

OCCURRENCE OF CORDAITALEAN LIKE FOLIAGE IN THE LOWER GONDWANA FLORA OF INDIA

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ABSTRACT. Cordaitalean like foliage in the Gondwana flora of India is represented by a simple leaf form genus, *Noeggerathiopsis* Feistmantel. The records of *Noeggerathiopsis* in the lower horizons of Indian Gondwana have been found to be different than the available specimens of upper horizons. As such, previously assigned specimens of Talchir and Karharbari formations are transferred under a new species, *N. feistmantelii* and *N. hislopii* (Bunbury) Feistmantel is retained for the leaves belonging to Kamthi and lower Triassic beds of India.

The investigations of plant fossil assemblages of South Rewa Gondwana Basin demonstrates the presence of *Cordaites* leaves along with *Noeggerathiopsis* leaves. New species, *C. dumanii* is instituted for leaves showing finer veins in between major veins.

KEY WORDS: Gondwana, cordaites, India

INTRODUCTION

Feistmantel (1879) instituted a genus, *Noeggerathiopsis* for the leaves having oblong and spatulate shape with straight, slightly diverging and distinctly once or several times bifurcating parallel to sub parallel veins. The genus is well represented in the Talchir and Karharbari formations (Feistmantel 1879, 1881, 1882, 1886, Surange & Lele 1956, 1957, Lele & Maithy 1964, Maithy 1965, Srivastava 1977), while sometimes it extends in the Lower Barakar flora (Bajpaj 1990, Srivastava in press). Definite record of the genus is not known in the Upper Barakar, Barren Measures and Raniganj formations, but they reappear in the flora of Kamthi and lower Triassic beds of India (Bunbury 1861, Feistmantel 1886, Lele 1956, 1962, Srivastava 1977, Bose & Banerjee 1976). In fact, such leaves were discovered for the first time in the Kamthi beds of Bharatwada, Nagpur by Bunbury (1861).

The external morphological features of cuticular species reported from the Karharbari formation viz. *N. indica* Lele & Maithy, *N. gondwanensis* Lele & Maithy, *N. bunburyana* Pant & Verma, *N. papillosa* Pant & Verma and *N. fibrosa* Pant & Verma (Lele & Maithy, 1964) are similar in every respect with the non cuticular leaves. Recent cuticular investigation of Gondwana gymnosperms suggests that cuticular structure vary within the same species and therefore specific delimitation on such characteres can not

be relied upon (Maheshwari & Tiwari, in press).

The observation of type and figured specimens of *Noeggerathiopsis hislopii* (Bunbury) Feistmantel 1879 at British Museum (Natural History), London by one of us (AKS) and examination of Kamthi and lower Triassic flora shows that such leaves possess only once or twice forking of veins.

The leaf forms reported by Feistmantel and others from the Talchir and Karharbari formations bear repeated dichotomy in the veins.

Plant fossil assemblages of Anuppur, Birsinghpur Pati Umaria and Chirimiri areas of South Rewa Gondwana Basin under investigation contain large number of *Noeggerathiopsis* leaves along with *Glossopteris* Brongniart and *Gangamopteris* Mc Coy leaves. It has been observed that many specimens which look like the foliage of *Noeggerathiopsis* possess finer veins or fibres in between thicker veins. Such specimens are distinct and possess characters of the leaf genus *Cordaites* Unger.

The study is based on the external morphological features of leaf and the specimens are mostly preserved in the form of impression on sandy to fine carbonaceous shale. All the type and figured specimens are preserved at the Museum of Birbal Sahni Institute of Palaeobotany, Lucknow.

