Palaeobotanist 48 (1999) : 211-216
0031-0174/99/211-216 $2.00

On the genus *Pantophyllum* Rigby 1984

H.K. MAHESHWARI* AND SHIV MOHAN SINGH

Birbal Sahni Institute of Palaeobotany, 53 University Road, Lucknow 226 007, India.
**Current Address : "Ganga-Moti", D-2228, Indira Nagar, Lucknow-226 016, India*

(Received 20 October 1998; revised version accepted 21 January 1999)

ABSTRACT

Maheshwari HK & Singh SM 1999. On the genus *Pantophyllum* Rigby 1984. Palaeobotanist 48(3): 211-216.

The nomenclature of *Cordaites*-type of leaves in the Permian Gondwana of India is re-examined. The authors agree that on the basis of the cuticular features these leaves may not be assigned to the genus *Cordaites* Unger. The hitherto commonly used name *Noeggerathiopsis* Feistmantel 1879 is also unacceptable because the type specimen of the generic type [*Noeggerathiopsis hislopii* (Bunbury 1861) Feistmantel 1879a] is a fragment of a leaf that probably had ginkgopsid affinities. The type specimen originates from the Kamthi Formation which according to new interpretation is dated as Triassic in age. It is therefore proposed that all *Cordaites*-type leaves from the Permian Gondwana of India earlier placed in the genus *Noeggerathiopsis* should be transferred to the genus *Pantophyllum*.

Key-words—*Pantophyllum, Noeggerathiopsis, Cordaites*, Nomenclature, India, Gondwana, Permian.

सारांश

पन्तोफिल्लम रिग्बी 1984 वंश के बारे में

हरिकृष्ण माहेश्वरी एवं शिवमोहन सिंह

परमियन युग में भारत के गोण्डवाना क्षेत्र की *कॉर्डेटीज़* प्रकृति की पत्तियों के नामकरण का पुनः परीक्षण किया गया। लेखक इस बात पर एकमत हैं कि उपचर्मी लक्षणों के आधार पर इन पत्तियों को *कार्डेट अंगर* के अन्तर्गत नहीं रखा जा सकता। अभी तक सामान्यतः प्रचलित नाम *नोएगेरियाथियॉपिसस फाइस्टमन्टेल* 1879 भी स्वीकार नहीं किया जा सकता, क्योंकि जाति प्ररूप के प्रादर्श *नोएगेरियाथियॉपिसस हिस्लोपाई* {(बनवरी 1861) फाइस्टमन्टेल} वर्णांश हैं, जो संभवतः गिंगकॉप्सिड के सजातीय थे। प्ररूप प्रादर्श कामथी शेल शैलसमूह से उत्पन्न हैं, जो नई व्याख्या के अनुसार ट्रायसिक युग के हैं। अतः यह प्रस्तावित किया जाता है कि भारत के गोण्डवाना क्षेत्र की समस्त *कॉर्डेटीज़* प्ररूप की पत्तियाँ, जो पहले *नोएगेरियाथियॉपिसस* वंश में थीं, को *पन्तोफिल्लम* वंश में स्थानान्तरित कर दिया जाना चाहिए।

INTRODUCTION

THE first *Cordaites*-type leaf to be reported from the Gondwana Supercontinent was *Zeugophyllites elongatus* from Tasmania (Morris, 1845). This species and comparative forms were later placed under the genus *Noeggerathia* Sternberg by Dana (1849) in his work on Australian plant fossils. Probably unaware of Dana's publication, Bunbury (1861) described somewhat similar forms as *Noeggerathia? (Cyclopteris?) hislopii* from the beds he considered to be Mesozoic; but which later were considered to be of Late Permian age (Kamthi Formation). More recently it has been suggested that the Kamthi Formation represents a Triassic sequence (Srivastava & Jha, 1997).

Feistmantel (1877), while discussing the identification of similar looking leaves from the Indian Gondwana sediments, expressed his reservation about the use of the name

© Birbal Sahni Institute of Palaeobotany, India

Table 1.

