

# SOME CONTRIBUTION TO THE KNOWLEDGE OF INDIAN LOWER GONDWANA FERNS

P. K. MAITHY

Birbal Sahni Institute of Palaeobotany, Lucknow

## ABSTRACT

A critical study of the sterile and fertile fronds of the Lower Gondwana ferns from India has been done. The ferns have been classified under *Dizeugetheca* Archangelsky & Sota, *Dichotomopteris* Maithy and *Neomariopteris* Maithy with a brief remark on their affinities with the modern fern families.

## INTRODUCTION

RECORDS of fern fronds from the Lower Gondwana of India date back to 1833 when Royle reported *Pecopteris lindleyana* from near Burdwan. Later M'clelland (1850) recorded *Pecopteris affinis* and Bunbury (1861) reported *Pecopteris* (?) and *Cladophlebis* from Nagpur. Feistmantel (1879) described *Neuropteridium validum* from the Karharbari formation. In 1881 Feistmantel described from the Damuda formation *Cyathea* cf. *tchihatcheffi*, *Sphenopteris polymorpha*, *Dicksonia hughesi*, *Asplenium whitbyensis*, *Alethopteris lindleyana*, *Alethopteris phegopteroides* and *Merianopteris major*. Zeiller (1902) transferred *Dicksonia hughesi* under *Sphenopteris hughesi*. Arber (1905) also made nomenclatural changes in some of the Lower Gondwana ferns. Srivastava (1955) described *Sphenopteris lobifolia* Morris and a fertile pinna as a *?Ptychocarpus* sp. All the above records were reviewed by Surange (1964). Maithy (1974 a, b) pointed out that the Lower Gondwana *Sphenopteris*, *Alethopteris* and *Merianopteris* from India are morphologically distinct from the typical *Sphenopteris*, *Alethopteris* and *Merianopteris* of the Euramerican flora and suggested new generic names *Neomariopteris* and *Dichotomopteris* to accommodate them.

## DESCRIPTION

*Dizeugetheca* Archangelsky & Sota, 1960

*Dizeugetheca phegopteroides* (Feistm.)  
n. comb.

Pls. 1, 2; figs. 1-4 & 6, Text-figs. 1 A-F

1876 — *Alethopteris phegopteroides* Feistmantel, p. 362, pl. 18, figs. 1, la, 2, 2a.

1881 — *Alethopteris phegopteroides* Feistmantel, p. 81, pl. 18A, figs. 1, la, lb.

1905 — *Pecopteris phegopteroides* Arber, p. 140.

1964 — *Pecopteris phegopteroides* Surange, p. 69, fig 38A & B.

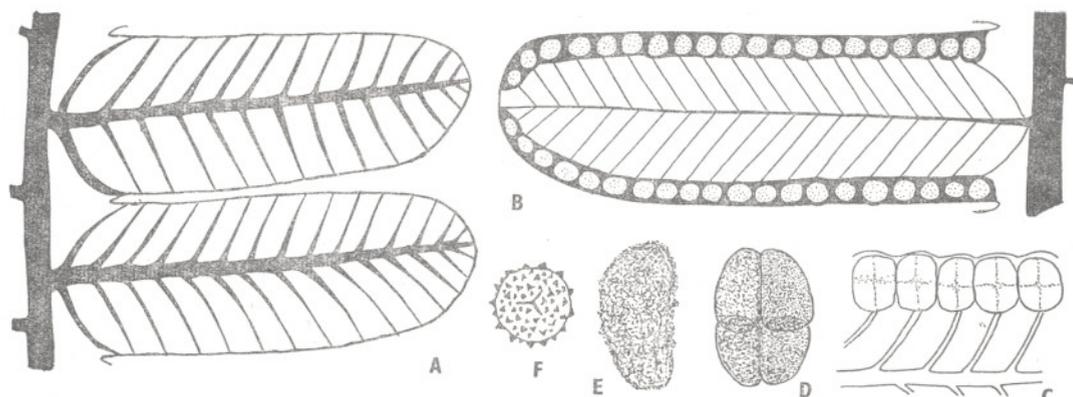
1965 — *Pecopteris phegopteroides* Maheshwari & Prakash, p. 118, pl. 1, fig. 6, text-fig. 3.

*Diagnosis* — Fronds tripinnate, main rachis punctate. Rachis of the pennultimate pinna attaining a width of 5-7 mm, ultimate pinnae arranged alternately, laminae touching laterally; ultimate pinnae long, lanceolate in shape, tapering distally into small broadly triangular terminal segment; pinnae rachis 2-3 mm broad, giving off pinnules at wide angle, usually 80°-90°; adjacent pinnules nearly touching each other, basally contiguous, cleft between pinnules deep. Pinnules elongated-oblong, straight, expanded at base, abruptly contracted at apical end into rounded apex; venation distinct; mid-vein thick, arising  $\pm$  at right angle from pinna rachis, persisting almost straight up to apex; lateral veins emerge at 40°-50°, alternate, straight, except basal one showing radial curvature, veins simple, unforked, density of veins 16-20 per cm. Vein arrangement catadromic. Sori small, ovoid, arranged in a row along margin of pinnules, laterally contiguous to one another, four sporangia in a sori, egg shaped, arranged in two rows opposite to each other. No dehiscence mark or annulus observed. Spores trilete, circular with conic, Y-mark faint reaching 1/3 of body. Spores identical to *Apiculatisporites inconspicuus* Salujha (1965).