DESCRIPTION

Genus *Noeggerathiopsis* Feistmantel, 1879

Type specimens *Noeggerathiopsis hislopii* (Bunbury) Feistmantel, 1879

Noeggerathiopsis hislopii (Bunbury) Feistmantel, 1879

- 1861 *Noeggerathia?* (*Cyclopteris*) *hislopii*, n. sp.; Bunbury, Quarterly Journal of Geological Society, London, v. 17; p. 334–335; pl. 10, fig. 5.
 1881 *Noeggerathiopsis hislopii* Bunb. sp. (Fstm) – Feistmantel, Memorials of the Geological Survey of India, Palaeont. Indica (ser. 12), v. 3 pt. 1, suppl.; p. 118; pl. 45A, figs 6–9.
 1956 *Noeggerathiopsis hislopii* (Bunb) – Fstm. Lele, Palaeobotanist, v. 4; p. 28, pl. 2, fig. 25.
 1962 *Noeggerathiopsis hislopii* Bunb – Lele, Palaeobotanist, v. 10; p. 78; pl. 3, fig. 32.
 1971 *Noeggerathiopsis* sp. – Srivastava, Palaeobotanist, v. 18; p. 291; pl. 6; figs 6–7; text-figs 7A–B.

Revised diagnosis. (Based on Bunbury's specimen and description 1861; pl. 10, fig. 5; p. 334–335): Leaf narrow wedge shape, widening gradually upwards from a narrow base not quite symmetrical, but very slightly oblique; terminal portion, very conspicuously oblique, rounded at the actual apex and from the sloping away with a gentle curve, forming a very obtuse and rounded angle with the other (flower) margin; veins numerous, all equal uniform strongly coarse, radiating from the base, spreading very gradually forming very small angles with one another so that for any short distance they appear nearly parallel; veins once or twice sparingly forked, branches diverging very gradually, all ending at terminal margin.

Lectotype. Specimens no. V 19649; British Museum (Natural History), London.

Locality. Bharatwada, Nagpur.

Horizon. Kamthi Formation, Upper Permian, Lower Gondwana.

Description. See Bunbury 1861, p. 334–335; pl x; fig. 5.

Comparison and discussion. The species includes all *Noeggerathiopsis* leaves showing once or twice forked parallel running veins in the Gondwana flora of India. The character of veins is distinctly available in all the leaves reported from the Kamthi and lower Triassic beds of India.

The leaves of *Noeggerathiopsis* reported from the Talchir and Karharbari formations are distinct in having frequently dichotomising parallel running veins.

Noeggerathiopsis feistmantelli sp. nov.

(Pl. 1, figs 1–3)