Name of species	Shape	Apex	Base	Venation	Cuticle
Pantophyllum bihariensis	Spathulate	Not known	Tapering	Veins thick, fibrous, dichotomising but not anastomosing, concentration of veins in basal region 10/cm, 22/cm in middle region.	Hypostomatic, veins not marked on nonstomatiferous surface.
Pantophyllum bunburyana	Narrow spathulate or lanceolate	Obtuse	Narrow tapering	Veins 10-13/cm in basal region, 13-19/cm in middle and apical regions, 429 μm thick in basal region and 312 μm thick elsewhere.	Amphistomatic, stomatiferous and nonstomatiferous bands outlined. Stomatal rows in each band 6-8. Papillae present only on some cells of lower cuticle. Stomatal frequency per mm^2 170-206, subsidiary cells 4-7.
Pantophyllum fibrosa	Spathulate	Obtuse	Narrow tapering	Veins 9-11/cm in basal region, 12-16/cm in middle and apical regions. Veins up to 367 micron thick in basal region, thicker towards apex. Interstitial fibres possibly present.	Hypostomatic, stomatiferous and nonstomatiferous bands present, 8-17 rows of stomata in each band. Cells of lower cuticle papillate; of upper rarely. Stomatal frequency per mm^2 251-300. Subsidiary cells 5-7.
Pantophyllum gondwanensis	Linear ± lanceolate	Bluntly pointed	Tapering	Veins ± indistinct, fine, close, about 22-25/cm in the broadest part.	Hypostomatic, cells of stomatiferous surface papillate. Stomata sparse, 1-4 across a band, subsidiary cells 4-6. Cells weekly cutinised, subsidiary cells, relatively thicker specially along their inner walls.
Pantophyllum indica	Linear spathulate	Broadly rounded	Tapering blunt base	Veins dichotomising, about 13-20 veins/ cm in widest region.	Cuticle amphistomatic, stomatiferous and nonstomatiferous bands outlined. Cells of stomatiferous surface papillate. 2-10 rows of stomata in each band, frequency 140-170 mm^2. Subsidiary cells 4-8. Cells of stomatiferous band and specially the subsidiary cells heavily cutinised.
Pantophyllum papillosa	Spathulate	Obtuse	Tapering	Veins 10-13/cm in basal region and 13-19/cm in middle and apical regions. Veins normally up to 222 μm thick, interstitial fibres absent.	Hypostomatic, stomatiferous and nonstomatiferous bands present, stomatal rows in each band 2-8. Papillae present on most cells of lower cuticle, absent on upper. Stomatal frequency per mm^2 186-284. Subsidiary cells 4-7.

Name of species	Shape	Apex	Base	Venation	Cuticle
Pantophyllum saharjuriensis	Linear spathulate	not known	Tapering	Veins straight, dichotomising but not anastomising. Concentration in the middle region being 26/cm.	Stomata present only on one surface, vein and inter-vein areas not marked on nonstomatiferous surface. On stomatiferous surface stomatiferous and nonstomatiferous bands outlined, cells of non-stomatiferous band rectangular, arranged end-to-end, those of stomatiferous bands polygonal. Stomata haplocheilic, arranged 2-5 in linear rows. Stomatal apparatus monocyclic, subsidiary cells 4-8.
Pantophyllum spatulata	Broadly spathulate or rhomboidal	Acute	Narrow-tapering	Veins thin, erect, frequently dichotomise, veins 16-18/cm, angle of divergence between two veins about 9^{o}-13^{o}.	Not known.
Pantophyllum zeilleri	Lanceolate	Bluntly pointed	Gradually tapering	Veins clear, arising straight from base, divergent, dichotomising frequently, about 13-14 veins/cm in the broadest part.	Stomata occur only on one surface. Cells of stomatiferous surface non-papillate. Stomata sparse, 1-3 or 4 across a band, subsidiary cells 5-6, hardly distinguishable from other epidermal cells.

