

A REVISION OF THE LOWER GONDWANA SPHENOPTERIS FROM INDIA

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ABSTRACT

Occurrence of *Sphenopteris* Brongn. is long known from the Lower Gondwana Formations of India. Detailed morphological studies of these fronds have revealed that they differ distinctly from *Sphenopteris* and represent a new morphological type. Hence, a new genus *Neomariopteris* has been instituted to accommodate these fronds.

The previous records, *Neomariopteris* (*Sphenopteris*) *polymorpha* (Feistm.) n. comb., *N. (S.) hughesi* (Zeill.) n. comb. and *N. (S.) lobifolia* are redefined and a new species *Neomariopteris talchirensis* is instituted.

INTRODUCTION

FERN fronds from the Lower Gondwanas of India showing deep cut or lobed habit of the pinna have been described under *Sphenopteris* Brongniart. Three species of *Sphenopteris*, viz. *S. polymorpha* Feistmantel (1876, 1881), *S. hughesi* (Feistm.) Zeiller (1902) and *S. lobifolia* Morris (1845), are known from India. The first named two species are known from the Barakar to the Raniganj Formations, whereas the third species is known only from the Raniganj Formation.

In some recent collections well-preserved remains of *Sphenopteris* have been collected from a number of Lower Gondwana Coalfields of India. The geological horizons of these beds range from Barakar to Raniganj Formations. A critical study of these fronds suggests that the forms up till now described under *Sphenopteris* are morphologically distinct from typical forms of *Sphenopteris* Brongn. and represent entirely a new morphological type. The same is discussed here with a revision of previous records from the Lower Gondwanas of India and other countries.

MATERIAL AND METHODS

The observations presented in this paper are based upon the examination of specimens earlier described by Feistmantel (1876, 1881, 1882) and Zeiller (1902) preserved at the Museum of the Geological Survey of India,

Calcutta, and the specimens described by Srivastava (1954), Maheshwari & Gyan Prakash (1965), Kar (1968), Maithy (1969) and Kulkarni (1970) preserved at the Birbal Sahni Institute of Palaeobotany, Lucknow. In addition to this 300 hand specimens collected from the Lower Gondwana Formations of Raniganj Coalfield, Jharia Coalfield, South Karanpura Coalfield, Auranga Coalfield, Daltonganj Coalfield, Ib-river Coalfield and Tattitola be s (Rajmahal Hills) have been examined. The specimens are commonly preserved in form of impressions, however, in many cases a carboniferous crust is preserved. A cellulose pull of plant substances often appears brown and translucent under transmitted light. Examination of pull under the microscope reveals various structural details. Maceration of leaf substances by usual Schulze's method results complete dissolution of plant substance, however, in cases one gets trace of cuticles.

DESCRIPTION

Neomariopteris gen. nov.

Generic Diagnosis — Imparipinnate fronds, deeply divided, tripinnate or quadripinnate; rachis winged, pinnules small to medium size, shape variable, decurrent, attached to rachis by broad base, apex variable (acute, obtuse or broadly rounded), pinnule margin entire, dentate, crenulate or undulated (lobed); median vein of each pinnule usually gives off simple or bifurcating nervules towards margin of pinnules (sphenopteroid venation).

Genotype — *Neomariopteris polymorpha* (Feistm.) n. comb.

Generic Description — The shape of the complete frond is a isobilateral triangle, because the petiole is continued as a central shaft to the apex and bore its subdivisions in pinnate manner (Text fig. 1B). Near the apical region the division of pinnule is not complete and one can count the number of