- 1879 *Noeggerathiopsis (Zamia ?) hislopii* Bunbury, sp. – Feistmantel, Memoirs of the geological Survey of India, Palaeontol. Indica (Ser 12) v. 3, pl. 1, p. 23; pl. 9, figs 1–6; pl. 20, figs 1, 1a.
- 1879 *Noeggerathiopsis hislopii* var. *subrhomboidalis* Feistmantel *ibid*; p. 24; pl. 20, fig. 2.
- 1881 *Noeggerathiopsis hislopii* Bunbury sp. (Feistmantel) – Feistmantel, Memoirs of the Geological Survey of India, Palaeontol. Indica (Ser 12) v. 3, pt. 3; p. 118; pl. 45a, figs 1–5, 10, 11; pl. 46a.
- 1881 *Noeggerathiopsis hislopii* Bunbury sp. (Feistmantel) – Feistmantel, Memoirs of the Geological Survey of India, Palaeontol. Indica, (Ser12), v. 3, pt. 1, suppl., p. 58; pl. 28, figs 1–4, 6, 7; pl. 29, figs 1–4; pl. 30, figs 5–9.
- 1882 *Noeggerathiopsis hislopii* Feistmantel (Bunbury sp.) – Feistmantel, Memoirs of the Geological Survey of India, Palaeontol. Indica (Ser 12) v. 4, pt. 1; p. 41; pl. 13, figs 2–4; pl. 14, figs 1–3; 6, 9; pl. 15, fig. 4b; pl. 18, fig. 1; pl. 20, fig. 10; pl. 21, figs 6, 8, 10.
- 1986 *Noeggerathiopsis hislopii* Fstm. – Feistmantel, Memoirs of the Geological Survey of India, Palaeontol. Indica (Ser 12), v. 4, pt. 2; p. 40; pl. 12A, fig. 5a; pl. 13A, fig. 5.
- 1920 *Cordaites (Noeggerathiopsis) hislopii* Bunbury–Seward & Sahni, Memoirs of the Geological Survey of India, Palaeontol. Indica (n.s.) v. 7, mem 2; p. 7; pl. 1, figs 8, 9 (in part).
- 1956 *Noeggerathiopsis hislopii* (Bunb) Feistm.–Surange & Lele, Palaeobotanist, v. 4; p. 28; pl. 21, fig. 25.
- 1957 *Noeggerathiopsis hislopii* Feistm.–Dutta, Quarterly Journal of the Geological Mining and Metallurgical Society of India, v. 29; p. 7; figs 18, 20.
- 1957 *Noeggerathiopsis hislopii* (Bunb) Feistm.–Surange & Lele, Palaeobotanist, v. 5; p. 84; pl. 1, figs 1, 2.
- 1959 *Noeggerathiopsis hislopii* Feistm. (Bunb sp.)–Ganguly, Quarterly Journal of the Geological Mining and Metallurgical Society of India, v. 31, p. 161; figs 3, 4, 11.
- 1964 *Noeggerathiopsis indica* Lele & Maithy–Lele & Maithy, Palaeobotanist, v. 12, p. 8; pl. 1, figs 1–7; pl. 2, figs 8–11; text–fig. 1.
- 1964 *Noeggerathiopsis gondwanensis* Lele & Maithy–Lele & Maithy, Palaeobotanist, v. 12, p. 10; ppl. 2, figs 12–16; text–figs 2, 3.
- 1964 *Noeggerathiopsis zeilleri* Lele & Maithy–Lele & Maithy, Palaeobotanist, v. 12, p. 12, pl. 3, figs 16–21; text–figs 4–7.
- 1964 *Noeggerathiopsis bunburyana* Pant & Verma–Pant & Verma Palaeontographica, v. 115 B, p. 25; pl. 10, figs 1–7; pl. 11, fig. 14; text–figs 1, 2, 3A, E.
- 1964 *Noeggerathiopsis papillosa* Pant & Verma–Pant & Verma Palaeontographica, v. 115 B; p. 27; pl. 11, figs 8–13; text–fig. 9.
- 1964 *Noeggerathiopsis fibrosa* Pant & Verma–Pant & Verma, Palaeontographica, v. 115 B; p. 30; pl. 12, figs 15–19; pl. 13; figs 20, 21; text–figs 3F, G; 5, 6
- 1965 *Noeggerathiopsis hislopii* (Bunbury) Feistmantel–Maithy Palaeobotanist, v. 13, p. 97; pl. 1, figs 1–3.
- 1982 *Noeggerathiopsis hislopii* (Bunbury) Feistmantel–Chandra & Srivastava, Palaeobotanist, v. 30; p. 157; pl. 1, figs 6–8; pl. 2, fig. 17.

Diagnosis. Leaves elongate, spathulate, gradually tapering towards base, apex obtuse, base narrow, margins entire, midrib absent; veins arise from base, uniformly thick, parallel to sub parallel, frequently dichotomise, anastomoses absent.

Holotype. Specimen no. 5032; Geological Survey of India, Calcutta.

Locality. Buriadi, no. 11A mine, Karharbari (Giridih) Coalfield Lower Permian, Lower Gondwana.

Description. See Feistmantel, 1879.

Comparison and discussion. *N. feistmantelii* sp. nov. differs from type species, *N. hislopii* in having repeated dichotomy in the parallel running veins. The listed specimens, include the cuticular species whose external morphological features are similar with *N. feistmantelii* sp. nov. The genus *Pantophyllum* instituted by Rigby (1984) to accomodate the cuticular species of *Noeggerathiopsis* is convincingly merged the genus, *Noeggerathiopsis* by Bajpaj (1990). The leaves of *N. feistmantelii* are distributed only in the Talchir and Karharbari formations of the Indian Lower Gondwana flora. Distribution in South Rewa Gondwana Basin, Anuppur, Umaria, Birsinghpur Pali and Chirimiri coalfields.

Genus *Cordaites* Unger, 1850

In the Gondwana flora of Zaire, Argentina and India leaves showing pseudo-veins/finer veins or fibres in between stouter veins have been found.