*Lectotype* — 5183, Geological Survey of India. Calcutta.

*Isotype* — 35104, Birbal Sahni Institute of Palaeobotany, Lucknow.

*Locality* — East Raniganj Coalfield, West Bengal.



1. A-E *Dizeugotheca phegopteroides* (Feistm.) n. comb. A, Sterile pinnules showing venation,  $\times 6$ ; B, Fertile pinnule showing sori arrangement and venation,  $\times 6$ ; C, Sori arrangement on pinnule,  $\times 10$ ; D, A single sori,  $\times 15$ ; E, Sporangium,  $\times 20$ ; F, Spore,  $\times 500$ .

*Horizon* — Raniganj Formation, Lower Gondwana.

*Age* — Upper Permian.

*Description* — The observations given below are based on the examination of fresh material, both sterile and fertile and the type specimens described earlier by Feistmantel (1876a, 1881) which were sterile.

This fern frond must have been quite large. Two pinnae have been figured. (Pl. 1, fig. 1). One pinna measures 6.5 cm. long. Pinnules are attached to pinnae rachises more or less at  $90^\circ$ . All pinnules are contiguous at the base; the cleft in between two pinnules is distinct (Pl. 1, fig. 2). Pinnules are alternate to subopposite to one another and 1-1.5 cm. long and 0.3-0.5 cm. broad. Few basal pinnules (commonly 3 pairs from base) are slightly smaller in size than the pinnules of the middle region which are large. Each pinnule has one thick, distinct mid-vein, emerging almost at right angles from rachis (Pl. 1, fig. 2, Text-fig. 1A), persisting almost straight up to apex. Lateral veins arise at an angle of  $40^\circ$ - $45^\circ$  and are alternate. They run  $\pm$  straight except the basal pair which shows strong inward curvature. As a result the basal contiguous region of pinnules is devoid of veins. The basal vein on the proximal side of pinnule emerge just at the point from where the mid-vein departs from the rachis. Lateral veins are thick, straight and non-dichotomising.

The fertile frond is similar to the sterile frond and is figured in Pl. 1, Fig. 3. All the pinnules of the ultimate pinna bear sori,

except the basal ones which are sterile. 16-26 pairs of sori are arranged in a single row, contiguous to each other all along the margin of the pinnules. (Pl. 1, fig. 4, Text-fig. 1B). The fertile pinnules are 14-18 mm. long and 3-4 mm. broad.

Each sorus is tetragonal in outline with rounded corners (Text-fig. 1D) and is supplied by a single vein. The sori are arranged close together in a row. A single sorus measures  $\pm 1$  mm. in length 0.5 mm. in breadth. Each sori has four sporangia. The sporangia are egg shaped. The 4 sporangia are arranged in a row, placed opposite to each other. The sporangium (Text-fig. 1E) is 500-700  $\mu$  long and 250-375  $\mu$  broad. No dehiscence mark is seen. The wall of the sporangium is thin and composed of elongated hexagonal cells. Each sporangium on maceration yielded spores. Isolated spores (Pl. 2, fig. 6, Text-fig. 1F) are  $\pm$  circular and, measure 19-24  $\mu$ . Y-mark faint, rays of the Y-mark reaching  $\pm 1/3$  body part, surface covered with closely arranged coni,  $\pm 1$   $\mu$  long and equally broad, 8-12 coni observed on *extrema-lineamenta*. The spores are identical to *Apiculatisporites inconspicuous* Salujha (1965) recorded from Seam IX of the, Raniganj Coalfield.

*Comparison & Discussion* — This fern frond was first described by Feistmantel (1876b, 1881) under *Alethopteris phegopteroides*. Arber (1905) considered it to be pectopteroid in habit and venation and therefore, transferred it to *Pecopteris* Brongniart. The Indian fern frond differs from the typical *Pecopteris* frond in having pin-

nules contiguous at base and without any veins, whereas in *Pecopteris* the pinnules are separate and the incision in between the pinnules reaches right up to the base. In having contiguous pinnules it resembles *Mariopteris* Kidston and *Alethopteris* Sternberg. *Mariopteris*, however, differs from *Dizeugetheca* in possessing sphenopteroid type of venation. In *Alethopteris* the pinnules are contiguous, but the contiguous region is supplied by a number of veins emerging directly from pinnae rachis. This is not so in *Dizeugetheca*. The fertile fronds of *Pecopteris* are described under different genera *Ptychocarpus*, *Asterotheca* and *Scolecopteris*. The three genera differ from the present frond in having sporangia fused together into synangium. Moreover in *Ptychocarpus*, *Asterotheca* and *Scolecopteris* the synangia are arranged on either side of a mid-vein in distinct groups whereas in *Dizeugetheca* the sporangia are marginal. The Indian fronds have, therefore, been placed under *Dizeugetheca* Archangelsky and Sota (1960). Archangelsky and Sota (*l.c.*) instituted a new genus to accommodate fertile fronds with linear arranged sori on the margin of pinnules with simple venation. The pinnules resemble our fronds in shape and venation.

Four species of *Dizeugetheca* are known from Argentina and Bolivia, viz., *D. waltonii* Archangelsky and Sota (1960), *D. neubergiae* Archangelsky and Sota (*l.c.*), *D. branissae* Arrondo (1967) and *D. furcata* Arrondo (1972). All the four species differ from Indian fronds of *Dizeugetheca* by possessing small pinnules and less number of sori. Moreover, in all the three species the basalmost pair of veins in the pinnules are straight whereas in our specimen the basal pair shows inward curvature. The Indian frond has, therefore, been placed under a new combination of *Dizeugetheca*, *D. phegopteroides* (Feistm.).