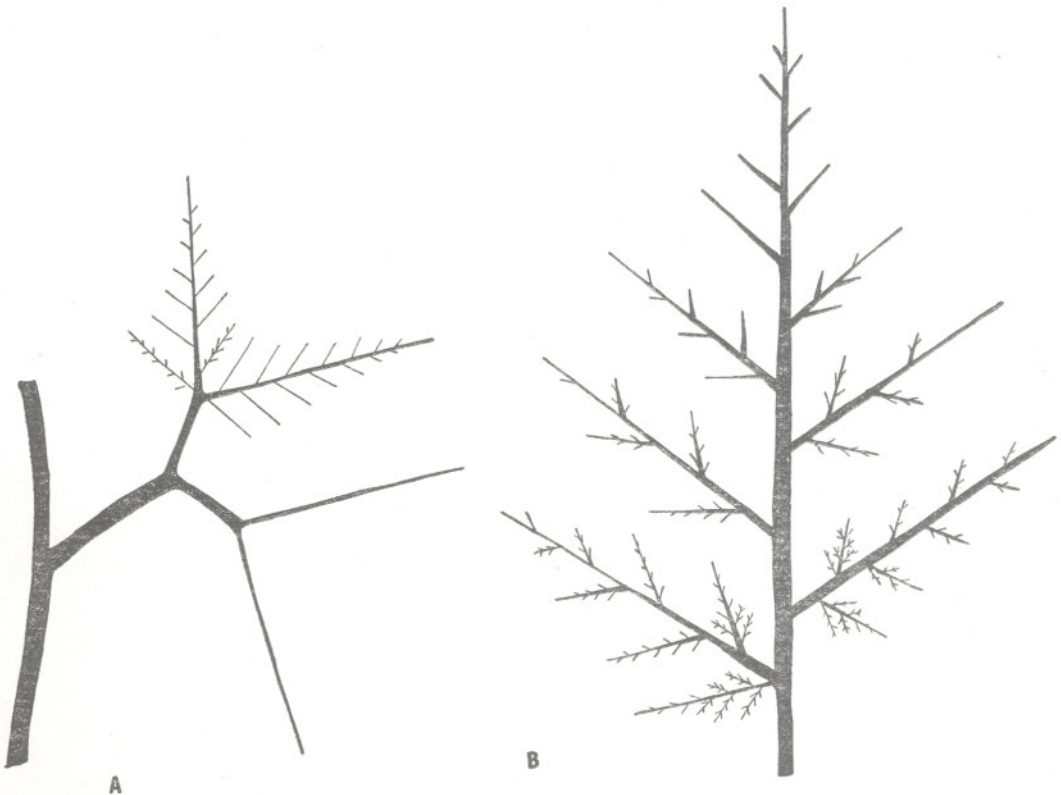
pinnules only by the emergence of midveins laterally from the pinnae rachis. The decurrent nature of the pinnules is well marked in all the species. The shape of the pinnules and its apex is distinguishable feature for the different species. Each pinnule has one distinct midvein. The midvein arises at $\pm 45^\circ$, from the point, where the lower margin of the pinnules joins the pinnae rachis. The midvein gives lateral nervules. The nervules passes to the margin either simple or bifurcating. Course of nervules may be straight or flexuosus.

Comparison—Brongniart (1828) instituted *Sphenopteris* to accommodate fern fronds with the following characters:

“The pinnules contracted at base and often attached by short stalks, usually small, oval or oblong in outline and lobed or toothed or sometimes cut into narrow acute or obtuse lobes. Midvein is straight or flexuosus. The lateral veins depart at acute angle and dichotomise a few times

and then pass either singly or in groups to the tips or the lobes of the pinnules.”

The type species of *Sphenopteris*, viz. *S. adiantoides* Schloth. (= *S. elegans* Brongniart, in Sternberg, 1825) is a typical sphenopteroid frond showing pinnules deeply lobed with cuneate base. Pinnules are laterally free, i.e. non-decurrent, though the forms from the Lower Gondwana of India are referred to *Sphenopteris* because of its venation characters. However, the Lower Gondwana forms differ from *Sphenopteris* because the pinnules are attached to the pinnae rachis by their broad bases and are decurrent in nature. This feature has also been marked by previous workers. Even Zeiller (1902, p. 7) while describing *Sphenopteris hughesi* has opined “Ces pinnules, quelque peu arquees en faux, prennent alors une grande ressemblance de forme avec celles de certains *Odontopteris* du terrain houiller, de l'*Odontopteris minor*



TEXT-FIG. 1 —A. Branching pattern in *Mariopteris* Kidston. B. Branching pattern in *Neomariopteris* gen. nov.

Brongniart, notamment, bien que la nervation, totalement différente, ne permette pas de les confondre". Due to these morphological peculiarities the Indian forms warrant their separation from *Sphenopteris*.

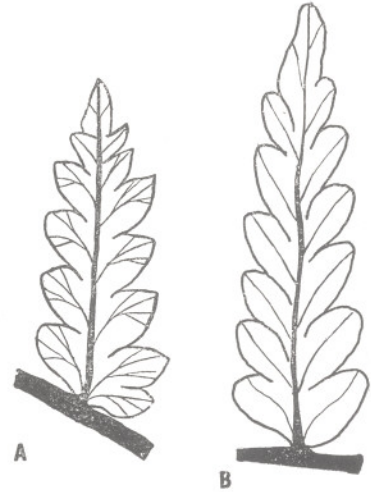
In its decurrent nature of pinnules the Lower Gondwana forms are comparable to *Alethopteris* Sternberg, *Alloiopteris* H. Potonié, and *Mariopteris* Zeiller. *Alethopteris* Sternberg differs from the Gondwana form in possessing a distinct midvein in the pinnules arising at right angle from pinnae rachis and the lateral nervules are also emerging oppositely from midvein at $\pm 90^\circ$. These nervules are either simple or branched into two. *Alloiopteris* is characterized by very small pinnules alternately arranged, decurrent and more or less united laterally. The veins entering the pinnule branches two or three times and the veinlets pass at a steep angle to the apex where they terminate usually in three more or less prominent teeth. Beside this the fertile leaf of *Alloiopteris* (*Corynopteris*) is known.

The Lower Gondwana forms show a close agreement both in the attachment of the pinnules and venations to *Mariopteris*. However, *Mariopteris* has dimorphic pinnules, i.e. basal, most pinnule on the posterior side of pinnae is distinctly larger than the other pinnules and is prominently bilobed. This pinnule also receives two distinct midveins. Beside this the branching pattern in both the fronds is different. In *Mariopteris* fronds, the petiole are forked near the top into equal branches, which has a second dichotomy producing four branches into two pairs (Text-fig. 1A) whereas in the present specimens the petiole is continued as a central shaft to the apex and bore its subdivisions in pinnate manner (Text-fig. 1B).