They are distinct from the leaves of *Noeggerathiopsis* (Hoeg & Bose 1960, Archangelsky & Leguizamon 1980, Archangelsky & Cuneo 1981, Srivastava 1988, in press) and considered as the true ally of *Cordaites* Unger.

Cordaites dumanii sp. nov.

Specific diagnosis. Leaves simple, spathulate lanceolate in shape; apex acute to obtuse; base narrowly contracted, margin entire; veins emerge from base, straight, bifurcating, 2–4 fine interstitial veins found in between thicker major veins.

Holotype. Specimen no. 36646 Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality. Duman Hill, Chirimiri Coalfield, Karharbari Formation, Lower Permian, Lower Gondwana.

Description. In all twenty five leave specimens are found preserved in the collection some of which are complete. They range from 6–7 cm in length and 1.2–2.8 cm in breadth at the widest region. The leaves are spathulate to linear–lanceolate in shape. They show acute to obtuse apex and their base is narrowly contracted. 6–8 thick veins emerge from the base, dichotomise 3–4 times, spread gradually and run parallel without anastomosing.

In between stouter veins or ribs 2–4 finer veins are also present running in the same direction. The density of finer veins is 15–20 per cm.

Comparison and discussion. *Cordaites dumanii* sp. nov. differs from the Argentinian species, *C. riojanus* Archangelsky & Leguizamon, 1980 and *C. casildensis* Archangelsky & Cunio, 1981 in having spathulate to linearlanceolate shape and 2–4

finer veins in between stouter veins. *Cordaites* sp. described from the Lower Barakar of Raniganj Coalfield, India (Srivastava, in press) is distinctly different in possessing obovate different shape and dissected apical margin of leaf. Incomplete leaf of *N. hislopii* by Hoeg & Bose, (1960, pl. 8, figs 3–4) shows resemblance to *C. dumanii* in having similar concentration or finer veins.

The type species, *C. borassifolia* (Sterberg) Unger is distinct in possessing ovate lanceolate shape and only once or rarely two finer veins in between stronger veins. *C. principalis* Germar and *C. palmaeformis* (Geoppert) Seward are distinguishable in having large size leaves and varying concentration of finer veins.

DISCUSSION

While instituting the genus *Noeggerathiopsis*, Feistmantel (1879) doubted its affinity with the plant group cycads, however, he was not sure and described it under a new family *Noeggerathiopsidae* Zeiller (1896, 1902) for the first time considered cordaitalean affinity of the genus on the basis of its close resemblance with the leaves of *Cordaites* Unger, 1850.

Zeiller (1902) also pointed out that the constant occurrence of cordaitalean seeds, viz., *Cardiocarpus* or *Cordaicarpus* in association with *N. hislopii* is an additional argument in favour of referring *Noeggerathiopsis* to *Cordaitales*. This view was seconded and favoured by many workers and Seward & Leslie (1908), Seward & Sahni (1920), Walton (1929), Archangelsky (1958), Maheshwari (1976) and Maheshwari & Meyen (1975) described it under *Cordaites*. But Arber (1905), Walkom (1922), Lele & Maithy (1964), Maithy (1965), Lacey et al. (1975), Appert (1977) and Srivastava (1988, in press) maintained the separate, identity of *Noeggerathiopsis* Feistmantel, 1879 in the absence of finer veins in between major veins.

The discovery of typical *Cordaites* leaves having alternately arranged thick and thin veins in the Gondwana flora of India alongwith the leaves of *Noeggerathiopsis* (Srivastava 1988, in press) fairly demonstrates the distinction of two leaf forms. It is quite likely that *Noeggerathiopsis* and *Cordaites* are closely allied to each other and in all probability may belong to the family *Cordaitaceae*. However, in the absence of typical cordaitalean fructification in the Gondwana flora of India it is not possible to ascertain their exact relationship.

