

Sphenopsids from the Barakar Formation of Hura Tract, Rajmahal Hills, Bihar

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Singh, V. K., Srivastava, A. K. & Maheshwari, Hari K. (1987). Sphenopsids from the Barakar Formation of Hura Tract, Rajmahal Hills, Bihar. *Palaeobotanist*, 35(3) : 236-241.

Sphenopsids from Lalmatia Incline (Lalmatia Top Seam, Barakar Formation), Rajmahal Hills, Bihar, belong to *Sphenophyllum gondwanensis* sp. nov., *Lelstotheca* sp. and equisetalean axes. Previous records of northern species of *Sphenophyllum* in Lower Gondwana sediments are reviewed and reassessed.

Key-words—Sphenophyllales, *Sphenophyllum*, Barakar Formation, Rajmahal Hills (India)

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सारांश

राजमहल पहाड़ियों (बिहार) में हुरा क्षेत्र के बराकार शैल-समूह में स्फेनोप्सिड

विनय कुमार सिंह, अश्वनी कुमार श्रीवास्तव एवं हरिकृष्ण माहेश्वरी

बिहार में राजमहल पहाड़ियों में लालमटिया आर्नात (लालमटिया शिखर सीम, बराकार शैल समूह) में प्राप्त स्फेनोप्सिड स्फेनोफिल्लम गोंडवानेन्सिस नव जाति, लेन्सटोथीका जाति एवं इक्वीसेटेली अक्ष से सम्बन्धित हैं। अधीर गोंडवाना अवसदों में स्फेनोफिल्लम की उत्तरी जातियों का अवलोकन तथा पुनर्निर्धारण किया गया है।

TRIZYGIA Royle (1839), one of the commonest Sphenopsids of the Lower Gondwana, is represented by foliage shoots whose slender, articulate axes have at each node a verticil of six leaves arranged in 3 pairs (two pairs of larger leaves and one pair of much smaller leaves). Most of the later workers, however, did not recognize the independent identity of the genus *Trizygia* and included the solitary species *T. speciosa* under the genus *Sphenophyllum*. Maheshwari (1968) argued that the trizygoid leaf arrangement and the epidermal features are significant characters to retain the independent identity of the genus *Trizygia*. It is not that the genus *Sphenophyllum* does not occur in Lower Gondwana; it has been reported from South America, Africa as well as India (see Archangelsky, 1958; Lacey & Huard-Moine, 1966; Arrondo, 1972; Maithy, 1978; Srivastava & Rigby, 1983, etc.).

We record some more specimens of *Sphenophyllum* from the Barakar Formation of Rajmahal

Hills, Bihar. The collection also includes a large number of glossopterid leaves, axes, scale leaves, seeds, sporangia and a few sterile pteridophylls. *Trizygia speciosa*, surprisingly, has not been found. Thin carbonified crust sometimes covers the fossils but cellulose pulls did not reveal cellular details.

Previous collections of *Sphenophyllum* available at Birbal Sahni Institute of Palaeobotany have also been examined.

Genus—*Sphenophyllum* Brongniart 1828

Sphenophyllum gondwanensis sp. nov.

Pl. 1, figs 1-5; Text-fig. 1a-d

1958 *Sphenophyllum thonii* Mahr : Archangelsky, *Acta geol. Lilloana* 2 : 29-31, figs 4,7.

1966 *Sphenophyllum thonii* Mahr : Lacey & Huard-Moine, *Symposium on Floristics and Stratigraphy of Gondwanaland*, Lucknow : 15,16; pl. 1, fig. 1.

1972 *Sphenophyllum thonii* Mahr : Arrondo, *Rev. Mus. Plata* (n.s.), 7 : 36-38, pl. 1, fig. 1.

1982 *Parasphenophyllum thonii* var. *minor* (Sterzel)
Asama : Singh, Maithy & Bose. *Palaeobotanist* 30 :
204, pl. 6, figs 38-40; text-figs 7 A-B.

Diagnosis—Sterile shoots, axes articulate, internodes with longitudinally running ribs, nodes with a whorl of six leaves each. Leaves cuneate, obovate or subtriangular in shape, do not form a leaf sheath. Leaves of younger whorl small, with finely denticulate distal margin; leaves of older whorl comparatively large, with fine to deeply incised, dentate distal margin. A single vein enters leaf base, dichotomises five to eight times, side veins radiate towards lateral margin, median veins go straight up, each ultimate veinlet terminates in a denticulation of distal margin.

Holotype—Specimen no. BSIP 35866; Middle Permian; Barakar Formation; Lalmatia Top Seam, Lalmatia Incline Colliery, Rajmahal Hills, Bihar.