MORPHOLOGICAL CHARACTERS FOR SPECIFIC DELIMITATION

The fronds of *Neomariopteris* show superficial resemblances to one another. But a close and careful study of the morphological details of the fronds recorded in our collection shows that certain characters are variable from one species to another species and they can be well utilized for the identification of species. The following characters are recognized important for specific delimitation:

1. Nature of rachis: The main rachis may be either broadly winged giving a robust



TEXT-FIG. 2 — AA complete pinnae of *Mariopteris* showing dimorphic nature of pinnules. B.A complete pinnae of *Neomariopteris*.

appearance to frond or narrow winged giving frail appearance to frond.

2. Outline of the pinnae: Ovate or lanceolate or linear or obovate.

3. Angle of attachment of pinnae to the rachis: Pinnae may be attached at right angles to the rachis or at an angle of 45° or less than 45° .

4. Shape of the pinnules: Oblong, lanceolate, spatulate, ovate or obovate, etc.

5. Apex of the pinnules: It may be either acute, obtuse or broadly rounded.

6. Margin of the pinnules: It may be entire, serrate, crenulate or undulated.

7. Attachment of pinnules to pinnae rachis: Pinnules are either attached at right angles to pinnae rachis or obliquely to rachis.

8. Shape of terminal pinnule: The terminal pinnule may be either broadly triangular in shape or lanceolate shape or linear shape.

9. Course of midvein and lateral veins: Veins may be either straight or flexuosus.

10. Number of nervules in one pinnule.

Neomariopteris polymorpha (Feistm.)
n. comb.

Pl. 1, Figs. 1-4; Text-fig. 3A

Synonymy

1876 — *Sphenopteris polymorpha* Feistmantel, p. 365, pl. XVI, figs. 5-7, pl. XVII, figs. 1-3.

1881 — *Sphenopteris polymorpha* Feistmantel, p. 76-77, pls. XVA, XVIA, XVIIIA, fig. 3.

1905 — *Sphenopteris polymorpha* Arber, *Glossopteris flora*, p. 131-133, text-fig. 31.

1966 — *Sphenopteris polymorpha* Surange, p. 66-67, figs. 36A-B.

Emended Diagnosis — Fronds large, at least tripinnate. Rachis broadly winged, secondary rachis broad, emerge alternately or subopposite from primary rachis at an angle of $\pm 90^\circ$. Pinnae ovate shape, arranged alternately, attached to secondary rachis at an angle of 70° - 90° . Lateral pinnules oblong shape, shows \pm equal width in the entire length, 4-10 mm. long and 2.5 mm. broad, i.e. the length to breadth ratio of the pinnule is 2:1; lateral pinnules alternately arranged standing at right angles or slightly obliquely to pinnae rachis, decurrent, attached by broad base, lateral fusion of two pinnules margin is $\pm \frac{1}{4}$ length of the pinnules from the base, apex broadly rounded; margin entire; the lower margin of the pinnule shows strong curvature towards the apex, whereas the upper margin is straight, terminal pinnules larger than the adjacent pinnules, triangular in shape, apex rounded. Median vein distinct, emerges at 45° from the point where lower margin of pinnule joins the pinnae rachis, course straight, median vein gives fine lateral nervules which dichotomises once before reaching the margin. 12-14 nervules are recorded in one pinnule.

Lectotype — 5165. Geological Survey of India, Calcutta.

Locality — Raniganj Coalfield, Bengal.

Horizon — Raniganj Formation.

Specimen Figured — 35020/1386, 35021/1386, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Raniganj Coalfield, West Bengal.

Horizon — Raniganj Formation.