#### *Dichotomopteris* Maithy, 1974

*Genotype* — *Dichotomopteris major* (Feistm.) Maithy, 1974b.

#### *Dichotomopteris major* Maithy

Pl. 2; fig. 7, Text-figs. 2 A-F

1881 — *Merianopteris major* Feistmantel, p. 83, pl. 19A, figs. 9-11.

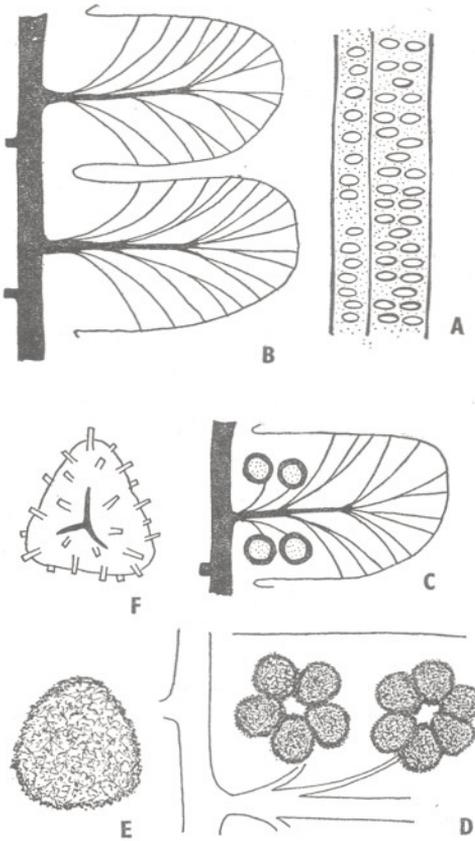
1964 — *Merianopteris major* Surange, p. 74, fig. 42.

1974b — *Dichotomopteris major* (Feistm.) Maithy, p. 366, pl. 1, figs. 1-4.

*Description* — A brief description of this genus has already been given (Maithy, 1974b). The specimen is described in detail here. The frond is tripinnate. Rachis is 3-4 mm. wide with a distinct median ridge or groove. Cellulose pulls taken from the rachis show narrow-elongate tracheids with small, opposite, transversely elongated, oval bordered pits. The pits are 2-3 in a row (Text-fig. 2A).

The penultimate pinnae (i.e. the rachis bearing the pinnae) are opposite and emerge from the main rachis at an angle of 70°-80°. The maximum length of a penultimate pinnae is 13.5 cm. long. Ultimate pinnae are closely arranged at wide angles (70°-80°) and are alternate to one another. The maximum length of the ultimate pinna is 4 cm. A pinna is oblong and has one terminal pinnule and 6-8 pairs of lateral pinnules. The basal pinnae are well dissected into distinct pinnules, whereas the apical pinnae are either entire or show faint to deep crenulations. Lateral pinnules are attached to rachis at an angle of 80°-90°. Pinnules are obovate in outline with rounded apex and are 4-6 mm. long and 3-4 mm. broad. Pinnules are contiguous near the base. The cleft between the two pinnules is deep. Terminal pinnule is broadly triangular and asymmetrical at the base with rounded apex. Mid-vein is distinct and persistent only up to half the distance and then it bifurcates into secondary veins which further dichotomise (Text-fig. 2B). Generally 2 lateral veins emerge on either side of mid-vein at an angle of 45°. The basal lateral veins usually show single dichotomy into two veins, whereas the distal one shows double dichotomy into three veins. When divided into three veins, the distal one divides into two and the proximal remains undivided. The lateral veins are arched and slightly flexuous.

In addition to this there are specimens representing the apical portion of a imparipinnate frond, which is triangular in outline. The pinnae in the apical region are attached to main rachis and show distinct incision to form obovate pinnules. The pinnae in the middle and basal portion of the frond are arranged on the secondary rachis. The pinnae in the middle region are entire or



2. A-F, *Dichotomopteris major* Maithy A, Tracheids showing pits,  $\times 500$ ; B, Sterile pinnules showing venation,  $\times 6$ ; C, Fertile pinnule showing sori arrangement,  $\times 6$ ; D, Sori and its arrangement,  $\times 100$ ; E, A single sporangium,  $\times 15$ ; F, Spore,  $\times 500$ .

show crenulations on the margins indicating incisions before the pinnules are formed. The basal pinnae are, however, well dissected into distinct pinnules.

The fertile frond is similar to sterile frond and is figured in Pl. 2, fig. 7. Two rows of sori are present only in the basal half of the pinnules on the underside. Sori are arranged on both sides of midvein occupying an intermediate position between the margin and the midvein. Each sorus is arranged on lateral vein ending (Text-fig. 2C, D). Sori are 2-3 mm in diameter and are circular-oval. In one sorus 5-6 separate sporangia are closely arranged round a central point. They are somewhat adpressed laterally but not fused. Each sporangium is  $\pm$  circular in shape (Text-fig.