Description—The collection has ten specimens, some with counterparts. A number of fragments of leaf whorls and scattered leaves are also present. The specimens represent sterile shoots. The shoot axis in flattened condition is 2 to 3 mm broad, articulate, ribbed, internodes being 0.8 to 2 cm long, nodal distance decreasing from basal to apical part. The nodes are slightly swollen, each node has a whorl of six leaves similar in size and shape. Leaves of successive whorls may differ in size and distal margin. Leaves of younger whorl are 0.5 to 1.5 cm long, 0.2 to 1 cm wide and show fairly crenulate distal margin. Leaves of older whorl are larger, 1 to 2.5 cm long, 0.5 to 1 cm broad and possess deeply crenulate/denticulate distal margin, latter sometimes being elongate, sharp and teeth-like which measure up to 3 mm.

One of the specimens (Pl. 1, figs 1, 2; Text-fig. 1a) shows remnants of 6 leaf whorls and an occasional internode. At least two or more leaves are preserved completely or partly in every whorl. Although, only two middle whorls are connected by the axis, all the whorls belong to the same foliage shoot, the intervening portions of the axis either lie unexposed in the rock or are covered by the overlying leaves. There is a gradual change in leaf size and distal margin (apex) from one end of the axis to other. The leaves of lower whorls are large, and have crenulate or denticulate apices. Those of upper whorls are comparatively small with finely crenulate apices. Leaves within a whorl, however, are isophyllous.

A single vein enters the leaf base and dichotomises 5 times or more. The ultimate veins radiate and diverge slightly towards the lateral margins of the lamina; the median veins run straight. Sometimes 2 or more veins seen entering the leaf base but a careful observation reveals that the single vein dichotomises immediately after entering the leaf and gives an appearance as if two veins are entering the leaf base.

Though the leaves are arranged in a whorl at nodes of shoot axis, in fossil state they are found preserved in

one plane. Sometimes, a part of whorl may lie in a different plane, often leaves of a whorl overlap the leaves of another whorl (Pl. 1, fig. 4; Text-fig. 1d) and so also the intervening internode hair, hooks or spines are lacking.

Comparison—The new species, *Sphenophyllum gondwanensis*, is characterised by the presence of heterophyllous leaf whorls. A similar variation in distal margin of leaves is already known in a number of northern species of the genus *Sphenophyllum*. *Lilpopia*, a genus which has leaves similar to *Sphenophyllum*, also shows heterophylly. Batenburg (1981) has worked in detail the leaf morphology of *Sphenophyllum* and according to him "heterophylly is not a peculiarity of a few species but a feature of the genus on a whole with the main exception of the older primitive forms with lacinate leaves only".

Thus, it appears that heterophylly is quite common in the species of *Sphenophyllum* and *S. gondwanensis* reports from the Lower Gondwana Formation of India enhances the possibility of the occurrence of heterophyllous forms of *Sphenophyllum* other than the northern hemisphere.

Among the heterophyllous forms, *S. miravallis* (Hettterscheid & Batenburg, 1984, pl. 2, fig. 1) is distinct in having asymmetrical pairs of leaf whorls; in *S. gondwanensis* all the six leaves of whorl are similar in size and shape. Further *Bowmanites cupulatus* Hettterscheid & Batenburg, 1984, a fertile part attributed to *S. miravallis*, is not known to occur so far in Indian Lower Gondwanas. Vegetative heterophyllous leaves of *Lilpopia raciborskii* (Kerp, 1984) resemble the leaves of *S. gondwanensis* but the former species characteristically has sporangiate cones coming up at the nodes, a character so far not known to occur in the genus *Sphenophyllum*.

S. thonii Mahr (1968) has larger leaves and fine, dense venation, the latter resulting in fine and numerous fringes which continue downwards on the lateral sides also. *S. archangelskyii* Srivastava & Rigby, 1983 differs in having elongate-obovate leaves with deeply incised distal margin and relatively dense distribution of lateral veins. In *S. waltonianum* Srivastava & Rigby, 1983 the leaves have a teeth-like serration and a median notch on the distal margin. Individual leaves of *S. sakoense* Appert, 1977 are comparable with *S. gondwanensis* but differ in showing considerable reduction in leaf size in a whorl.

Genus—*Lelstobeca* Maheshwari 1972

Lelstobeca sp.

Pl. 1, fig. 6

Description—There are twelve pieces of foliage shoots in the collection. The leaves are arranged in star-shaped verticils at the swollen nodes which are 1–1.5 cm apart. The leaves are linear in shape 1–3.5 cm long and 1–2.5 mm wide, the lateral sides being parallel to each other except near the apices, which are acute. Each leaf has a persistent midrib.