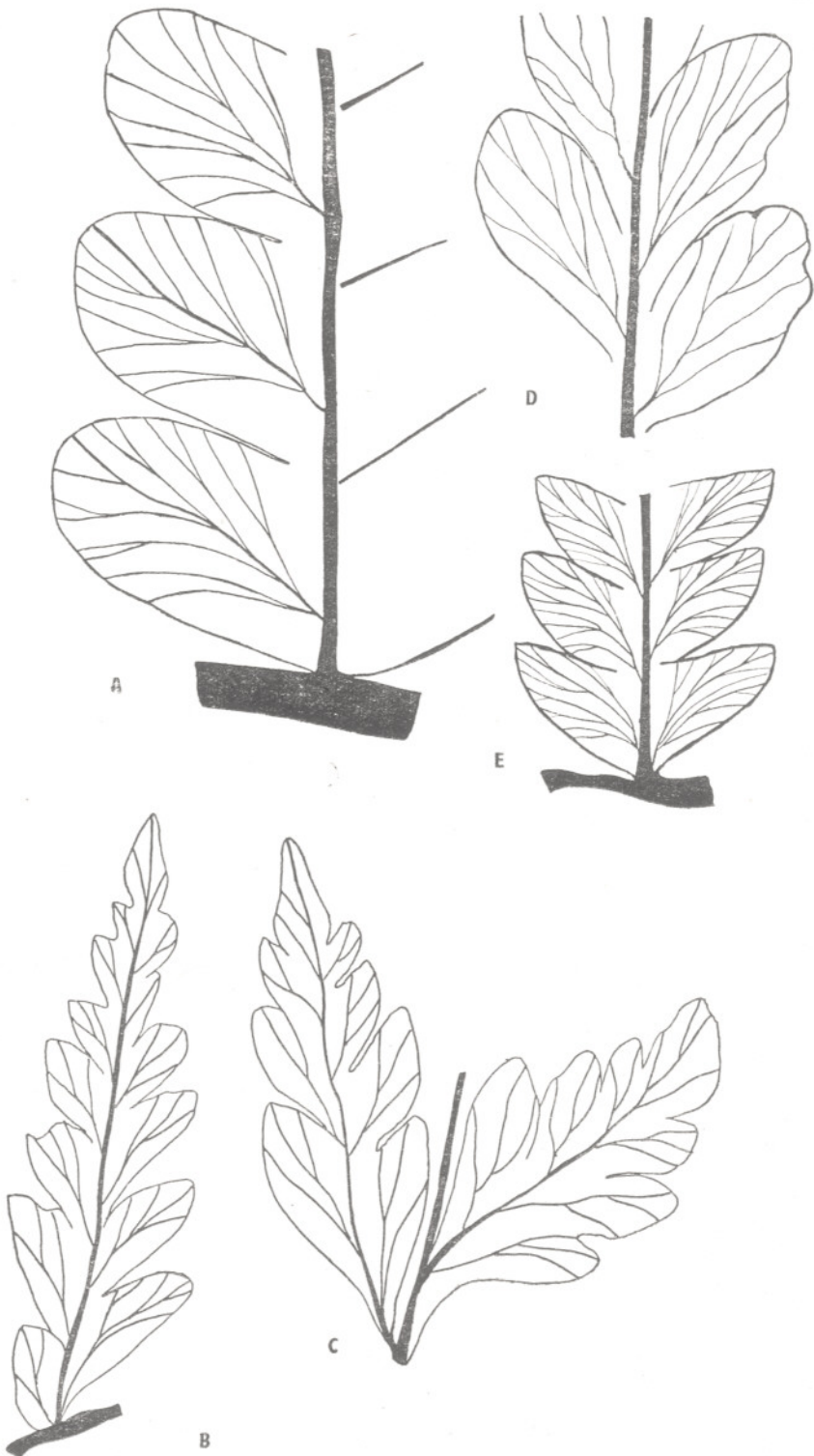
Description — 25 specimens of this type are in the collection. Beside this the type specimens of Feistmantel (1876) preserved at the Geological Survey of India have been examined. The specimens figured in Pl. 1, Fig. 1 show the apical portion of frond. Both the impressions are incomplete at the apical portion. The pinnae near the apex are not completely lobed. Pinnules show distinct decurrent nature. Lateral pinnules oblong shape with obtuse apex and attached

to pinnae rachis more or less at right angle. The terminal pinnule (Pl. 1, Fig. 3) is asymmetrical, broadly triangular in shape, bigger than the adjoining lateral pinnules. The pinnule margin on the superior side is larger drawn than the inferior side.

The specimen figured in Pl. 1, Fig. 2 represents the middle or the lower portion of frond. The rachis is broadly winged 3 mm broad. Pinnae are alternate or subopposite arranged, \pm at 90° . Pinnae rachis is distinct, 1 mm. broad. Pinnae rachis gradually diffuses into fine nervules as it enters the basal region of terminal pinnule. Lateral pinnules oblong shape, decurrent at base (Pl. 1, Fig. 4). Lateral margin fusion of two pinnules is $\pm \frac{1}{4}$ length of the pinnules. Apex of the pinnules broadly obtuse

Comparison and Discussion — The specimens earlier described by Feistmantel (1876, 1881) under *Sphenopteris polymorpha* are now transferred to the new genus because of the decurrent nature of pinnules and sphenopteroid venation.

Kulkarni (1970) described a specimen from the Lower Nakari Seam (Barakar) of the South Karanpura Coalfield under *Sphenopteris polymorpha* Feistm. On the basis of her examined specimens she expressed the opinion that both the species *S. polymorpha* Feistm. and *S. hughesi* Zeiller (1902) are identical, and proposed to merge the latter species with the former species. According to her the only distinction between the two species is that the pinnules are unlobed in *S. polymorpha* and lobed in *S. hughesi*. She had observed in her specimen that the pinnules are unlobed (cf. *S. polymorpha* type) at the apical portion of frond and lobed at the posterior side (cf. *S. hughesi*). The specimen of Kulkarni (*l.c.*) preserved at the Birbal Sahni Institute of Palaeobotany has been reexamined by me. From the examination of frond it appears to me that Kulkarni (*l.c.*) has failed to understand the variations present in complete fern frond from apex towards base. The present study does not support the view of Kulkarni (*l.c.*) for the specific identification, rather confirms with the original specific identification proposed by Feistmantel (1881), Zeiller (1902) and Arber (1905). The present study has brought to light a number of distinguishable morphological characters present in between the two species. The same has been discussed on p. 76 and Table 1.