Noeggerathia for these leaves. He believed the latter to be "more allied to *Zamia* than any other genus". Feistmantel (1879a) brought out the fact that the leaves of the genus *Noeggerathia* Sternberg 1822 (Type species: *N. foliosa*, Upper Carboniferous of Bohemia) had simple, and not forked veins; on the other hand, the Indian leaves had distinctly dichotomous veins. He also compared the Indian leaves with those of the genus *Cordaites* Unger. The latter are, however, strap-shaped with parallel margins, only slightly narrower at the base whereas the Indian leaves are usually spathulate in shape. He, therefore, proposed a new genus "*Noeggerathiopsis*" for all leaves formerly referred to *Noeggerathia* and which were distributed in sedimentary deposits ranging from the Talchir to the Kamthi. He again emphasised on their cycadalean connection. Bunbury's *N. hislopii* was included under this genus as *Noeggerathiopsis (Zamia?) hislopii*. In the following years this species came to be regarded as the type species of the genus.

Feistmantel (1879b) transferred Dana's species to his new genus while maintaining their separate specific identities. This being the case, *N. spatulata* (Dana 1849) Feistmantel 1879 has priority over *N. hislopii* (Bunbury 1861) Feistmantel 1879, and hence the latter species was merged with *N. spatulata* by Rigby, Maheshwari and Schopf (1980). Thus *N. spatulata* replaced *N. hislopii* as type species of the genus. *Zeugophyllites elongatus* Morris, that was considered by Dana (1849) as another species of *Noeggerathia*, was transferred to *Podozamites* by Feistmantel (1890) and to *Phoenicopsis* by Seward (1903). Interestingly, specimens of *Noeggerathiopsis hislopii* reported by Zeiller (1902/1903) from Tonkin (Vietnam) were also included under *Phoenicopsis elongata* (Morris) Seward (Seward, 1903).

Zeiller (1896) recovered cuticles from specimens which he believed belonged to *Noeggerathiopsis hislopii*. The specimens, collected from the area near Johannesburg, South Africa, are a mixed lot. One of the specimens (Zeiller, 1896, pl. 18, fig. 6) is closer to *Noeggerathiopsis (Glossozamites) stoliczkanus* (Feistmantel) Arber 1905 than to *N. hislopii*. Another specimen (*loc. cit.*, pl. 18, fig. 7) has a very narrow base unlike that known in any *N. hislopii*-type leaf. The line drawings of cuticular pieces apparently show sunken stomata, a character not noticed in later investigations on cuticular anatomy of *Noeggerathiopsis* leaves (Lele & Maithy, 1964; Pant & Verma, 1964; Bajpai, 1990).

The creation of the genus *Noeggerathiopsis* by Feistmantel has been disputed by many later workers. Seward (1903) pointed out that "had the leaves referred to *Noeggerathiopsis* been found in European Palaeozoic rocks there can be little doubt that they would have been described under the name *Cordaites*". Seward and Leslie (1908), Seward (1912, 1917), Seward and Sahni (1920), Walton (1929),

Feruglio (1951), Meyen (1963, 1964), Archangelsky and Arrondo (1973), Rigby, Maheshwari and Schopf (1980), and others followed this line of argument and used the name *Cordaites*. Meyen (1964, p. 98) remarked "I consider that the genus *Noeggerathiopsis* was based on a mistake and should be abolished. Most Gondwana Cordaiteans should be referred to *Cordaites* s.l.". He also did not believe that the Gondwana and Angaran cordaitean leaves belonged to the same genus. He observed presence of dorsal furrow in some Angaran leaves, a character of great significance in taxonomy, and established the genus *Rufloria* for the same. *Cladostrobus*, the male fructification assigned to this genus (Maheshwari & Meyen, 1975), has an organisation not known in the fructifications associated with *Cordaites*. McLoughlin and Drinnan (1996) have shown that in leaf anatomy, as observed in permineralised specimens from Antarctica, leaves of *Noeggerathiopsis* are quite different from the Northern Hemisphere cordaites.