Text-figure 1—A-D. *Spbenophyllum gondwanensis* sp. nov., **A**, holotype, fragments of 6 leaf whorls, two whorls show attachment with an articulate stem; leaves of younger whorl show fine crenulate distal margin; leaves of older whorl show deeply incised dentate distal margin. Specimen no. BSIP 35866 $\times 4$ (see also Pl. 1, figs 1,2). **B**, remains of 3 younger leaf whorls showing leaves with smooth/crenulate distal margins, arranged around a node. Specimen no. BSIP 35867 $\times 4$ (see also Pl. 1, fig. 3). **C**, a fragment of two leaf whorls showing crenulate to dentate distal margin and venation pattern. Specimen no. BSIP 35868. $\times 4$ (see also Pl. 1, fig. 5). **D**, showing leaves of older whorl with deeply dentate distal margin. Specimen no. BSIP 35866. $\times 3$ (see also Pl. 1, fig. 4).

PLATE 1

1. *Spbenophyllum gondwanensis* sp. nov. Holotype, showing six leaf whorl fragments, two whorls show attachment with a slender axis. Leaves of younger whorl show fine crenulate distal margin and leaves of older whorl show deep incised, dentate distal margin. Specimen no. BSIP 35866. Natural size.
2. *S. gondwanensis* holotype, enlarged to show the details of venation pattern and distal margin. $\times 2$.
3. *S. gondwanensis* showing detached fragments of older and younger leaf whorls. Older whorl shows 4 leaves with dentate distal margin, younger fragment shows three whorls of smaller leaves with fine crenulate distal margin. Specimen no. BSIP 35867. $\times 2$.
4. *S. gondwanensis* showing a fragment of older leaf whorls with deeply incised dentate distal margin. Specimen no. BSIP 35866. $\times 2$.
5. *S. gondwanensis* showing a fragment of two leaf whorls with fine dentate to crenulate distal margin. Specimen no. BSIP 35868. $\times 2$.
6. *Lelstobeca* sp. showing detached fragments of leaf whorls. Specimen no. BSIP 35869. $\times 0.8$.