2E) and measures 375-500  $\mu$ . The wall of sporangium in dry stages show broad reticulate structure with a marginal rim. Sporangium wall is thin. No annulus is seen. Spores were recovered from sporangium which showed little variations in shape and size. Spores are distinctly triangular with straight to slightly concave sides and broadly rounded corners, convex sides are rather rare (Text-fig. 2F). Spores measure 22-35  $\mu$  and the rays of the Y-mark are usually  $2/3$  the radius, sometimes open and almost reaching equatorial margin. Apex and vertex of the Y-mark is low and labra are thin. Exine is ornamented with usually curved bacula, 2-4 $\mu$  long, longer than broad and with blunt tips, individual bacula are spaced apart. 7-14 baculae are on the *extrema lineamenta*. The spores are identical to dispersed spores described as *Horriditrites curvibaculosus* Bharadwaj and Salujha (1964), which were reported from the Seam VIII of the East Raniganj Coal-field, West Bengal.

*Comparison & Remarks* — Earlier fronds of this type have been described by Feistmantel (1881, Pl. 19A, figs. 9-11) under *Merianopteris major*. The genus *Merianopteris* Heer described from Keuper of Switzerland is characterized by the basal veins of one pinnule fusing with the basal veins of adjoining pinnules and dimorphic leaves. Feistmantel (*l.c.*) believed that the two lower lateral nerves of each pinnule join with similar veins of the adjoining leaflets in a pointed and arched manner. Arber (1905:145) pointed out that the union of the two lateral veins has not been clearly shown in the figures of Feistmantel (*l.c.*). The specimens of Feistmantel have been reexamined by me and I am fully convinced that the lower lateral veins are free and not fused. The lateral coalescent appearance of basal veins in between two lateral pinnules is due to basal contiguity of pinnules. Hence, the placement of these Lower Gondwana forms under *Merianopteris* Heer is not correct and so these ferns have now been transferred under a new genus *Dichotomopteris* Maithy (1974b).

*Dichotomopteris major* Maithy (1974b) resembles *Asterothecca andersonii* Archangelsky and Sota (1960) recorded from Argentina in the position of sori. But *A. andersonii* differs from *D. major* in the details of venation. In the former the lateral veins

dichotomize into four veinlets, whereas in the latter the lateral veins are either divided into two or three veinlets. Moreover, in *A. andersonii* the sporangia are fused into synangia whereas in *D. major* they are free.

*Dichotomopteris lindleyii* (Royle) Maithy, 1974

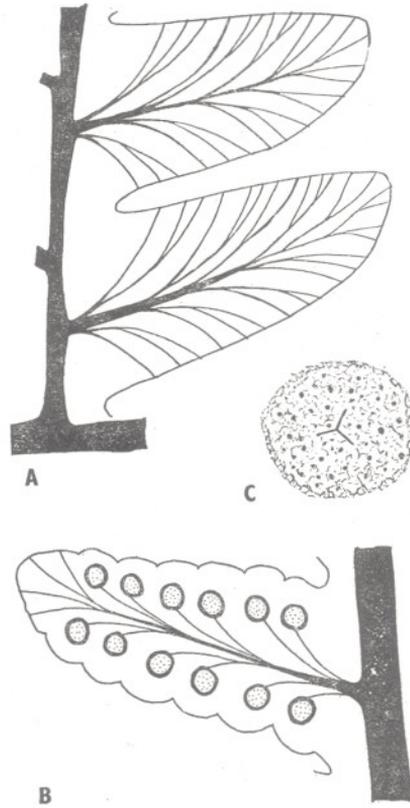
Pls. 1, 2; figs. 5 & 8; Text-figs. 3 A-C

*Synonymy*

- 1883 *Pecopteris lindleyana* Royle, p. 29, pl. 2, fig. 4.
- 1850 *Pecopteris lindleyana* M'clelland, p. 56, pl. 13, figs. 10-a-c.
- 1876a *Pecopteris lindleyana* Feistmantel, p. 76.
- 1876b *Alethopteris lindleyana* Feistmantel, p. 360. pl. 20, fig. 7.
- 1880 *Alethopteris lindleyana* Feistmantel, p. 80. pl. 18A, figs. 2, 2a, pl. 19A, figs. 3, 3a, pl. 23A. figs. 11, 11a, pl. 39A, figs. 10-11.
- 1902 *Cladophlebis roylei*, Arber, p. 548.
- 1905 *Cladophlebis roylei* Arber, p. 142, figs. 33A, B.
- 1955 ?*Ptychocarpus* sp. Srivastava, p. 71. pl. 1, figs. 4-8. text-fig. 2.
- 1964 *Alethopteris lindleyii* Surange p. 76. figs. 44, 45A-B.
- 1964 *Ptychocarpus srivastavae* Surange p. 72, fig. 41. A, C.
- 1974b *Dichotomopteris lindleyii* Maithy p.366, pl. 1, figs. 5-8.

*Description* — The observations presented here are based upon the examination of fresh material (both sterile and fertile) and the specimens described earlier by Royle (1883), Feistmantel (1876a, b, 1881) and Srivastava (1955).

