kar (MS) and Middle-Late Eocene sediments of Kutch by Kar & Saxena (1981).

Kar (1984) opined that *Ceratopteris* originated in India during Middle Eocene while it was situated in tropical realm. The occurrence of *Striatriletes* in the post Eocene sediments of West Indies, Venezuela, Nigeria and Malaysia led him to postulate this hypothesis. Germeraad, Hopping and Muller (1968) also remarked that the absence of *Ceratopteris* in Cretaceous and Palaeocene indicates that this genus originated during Middle Tertiary. The dispersal of *Ceratopteris* from India within 50 million years to pantropical region indicates that the spores are very adept in quick dispersal. This also reveals that *Ceratopteris* in comparison to other ferns, is rather

young because it evolved during Middle Eocene and not a relict species as advocated by Tryon and Tryon (1982).

The spores of *Ceratopteris* are found in good numbers in Middle-Late Eocene sediments of India and became very dominant in Oligocene and Miocene, particularly in northeast and west India. After Miocene they decline probably because of the scarce existence of the alluvial flat which is their natural habitat.

Polypodiaceae

The family Polypodiaceae is divided into 3 tribes, viz., Polypodieae, Loxogrammeae and Grammitideae. Of these, Polypodieae produces only monolete spores, Loxogrammeae has both trilete and monolete spores and Grammitideae has only trilete spores. The spore type in *Polypodium* is generally consistent within the species alliances. The Indian species of *Polypodium* has been investigated by Santha Devi (1977). The spores of *Polypodium* can easily be recognized by their bean shape, monolete mark and presence of verrucae, tubercles, grana and coni of different dispositions. There are, however, some ferns like *Blechnum* and *Nephrolepis* which also produce more or less same type of spores.

The polypodiaceous spores from the Indian Tertiary sediments are mostly known as *Polypodiaceasporites* Thiergart (1940), *Polypodiisporites* Potonié (1934) and *Seniasporites* Sah & Kar (1969). These genera are encountered in Palaeocene and Eocene in good percentage and become dominant during the Oligocene and Miocene. In some sediments their percentage is subdued due to the good representation of gymnospermous pollen. This behaviour pattern of polypodiaceous spores is similar to that of *Ceratopteris*.

Osmundaceae

Osmundaceae is indeed an old family having fossil records from the Carboniferous. Present day Osmundaceae in the opinion of Tryon and Tryon (1982) seems to be related with the Palaeocene. It is represented by genera, viz., *Osmunda*, *Todea* and *Leptopteris*.

Spores of *Osmunda regalis* studied by Lugardon (1971) exhibit the formation of a massive, rugose exospore, which is covered by a relatively thin perispore with delicate echinate projections. The spores are subcircular in shape and contain well developed trilete mark that extends upto three-fourths radius.

The fossil spores of *Osmunda* are known as *Osmundacidites* Couper (1953). In the fossil spores, the echinate perispore is lost and only the verrucose, granulose exospore is retained. The character of the exospore, subcircular shape and prominent trilete rays help to identify the dispersed spores. Southworth (1974) shown that the spore wall of *Osmunda* is very stable and is not

affected by agents which generally disintegrate the sporopollenin. So spores of *Osmunda* have a better chance of fossilization.

Osmundacidites was present in India throughout the Tertiary period. They exhibit the maximum development in northeast India during Middle-Late Eocene epoch (Kar, MS). However, in Oligocene they are replaced by *Ceratopteris* and polypodiaceous spores.

OBSERVATIONS

The distributional pattern of the spores of pteridophytes during the Tertiary period in India leads to the following observations:

1. The reticulate type of *Lycopodium* spores were most prevalent in Palaeocene than pitted foveolate types.
2. *Lycopodiumsporites* and *Dandotiaspora* were the two most dominant genera during Palaeocene in India.
3. *Osmunda* spores represented by *Osmundacidites* were never very prominent but exhibits their maximum development during Middle-Late Eocene.
4. *Ceratopteris* spores have the oldest fossil record in India. So it seems that this genus originated in India during Middle Eocene and migrated to other tropical countries.
5. *Ceratopteris* spores known as *Striatriletes* in the dispersed fossil condition were most common in Oligocene and Miocene.
6. Polypodiaceous spores commonly known as *Polypodiaceasporites* and *Seniasporites* though encountered throughout the Tertiary were most prominent in Oligocene and Early Miocene.

ACKNOWLEDGEMENT

The author is grateful to Dr B.S. Venkatachala, ex-Director, Birbal Sahni Institute of Palaeobotany, Lucknow for kindly reading the manuscript and giving fruitful suggestions.

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