Rigby, Maheshwari and Schopf (1980, p. 20) were of the opinion that all the leaves referred to different species of *Noeggerathiopsis* on the basis of differences in cuticular features belong to a single morphological type and went on to propose "that all non-cuticular cordaitalean leaves from Lower Gondwana strata identified to date be given the name *Cordaites spatulata*". They left out Gondwana cordaitalean leaves with cuticles from the circumscription of *C. spatulata*. Rigby (1984) proposed the generic name *Pantophyllum* "for species formerly attributed to *Noeggerathiopsis* that have distinctive cuticles, thus can not be recombined with *Cordaites*". Bajpai (1990), however, disagreed. She pointed out that if new genera were created simply because a leaf had yielded cuticle one would have to create new genera for all the species/specimens with cuticle in the genera *Glossopteris, Gangamopteris, Palaeovittaria, Buriadia*, etc. She hence maintained the genus *Noeggerathiopsis*. Bajpai (1992), however, observed that Bunbury's specimens from Late Permian Kamthi sediments, which formed the base of Feistmantel's *Noeggerathiopsis*, may have ginkgopsid, rather than cordaitalean affinities. The Early Permian *Cordaites*-type leaves from the Gondwana were thus left without a formal generic name. She therefore adopted the generic name *Pantophyllum* Rigby for all *Noeggerathia spatulata*-type leaves.

Kovács-Endródy (1987) raised another problem, that is, the presumed difficulty of separation of *Palaeovittaria* from *Noeggerathiopsis*. Of the seven specimens illustrated in her paper as leaves of *Palaeovittaria*, probably none belongs to this genus. The single specimen that she assigns to *Noeggerathiopsis* is more likely to be a ginkgopsid leaf.

To summarise the above discussion:

1- Cordaites-type leaves are reported from Early Permian or Gondwana Supergroup;
2- Similar looking leaves from the Late Permian/Early Triassic Kamthi Formation probably are not related;
3- The name *Noeggerathiopsis* (because of its association with species *hislopii)* thus needs to be restricted to Late Permian/Early Triassic forms;
4- For Early Permian leaves one may use either of the generic names *Cordaites* or *Pantophyllum*.

Zeiller (1896), Pant and Verma (1964), and Maithy (1965) have made a valid point for not using the name *Cordaites* for Gondwana leaves. Therefore the name *Pantophyllum* Rigby can be adopted; its circumscription being the same as proposed by Pant and Verma (1964) and Maithy (1965) for "*Noeggerathiopsis*".

Diagnosis (based on Rigby, Maheshwari & Schopf, 1980; Maithy, 1965, and Pant & Verma, 1964):

Leaves simple, broadly symmetrical, lamina broadening gradually upwards from a narrow and truncate base, widest in the region near the apex, linear, oval-spathulate, spathulate, or obovate. Apex acute, obtuse or broadly rounded. Margin entire. Lamina tapering towards the base, broadening slightly at base. Midrib absent. Veins numerous, radiating from base where there are four equally sized veins; veins dichotomising once or several times, spreading very gradually, appearing parallel over a short distance, and running straight up to the margin without curving or anastomosing; interstitial fibers occasionally present. Lamina amphistomatic or hypostomatic. Upper cuticle comparatively thick, showing no differentiation of cells in areas between and above veins and all cells arranged in rows parallel to veins; stomata, where present, fewer than those of lower cuticle. Lower cuticle showing alternately arranged non-stomatiferous and stomatiferous bands, respectively above and between veins; stomata haplocheilic, arranged in one to many ill-defined longitudinal rows between veins. Guard cells longitudinally orientated, subsidiary cells usually six.

Speciation in *Pantophyllum*

Morphographically, i.e., in external characters, such as, shape, venation, etc. almost all the leaves can be assigned, and actually have been assigned to one species. This species is now named as *Pantophyllum spatulata* (Dana, 1849) Bajpai 1992.

The investigation of the cuticular features of these leaves, however, has led to institution of several new species (Lele & Maithy, 1964; Pant & Verma, 1964; Bajpai, 1990) which were earlier placed under the genus *Noeggerathiopsis*. Now with the proposed restriction of the name *Noeggerathiopsis* to possibly ginkgopsid leaves of *N. hislopii* Bunbury-type from the Late Permian/Early Triassic, the other species need to be transferred to the genus *Pantophyllum*.