TEXT-FIG. 3

TABLE 1 — SHOWING COMPARISON OF MORPHOLOGICAL CHARACTERS OF SPECIES OF NEOMARIOPTERIS RECORDED IN THE PRESENT COLLECTION

Name of species	<i>N. polymorpha</i>	<i>N. hughesi</i>	<i>N. lobifolia</i>	<i>N. talchirensis</i>
<i>Morphological characters</i>				
1. Nature of rachis	Broadly winged	Narrowly winged	Narrowly winged	Mediumly winged
2. Pinnæ outline	Ovate	Linear	Linear-lanceolate	Lanceolate-ovate
3. Angle of attachment of pinnæ to rachis	± 90°	± 45°	± 45°	± 70°
4. Shape of pinnules	Ob'long	Lanceolate	Obovate	Ovate
5. Apex of pinnules	Broadly rounded	Acute	Obtuse	Acute
6. Margin of pinnules	Entire	Crenulate	Undulいた	Entire
7. Angle of attachment of pinnules to pinnæ rachis	At right angle	Oblique	Oblique	At right angle
8. Shape of terminal pinnule	Broadly triangular	Lanceolate	Linear	Lanceolate
9. Number of nervules in one pinnule	12-14	5-7	8-12	12-16

According to present study the specimens of Kulkarni (*l.c.*) recorded from South Karanpura belongs to *S. hughesi* Zeiller.

In view of this confusion it will be of utter importance to record here the previously reported specimens which confirm with the diagnosis of *Neomariopteris polymorpha* n. comb.

- 1876 *Sphenopteris polymorpha* Feistmantel, p. 356, pl. 16, fig. 5-7, pl. 17.
- 1881 *Sphenopteris polymorpha* Feistmantel, p. 76-77, pl. 15A, fig. 3, pl. 16A bis, figs. 1-6.
- 1922 *Sphenopteris polymorpha* Walkom, pl. 5, figs. 26, 26A.
- 1958 *Sphenopteris polymorpha* Archangelsky, fig. 25, 26.

The following are regarded distinct from *Neomariopteris polymorpha*:

- 1902 *Sphenopteris polymorpha* Arber, p. 12, pl. 1, figs. 4-5.
- 1958 *Sphenopteris polymorpha* Archangelsky, fig. 29.
- 1961 *Sphenopteris polymorpha* Lele, p. 71-72, pl. 1, fig. 5.
- 1969 *Sphenopteris polymorpha* Maithy, p. 266-267, pl. 1, fig. 4.

Neomariopteris hughesi (Zeiller) n. comb.

Pl. 2, Figs. 7-11; Text-fig. 3B,C

Synonymy

- 1877 *Dicksonia* cf. *concina* Feistmantel, p. 198, figs. 10, 11.
- 1881 *Dicksonia hughesi* Feistmantel, Palaeont., p. 78, pl. 23A, figs. 1, 3, 12, 12a, 13.
- 1902 *Sphenopteris* (*Dicksonia*) *hughesi* Zeiller, p. 6, figs. 1, 2, 2a, 2d.
- 1905 *Sphenopteris hughesi* Arber, p. 133-135, text-fig. 32.
- 1966 *Sphenopteris hughesi* Surange, p. 66-67, figs. 37A-B.
- 1970 *Sphenopteris polymorpha* Kulkarni, p. 208-211, pl. 1, text-fig. 1-4.

Emended Diagnosis — Fronds large, at least tripinnate. Rachis extremely narrow, 1-2 mm, secondary rachis narrow emerge alternately, subopposite or ± opposite from primary rachis at an angle of 45°-60°. Pinnæ linear in shape, attached alternately to the secondary rachis at an angle of 45°. Lateral pinnules lanceolate shape, pinnules show maximum width at their middle portion, 2-6 mm. long and 1-3 mm. broad, the length to breadth ratio of the pinnules is 2:1, pinnules arranged alternate, arising

TEXT-FIG. 3 — Pinnules enlarged to show shape and venations. A. *Neomariopteris polymorpha* n. comb. B-C. *Neomariopteris hughesi* n. comb. D. *Neomariopteris lobifolia* n. comb. E. *Neomariopteris talchirensis* sp. nov. (All specimens figured × 5).

obliquely from the rachis, attached by their broad base, pinnules near the base shows lateral fusion, apex acute, margins crenulate, both the lateral margins show equal curvature, terminal pinnule lanceolate, longer than broad, apex acute, margin crenulate; a gradual increase in size of the pinnules is present from apex to base of the pinnae; venation thin, median vein arises from the point where the basal margin of pinnule joins the pinnae rachis, median vein gives fine lateral nervules, which show rare dichotomy before reaching to the margin. 5-7 nervules are recorded in one pinnae.

Lectotype — 5207 Geological Survey of India, Calcutta.