The recorded specimen is a bipinnate frond. Main rachis is 2 mm. broad and pulvinus in nature. Pinnae emerge alternately at an angle of 45° from the main rachis. The pinna shown in Pl. 1. fig. 5 is 13.2 cm. long. The pinnules near the apical portion are fused together and separate pinnules are only recognizable by the number of mid-veins. The pinnules below this are distinct. They are 1-1.5 cm. long and 0.4-0.6 cm. broad. Lateral pinnules are oblong-oval in shape with obtuse apex and fused with adjoining pinnules for  $\pm 1/3$  length from the base. The distal margin of pinnules is  $\pm$  straight,



3. A-C, *Dichotomopteris lindleyii* Maithy A, Sterile pinnules showing venation,  $\times 6$ ; B, Fertile pinnule showing sori arrangement,  $\times 6$ ; C, Spores,  $\times 500$ .

whereas proximal margin is somewhat curved. Each pinnule has a distinct mid-vein persisting up to 3/4th distance from base, bifurcating upwards into secondary veins which further dichotomize (Text-fig. 3A). Lateral veins are usually 4 or 5 on either side of the mid-vein. Each lateral vein dichotomizes usually twice into 3 veinlets or rarely into only 2 veinlets. When 3, the proximal veinlet remains undivided while the distal veinlet dichotomizes into two. No veins are present in the basal contiguous portion of two pinnules. The terminal pinnule is elongate-triangular in shape with acute apex. Beside, this in collection a portion of frond is preserved representing both the sterile and fertile parts.

The specimen figured in Pl. 3. fig. 20 represents a portion of a fertile pinna which

is comparable to the specimen figured by Srivastava (1955) under ?*Ptychocarpus*. Eight pairs of pinnules are arranged alternately on pinnae rachis, which is  $\pm 1.5$  cm. broad and pulvinus in nature. Pinnules (Pl. 2, fig. 8, Text-fig. 3B) are attached somewhat obliquely to the rachis. They are oblong with obtuse apex and measure 1.2 cm. in length and 0.8 cm. in breadth. Their margin is crenulate. Six sori are arranged in rows on either side of the mid-vein on the lateral vein endings. The sori occupy intermediate position between the mid-vein and margin. The sori are circular and measure  $\pm 1$  mm. in diameter. Each sorus consists of 5-6 free sporangia which are arranged round a central point. Each sporangium is circular in shape. Annulus is not seen. Spores (Text-fig. 4C) are 60-80  $\mu$  with distinct Y-mark which reaches  $\pm 1/2$  body diameter. Exine bears distinct, minute, roundish, elliptical puncta, usually clearly separated from the adjacent ones. The spores are identical to *Eupunctisporites poniatiensis* Bharadwaj (1962) recorded from Poniati mine, East Raniganj Coalfield, West Bengal. Playford & Helby (1968) while describing spores from a Carboniferous section in the Hunter Valley, New South Wales have considered *Eupunctisporites* Bharadwaj (1962) to be synonymous to *Foveosporites* Balme. To me both of them appear to be distinct. In *Foveosporites* the distal exine has foveolate to foveolate-vermiculate sculpture, whereas in *Eupunctisporites* puncta are present on the entire surface of the spores. These two spore genera should therefore be kept distinct.

The specimen 5184 figured by Feistmantel (1881, Pl. 19A figs. 3-3A) represents apical portion of a fertile pinna. The pinnules on the proximal side show 4 rows of sori. However, a gradual reduction is observed in the number of sori as one passes towards the terminal portion of the pinnae. The ultimate pinnule has only one row.

*Comparison & Remarks* — Maithy (1974b) transferred the fronds described earlier under *Alethopteris lindleyi* and *Ptychocarpus srivastavae* to a new genus *Dichotomopteris*. The sterile fronds were first described by Royle (1883) under *Pecopteris*. This was later transferred by Feistmantel (1876b) under *Alethopteris lindleyana*. Arber 1905 again transferred this species under *Cladophlebis roylei* for the reason that the genus

*Alethopteris* is used in a restricted sense. Surange (1964) opined "This, however, is no valid reason for nomenclatural change, for, *Alethopteris* is a form genus and, moreover *Cladophlebis* is typically a Mesozoic genus generally restricted to sterile osmundaceous frond". Therefore, he preferred to use *Alethopteris* for these Indian Lower Gondwana fronds. Recently Surange (1971, p. 66) has remarked that the Indian *Alethopteris* differs in details of its venation from its typical Euramerican representatives.

Fertile fronds of this type were earlier described by Feistmantel (1881, Pl. 19A, fig. 3A and Pl. 23A, fig. 11, 11A). He considered these fronds to be of polypodiaceous nature. Similar looking fertile frond was described by Srivastava (1955) under ?*Ptychocarpus* sp. This was later described by Surange (1964) as *Ptychocarpus srivastavae*, a new species. The recent record of fertile and sterile pinnules on a single pinnae suggests that both the types of fronds belong to one plant and, therefore, they should be described under one species. Morphologically these fronds fall under the generic circumscription of *Dichotomopteris* Maithy, as the fronds are characterized by contiguity of pinnules near the base, evanescent mid-vein, characteristic pattern of lateral veins and sori composed of free sporangia.

*Dichotomopteris lindleyi* Maithy (1974) differs from *D. major* Maithy (1974) in the shape of terminal and lateral pinnules, more double dichotomous veins, the distribution of sori on pinnules and the different types of spores.

#### *Dichotomopteris falcata* sp. nov.

Pl. 2; fig. 9; Text-fig. 4

- 1876b *Alethopteris* cf. *whitbyensis* Feistmantel, p. 362, pl. 21, fig. 6, 6a.  
 1881 *Asplenium whitbyensis* Heer, Feistmantel, p. 79, pl. 19A, figs. 2, 29, pl. XIA, figs. 2, 3.  
 1881 *Alethopteris* (*Asplenium*) *whitbyensis* Göpp., Feistmantel Pl. 23A, fig. 11, 11a.  
 1905 *Cladophlebis* sp. Arber, p. 144.  
 1964 *Alethopteris* sp. Surange, p. 78, fig. 46.