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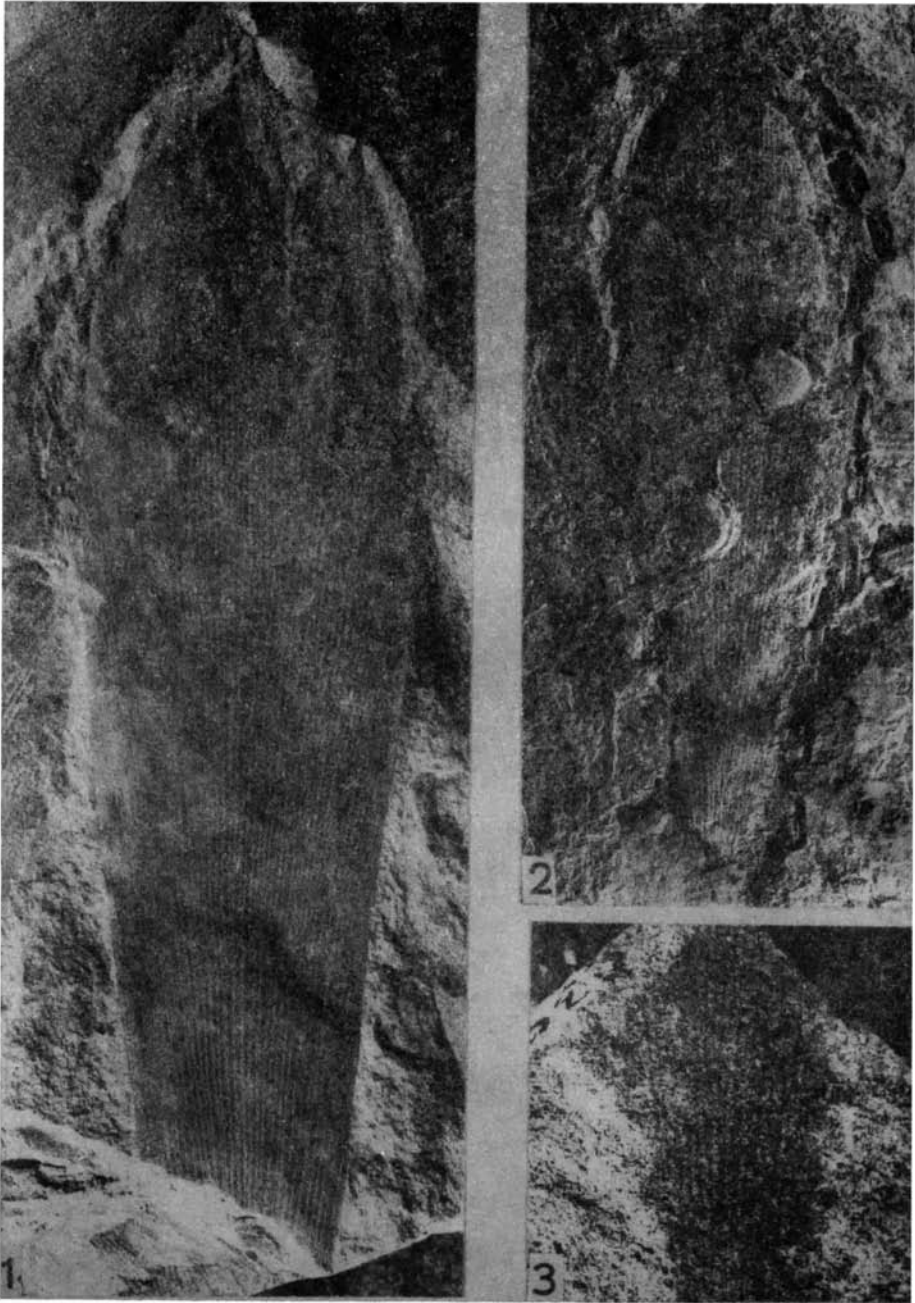
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PLATES