Locality — Jharia Coalfield, Bihar.

Horizon — Raniganj Formation.

Specimen Figured — 35022/1069, 35023/1227, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Churulia pit, East Raniganj Coalfield, West Benal.

Horizon — Barakar Formation.

Description — 100 hand specimens of this type were examined. Beside this the type specimens described by Feistmantel (1881) and Zeiller (1902) were also examined. The specimen is a tripinnate frond. Primary rachis thin measuring 1 mm. broad. Secondary rachises emerge at an angle of 60° from primary rachis. They are arranged alternate or subopposite. Secondary rachis is also narrow (1 mm.) like primary rachis. Pinnae linear shape, varying size, smaller towards apex and bigger towards proximal side. Pinnae attached to rachis alternately at an angle of 45°. Pinnae at the very extreme apex of the frond is unlobed. However, the subsequent pinnae show gradual lobing resulting in the formation of pinnules. Pinnules show a variation in their shape. Pinnules near the apical portion of frond small linear lanceolate shape with slight crenulation of pinnule (Pl. 2, Fig. 7). The pinnules towards the posterior side are lanceolate-spathulate shape, comparatively bigger in size and the margins of the pinnules show pronounced crenulation (Pl. 2, Fig. 8, Text-fig. 4D). Veins fade out and arise at the point where lower margins of the pinnule join the pinnae rachis (Pl. 2, Figs. 7, 8). It gives lateral nervules which dichotomise rarely before reaching the margin of the pinnules.

Cuticle — Epidermal structure is seen in translucent pulls of pinnules. Although

the preservation is not very good but under the binocular two layers of epidermis are marked. Stomatiferous and non-stomatiferous surfaces. The stomatiferous surface is thick (Pl. 2, Fig. 10). Epidermal cells are trapezoidal or polygonal in outline. Intervening cell walls thick, the stomata at certain places is well marked. They are haplocheilic with thickened lateral lamellae. The subsidiary cells are like ordinary epidermal cells, and the polar subsidiary cells are not different from the lateral ones (Pl. 2, Fig. 11, Text-fig. 4). Non-stomatiferous surface is thin (Pl. 2, Fig. 9). Cells are polygonal in outline. Intervening cell wall is thin.

Comparison and Discussion — Feistmantel (1881) described these fronds under *Dicksonia concina* Heer. The same was transferred by Zeiller (1902) to a new species of *Sphenopteris*, *S. hughesi*. Since the form shows decurrent nature of pinnules, it is, therefore, proposed to transfer them under the new genus. Kulkarni (1970) considered this species similar to *Neomariopteris* (*Sphenopteris*) *polymorpha*. The present morphological study of fronds shows that both the species are different. *N. polymorpha* is a robust form, because of strong wide rachis with bigger oblong pinnules, attached to rachis at $\pm 90^\circ$, pinnule apex is obtuse with entire margins. Contrary to this *N. hughesi* is a weak form with a delicate narrow rachis. The form has small linear pinnules, attached to rachis obliquely, $\pm 45^\circ$, pinnule apex is acute with crenulate margins. Thus the two forms are morphologically different, hence it is proposed here to keep *N. hughesi* as distinct from *N. polymorpha*.

It will not be out of place to list those previous records which agree with the diagnosis of *N. hughesi*. They are as follows:

- 1881 *Dicksonia hughesi* Feistmantel, p. 78, pl. 23A, figs. 1, 3, 12, 12a, 13.
- 1882 *D. hughesi* Feistmantel, p. 28, pl. 12, figs. 3, 3a, 3b.
- 1902 *Sphenopteris* (*Dicksonites*) *hughesi* Zeiller, p. 6, pl. 4, figs. 1, 2, 2a-2d.
- 1965 *S. hughesi* Maheshwari & Gyan Prakash, p. 120, pl. 1, fig. 10.
- 1970 *S. polymorpha* Kulkarni, p. 208-211, pl. 1, figs. 1-5, text-figs. 1-4.

The following are recorded as distinct from *Neomariopteris hughesi*:

- 1968 *Sphenopteris hughesi* Kar, p. 245, pl. 1, figs. 3, 4.

Neomariopteris lobifolia (Morris) n. comb.

Pl. 2, Figs. 12-13; Text-fig. 3D

Synonymy

- 1845 *Sphenopteris lobifolia* Morris in Strezelecki's New South Wales, p. 246, pl. vii, figs. 3, 3a.
 1847 *Sphenopteris lobifolia* McCoy, p. 149.
 1905 *Sphenopteris lobifolia* Arber, p. 135-138, pl. V, fig. 2, 3.
 1954 *Sphenopteris lobifolia* Sivastava, p. 70-71, pl. 1, figs. 1-3.
 1966 *Sphenopteris lobifolia* Surange, p. 68-69, fig. 38A, B.
 1966 *Sphenopteris lobifolia* Rigby, p. 128-129, pl. 33, fig. 32.