*Diagnosis* — Fronds tripinnate; rachis smooth, striated; pinnae arranged alternate at a wide angle of 70°-80°, lanceolate; pin-

nules falcate with acute apex alternate, attached to rachis at wide angle,  $80^{\circ}$ - $90^{\circ}$ , contiguous to each other near base, clefts between pinnules deep; mid-vein thin persistent up to  $3/4$ th distance, then bifurcating into secondary veins which further dichotomize; lateral veins usually 4 on either side of mid-vein, each dichotomizing once, rarely twice; when dividing into three veins, distal one dichotomizes into two and proximal remains undivided. Fertile pinnules not known.

*Lectotype* — 5217, Geological Survey of India, Calcutta.

*Isotype* — 3511 and 3512, Birbal Sahni Institute of Palaeobotany, Lucknow.

*Locality* — Raniganj Coalfield, Bengal.

*Horizon* — Raniganj formation, Lower Gondwanas.

*Age* — Upper Permian.

*Description* — The observations given here are based upon fresh collection and the specimens earlier described by Feistmantel (1881). In the sterile pinnae, the pinnae rachis is 1 mm. wide and smooth. Pinnules are of variable size, but they are comparatively bigger in the middle than in the basal and the apical region. The pinnules are 1.0-1.5 cm. long and 0.4-0.6 cm. broad and are falcate in shape (Pl. 2, fig. 9) with acute apex. Pinnules are contiguous at the base but well spaced from each other where they are separate. Each pinnule is supplied by a thin mid-vein which persists up to  $3/4$  length from base and then dichotomizes further into secondary veins (Pl. 2, fig. 9; Text-fig. 4). 4 lateral veins are present on either of the mid-vein. Lateral veins divide frequently into 2 rarely

into 3 veinlets. When divided into three, the proximal veinlet remains undivided while the distal one divides into two.

*Comparison & discussion*: Although no fertile pinnules are known, the sterile pinnules resemble in venation and attachment *Dichotomopteris* Maithy (1974). Hence, it is proposed here to place the specimens under *Dichotomopteris*.

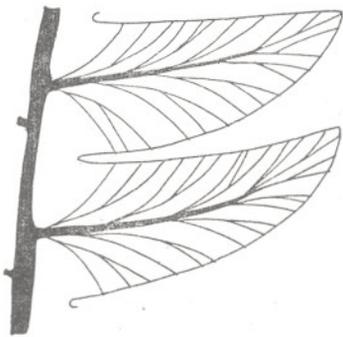
Feistmantel (1881) attributed his Raniganj forms to *Asplenium whitbyensis* Heer known from the Jurassic of Yorkshire, because he considered them to be morphologically alike. Surange (1964) placed them under *Alethopteris* sp. From the present study it is evident to us that the Raniganj forms are identical to *Dichotomopteris* Maithy (1974). A new specific name *D. falcata* is used for the Raniganj forms to avoid nomenclatural confusion, because the name *whitbyensis* is a valid specific name for Jurassic *Asplenium*.

*Dichotomopteris falcata* sp. nov. though compares closely to *D. lindleyii* (Royle) Maithy (1974) but differs in the falcate shape of pinnules and acute apex. *D. major* (Feistm.) Maithy (1974b) differs by the obovate shape of pinnules and rounded apex.

#### *Neomariopteris* Maithy, 1974

*Emended diagnosis* — Imparipinnate tripinnate frond; rachis winged; pinnules variable in shape, attached by broad base, contiguous with pinnules below by decurrent base; sori circular arranged near lobed margin on lateral vein endings, 4-6 free sporangia arranged round a central point, sporangia circular in outline.

*Comparison* — Maithy (1974a) had stated earlier that the Indian Lower Gondwana species of *Sphenopteris* do not agree with the generic circumscription of *Sphenopteris* and that the Indian ferns are morphologically distinct from the northern hemisphere *Sphenopteris*. In Indian fronds the pinnules are laterally contiguous by their decurrent bases, whereas in *Sphenopteris* the pinnules are separate. The Indian fronds resemble *Mariopteris* in the contiguous pinnules and sphenopteroid venation, but *Mariopteris* has dimorphic leaves. Hence, a new generic name *Neomariopteris* was proposed by Maithy (*l.c.*) for the Indian Lower Gondwana fronds described earlier under the genus *Sphenopteris*. So far only their sterile



4. *Dichotomopteris falcata* sp. nov. Sterile pinnules showing venation arrangement.,  $\times 6$ .

fronds were known, but now fertile specimens have also been collected.