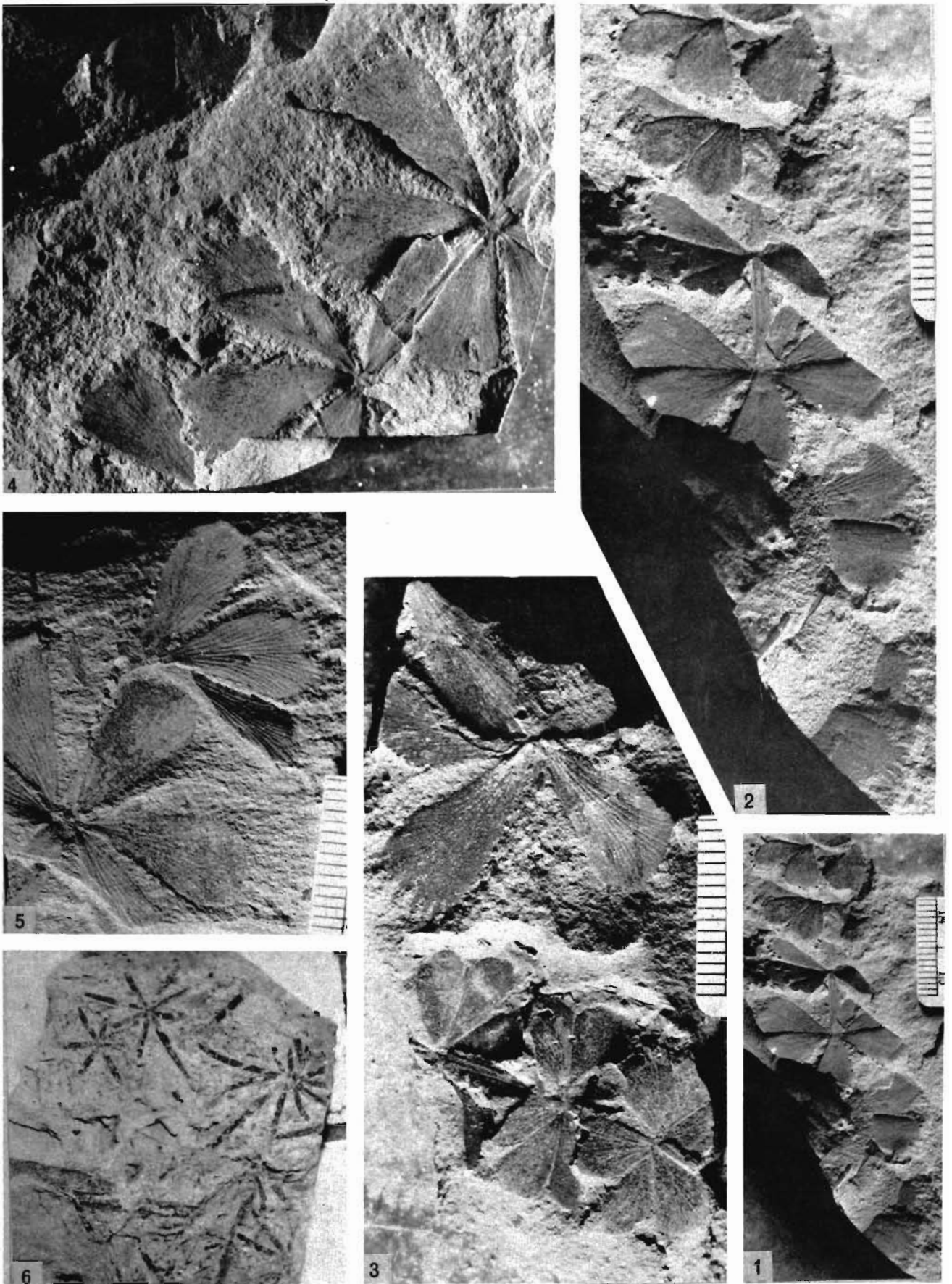


PLATE 1

Comparison—The specimens show a general resemblance to *Lelstotheca robusta* (Feismantel) Maheshwari. The leaves in typical species of *L. robusta* are widest near the base gradually taper towards the apex, whereas in the present specimens the leaves are equally broad all along and abruptly turn into an acute apex.

Somewhat similar shoots have earlier been reported from Zimbabwe by Huard-Moine (1965, pl. 1, fig. 4) and Lacey and Huard-Moine (1966, pl. 1, fig. 8) as doubtful records of *Annularia*. Rigby (1966a, pl. 1, fig. 4) has reported comparable specimens as *Stellotheca* sp. from New South Wales, Australia.

EQUISETALEAN AXES

Description—Compressions of leafless, articulate axes showing ridges and furrows in successive internodes occur abundantly in our collection. The axes are 4-15 cm long and 0.1-2 cm wide, generally with swollen nodes. The length of internodes varies from 1-5.5 cm. The ridges are about 1-2 mm apart, parallel to each other and always continuous in successive internodes.

Discussion—Leafless, articulate axes have been reported from different formations of Lower Gondwana as equisetalean axes or sphenopsid axes or have been assigned to the genus *Phyllotheca* or *Schizoneura* on grounds of their associations or close similarity with the stems having attached leaf-sheaths of the respective sphenopsid. Rigby (1966a) introduced the genus *Paracalamites* Zalesky in Lower Gondwanas for such axes. *L. robusta* was reportedly found attached to *Paracalamites*.

GENERAL DISCUSSION

The genus *Sphenophyllum* Brongniart, 1828 is a common sphenopsid in the Permian-Carboniferous of Northern Hemisphere. Till recently typical *Sphenophyllum* forms were not adequately known from the Lower Gondwana of India though such forms were documented from Lower Gondwana of South America, Australia and Africa (Arber, 1905; Walton, 1929; Teixeira, 1947; Archangelsky, 1958, 1960; Lacey & Huard-Moine, 1966; Rigby, 1966b; Arrondo, 1972; Appert, 1977). Now Maithy (1978), Chandra and Rigby (1981), Singh, Maithy and Bose (1982), Srivastava and Rigby (1983) and Pant, Srivastava and Das (1985) have reported some typical forms of *Sphenophyllum* from India. It would thus seem that *Sphenophyllum*, though a rare plant in the Lower Gondwana, was of wide occurrence. However, the genetic relationship between the typical *Sphenophyllum*s of Northern Hemisphere and similar looking forms from Gondwanaland is yet unknown.

The sphenophyll species which occur in the Permian sediments of the Gondwanaland fall into

two basic categories, viz., the trizygoid and symmetrical (Asama, 1966), represented by the genera *Trizygia* and *Sphenophyllum* respectively.

The stratigraphic distribution of the various species of *Sphenophyllum*/*Trizygia* in the Gondwana sediments shows that of the trizygoid species, four species, viz., *S. oblongifolium*, *S. verticillatum*, *S. wankianum* and *T. maithyana* are present in the Lower Permian and only one species, *T. speciosa*, is frequent in the Upper Permian. Similarly, amongst the non-trizygoid species, four, i.e. *S. gondwanensis*, *S. churulianum*, *S. waltonianum* and *S. rhodesii* are restricted to Lower Permian and only one, *S. crenulatum*, occurs in the Upper Permian. Though, the sphenophylls were comparatively less abundant in the Lower Permian Gondwana, yet the number of species was relatively very high. Eight species are so far known from the Lower Permian of Gondwana as compared to only two from the Upper Permian of Gondwana. This shows that the sphenophylls were evolving rather fast in the Lower Permian and had stabilized by the Upper Permian.

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