(For other Synonymy see Arber, 1905)

Emended Diagnosis — Fronds probably tripinnate, triangular in contour. Rachis extremely narrow 1-2 mm. broad, winged. Pinnae linear-lanceolate shape, attached alternate to subopposite to the rachis at an angle of 45°. Lateral pinnules obovate shape, pinnules show maximum width at their middle portion, 3-8 mm. long and 2-4 mm. broad, pinnules arranged alternate, standing obliquely to the rachis, attached by their contracted base, pinnules at the base are decurrent in nature; apex obtuse with slight lobed margin, both the margins show equal curvature, terminal pinnule linear in shape, median vein of the pinnule sinuate, supplying simple or bifurcating branches to the margins. 8-12 nervules are found in one pinnule.

Holotype — Morris 13,530 Mus. Geol. Soc. London.

Locality — New South Wales, Australia.

Horizon — Permo-Carboniferous.

Specimen Figured — 35024/1384, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Mahavir Colliery, East Raniganj Coalfield.

Horizon — Raniganj Formation.

Description — The figured specimen is a tripinnate frond. The extreme apical portion is not preserved. Pinnae are arranged alternately towards the basal portion and show a subopposite tendency towards apical part. The pinnae near the terminal portion are unlobed. The lobing increases as we pass to the posterior side of frond (Pl. 2, Fig. 12). Pinnules are attached obliquely (30° angle) to the pinnae rachis. Pinnules obovate shape and closely placed. Pinnules show lateral fusion of margins

near the base. The lateral fusion of pinnules is about 1/5th length of the pinnule from base. Median vein of pinnule arises from the point where the lower margin of pinnules joins the narrow pinnae rachis. Median vein sinuate (Pl. 2, Fig. 13) supplying simple or bifurcating branches to margin. Bifurcating branches are rare.

Comparison and Discussion — Due to the decurrent nature of pinnules the fronds earlier described under *Sphenopteris lobifolia* Morris are now transferred under the new genus *Neomariopteris*.

Neomariopteris polymorpha differs from *N. lobifolia* in having broad and strong rachis, oblong pinnules with entire margin attached \pm right angles to the pinnae rachis. The present form shows a close comparison to *N. hughesi* by the narrow rachis and oblique attachment of pinnules. However, *N. hughesi* differs by lanceolate shape of pinnules with acute apex, attached to the rachis by their broad base; whereas the pinnules in *N. lobifolia* are obovate with obtuse apex and slightly contracted base.

Neomariopteris talchirensis sp. nov.

Pl. 1, Figs. 5-6; Text-fig. 3E

Synonymy

- 1876 *Sphenopteris polymorpha* (partim) Feistm., p. 356.
 1881 *Cyathea* cf. *tchihatcheffi* Feistmantel, p. 75-77, pl. 16A, figs. 1-2 & 4.
 1969 *Sphenopteris polymorpha* Maithy, p. 266-267, pl. 1, fig. 4.

Diagnosis — Fronds tripinnate. Rachis broad 3 mm. wide, winged. Secondary rachises broad emerge alternately or subopposite from primary rachis at a wide angle, i.e. 70°. Pinnae lanceolate-ovate shape, arranged alternately, attached to the secondary rachis \pm right angles. Lateral pinnules 6-8 mm. long and 3-4 mm. broad, ovate shape, decurrent, standing \pm at right angles to the pinnae rachis, attached by their broad base. Lateral fusion is about $\frac{1}{4}$ length of the pinnule from the base; apex acute, margin entire, lower margin of the pinnule shows strong curvature from base towards apex, whereas the upper margin is \pm 90° (straight) from pinnae rachis. Terminal pinnule lanceolate with acute apex. Venation distinct. Median vein somewhat sinuous, dichotomises once before reaching

to the margin. 12-16 nervules are recorded in one pinnule.

Lectotype — 5169, Geological Survey of India, Calcutta (Pl. 16A, Fig. 4).

Locality — Talchir Coalfield.

Horizon — Barakar Formation.

Figured Specimen — 33119/838, Birbal Sahni Institute of Palaeobotany, Lucknow.

Locality — Junction of Lobjee and Sadabaha rivers, Daltonganj Coalfield.

Horizon — Barakar Formation.

Description — The present description is based upon the specimens No. 5166 (Feistm., 1881, Pl. 16A, Fig. 1), 5167 (Pl. 16A, Fig. 27) and 5169 (Pl. 16A, Fig. 4) preserved at the Geological Survey of India, Calcutta. The best preserved specimen is 5169 which is a tripinnate frond, whereas 5166 shows the apical portion of frond and 5167 the middle portion of frond.

The specimens figured here have earlier been described by Maithy (1969) under *Sphenopteris polymorpha* from the Barakar beds of Daltonganj Coalfield. The portion of the frond figured here shows that the pinnae rachises are arranged alternately at a distance of 0.5-0.8 cm. Pinnæ 0.5 cm. to 3 cm. long. Pinnæ lanceolate, pointed towards apex. Pinnule small, 3-4 mm. long and 1-2 mm. broad, ovate shape, acute apex, attached to pinnae rachis by their sessile wide base. Pinnules are decurrent in nature. Margin of the pinnules is entire. Secondary veins emerge at acute angle, dichotomous and flexuosus.