*Neomariopteris hughesii* Maithy, 1974

Pl. 2, figs. 10-11, Text-fig. 3 A-C

The fern frond is bipinnate (Pl. 2, fig. 10) with extremely narrow median rachis which is 1 mm. broad; ultimate pinnae are arranged alternately on the main rachis at an angle of 45°. Pinnae are linear-triangular and the pinnules are lanceolate in shape with acute and crenulate margin, measuring 4-10 mm. in length and 2-6 mm. in breadth, they are arranged alternately and attached to rachis obliquely by broad base. Pinnules are contiguous by their decurrent bases. The mid-vein arises from the rachis where the decurrent margin base joins the pinnae rachis. Lateral veins arise alternately at an angle of 30° from the mid-vein. Mid-vein as well as the lateral veins are thin and flexuosus. Isolated, circular sori are arranged on

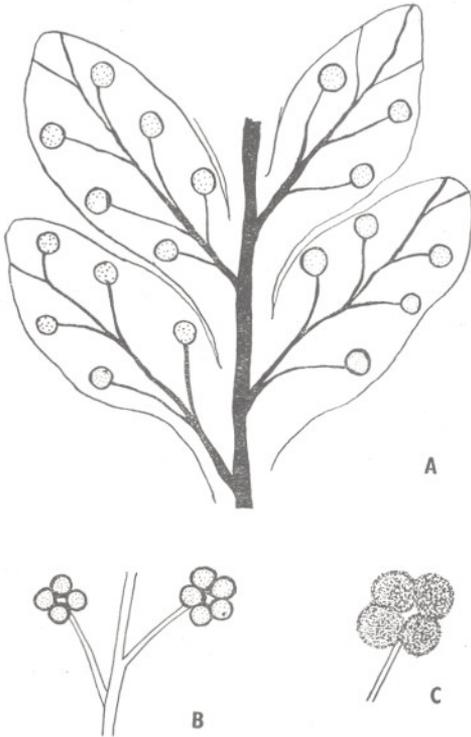
lateral veinlet endings, a little away from the lobed margin (Pl. 2, fig. 11; Text-fig. 5A). The number of sori is related to the size of the pinnules and it varies from 3 to 6 in pinnule segments. Each sorus is most probably composed of 4-6 free sporangia,  $\pm$  circular in outline, arranged round a central point (Text-fig. 5 B & C). Attempts were made to isolate spores by maceration, but no spores were found.

*Comparison* — The fertile fronds are similar to the sterile fronds of *Neomariopteris hughesii* Maithy (1974). A fertile frond of this type has earlier been reported by Feistmantel (1882, Pl. 12, figs. 3, 3a, 3b) under *Dicksonia hughesi* from Son river near its junction with Murna river. The fronds described by Archangelsky & Sota (1960) from Argentina under *Sphenopteris* II (Text-fig. 65) is identical to the present frond. Huard-Moine (1964), and Lacey and Huard-Moine (1966) reported fertile fronds from Wankie, South Rhodesia under *Sphenopteris cladophleboides*. In the arrangement and organization of sori, it agrees with the Indian frond, but *S. cladophleboides* differs in the shape of pinnules.

#### CONCLUDING REMARKS

In the northern hemisphere some of the families of living ferns can be traced as far back as the late Palaeozoic, e.g. Marattiaceae (*Acitheca*, *Asterotheca* and *Ptychocarpus*) Schizeaceae (*Senftenbergia*), Gleicheniaceae (*Oligocarpia*) and Osmundaceae (*Thamnopteris*). In *Dizeugothea* Archangelsky and Sota the pattern of venation is simple. Sori are present on vein endings, composed of four free sporangia arranged round a central point on the pinnule margin. Due to marginal position of sori the frond compares with Schizeaceae, but differs in the absence of annulus in the sporangium. In the organization and arrangement of sporangia it compares with Marattiaceae. But in Marattiaceae the sporangia form syngangium, while in *Dizeugothea* they are all free.

In *Dichotomopteris* Maithy the sori position is superficial. 4-7 sporangia are freely arranged round a central point in a rosette fashion. Similar arrangement is seen in modern Gleicheniaceae, Matonieae and Marattiaceae. Both Gleicheniaceae and Matonieae differ by the presence of annulus,



5. A-C, *Neomariopteris hughesii* Maithy. A, Fertile pinnules showing the arrangement of sori,  $\times 6$ ; B-C, Organization of sori.

while Marattiaceae differs due to fusion of sporangia into a synangium, whereas in *Dichotomopteris* the sporangia are free.

In *Neomariopteris* Maithy (1974) the sori are arranged near the margin; sorus consists of 4-6 free sporangia arranged in a rosette round a central point. In the position of sori on pinnule it agrees with Hymenophyllaceae, but in Hymenophylla-

ceae the sporangia have annulus. In the arrangement of sorus it resembles Marattiaceae, but differs by the fusion of sporangia into synangium. Thus, the Lower Gondwana ferns differ in one aspect or other from the modern families of fern. However, in their arrangement of sporangium and sori organization they come somewhat closer to Marattiaceae.

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## EXPLANATION OF PLATES

(All the figured specimen and slides are preserved at the museum of Birbal Sahni Institute of Palaeobotany, Lucknow)

## PLATE 1

*Dizeugotheca phegopteroides* n. comb.

1. Two sterile pinna,  $\times 1$ , specimen No. 35103.
2. A portion of sterile pinna enlarged to show attachment of pinnules and venation,  $\times 6$ ; specimen No. 35145.
3. A fertile frond,  $\times 1$ ; specimen No. 35104.
4. Two pinnules enlarged to show the arrangement of sori on the pinnules,  $\times 6$ .

*Dichotomopteris lindleyii* (Royle) n. comb.

5. A sterile pinna showing unlobed condition of pinnules in the apical part.  $\times 1$ , specimen No. 35108.

## PLATE 2

*Dizeugotheca phegopteroides* n. comb.