1. *Pantophyllum spatulata* (Dana) Bajpai 1992

[=*Noeggerathia spatulata* Dana, 1849: Australia. *non*

Noeggerathia hislopii Bunbury, 1861; Late Permian/Early Triassic, Kamthi Formation, India]

[=*Noeggerathiopsis densinervis* Maithy, 1965; Early Permian, Karharbari Formation, Giridih Coalfield, India]

2. *Pantophyllum bunburyana* (Pant & Verma) Rigby 1984

[=*Noeggerathiopsis bunburyana* Pant & Verma, 1964; Early Permian, Karharbari Formation, Manendragarh Coalfield, India]

3. *Pantophyllum papillosa* (Pant & Verma) Rigby 1984

[=*Noeggerathiopsis papillosa* Pant & Verma, 1964; Early Permian, Karharbari Formation, Manendragarh Coalfield, India]

4. *Pantophyllum fibrosa* (Pant & Verma) Rigby 1984

[=*Noeggerathiopsis fibrosa* Pant & Verma, 1964; Early Permian, Karharbari Formation, Manendragarh Coalfield, India]

5. *Pantophyllum indica* (Lele & Maithy) comb. nov.

[=*Noeggerathiopsis indica* Lele & Maithy, 1964; Early Permian, Karharbari Formation, Ganjra Nala Beds, South Rewa Basin, India]

6. *Pantophyllum gondwanensis* (Lele & Maithy) comb. nov.

[=*Noeggerathiopsis gondwanensis* Lele & Maithy, 1964; Early Permian, Karharbari Formation, Ganjra Nala Beds, South Rewa Basin, India]

7. *Pantophyllum zeilleri* (Lele & Maithy) comb. nov.

[=*Noeggerathiopsis zeilleri* Lele & Maithy, 1964; Early Permian, Karharbari Formation, Giridih Coalfield, India]

8. *Pantophyllum saharjuriensis* (Bajpai) comb. nov.

[=*Noeggerathiopsis saharjuriensis* Bajpai, 1990; Early Permian, Karharbari Formation, Saharjuri Outlier, Deogarh Coalfield, India]

9. *Pantophyllum bihariensis* (Bajpai) comb. nov.

[=*Noeggerathiopsis bihariensis* Bajpai, 1990; Early Permian, Karharbari Formation, Saharjuri Outlier, Deogarh Coalfield, India]

The morphographic and cuticular characters of different species are plotted in Table 1.

Acknowledgement—*The authors thank Dr Kathleen B. Pigg for reviewing the manuscript.*

REFERENCES

Archangelsky S & Arrondo OG 1973. Palaeophytologica Kurtziana. III. 10. La taphoflora Permica de Sierra de los Llanos Provincia. Ameghiniana 10 : 201-228.

Bajpai U 1990. Floristics, age and stratigraphical position of fossiliferous band in Chitra Mine area, Saharjuri Outlier, Deogarh Coalfield, Bihar. Palaeobotanist 37(3) : 306-315.

Bajpai U 1992. Morphological trends in Gondwana plants. Palaeobotanist 40 : 128-146.

Bunbury CJF 1861. Notes on a collection of fossil plants from Nagpur, central India. Q. Jl geol. Soc. London 17 : 325-346.

Dana JD 1849. Fossil Plants, appendix 1, in United States exploring expeditions during the years 1838-1842, under the command of Charles Wilkes USN, C Sherman, Philadelphia Geology 10 : 714-720.

Feistmantel O 1877. Notes on fossil floras in India-XI. Note on plant fossils from Barakar District (Barakar Group). Rec. geol. Surv. India 10 : 73-74.

Feistmantel O 1879a. The fossil flora of the Lower Gondwanas -1. The flora of the Talchir-Karharbari beds. Mem. geol. Surv. India, Palaeont. indica, ser. 2, 1(4) : 1-48.

Feistmantel O 1879b. Bemerkungen über die Gattung *Nöeggerathia* Stbg., sowie die neuen Gattungen *Nöggerathiopsis* Fstm. und *Rhiptozamites* Schmalh. Sitz.-berich. König. böhm. Gesellsch. Wissensch. Math.-naturwissensch. klasse 44 : 444-454.

Feistmantel O 1890. Geological and palaeontological relations of the coal and plant-bearing beds of Palaeozoic and Mesozoic age in eastern Australia and Tasmania; with special reference to the fossil-flora. Mem. geol. Surv. N.S.W., Palaeontology 3 : 1-183.