Comparison and Discussion — These specimens were first described by Feistmantel (1876) under *Sphenopteris polymorpha*. Later Feistmantel (1881, p. 75, 76) opined that these specimens are different from *Sphenopteris polymorpha* and show a resemblance to *Cyathea tchihatcheffi*. A reexamination of the specimens of Feistmantel (*l.c.*) and Maithy (1969) shows that they conform with the generic diagnosis of the new genus proposed here. The decurrent nature of the pinnules at the base has also been marked by Feistmantel (Feistm. *l.c.* p. 76). Hence the forms described under *Cyathea cf. tchihatcheffi* and *S. polymorpha* Maithy (*l.c.*) from Daltonganj Coalfield are now transferred under a new species of *Neomariopteris*, *N. talchirensis*.

The present form compares closely with *Neomariopteris polymorpha* (Feistm.) n. comb. due to its winged rachis, and the pinnules being attached $\pm 90^\circ$ to pinnae rachis.

However, *N. talchirensis* differs by the ovate shape of pinnules with acute apex and lanceolate shape of terminal pinnules. *N. hughesi* n. comb. and *N. lobifolia* n. comb. differs in having narrow rachis, pinnules attached obliquely to the rachis, and in the different shape of the pinnule.

REMARKS ON *SPHENOPTERIS ALATA* (BRONGNIART) STERNBERG AND OTHER LOWER GONDWANA *SPHENOPTERIS*

The species discussed here are based only on the basis of literature. No referable specimens are available in our collections.

A good deal of nomenclatural confusion exists about the species *Sphenopteris alata* (Brngn.) Sternberg, because many of the authors who have mentioned this fossil have fallen into error in some form or the other. The main cause of this is due to the fact that Brongniart described and figured in 1828, two ferns with the specific title *alata*: (1) *Pecopteris alata* (p. 361, pl. cxxvii) from New South Wales and (2) *Sphenopteris alata* (p. 180, pl. xlvi, fig. 4) from Germany. Sternberg (1820-38, Pt. ii, pp. 59 & 131) transferred the form described under *P. alata* to *Sphenopteris*. Therefore, in his work two different forms are described, one under (1) *Sphenopteris alata* (Brngn.) and the other under (2) *Sphenopteris alata* Brongniart. However, the German type (2) is now known as *Sphenopteris grandini* (Goepf.) Schimper (1869, Vol. 1, p. 404). Thus the only *Sphenopteris* with the specific title *alata* is the Australian form earlier described under *Pecopteris alata* Brngn. Very little is known about this form. The only specimens recorded are of Brongniart (1828) obtained from the coal mines on the Hawkesbury river near port Jackson and the other specimen reported by McCoy (1847) from New Castle, New South Wales. Dutoit (1932) reported a specimen from a locality northwest of Bergville, Natal (Lower Beaufort beds). All these specimens show decurrent nature of pinnules and conform with the diagnosis of *Neomariopteris*. Since no referable material is in our collection, therefore, it is proposed to keep it under *Sphenopteris* till fresh material is collected or the type forms are examined.

The same holds true also for *Sphenopteris hastata* McCoy (1847), *S. flexuosa*

McCoy (*l.c.*), *S. plumosa* McCoy (*l.c.*) and *S. germanus* McCoy (*l.c.*) which are based upon fragmentary specimens. Arber (1905, p. 135) has considered them synonymous to *S. lobifolia* Morris.

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EXPLANATION OF PLATES

PLATE 1

Neomariopteris polymorpha n. comb.

1. Apical portion of frond, × 1.5 (specimen no. 35020/1396, Raniganj Coalfield, Raniganj).
2. Portion from the middle region of frond, × 1.5 (specimen no. 35021/1396, Raniganj Coalfield, Raniganj).
3. A pinnae enlarged to show the terminal pinnule and lateral pinnules, × 3.

4. Pinnules enlarged to show venation and decurrent nature of pinnules, × 5.

Neomariopteris talchirensis sp. nov.

5. A portion of frond, × 1 (specimen no. 33119/838, Daltonganj Coalfield, Barakar).
6. The same enlarged to show venation and shape of pinnules, × 5.

PLATE 2

Neomariopteris hughesi n. comb.

7. A portion of frond showing the arrangement of pinnae and the decurrent nature of pinnules, $\times 5$. (specimen no. 35022/1069, Raniganj Coalfield).

8. Median portion of frond is enlarged to show pinnules and venation, $\times 5$ (specimen no. 35023/1227, Raniganj Coalfield, Barakar).

9. Epidermal structure of non-stomatiferous surface, $\times 250$.

10. Epidermal structure of stomatiferous surface, $\times 100$.

11. A stomata and subsidiary cells enlarged (S = stomata), $\times 500$.

Neomariopteris lobifolia n. comb.

12. A portion of a frond showing arrangement of pinnae, $\times 1.5$ (specimen no. 35024/1384, Raniganj Coalfield, Raniganj).

13. Portions of pinnae enlarged to show the nature of pinnules, $\times 5$.