6. Spores isolated from the sporangia;  $\times 1000$ ; Slide No. 4485.

*Dichotomopteris major* Maithy

7. A portion of fertile frond showing arrangement of sporangia,  $\times 1$ ; specimen No. 35106.

*Dichotomopteris lindleyii* Maithy

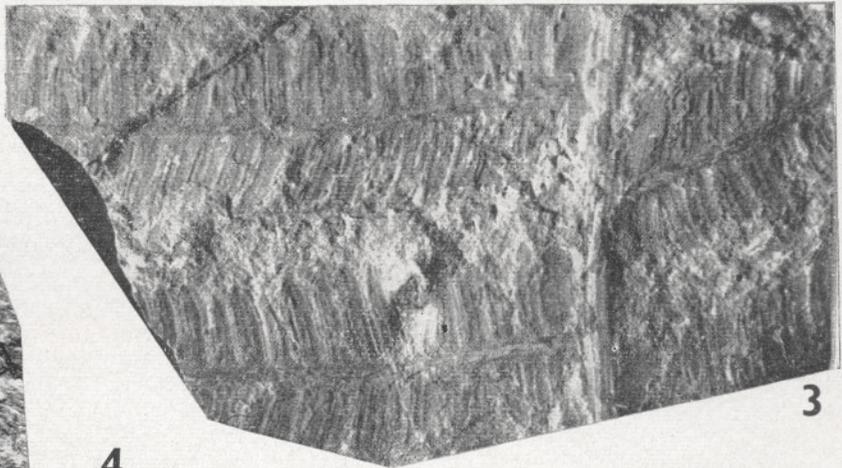
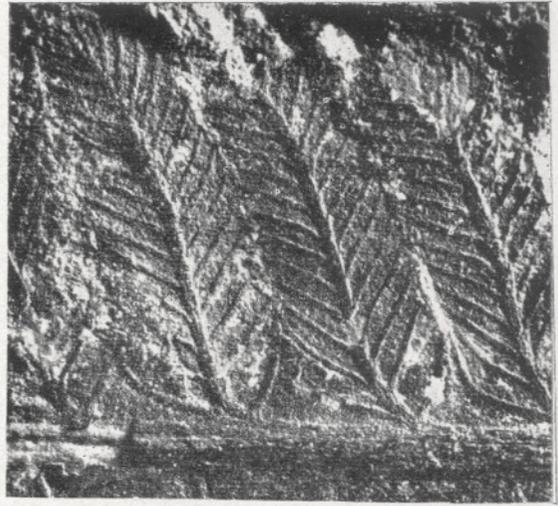
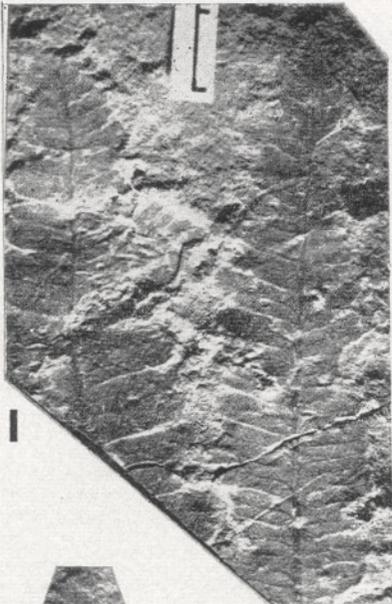
8. A portion of fertile pinnae enlarged,  $\times 4$ ; specimen No. 35110.

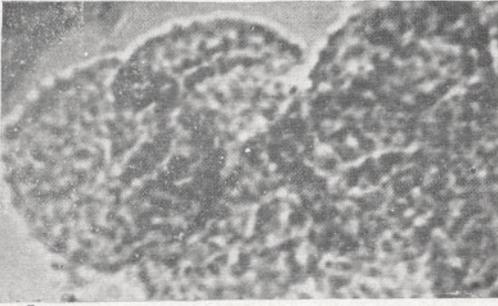
*Dichotomopteris falcata* sp. nov.

9. Pinnules enlarged to show venation,  $\times 6$ ; specimen No. 35112.

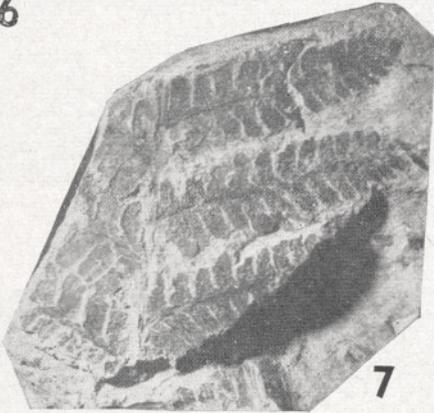
*Neomariopteris hughesii* Maithy

10. Portions of fertile frond,  $\times 1$ ; specimen No. 35113.
11. A portion of fertile pinna enlarged,  $\times 4$ .





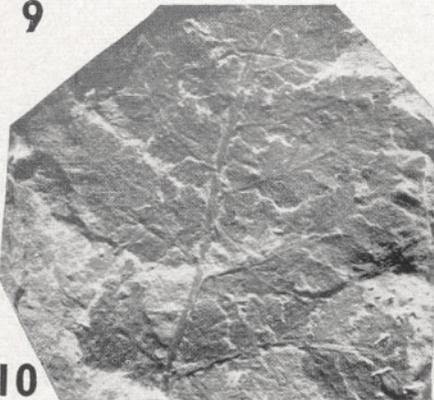
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