Feruglio E 1951. Su alcune piante del Gondwana Inferiore della Patagonia. Publ. Inst. Geol. Univ. Torino 1 : 1-34.

Kovács-Endródy É 1987. Clarification of the genus *Palaeovittaria* Feistmantel. Palaeont. Afr. 26(6) : 59-68.

Lele KM & Maithy PK 1964. Studies in the Glossopteris flora of India-15. Revision of the epidermal structure of *Noeggerathiopsis* Feistmantel. Palaeobotanist 12 : 7-17.

Maheshwari HK & Meyen SV 1975. *Cladostrobus* and the systematics of cordaitalean leaves. Lethaia 8 : 103-123.

Maithy PK 1965. Studies in the Glossopteris flora of India-20. *Noeggerathiopsis* and allied remains from the Karharbari beds, Giridih Coalfield, India. Palaeobotanist 13 : 94-100.

McLoughlin S & Drinnan AN 1996. Anatomically preserved Permian *Noeggerathiopsis* leaves from East Antarctica. Rev. Palaeobot. Palynol. 92 : 207-227.

Meyen SV 1963. Leaf anatomy and nomenclature of Angaran cordaites. Paleont. Zh. (3) : 96-107 (in Russian).

Meyen SV 1964. On the morphology, anatomy and nomenclature of leaves of the Angara-Gondwana genus *Noeggerathiopsis*. Dokl. Soviet. Geol. 9 : 87-99.

Morris J 1845. Fossil flora. *In* : Strzelecki PE (Editor)—Physical description of New South Wales and van Diemen's Land. Longmans, Brown, Green & Longmans, London. pp. 245-254.

Pant DD & Verma BK 1964. The cuticular structure of *Noeggerathiopsis* Feistmantel and *Cordaites* Unger. Palaeontographica B115 : 21-44.

Rigby JF 1984. Some aspects concerning Permian cordaitalean plants from Gondwanaland. Mem. III Cong. Latinoam. Paleont. Mexico. pp. 140-142.

Rigby JF, Maheshwari HK & Schopf JM 1980. Revision of Permian plants collected by J.D. Dana (1839-1840). Geol. Surv. Queensland Publ. 376, palaeont. Pap. 47 : 1-25.

Seward AC 1903. Fossil floras of Cape Colony. Ann. S. Afr. Mus. 4 (1) : 1-122.

Seward AC 1912. Lower Gondwana plants from the Golabgarh Pass, Kashmir. Mem. geol. Surv. India, Palaeont. indica, new ser. 4 (3) : 1-10. Reprinted 1979 by Bishen Singh Mahendra Pal Singh, Dehradun.

Seward AC 1917. Fossil plants. 3. Cambridge University Press.

Seward AC & Leslie TN 1908. Permo-Carboniferous plants from Vereeniging. Q. Jl geol. Soc. London 64 : 109-125.

Seward AC & Sahni B 1920. Indian Gondwana plants. A revision. Mem. geol. Surv. India, Palaeont. indica, n. ser. 7(1) : 1-54.

Srivastava AK 1992. Plant fossil assemblage from the Barakar Formation of Raniganj Coalfield, India. Palaeobotanist 39 (3): 281-302.

Srivastava SC & Jha N 1997. Status of Kamthi Formation: lithological and palaeobotanical evidences. Palaeobotanist 46 : 88-96.

Walton J 1929. The fossil flora of the Karroo system in the Wankie District, Southern Rhodesia. Bull. geol. Surv. S. Rhodesia 15 (2) : 62-75.

Zeiller R 1896. Etude sur quelques plantes fossiles, en particulier *Vertebraria, Glossopteris* des environs de Johannesburg (Transvaal). Bull. Soc. Geol. France, ser. 3, 24 : 344-377.

Zeiller R 1902-1903. Flora fossile des Gîtes de charbon du Tonkin. Etudes gîtes mineraux de la France, Colonies Francaises. Imprimerie Nationale, Paris. Atlas, 1902; Text, 1903, pp. viii+328.