Plate 1

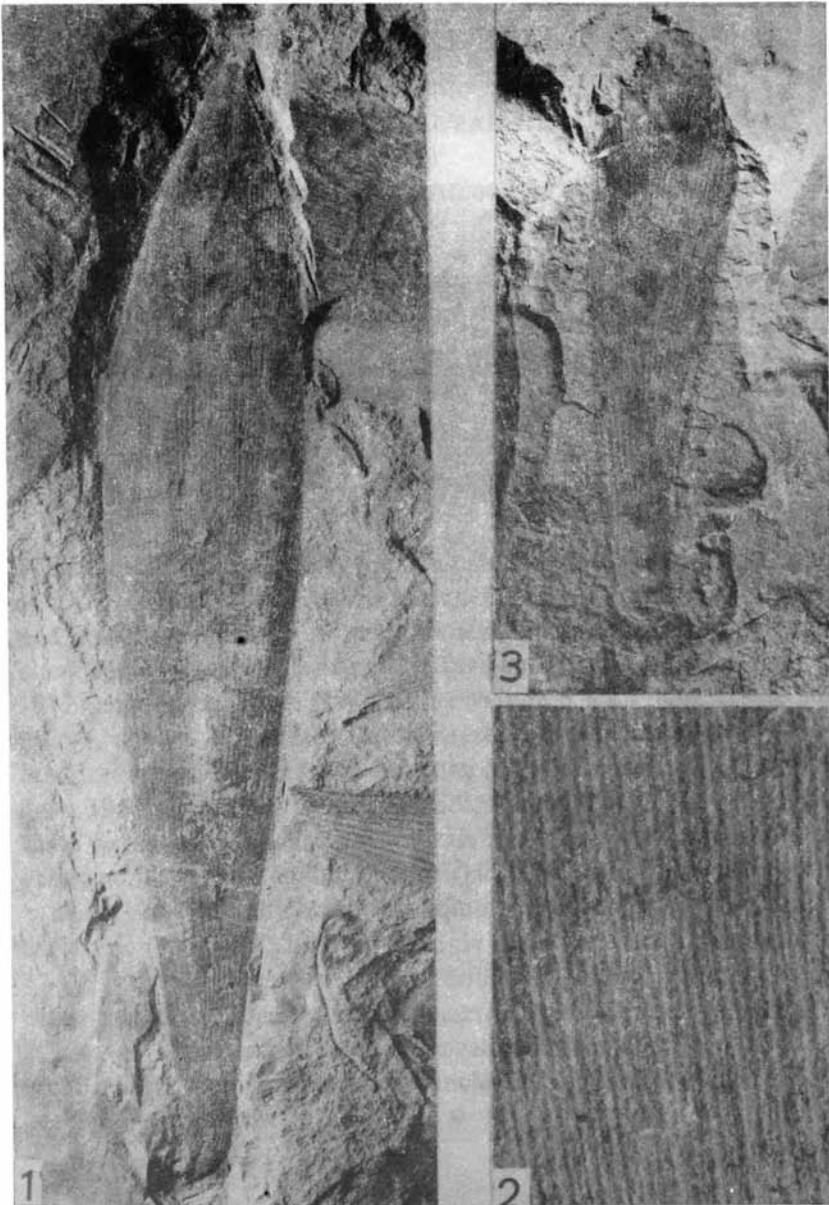
1. *Noeggerathiopsis feistmantelli* sp. nov. leaf showing frequently dichotomising, non anastomosing parallel running veins. BSIP specimen no. 36644, Duman Hill, Chirimiri Coalfield, M. P. India, Nat. Size
2. *N. feistmantelli* sp. nov. complete leaf showing apex and base, BSIP Specimen no. 36645, Ganjra Nala Station, Birisinghpur Pali, M. P., India, Nat. Size
3. A portion of leaf enlarged to show venation pattern. x 2



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Plate 2

1. *Cordaites dumanii* sp. nov., Holotype, complete leaf showing apex, base and shape of leaf. BSIP Specimen no. 36646, Duman Hill, Chirimiri Coalfield, M. P., India, Nat. Size
2. A portion of holotype enlarged to show interstitial veins in between major veins, x 6
3. *C dumanii* sp. nov., specimen other than holotype showing spatulate shaped leaves. BSIP Specimen no. 36647, Duman Hill, Chirimiri Coal field, M. P., India, Nat. Size



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